New Technologies and Innovations in Agricultural Economics Instruction

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Lest We Forget: Measuring the Costs and Benefits of Teaching Innovations

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If a teacher is pushed to explain why he/she uses (and possibly developed) an innovation, the teacher will produce a list of reasons that typically center on the learning process. These reasons usually include such notions as: 1) to make class more interesting to the student, the teacher, or both, 2) to increase the efficiency of communicating information on a topic, 3) to save the teacher's time, and 4) to increase student learning. Reasons such as these, whether or not explicitly stated when a teacher makes the decision to adopt an innovation, are the objectives in the adoption decision. Subsequent evaluation of an innovation then depends on whether the standards set forth by these objectives are met. Three different evaluation methods can be envisioned: data-free evaluation, passive evaluation, and active evaluation.

Data-free evaluation involves thought processes such as, "This innovation utilizes a computer. Teaching with computers is good. Therefore this innovation is good. Besides, the innovation utilizes color and a super VGA display so it is doubly good." Such a methodology is appropriate if the instructional objective is simply to utilize computers. Otherwise, this methodology is flawed for rather obvious reasons.

Passive evaluation might use the data collected in required formal course evaluations. For example, a representative item in a formal course evaluation questionnaire might be, "The instructor uses methods that are appropriate." to which the student indicates a level of agreement between strongly agree and strongly disagree. The problem with these data is that the response evaluates all methods used in the course. Gleaning objective information about a particular innovation from these responses is impossible because the response aggregates the useful information about a specific innovation with information about other methods. Another type of passive evaluation includes discussion with students. This type of evaluation is potentially biased in that only students who like (as opposed to those who dislike or are indifferent to) the innovation will seek out the teacher and submit themselves to interrogation. Also negative comments are all too easily discounted.

Active evaluation includes pursuing data tailored to evaluating a specific application of a teaching innovation. The data collected should be guided by the objectives of the adoption decision and might focus on measuring student attitudes toward the innovation, measuring the costs and benefits of the innovation, or measuring the innovation's impact on learning production. Cost-benefit analysis and learning achievement analysis both require a learning production function model which has been presented elsewhere (Dahlgran, 1990). This model utilizes the popular notion of a learning curve where time spent under a traditional teaching method is an input and learning is the output of a production function. The adoption of an innovation adds a second input to the production function, namely student time under the innovative teaching method. The amount of learning generated is determined by the marginal conditions of production and occurs where the value (to the student) of the marginal learning achieved is equal to the opportunity cost of the student's time. The comparative statics of this standard production model are well known. Depending on the nature of the production

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function and time and learning valuations, employment an existing factor (student time under the traditional learning method) may either increase or decrease, and total production (learning) may also either increase or decrease.

The implications of this model are twofold. First, controlled experimental results must be interpreted in the context of the production model because they focus exclusively on output, while ignoring input usage. For example, a controlled experiment may indicate that an innovation is worthless because student learning did not increase. However, if students in the experimental group learned the same amount as students in the control group in substantially less time, then the innovation is more beneficial than the controlled experiment indicates. Second, it should be recognized that the learning production function is unique to each student and that each student has a different preferred learning style and capabilities. Accordingly, the distribution of benefits across student populations may not be uniform.

A Case Study of a Specific Innovation

The upper-level undergraduate course that I teach, "The Economics of Futures Markets," encompasses two extremes. On one hand, the economic theory of futures market price determination is abstract, dry, and difficult to teach in an enlivening manner. But futures markets are generally perceived as turbulent and exciting. For example, the movie "Trading Places" portrays futures market speculators who, on a hunch, coolly invest huge sums of money and quickly make or lose fortunes. Though not much fun, the economic theories of price determination in futures and related spot markets are important and constitute half of the material taught in the course. The remainder of the material covers the mechanics of futures market transactions and hedging and speculative applications of futures markets. All of this material could be taught with detailed lectures, but a trading simulator is used to supplement the traditional lecture approach. Other agricultural economists have utilized computerized simulators and generally find them to be useful (Babb, Blank; Boehlje and Eidman; Brown and Schoney; Conley; Dahlgran, 1987, 1990; Osburn, Schneeburger, Wilson and Reber) though some general economists remain skeptical (Siegfried and Fels).

I have several reasons for using a simulator, but making students better speculators is not one of them. First, I assume that with all else constant, student-instructor interaction in a large class will be less than in a small class. Because my class is fairly large (typically 100 students), I am eager to use any device that will increase interaction. Second, I want to tie the economic theory covered in lecture to futures price behavior in the real world. I could devote lectures to describing this linkage but that would not be a memorable "discovery experience" for the students. Third, the diversity of the students in the class and the size of the class require that I do everything possible to create interest in the course. Finally, I want to provide students with a learning device that will fit a variety of learning preferences (Kolb, 1981).

