Facilitating Classroom Economics Experiments with an Emerging Technology: The Case of Clickers

by

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For the uninitiated undergraduate student, economics can be very abstract. When the price of a popular item falls, most students may find themselves increasing the consumption of the good. However, when stated in a more formal fashion by an economics professor that the demand curve for the good is downward sloping, often students are dumbfounded. Due to limited exposure, the linkage between an economic model and the underlying economic pattern the model depicts is often not as straightforward as the linkage between a city map and the underlying city the map represents. Even for those students who are analytically inclined and can learn from abstraction, the task still remains of convincing them that instead of being merely the product of some mathematical constructs economic principles are actually as useful in explaining and predicting economic behavior as their city maps in helping them navigating the city. Too much abstraction with which students have no experience and the seemingly lack of relevancy of the abstraction are the double hurdles keeping the uninitiated from jumping over the intellectual fence to become the converted.

While potential solutions abound, one way to deal with the problems is to force the reality into the classroom through experiments, which are broadly defined by Laury as "any interactive exercise that gets students involved in the economic problem that is being taught." For example, before introducing the concept of downward sloping demand curve, the instructor could conduct an auction to elicit the amount of the good each student is willing to buy under various price scenarios. Upon analyzing data from the experiment, students will: i) appreciate better, through concrete experience, the concept of downward sloping demand curve and ii) recognize, via reflective observation of their own behavior in the experiment, the relevancy of the abstract conceptualization.[1]

This article reports a new method of conducting classroom economics experiment by taking advantage of the audience response system (ARS, used here as a generic name). The ARS is an emerging classroom technology that enables students to respond privately to questions posed by the instructor who then has the option of immediately accessing the responses at the end of the question period. Using the ARS to facilitate active learning by engaging students in economics experiment represents an added advantage, on top of such conventional functions as taking attendance, administering quizzes, and getting instantaneous feedback, of this increasingly popular wireless classroom technology.

We first present the learning theory behind classroom experiments in Section 2, followed by a discussion on various ways of conducting experiments including the use of the ARS. We then outline in Section 4 our procedure of using the ARS for conducting pit market experiments and discuss in Section 5 how trading data can be displayed in real time. In Section 6 we evaluate the learning outcome of two pit market experiments conducted in a microeconomic principles class and in Section 7 we make suggestions on extending the applications of the ARS to experiments other than pit market trading. Section 8 concludes.

Learning theory and existing literature

Recent work in educational theory and findings from educational research provide a number of reasons to think that classroom experiments of engaging students through interactive exercises can have salutary effects on students' learning experience. First, by providing the missing link between abstraction and reality and by making learning participatory and interesting, classroom economics experiments can improve student engagement and motivation (Judson and Sawada 2002). Intrinsic motivation, in particular, has been shown to be a powerful predictor of academic success (Deci and Ryan 1985). Second, classroom experiments may provide immediate feedback on student performance. Learning is given focus by students' understanding of what they know and what they do not know, and feedback is central to creating this understanding (Chickering and Gamson 1987). Empirical studies have shown improvements in learning through prompt, constructive feedback – particularly formative feedback – on student activities (Bangert-Drowns, et al. 1991; Higgins, Hartley, and Skelton 2002). Finally, classroom experiments provide instructors with a vehicle for eliciting, diagnosing, and correcting student misconceptions. This ability is crucial to good teaching, because students' prior knowledge in a domain is the foundation upon which they build further knowledge (Angelo and Cross 1993; Bransford, Brown, and Cocking 2000).

A growing empirical literature confirms the potential of classroom experiments to enhance student learning in economics classes. For instance, Gremmen and Potters (1997) used an experimental design to examine the effect on student learning outcomes of an in-class simulation of international economic relations. Though their sample size was small and the intervention limited to a single experiment, the authors found an improvement in pre-post difference scores that was marginally significant.

Emerson and Taylor (2004) improved on Gremmen and Potters by using a stronger intervention and a larger sample to examine the efficacy of a series of 11 classroom experiments. The authors found significant gains in student performance on the Test of Understanding in College Economics (TUCE) in the experimental section, particularly with respect to questions that measure understanding at the highest cognitive level. Dickie (2006) reported results similar to those of Emerson and Taylor, though his study found that in-class experiments may actually impair the performance of students of lesser ability.

