Wireless Interactive Teaching Simulations (WITS)
Kevin Oliver, Catherine Eckel, Sheryl Ball
Programmers: Andrew Fabian, Josh Goad, Virginia Prudom

Abstract

A demonstration of Wireless Interactive Teaching Simulations (WITS) will illustrate a technological solution to improving educational experiences of undergraduates in large lecture courses. Three separate goals are addressed by the project: integrate hand-held technology into large classes to conduct simulations, develop pedagogically-sound exercises for a microeconomic principles course, and demonstrate the cost-effective impact of wireless solutions on learning in the very large classroom.

Purposes

In the last 50 years, conventional wisdom on using laboratory methods to study and teach economics has changed considerably. Simulated markets, group decisions, and games--also known as "experiments"--are used by many teachers of economics to improve the learning environment for students. Bergstrom and Miller (1997), in their popular textbook Experiments with Economic Principles, describe their purpose in using experiments for teaching as follows:

We got tired of it. Lecturing to sleepy students who want to "go over" material that they have highlighted in their textbooks so they can remember the "key ideas" until the midterm. We want to engage our students in active learning (p. ix).

The difficulty with classroom simulations is that they are effectively impossible to conduct in large lecture courses. The reality at most state institutions is that large classes are the norm for introductory economics. Our Principles of Economics classes, for example, range in size from 150 to over 600, and serve about 2500 students per semester. Conducting simulations by hand with large numbers is cumbersome and time-consuming. The computer labs necessary to conduct faster, computer-assisted simulations rarely hold more than twenty or thirty machines. In order to implement the simulations, therefore, either classroom size must be reduced dramatically or a large number of graduate student assistants must be enlisted and trained to conduct the simulations in recitation sections. The resources required to implement either change are simply unavailable. Our goal in this project is to develop wireless classroom technology to allow students in large classes to participate in simulations during class. This would allow us to improve the quality of education at a relatively low, manageable cost.

Theoretical Framework

Economics students enrolled in large lecture courses rarely have the opportunity to interact with course content. Students attend lectures, take notes, and generate similar responses on quizzes, but because of the absence of active learning and lack of student interaction, do not gain a deep understanding of the material nor the ability to analyze and interpret complex economic events. A recent solution to this problem in economics education has been to incorporate classroom simulations of markets and other exchange situations, a strategy that has been shown to improve student learning at all levels, but especially for introductory courses (Gremmen & Potters, 1997). In addition, a growing body of instructional technology research indicates that simulated experiences allow students to develop more advanced mental models of course concepts (Land & Hannafin, 1997), and to more easily transfer these models to help solve related problems (Jacobson & Spiro, 1995).

Method

Imagine a relatively small introductory class with 100 students. For each round of the exercise, the instructor must collect 50 offers to sell and 50 bids to buy, match buyers and sellers and then complete and distribute forms to notify each of the 100 students individually if they have bought or sold. The instructor will also want to record the 100 bids and offers on the blackboard so that they can be analyzed. It always takes several rounds for prices to reach the competitive equilibrium (five is probably ideal), so with 100 students this exercise would likely require more time than a standard 50 minute class allows. More importantly, perhaps, is that the ratio of students "doing something" to "waiting for something to happen" is too low. Boredom and confusion set in and students lose interest in the exercise.

The solution to this dilemma is to have students use a system of portable computing devices (such as a Palm, Compaq, or Cybiko device) to input price, quantity, and perhaps quality values in the classroom market. Using a wireless link, the devices will send data to a classroom server that will determine if student "buyers" have matched their parameters with student "sellers." A live graphic would be generated through the server and projected in the classroom, displaying the prices at which trades occur. Developing this wireless mechanism will enable us to conduct the simulations in large classrooms. The system needs to be completely portable so that specially-equipped classrooms are not required for its use.

The technology itself has clear advantages over the paper-and-pencil approach. Because of the speed and flexibility of the wireless system, multiple simulations can be run in the large lecture classroom, allowing students to switch roles and experience the same market from different perspectives (e.g., high-cost seller, low-cost seller). It would also allow instructors to answer student questions by immediately conducting a new simulation to illustrate the answer. Students can engage in "what if" reasoning, proposing their own simulations, and then facilitating these new market simulations to correspond with student hypotheses (e.g., "everyone who bought high at 9, now try selling low at 4 to test Keith's prediction."). In addition, the wireless system will capture the data from the exercises. Students can then access the data on a dedicated Web site, manipulating the data using standard spreadsheet and statistical software to test hypotheses. The Web site can be used to disseminate additional out-of-class exercises to reinforce and extend the lessons of the classroom simulations.

Results

This project is organized into four phases. The first phase of this project, already underway, is to develop a system of handheld wireless devices and a means by which they can communicate with a standard Windows OS portable computer. We have already begun working on solving the technical challenges of adopting a retail device as the wireless unit. The device we are working with retails for $99 (Cybiko, 2001). By the end of Summer 2001, we plan to administer paperless multiple-choice quizzes. This phase of the project is funded by a grant from our campus Center for Innovation in Learning, which provides us with funding for two programmers, an electrical engineering student, as well as $5,000 in test equipment. We are also pursuing discussions with several personal digital assistant (PDA) manufacturers, and hope to secure a donation of 100-200 PDA devices. Cybiko (2001) has verbally committed to donating 50 of their new, hand-held devices upon release in Fall 2001.