Data on students enrolled in past offerings of the course are summarized in table 1. Enrollment is mostly (95%) juniors and seniors. The course is cross-listed in economics, finance and agricultural economics and satisfies restricted electives in all of these curricula (as well as general business) but is not specifically required in any curriculum. Consequently, student backgrounds, preparations and interests are diverse and no one major accounts for a majority of the enrollment (table 1). Curriculum requirements in the business school also indirectly influence students to take the course. Upper division business and economics courses have a 2.75 cumulative grade point average enrollment requirement. My course does not have this requirement because its primary department is agricultural economics. As a result, a number of students are in the course to maintain a full schedule while their core courses are not available. To objectively determine student motivations for enrolling in the course, students are asked to allocate 100 points among several likely motivations. The data indicate that students enroll in the course primarily to meet degree requirements. The students have substantial diversions in that 62% of the students are employed, that 23% of the students have career-related employment, and that employed students spend about 20 hours per week at work. Most (92%) of the students are full-time (attempting twelve or more credits).

Development of a futures trading simulator began in fall of 1988 and has continued with each subsequent annual offering of the course. The simulator was designed with the goal of enhancing student motivation through the creation of student interest. This lack of student interest is caused to varying degrees by the large class size, heavy work schedules, the diversity of student backgrounds, and curriculum requirements that make some students view this course as required while other view it as a "settle-for" course. My strategy for generating interest is to use a simulator to show the applicability of the material to real-world situations, and to capitalize on the glamorous aspects of futures markets. Thus, the objective in using this simulator is to increase student interest in the course which will hopefully generate increased student learning.

In the simulation, students assume the role of off-exchange futures traders in concurrent time. Current events, such as unusual weather, strikes, stock market corrections, prime interest-rate changes, etc., are relevant to the student-participant just as these events are relevant for actual traders. This makes the simulation as realistic as possible. A commodity trader's objectives are profits but students have course-grade, learning and curriculum objectives which supersede their role objectives. To get students to realistically role-play commodity traders, the simulation performance is worth ten percent of the credit toward the course grade. This ten percent is divided between two activities: profit-search trading and assigned trading.

With profit-search trading, the student can earn up to five percent of the course score by opening, then closing, five futures market positions that generate a profit of at least $1,000 in excess of commission fees ($35 per contract). The student has the entire semester to execute these trades and is limited by initial capital ($50,000) plus accumulated profits and losses to cover margin requirements. The student has to decide the number of futures contracts to buy or sell, which contracts to trade, which maturity of the contract to trade, the timing for opening positions, and when to take profits or losses on open positions.

Five other points can be obtained by correctly executing five assigned trades as they are discussed in lectures. These trades are typically tied to actual market conditions and have included: 1) hedging stock portfolios during a replay of the October 13, 1989 stock market "correction", 2) constructing orange juice spreads in advance of an announcement of a bumper orange harvest in Brazil, 3) executing government security futures spreads to profit from a change in Federal Government financing strategies, 4) executing government security futures spreads to profit from a change in Federal Reserve interest rate targets, and 5) constructing cross-rate currency spreads. These exercises are initiated with an announced price misalignment and a date when price realignment will occur. Students must then buy and/or sell the appropriate number of futures contracts to guarantee a profit from the trade. The assignments require that students calculate spread-ratios and budget their available capital so that other positions are not liquidated due to the lack of funds.

Accounting for the simulation results ensures that participants role-play true to role objectives. This accounting is done with relational database software. A student interface has been created in the database programming language so that the student can interact directly with the simulator through networked (Novell) microcomputers. Each computer displays a menu of student operations which include: change account password; view or print tradable contracts; view historical textual price data; place, view or print orders; place orders with a dartboard; view or print account statement; and view price graphs. The student's account number and password are required to access the system. Once access is gained, operations can be carried out in any order but the typical student session begins by viewing the screen which shows the account statement. This statement can be printed for a permanent record. Next the student might check price graphs or textual price data looking for indicative price trends or structures for contracts of interest. Based on this information, the student decides which and how many contracts to buy or sell so as to get credit for specific assignments. Once these decisions are made, the student enters the desired buy and sell orders on the order-entry screen. This direct order entry saves administrator time, provides instantaneous error checking by rejecting non-tradable orders, and assigns all responsibility for accuracy to the student. Once orders are entered and confirmed, they can be printed or revised. Some students might want to experiment with luck and use the investment dartboard, where they enter the amount of money to invest and let the computer place their order in a futures contract chosen at random. If desired, students can have several sessions during the day which gives them an opportunity to revise orders.