Finally, Durham, McKinnon, and Schulman (2007) extended the evaluation of classroom experiments by examining the effects of a series of experiments not only on student learning, but also on student retention of knowledge and student attitudes, using student learning styles as a factor in the analysis. The findings indicated that some of the experiments improved retention and learning while others did not, leading the authors to hypothesize that for certain topics a lecture-and-discussion approach may be superior. The authors also found that learning style mediates the effects of classroom experiments.

Implementation by means of ARS

Classroom experiments could be run using the traditional pencil-and-paper method, which entails having each student fill in numbers in a questionnaire, with instructor painstakingly compiling the raw data into a useful form thereafter. If the instructor works fast enough, he or she would be able to present the compiled data to the class the next session and provide a bridge between the students' simulated reality and the abstract economic model at hand.

Clearly, the cost to the instructor of the above teaching method is extremely high. This would be especially true for large classes, characteristic of many introductory economics courses. The cost-benefit analysis principle thus dictates that an instructor may shy away from this potentially rewarding mode of classroom interaction and stick to the more conventional way of simply lecturing.

With advances in computer technology and its widespread adoption as a teaching and learning tool, significant strides have been made to overcome the above mentioned limitation associated with the pencil-and-paper method of conducting classroom economics experiments. For example, networked computer labs have been used to facilitate economics experiments for pedagogical purposes (Wells 1991; Hester 1991; Williams and Walker 1993). While potentially labor saving and capable of providing instantaneous feedback, the factor substitution possibility in favor of such specialized capital inputs as lab facilities, computer equipment, and simulation software may not be available to many instructors, especially those from less endowed institutions. In any case, introductory economics classes are oftentimes too large for networked computer labs to accommodate in one sitting, thus presenting a logistic challenge when a subdivision of the large group is not feasible.

The above lab facility related problems appear to be solved with the advent of the Internet technology which allows students to participate in economics experiments from remote sites wherever and whenever they choose, as long as it is within a specific timeframe specified by the instructor (Cardell, et al. 1996; Grobelnik, Holt, and Prasnikar 1999; Ironside, Joerding, and Kuzyk 2004).[2] Compared to the classroom and computer lab settings, the Internet approach of conducting economics experiments for teaching purposes does leave something to be desired: it removes the face-to-face interaction among students and between the student and the instructor, potentially hampering instantaneous feedback.

Another method of implementing classroom experiments involves the audience response system (ARS), which is a device for fostering interactivity in classroom environments. Varieties of the ARS have been in use for at least 20 years (Duncan 2005; Judson and Sawada 2002; and Wikipedia) and are known by a number of brand names such as Personal Response System (by Interwrite) and Classroom Performance System (by eInstruction), or more unceremoniously as “the clickers”. What all varieties of the ARS have in common is that they are fundamentally devices for questioning and feedback: they enable instructors to pose and students to answer questions and typically have the ability to instantaneously produce a display of student answers for review and discussion.

The ARS can be used to facilitate many different teaching techniques: as an assessment device for giving instructors a snapshot of student understanding, as a feedback mechanism for obtaining opinions on the instructor’s teaching, as a testing process for engaging student in self- or peer assessment, as a facilitating vehicle for initiating student discussion, and as a data collection tool for implementing experiments using human responses. An extensive literature on the ARS documents a number of potential educational benefits of using the system, including improvements in student achievement, increased attendance, reduced attrition, and a more engaged class environment (Angelo and Cross 1993; Cox and Junkin 2002; Crouch and Mazur 2001; Draper and Brown 2004).

For the past four years we have implemented in our economics classes a pedagogical paradigm combining the conventional learning cycle teaching practice with the ARS classroom technology. Each class session is divided into three to four learning cycles comprised of lecturing, problem solving/cooperative learning, discussion/ critiquing, and summarization. Upon the completion of each lecture topic (every ten minutes or so) a question is posed. Using a wireless transmitter, each student has the opportunity to enter his or her answer into the ARS within a specified timeframe (usually two minutes). In figuring out the answer, students are encouraged to pair up and work as a team. At the end of the question session, a student is selected to articulate to the class the reason underlying his or her answer. Other students may be invited to either support or refute the answer given by the first student. At times, a team may be called upon to come to the front to explicitly solve the problem and explain the answer to the class. Before moving to the next lecture topic, we use the projection system to show a histogram summarizing class performance, then offer final remarks.[3] In addition, we have also used the ARS to conduct in-class Jeopardy games for reviewing materials, and to administer multiple-choice exams in which students enter their answers into the system at their own pace. In this student-managed mode ARS application, each student has on the projection screen an identification box indicating the question number that he or she is currently on and is free to move from one question to the other by simply pressing the appropriate arrow key.