The second phase of the project is to develop appropriate software applications. We have already created several test applications running on standard desktop computers for a research lab (Laboratory for the Study of Human Thought and Action, 2001). For the wireless system, we plan to create approximately seven different classroom simulations that illustrate standard concepts covered in principles of microeconomics courses (e.g., competitive markets, public goods, oligopoly markets, economic games, labor markets, pollution permit markets). All of these exercises have already been developed in some form for use in the classroom (e.g., Holt, 1996; Holt & Capra, 2000; Estenson, 1994; Kilkenny, 2000; Nelson & Beil, 1995; Williams & Walker, 1993).

The third phase of the study is implementation and beta-testing. In late Fall 2001, we will test each of the simulations with small groups of students and make revisions to the software. Several instructors of smaller, upper-division classes have made their classrooms available for testing.

The fourth phase of the study is full implementation. In Spring 2002, we will conduct a controlled experiment to evaluate the impact of this technology in a large class. This experiment will examine technological, pedagogical, and cost-effectiveness. It is sponsored by a grant from the Mellon Foundation's Cost-Effective Uses of Technology in Teaching program (CEUTT, 2001). Three treatment groups will be compared--a "control" section which receives lecture only, a "traditional" section which receives lecture plus seven simulation activities in recitation sessions, and an experimental "wireless" section which receives lectures integrated with wireless-based simulations (no recitation).

Data Sources

We have outlined various outcome measures or data sources that will be collected across the three treatments during the controlled experiment (see Table 1). In addition, we have outlined cost categories and specific resources to be costed. These items represent the "input structure" or "ingredients" for the cost analysis, and include resources tied to personnel, facilities, equipment, materials, and services (Levin, 1975; Wolf, 1990). Using a baseline figure, cost per student served, we will specify which course sections cost more to deliver. For example, we may find the three course sections cost $14, $24, and $32, per student to deliver respectively. Outcome information will be displayed in a spreadsheet. Average scores will be obtained for each evaluation item (e.g., motivation/satisfaction), for each test item (i.e., conceptual and transfer-related), and for final course grades, within each treatment group. The scores will be analyzed for statistical differences, so if a given treatment costs $2 more per student to deliver, we can specify what benefits if any were realized for the extra cost. A measure of cost effectiveness can be derived by dividing the cost per student served by average scores on outcomes measures (Popham, 1993).

Table 1
Outcome Measures and Instruments

Outcome	Instrument to Use in Data Collection
motivation, satisfaction	course evaluations
learning--conceptual	basic course exams, minute papers, conceptual diagnostic tests, departmental "Economics Knowledge Assessment Exam"
learning--transfer, short term	problem solving questions
course grades	course grades, average score
pass/fail ratio	course grades, percent passing
completion/dropout ratio	course rosters, credit hours generated
engagement, questioning	observation protocol, seeking number and types of questions asked by students in different treatment groups
experience	observation protocol, seeking number and variety of simulations students are exposed to in different treatment groups; web tracking, seeking number of hits and student usage of Web site that stores wireless classroom simulation data

Educational Importance

While we expect that both methods for incorporating simulations (i.e., wireless vs. paper-based recitation) will improve student comprehension, we expect students in the wireless group will be better able to transfer their knowledge to solve novel economics problems. The wireless environment facilitates student questioning and requests for multiple new simulations with slightly altered variables. When allowed to rapidly inspect multiple models, students have been shown to move from an "initial" mental model of personal constructs to a "synthetic" mental model of conflicting cultural information attached to the initial theories (i.e., misconceptions), and finally to a correct understanding of a concept or phenomena (Vosniadou, 1994). Simulated experiences can promote mental model development (Snir & Smith, 1995; White & Frederiksen, 2000), which in turn help students solve new problems (Jacobson & Spiro, 1995).

Project findings will be of value to faculty interested in the development of wireless technologies as well as the application of simulations to improve student mental models. This audience is extremely large, as simulations are scalable to multiple disciplines. Large classes that may benefit from similar wireless-enabled simulations are found in social sciences (political science, sociology, psychology) as well as engineering, biological sciences, and other fields of study for which students can interact with and manipulate systems to gain a flexible understanding of their structures. Project findings will also be of value to decision makers interested in cost-effective solutions to improve undergraduate learning. With its unique focus on technology and learning within the bounds of cost-effectiveness, this demonstration proposal emphasizes the "value" theme espoused by the 2002 AERA conference.

The proposed project represents a unique cross-discipline effort to improve undergraduate education, and the results may be disseminated to multiple fields of study. Conference presentations and journal publications will be utilized to report results of project technical capacities, processes, and outcomes not only to faculty in Economics, but also to faculty in Instructional Technology, Education, and Electrical Engineering. Presentations and articles will be archived on the project Web site (WITS, 2001).

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