The simulation administrator updates the databases overnight. This is accomplished with the administrator's program which is also written in the database programming language. The required steps are: 1) tradable-futures-contract prices are downloaded from CompuServe or entered from the Wall Street Journal into a prices database, 2) students' orders from the day are printed for verification, and priced from the prices database, 3) priced orders are added to the positions database, 4) orders intended to close positions are matched with the appropriate open position, 5) open positions are marked to market, i.e., valued at the current prices, 6) account totals are computed for each student, 7) margin calls are made (positions are closed and account balances are recomputed) if a student does not have enough cash available to post the margin required for his futures market positions, and 8) price graphs are generated. The updated files are copied onto the network so that the next day's reports will include the latest trades, margin calls and market valuations.

The features which distinguish this simulator from other futures market simulators are: 1) it simulates profit outcomes under actual market conditions, 2) it provides a historical database of prices, volume and open interest, presented both graphically and textually, and this database can be used for research or teaching independent of the simulation, 3) it provides random investment selection (i.e. the dartboard) for baseline comparisons, 4) it provides a student interface so that students perform the order entry, 5) price data can be downloaded from electronic sources, 6) processing is microcomputer based, and 7) it maintains a log of all simulator activity which can be used to analyze trader decision making.

Evaluation

A computer-based simulation has several advantages over alternative approaches. One alternative, a paper-based simulation, is not practical because of the volume of information processed. Table 2 shows that the class averaged 2,653 positions per semester over the last three course offerings. The daily marking-to-market and margin computations for these positions practically requires automation. Had processing been decentralized with students maintaining their own accounts, the computational burden would likely have discouraged experimentation with various contracts and spreads, and auditing would have been an overwhelming administrative chore. Other advantages of a computerized system over a paper-based system are 1) substantial reference information in the form of historical daily open, high, low and closing prices and volume and open interest for each of the roughly 100 contracts traded readily available to the student in both textual and graphical forms, 2) a controlled random investment selection procedure is provided with the investment dartboard, and 3) databases are easily queried, sorted and summarized in various ways so that the class can see its overall trading performance.

A second alternative is to assign problem sets instead of using the trading simulator. However, the assigned trades are, in essence, assigned and graded homework problems. The advantage of putting these problems in the computerized databases is that queries, searching for specific combinations of timing, contracts, and positions, serve as a computerized grading mechanism for these problems. As a result, 100 problem sets can be graded and recorded in a matter of minutes. The savings in instructional time are substantial.

A third alternative is to convey the lessons taught by the simulator in lecture. This approach would have displaced: 1) students' attempts to connect actual market behavior with the theory taught, 2) students' mental processing of contract specifications, expected price behavior and budgeting for futures transactions, 3) the interest generated by the simulator, and 4) the experience-based learning about futures market price behavior.

The effectiveness of the simulator has been a primary concern during its development. Consequently, students are given one point for completing a four-page survey questionnaire administered at the semester's end. The survey is designed so that its data can be connected to other data on exam performance and trading participation. The general categories of the data collected include: 1) demographics (major, classification, sex, race, nationality, cumulative grade point average), 2) time allocation (credits completed during semester, employment, hours of employment, career related employment), 3) Kolb's Learning Style Inventory (Kolb, 1976), 4) attitudes toward course, 5) attitudes toward simulator, and 6) the impact of the simulator on studying and learning. The questionnaire also solicits written comments. The questionnaire was administered in 1988, refined in 1989 and has been used since. The survey contains 43 items in addition to the Learn Style Inventory. The data in table 1 is compiled from these surveys.

Table 3 shows some of the data on student's attitudes toward the simulator. Close inspection of these data will reveal that students have been very supportive of the development of the simulator and its integration into the course. The students generally agreed that the trading simulator reinforced concepts presented in lecture (item 2, 90%), helped them learn about futures markets (item 3, 90%), and made the class more interesting (item 4, 94%). The students were also asked to compare the course with the simulator to an imaginary course without the simulator. In response to these items, students indicated that the simulation made class attendance more worthwhile (item 5, 62%), caused them to spend more time on the course (item 6, 76%), did not "crowd out" the traditional learning activities of reading and studying (item 7, 84%), and caused them to learn more from the course (item 8, 84%). Statistically, these positive attitudes are not negligible as the smallest chi-square test statistic is significant at beyond 10. Tracking responses to each individual item through time generally reveals an increase in student's positive attitudes toward the simulator. This represents enhancements of the simulator and more effective integration of the simulator into the course. These data support the contention that the simulator has increased the general level of interest in the course.