In the remainder of this paper, we will describe an innovative method of utilizing the ARS to collect and compile data from classroom experiments. The use of the ARS to facilitate classroom economics experiments has pedagogical advantages over both the labor-intensive approach of pencil-and-paper and the capital-intensive route of relying on networked and on-line computer labs. Unlike the pencil-and-paper approach, the ARS permits real-time data collection and immediate feedback on the economics experiment at hand. Unlike the online approach, the ARS allows face-to-face student interaction, providing both cognitive and affective engagement. Finally, the ARS makes smaller demands on capital resources than the networked computer lab approach and enables the instructor to approximate a real market situation in the classroom, thus allowing students to learn in a semi-authentic context. Despite these advantages, to our knowledge the ARS has never before been used to facilitate classroom economics experiments.

Procedures and the experiments

Due to the pilot nature of the project, only two experiments were conducted, both involved pit market trading, characterized by haggling between buyers and sellers through open outcry in a designated trading area located in the center of the classroom. The protocol for conducting classroom pit markets and the usefulness of the experiment in illustrating the working and efficiency of competitive markets have been documented in detail in the literature (Holt 1996; Ruffle 2003; DeYoung 1993). This study adopts the established procedure to accommodate the use of ARS in facilitating the experiment.

To illustrate the procedure, consider our case of a 50 minutes class session with 34 students. Upon entering the classroom at the beginning of a session, each student is told to sit on one of the two sides of the classroom, designated for buyers and sellers, respectively. A one-page Instruction Sheet is handed out, informing each trader that: i) there will be three trading rounds with each round being three minutes in length, ii) each seller (buyer) will have the opportunity of selling (buying) one unit of the good per round, iii) each seller will be assigned a production cost of producing one unit of the good and each buyer a value of owning one unit of the good, iv) there is a rationality rule that the ask price of a seller cannot be no lower than his or her reservation price (i.e., cost of producing the good) and the bid price of a buyer cannot be higher than his or her reservation price (i.e., value of owning the good), and v) there is a futures contract provision that a seller will not incur any production cost if he or she does not make a sale in the round.

While the students are reading the instructions, ID tags are distributed with seller's ID numbers ranging from 101 to 117 and buyer's ID numbers from 901 to 917. Students will be asked to wear their ID tags when trading in the pit, identifying potential trading partners by the two distinct colors of the ID tags. At this point, the instructor engages the ARS using student-managed mode (which can accommodate both multiple-choice and numeric value questions) and instructs each student to enter his or her ID tag number to the system as the answer to the first question. While the TAs are distributing the seller cost cards and buyer value cards, the instructor then summarizes the key points of the trading procedure and reminds the students that in no way should they reveal their reservation prices to the other traders. The cost cards (e.g., Seller Cost $10) and value cards (e.g., Buyer Value $28), being laminated 5 in. by 4 in. cards, can be handled easily and their colors are the same as the two colors used for seller and buyer ID tags. The students then enter their reservation prices to the system as the answer to the second question. There are five questions in total as the students are yet to enter their transaction prices from the three trading rounds.

To begin the first round, the instructor signals the students to enter the trading pit (with buyers staying on the buyer side and sellers on the seller side), carrying with them their wireless transmitters and cost/value cards (without revealing the information thereon). The instructor opens the market and starts the clock. When a buyer and a seller agree upon a price, they proceed to the recording booth in the front, turning in their cost and value cards (facing down) to one of the two booth operators (the TAs) and informing her of the agreed upon transaction price.[4] The booth operator then checks if the transaction price obeys the rationality rule by comparing it against the reservation prices of the two traders. If invalid, the party is instructed to return to the trading pit to resume trade. If valid, the booth operator will announce aloud the transaction price and a recorder standing in front of a whiteboard will repeat the price quote one more time aloud before writing it down in a sequential manner on the board. The booth operator then instructs the two trading partners to enter their transaction price into the ARS as the answer to the third question. Once the booth operator returns the cost and value cards to the traders, they return to their seats and, to stay engaged, fill in their Earning Recording Sheets appearing on the backside of the Instruction Sheet. At the end of the round, those traders who did not negotiate a trade in the round are prompted to press an arrow key in the transmitter to advance to the next question so that all the traders are on the same page ready for the next round. The procedure outlined in this paragraph is repeated for the second and third rounds; the traders enter their transactions prices as the answers to the fourth and fifth questions, respectively.

With all three rounds completed, the instructor exits the ARS and toggles off the overhead screen projection. The recorder then takes over the desktop computer, manipulates the three-round data generated by the ARS, creates the necessary graphs and tables, and inserts them via cut-and-paste into the instructor's Powerpoint presentation file at pre-specified slide locations. This data manipulation step takes about five minutes (see next section for details), giving the instructor just enough time to prep the students for post-experiment discussion.

The above ARS-facilitated method of conducting pit market experiments was implemented during the Fall semester of 2006 in a microeconomic principles class which had approximately 110 students. The class consists of two 50 minutes lecture sessions per week, with students breaking up into three 50-minute discussion sessions (34 ~ 36 students each) on Fridays led by a TA. We now briefly describe the two pit market experiments which were conducted during the discussion sessions.

The objective of the first experiment was to instill in students the predictive function of the supply-demand equilibrium model, and to demonstrate how competitive markets clear and their efficiency in capturing economic surplus (arising from the discrepancy between the reservation prices of buyers and sellers). The experiment was also used to illustrate the effect on equilibrium of a government price control. As illustrated in Figure 1, the equilibrium model predicts a price of \$30 ~ \$32, a quantity of 13 units, and a maximum economic surplus of \$284, given the assigned reservation prices.[5]

Upon manipulating the data generated in the experiment, students are shown their trading performance in each round by graphs such as Figure 2. Note in the figure that Buyer #1 struck a deal with Seller #15 (a high cost producer) at a price of \$40 a unit, suggesting that inefficient trades exist in this particular round. Students were impressed

Figure 1: Reservation Prices of Buyers and Sellers

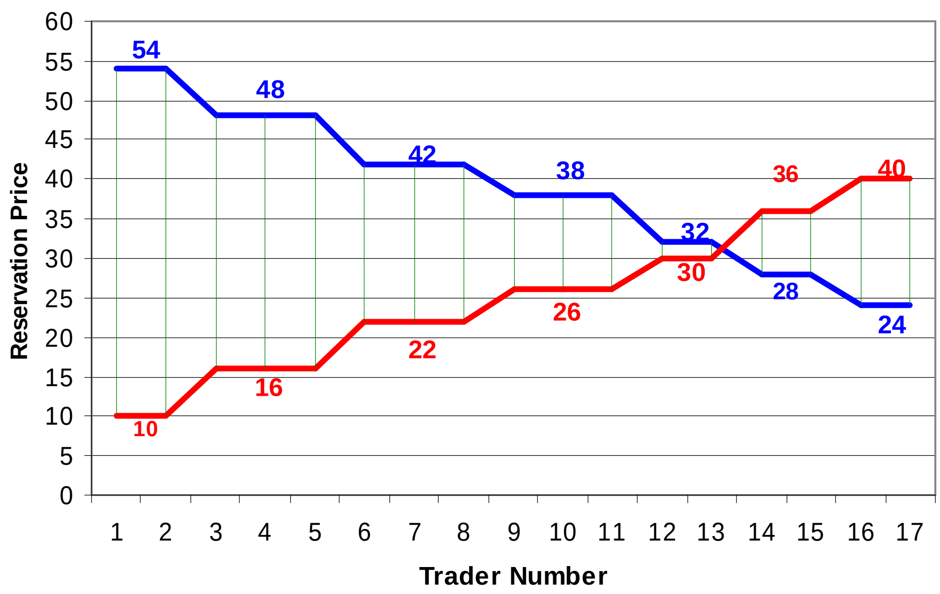
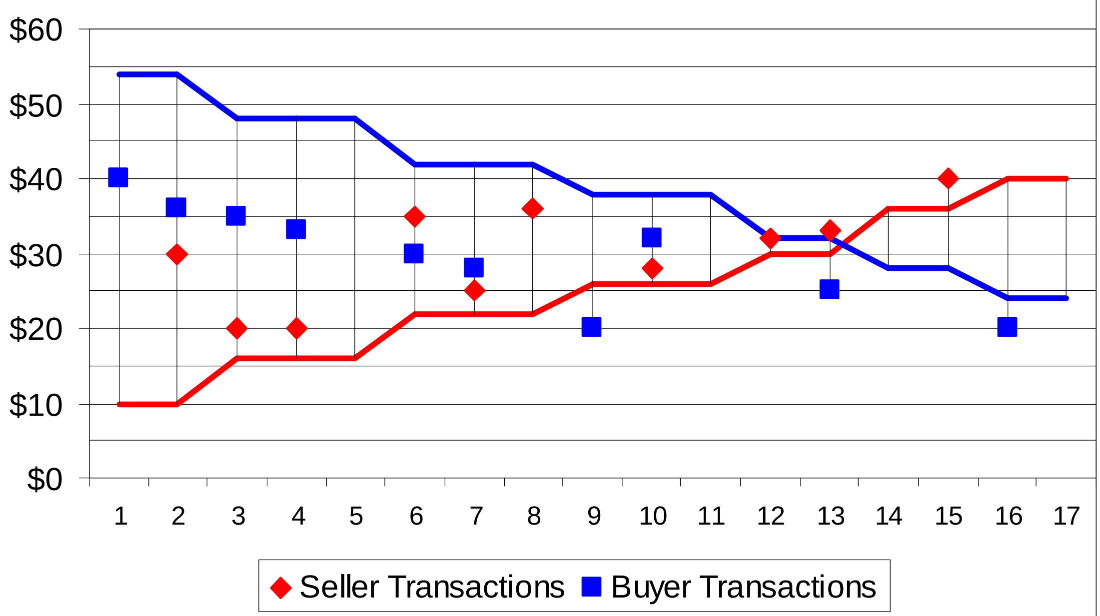