A cross-classification of items six and eight in table 3 permits an evaluation of the innovation's impact on the learning production process. Of the 267 responses with complete information, 182 (13.3 more than expected) indicated that the innovation caused more time to be spent on the course and more learning to be achieved. These students found the innovation to be "time using". Momentarily aggregating the remaining responses for the two items to rid the cross classification of sparsely populated cells, results in a chi-square statistic for the test of independence of these two items of 26.15 which is significant at beyond 10^{-7}. This test supports the production function notion whereby learning is positively related to the time spent on the course. Forty-two students found the innovation to be "time saving", reporting either more learning in the same or less time, or the same learning in less time.. Twenty three students indicated that the innovation had no appreciable effect on either the time spent on the course or learning. Twenty students indicated the innovation to be inefficient, requiring more time to be spent on the course but with no corresponding learning increment. Finally, no one indicated that the innovation was inferior whereby time spent and learning both decreased.

Regression analysis can be used to evaluate whether the simulator's impact on interest translates into more or better student learning. Learning is measured as student i's correct responses ($SCORE_i$) to the 90 multiple choice examination questions administered in the course during the fall semesters of 1989, 1990 and 1991. The examination questions covered the definitions and economic theories of futures pricing presented in lectures but none of the questions specifically covered the futures trading assignments. Experimental design variables ($D89_i$ and $D90_i$) were used to account for differences in difficulty between the 1989 and 1991 examinations and between the 1990 and 1991 examinations, respectively.Student participation in the simulation was measured by the number of futures market positions taken by the student over the course of the semester. Students were classified as participants ($PART_i = 1$) if they had more than six simulated futures market positions. Otherwise, $PART_i = 0$. According to this classification, there were 23 nonparticipants and 287 participants. This classification was used because of the break in the distribution of positions at six, a relatively small number of positions. The distribution of position counts (from 0 through 6) for nonparticipants is (10,2,4,2,2,2,1). The median and average number of positions for participants is 26 and 27.75, respectively. The ordinary least squares estimation of examination performance is

$$\begin{aligned} SCORE_i = \; & \underset{\substack{(2.40)\\ [.000]}}{56.85} - \underset{\substack{(1.49)\\ [.020]}}{3.47}\, D89_i \\ & + \underset{\substack{(1.48)\\ [.000]}}{5.68}\, D90_i + \underset{\substack{(2.31)\\ [.015]}}{5.62}\, PART_i \end{aligned}$$

$R^2 = 0.122$
$F(3,306) = 14.144$
Prob of larger F = 0.000

where standard errors of estimates are in parentheses and probabilities of larger t-statistics are in brackets. These results show that the average respective exam performances in 1989 and 1990 were 3.5 questions below and 5.7 questions above the 1991 exam performance. These differences are statistically significant. More importantly however, students that participated in the trading simulator averaged 5.6 more correct examination responses than nonparticipants after correcting for the differences in examination difficulty. Further analysis indicates that the average cumulative grade point of the participants was .17 above the cumulative grade point average of the nonparticipants but that this difference is not statistically significant.

Conclusions

These results indicate that this simulator enters the teaching/learning process in beneficial ways. It accomplishes the objective of creating student interest and this heightened interest results in greater learning. This conclusion can be generalized to similar courses at other universities. These courses are typically large and widespread.

The simulator also has research applications. First, the futures price, volume and open interest data collected can be used in econometric investigations of futures market price behavior. Second, the data from the simulator's log also has research potential. For example, the log from fall semester 1991 contains 28,844 records from 3,298 individual sessions which identify the student, the information viewed, and the length of time spent viewing the information. These data can be used to examine the relationship between the occurrence of price structures and amateur trading behavior as well as to further study the relationship between specific types of simulator output and learning. More generally, this illustrates how clocks and data gathering capabilities sometimes can be built into teaching innovations, especially if the innovation utilizes computer technology.

A third general conclusion is that evaluating innovations simply in terms of technological "glitz" is not appropriate. The development of teaching innovations is costly if measured only by the opportunity cost of the faculty time involved. Accountability requires that developers should readily be able to identify as well as quantify the benefits of their innovations and they should understand how the innovation fits into the teaching/learning process. Thus, developers need to focus not only on development but also on collecting data and applying models appropriate to evaluating the innovation.

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Table 1. Characteristics of students in "Economics of Futures Markets."