Figure 2: Transaction Prices



to find that most of them were able to trade at or near the equilibrium prices after only one round of trading, achieving on average an efficiency level of 73% in the second round.[6] In contrasting the results from the first two rounds, students were also able to appreciate the effect of inefficient trades on economic surplus and on price dispersions. Students adjusted quickly to the new equilibrium in the third round in which a binding government price ceiling of $24 per unit was imposed.

The objective of the second experiment was to demonstrate the effects on market outcomes of a buyer tax and a seller tax, as well as the equivalency of the two tax measures. Students were first reminded of the previous pit market experiment three weeks prior and lessons learned, followed by a pre-experiment discussion on the pros and cons of taxing the sellers vs. the buyers. As a warm up, tax was imposed on neither the sellers nor the buyers in the first round. The previous non-intervention equilibrium price of $30 ~ $32 was quickly realized in the first round, though the role as a seller or as a buyer has been reassigned in this experiment. In the second round a seller tax of $15 per unit was imposed. During the discussion of results, students were impressed to see the Powerpoint presentation of a vertical upward shift in their supply curve due to the imposition of the seller tax and some of them were quick to figure out from the graph the effect of the tax on consumer and producer prices. The instructor then discussed the deadweight loss of taxation by having students identify in the graph the areas for consumer surplus, producer surplus and tax revenues. Students were amused to see the extent of market noise in this round by noticing their transaction prices being widely different from the predicted values, but were glad to find out that they recovered quickly in the third round (efficiency level = 89%) in which a buyer tax of $15 was imposed instead. Students were also surprised to find their pre-experiment conjectures on the superiority of one tax scheme over the other did not bear out, upon comparing the theoretical predictions for the two cases. The instructor closed the experiment by invoking the transaction costs argument of tax collection to explain the prevalence of seller taxes students have typically observed in real life.

Displaying student data in real time

Creating data displays for immediate feedback on student performance in the experiment took place in two stages. In the first stage, prior to the class in which the experiment was conducted, Excel spreadsheets were created, designed to perform calculations on the data produced by students during the experiment and to display those data in illuminating ways. To do this, we conducted small trial runs with the ARS and exported the generated data (in text format, in order to determine the location within the spreadsheet of students' tag ID numbers, reservation prices, and transaction prices). We then created calculations and charts within the spreadsheets that took as inputs the data at these predetermined locations.

The second stage occurred during class. After three rounds of trading, the instructor exported the text data from the ARS system, saving the file with a predetermined filename. As the instructor engaged the class in discussion about what they had just experienced, the recorder opened the text date file, cleaned up any student data entry errors (e.g., via asking students to verify their entries), separated buyers from sellers, and opened the Excel spreadsheet template created in the first stage. The spreadsheet performed calculations on the live student data (including potential surplus, realized surplus, efficiency, mean transaction price, and standard deviation of transaction prices) and generated graphs such as Figure 2.

The data display procedure described above was not without challenges. For instance, during the first lab session of the first experiment, the ARS generated unexpected extraneous data (due to a first-stage programming oversight) which caused the Excel spreadsheets not to function properly, resulting in faulty data displays. It was also learned that cleaning up the text data could be a taxing operation because it was conducted in real time, in front of a classroom of students, and that practice was required to carry out this task smoothly and quickly. Given the need to clean up student data entry errors, it is unlikely that this data cleaning process could be automated. Creating the data display templates in Excel was also complicated by the need to make allowances for the fact that the number of transactions in each round may differ. Adjustments also had to be made on the spot in the computation of efficiency rate in a specific lab session in which less than 26 (i.e., 2 * equilibrium quantity) students showed up for the experiment, rendering the maximum surplus less than that depicted by the usual welfare triangle. We expect, however, that this expenditure of time will be reduced significantly in the future as the experimenters gain proficiency.

Evaluations of student attitudes and learning outcomes

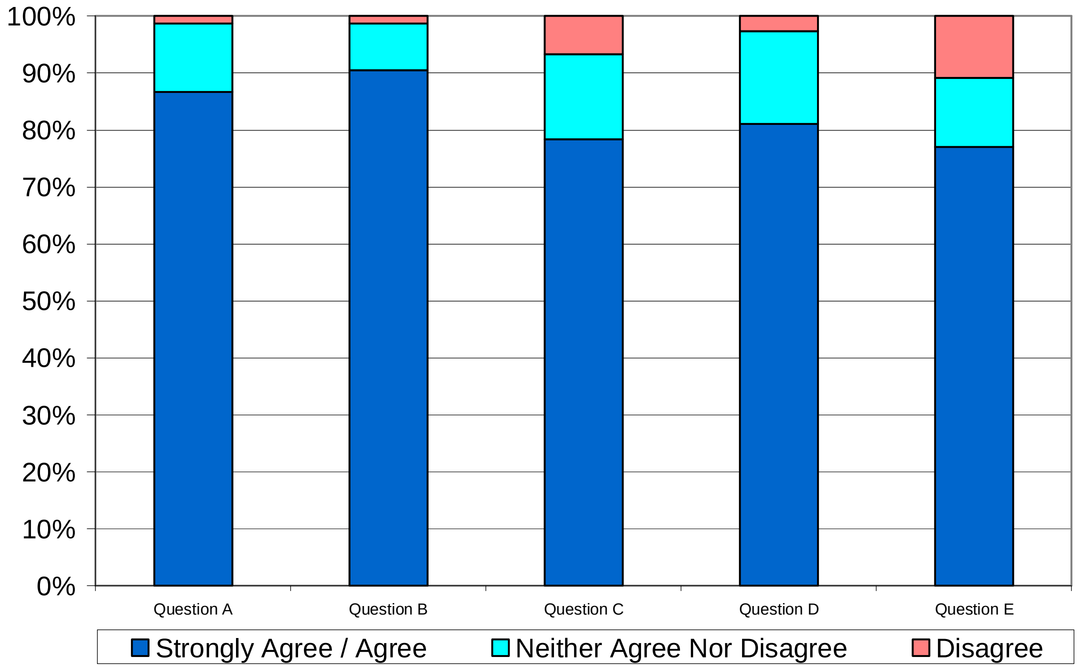
While the focus of this paper is on the use of ARS in facilitating classroom experiments, it is useful to briefly discuss the responses from a post-experiment survey and compare the learning outcomes of students in the experiment group with those in a controlled group to which the experiments were not administered. The survey results are reported first, followed by a discussion on the learning outcome comparison.

In the lecture session following the first pit market experiment, the students in the experiment group were surveyed about their experience and the usefulness of the experiment. Each survey question has six possible answers including: strongly agree, agree, neither agree nor disagree, disagree, strongly disagree, and I did not attend the experiment. Using the ARS, the students were asked to answer the following question statements:

A) I enjoyed the pit market experiment last Friday.
B) The experiment helped me understand how the equilibrium prices and quantities are determined in a competitive market.
C) The experiment helped me understand the concept that: buyers' reservation prices = demand curve, and sellers' reservation prices = supply curve.
D) The experiment helped me understand the concept of consumer surplus and producer surplus.
E) The experiment helped me understand the concept of economic efficiency.

Approximately 100 students participated in both the first pit market experiment and the post-experiment survey. Figure 3 reports students' responses to each question, with the lower segment of a bar representing the percentage of students either "strongly agreed" or "agreed" with the question statement, the middle segment "neither agreed nor disagreed", and the upper segment "disagreed" or "strongly disagreed". Regarding Statement A of finding the experiment enjoyable, 86 percent of the students either

Figure 3: Students' Post-Experiment Survey Responses



"strongly agreed" or "agreed", 13 percent of them "neither agreed nor disagreed", and the remaining one percent or so either "disagreed" or "strongly disagreed". Likewise, the results pertaining to Statements B to E indicate that the majority of the students found the experiment useful in helping them understand the economic concepts the instructor intended to convey.