	1988	1989	1990	1991	Average
Class size	83	102	108	100	98
Distribution by Class					
Seniors	72.3%	66.7%	75.0%	76.0%	72.5%
Juniors	24.1	27.4	18.5	18.0	21.9
Other	3.6	5.9	6.5	6.0	5.6
Distribution by Major					
Economics	9.6%	30.4%	22.2%	26.0%	22.6%
Finance	39.8	21.6	30.6	32.0	30.5
General Business	19.3	17.6	13.9	15.0	16.3
Agr Economics	2.4	6.9	13.0	11.0	8.7
Other majors	28.9	23.5	20.3	16.0	21.9
Motivation for taking course:					
Career related		28.9%	27.4%	28.4%	28.2%
Degree requirements		35.9	41.2	39.9	39.0
Curiosity about subject		32.2	29.8	30.3	30.8
Other		3.0	1.6	1.4	2.0
Employment:					
Employed	54.9%	64.3%	70.6%	57.5%	62.1%
Career related	18.3%	27.6%	28.3%	16.1%	22.8%
Hours/wk(emp only)	20.1	20.4	20.4	19.2	20.0
Academic Loads:					
Twelve or more cr	92.5%	92.3%	93.3%	89.4%	92.5%

Table 2. Student participation in the futures market simulator.[a]

	1989	1990	1991	Average
Number of positions	3,072	2,277	2,611	2,653
Number of contracts traded	59,129	34,102	26,368	39,866
Value of contracts traded($ bill)	2.2	2.0	1.8	2.0

a/ These data depend on the nature of assigned trades which varied from year to year. Data for 1988 are not given because the database structures and incentives for 1988 are not comparable with 1989 and later.

Table 3. Student evaluation of futures trading simulation, 1988 through 1991.

Item	Evaluative statement: The trading simulation ...	Year	AS	A	D	DS	Resp
			Responses[a] and Distribution(%)				
1.	... should not be used again in this course.	88	2.4	6.0	41.6	50.0	84
		89	3.1	4.1	29.6	63.3	98
		90	2.2	4.4	39.6	53.8	91
		91	3.5	1.2	20.9	74.4	86
		Average&Total	**2.8**	**3.9**	**32.9**	**60.4**	**359**
2.	... reinforced concepts presented in lecture.	88	12.9	74.1	12.9	0.0	85
		89	24.5	64.3	10.2	1.0	98
		90	24.2	65.9	9.9	0.0	91
		91	29.1	66.3	4.6	0.0	86
		Average&Total	**22.8**	**67.5**	**9.4**	**.3**	**360**
3.	... helped me learn about futures markets.	88	30.6	57.6	9.4	2.3	85
		89	43.9	45.9	8.1	2.0	98
		90	33.0	54.9	12.1	0.0	91
		91	47.1	46.0	6.9	0.0	87
		Average&Total	**38.8**	**51.0**	**9.1**	**1.1**	**361**
4.	... made this class more interesting.	88	42.3	51.8	4.7	1.2	85
		89	57.1	36.7	5.1	1.0	98
		90	47.2	42.9	8.8	1.1	91
		91	60.9	36.8	2.3	0.0	87
		Average&Total	**52.1**	**41.8**	**5.3**	**.8**	**361**
				M	NM/L	L	Resp
5.	... made class attendance ________ worthwhile than it would have been if the simulation had not been used.	89		62.6	34.1	3.3	91
		90		59.3	38.5	2.2	91
		91		62.8	37.2	0.0	86
		Average&Total		**61.6**	**36.6**	**1.8**	**268**
6.	... caused me to spend ________ time on this course than I would have if the simulation had not been used.	89		73.6	24.2	2.2	91
		90		70.3	28.6	1.1	91
		91		83.7	16.3	0.0	86
		Average&Total		**75.7**	**23.1**	**1.1**	**286**
7.	... caused me to spend ________ time reading and studying than I would have if the simulation had not been used.	89		3.3	79.1	17.6	91
		90		3.3	80.2	16.5	91
		91		0.0	87.2	12.8	86
		Average&Total		**2.2**	**82.1**	**15.7**	**286**

Table 3. Continued

8. ... caused me to learn __________ from this course than I would have if the simulation had not been used.	89	81.3	17.6	1.1	91
	90	77.8	21.1	1.1	90
	91	91.9	8.1	0.0	86
	Average&Total	**83.5**	**15.7**	**.7**	**267**

a/ Responses: AS = agree strongly, A = agree, D = disagree, DS = disagree strongly, M = more, NML = no more and no less, L = less to fill in blank.