In addition to the class received the pit market experiments, the instructor also taught a second microeconomic principles class similar to the first one: about the same size (110 students), during the same semester (Fall 2006), in the same lecture hall (back-to-back), and with a similar Friday break-out pattern of three discussion sessions (concurrent to those for the first class, albeit led by a different TA). In evaluating the effect on learning outcome of the experiments, this second class is served as the controlled group; students in this group received standard lecture-style lessons (augmented with whiteboard drawings and Powerpoint slides) on the topics at hand at the time when the experiments were being treated in the first class.

Three performance measures were adopted for assessing learning impacts. The first measure is the percentage change between the TUCE test scores administered at the beginning and the end of the semester, aiming at determining the effect of the treatment on the overall economics literacy of the students.[7] The second measure is the score on five specific multiple-choice questions in the final examination, designed to gauge students' understanding of the issues related to consumer and producer taxes addressed in the second pit market experiment. The third measure is the semester score from the course, assessing the effect of the treatment on the overall learning outcome of the students. Considering the heterogeneity in personal characteristics, we controlled in the regression analyses for such factors as gender, age, race, reason for taking the course (required or elective), cumulative GPA up to the end of previous semester, and the average hours spent per week working on jobs and studying for the course, respectively, during the semester. In the two equations in which the dependent variable is the percentage change in TUCE test score and the overall semester score, ordinary least squares estimation procedure is used. Recognizing the discrete nature of the dependent variable, an Ordered Logit procedure is used in the estimation of the regression equation in which the performance measure is the score on the five tax related multiple-choice questions.

Estimation results suggest some positive impacts on learning outcomes of the experiments, based on the three performance measures: attending experiments increases the post-test TUCE scores by 3.5%, boosts the score of tax specific questions in the final examination by 2.4% and heightened the overall semester score by 2.2% when compared to the controlled group. However, the effects are not statistically significant at the conventional confidence levels. We also found weak evidence suggesting that younger students with lower GPA who spend more hours on studying for the course tend to benefit more from the experiments than students with a different set of characteristics; a result appears to be in line with Durham, McKinnon and Schulman's (2007) finding that the effectiveness of classroom experiments on learning is a function of student's learning styles.

The lack of strong statistical evidence on learning impacts could be a reflection of the fact that there is no difference in learning outcomes between the conventional lecture approach and the more active learning format of utilizing classroom experiments. Given the recent significant positive findings of Durham, McKinnon and Schulman (2007) and Emerson and Taylor (2004), however, one should look harder for reasons leading to the insignificant result. First, it could well be due to a lack of proficiency on our part in implementing the experiments (our very first time). Second, it is also possible that we have not used the appropriate performance measure for learning impact and/or have failed to control adequately the heterogeneity among student subjects. Third, it could be due to the fact that the number of experiments administered was insufficient, not giving students enough exposure to overcome the minimum threshold that is required for learning impacts. As such, we believe that our future efforts should lie in the areas of perfecting our experiment procedure and ways of engaging student subjects, refining our research methods on performance evaluation, and including additional experiments into our teaching repertoire. In these regards, we find insights aplenty in Durham, McKinnon and Schulman (2007).

Other ARS Applications

In addition to the two pit market experiments discussed, the ARS can potentially be utilized in other types of experiments. Staying for a while within the confine of pit market trading, the ARS can be used to facilitate those experiments which are to illustrate the effect of market imperfections and the various measures of correcting for market failures. For example, consider the externality experiment discussed in Bergstrom and Miller (2000, Ch. 6) in which a tax scheme is used to steer the equilibrium of a polluting economy toward the one characterized by social optimality. The use of ARS in this case would be similar to our second pit market experiment of producer tax. If pollution permits are to be issued and traded, then one can set up two pit markets, trading first the pollution permits and then the underlying good. In this case, the ARS procedure outlined in previous sections would still apply.

Stepping outside of the box of pit market trading, one can still find usefulness in using the ARS in classroom experiments. Consider the case of social dilemma of voluntary provision of a public good as discussed in Holt and Laury (1997). Instead of laboriously collecting playing cards from student subjects to determine the amount of money they are investing in a public account and then painstakingly returning the cards back to the students in a correct sequence to be ready for the subsequent round,[8] one can simply have each student keys in his or her contribution amount to the ARS system, avoiding altogether the use of playing cards and other props. Another potential application of the ARS is in the demonstration of the effect of free entry and exit on long-run equilibrium profits. In Garrett (2000) each student is to decide, round by round, whether to supply to the market one unit of a crop from a choice of four crops. The price in each market, dictated by an anonymous demand equation, is a function of the supply quantity and will be announced to all potential suppliers before moving onto the next round in searching of the long-run equilibria. With a multiple-choice question, the ARS can be used to collect and compile information on the type of crop (if any) each student is to produce in a specific round, serving as the basis for the computation of the price and the profits in each of the four markets.

In sum, any classroom experiment focusing on utilizing the aggregate outcomes generated therein can potentially find the ARS a facilitating tool, because the inputted data can be easily extracted and exported to a spreadsheet program for further compilation and analysis. On the other hand, for those experiments whose learning impacts rely more heavily on the disclosure of results from interactions among individuals (e.g., results from a two-person prisoner’s dilemma game), one may find the tool of limited usefulness by the very nature that disaggregated outcomes can be best revealed by a direct observation of the subjects themselves. Even in this case, one can still use the ARS to demonstrate the average outcome of the experiment and allow the class to gain comparative static insights on how the aggregate outcome would change when an underlying parameter of the game is altered.

Summary and Conclusions

Our intention in this pilot study was to assess the feasibility and efficacy of using the ARS to implement classroom economics experiments and to identify an efficient procedure for the implementation. The ARS approach reduces the time costs of the paper-and-pencil method of conducting classroom experiments, allowing instantaneous feedback of the results, while preserving the face-to-face student interaction that the online method lacks. Further, unlike the capital-intensive route of relying on networked computer labs, the ARS approach makes only minimal demands on equipment, rendering it especially attractive for instructors facing capital resource constraints.

A set of procedures for pit market experiments was identified and suggestions on extending the procedure to applications other than pit market trading were forwarded. The ARS-facilitated pit market experiments were implemented in a microeconomic principles class of 110 students in Fall 2006. While the initial Excel programming time required for generating real-time data displays was non-trivial and it took a bit of practice to seamlessly process, in front of student subjects, the generated data into a form that is conducive to post-experiment discussion, we believe that the costs can be significantly lessened in the future as the experimenters gain proficiency. The experiments themselves, along with the real-time display of student-generated data made possible by the ARS, appeared to excite, interest, and motivate students. Anecdotal evidence and survey results show that students enjoyed the experiments and found them helpful in learning the concepts involved. However, we found only modest, statistically non-significant increases in pre-post test scores, which may be attributable to the low power of our intervention (only two experiments were conducted). Future iterations of the ARS method will use the system to conduct a larger number of experiments, when we expect a more substantial impact on student learning outcomes.

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Footnotes

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[1] This is consistent with Kolb's (1984) experiential learning cycle paradigm in which the process of information grasping and transformation is thought to be best facilitated when the learner goes through a four-stage cycle of concrete experience, reflective observation, abstract conceptualization, and active experimentation.

[2] EconPort, an online collection of economics education material, hosts online economics experiments; see http://www.econport.org for details. Charles Holt offers a similar service at http://people.virginia.edu/~cah2k/programs.html.

[3] Based on anecdotal observations, student comments, and peer evaluations, this system has proven to be very effective in helping students stay reflective and focused, and it has encouraged the formation and strengthening of a learning community as the semester progresses.

[4] Two booth operators can easily handle 20 pairs of traders. For a class with a size larger than 50 students, an additional booth operator may be called for.

[5] The reservation prices for the 17 buyers are $54, $54, $48, $48, $48, $42, $42, $42, $38, $38, $38, $32, $32, $28, $28, $24, and $24, while the reservation prices for the sellers are $10, $10, $16, $16, $16, $22, $22, $22, $26, $26, $26, $30, $30, $36, $36, $40, and $40.

[6] The efficiency rate is computed as the ratio of the realized economic surplus to the potential economic surplus of the round.

[7] Due to time constraints, only a subset of the standard TUCE questionnaire was included in the pre- and post-test. Students had about 45 minutes to answer 20 multiple-choice questions, with each having four possible answers. To motivate the students to try

hard, they were told that a bonus of 0.5 semester points will be granted if they score at least six out of 20 in the pre-test and 11 out of 20 in the post-test.

[8] The experiment is typically repeated in a series of rounds to allow for learning and strategizing.