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Abstract

The authors discuss how they used the audience response system (ARS) to facilitate pit market trading in an applied microeconomics class and report the efficacy of the approach. Using the ARS to facilitate active learning by engaging students in economics experiments has pedagogical advantages over both the labor-intensive approach of pencil-and-paper and the capital-intensive route of relying on networked or on-line computer labs which oftentimes preclude or restrict face-to-face student interactions. Thus, the new method of conducting experiments represents an added advantage on top of such conventional functions as taking attendance and administering quizzes of this increasingly popular classroom technology.

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

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 (2007, no pagination) 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

[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.

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 survey students' attitudes toward the usefulness of two pit market experiments conducted in a microeconomic principles class and evaluate their learning outcomes. Section 7 concludes.

Learning Theory and Empirical Evidence

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 & Sawada, 2002). 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 & Gamson, 1987). 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, & Cocking, 2000).

A growing empirical literature confirms the potential of classroom experiments to enhance student learning in economics classes. Gremmen & Potters (1997) examined the effect on student learning outcomes of an in-class simulation of international economic relations and found an improvement in pre-post difference scores that was marginally statistically significant. Emerson & Taylor (2004) examined the efficacy of a series of 11 classroom experiments and 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. Most recently, Durham, McKinnon, & Schulman (2007) assessed the effects of a series of classroom experiments not only on student learning, but also on student retention of knowledge and student attitudes towards economics. 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 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.

Computer technology provides a way of overcoming the limitations of 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 & 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.

Internet technology appears to solve the above lab facility related problems by allowing 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, & Prasnikar, 1999; Ironside, Joerding, & 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-

[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.

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 & Sawada, 2002; and Wikipedia) and are known by a number of brand names 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.

An extensive literature on the ARS showcases the many teaching techniques which the ARS can be used to facilitate active learning and documents the potential educational benefits of using the system, including improvements in student achievement, increased attendance, reduced attrition, and a more engaged class environment (Angelo & Cross, 1993; Cox & Junkin, 2002; Crouch & Mazur, 2001; Draper & 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.

[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.

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

For our pilot, we conducted two pit market experiments in each of the three sections of a microeconomic principles class which had a total of about 110 students. The pit market experiments, amply documented in the literature (Holt, 1996; Ruffle, 2003; DeYoung, 1993), involves buyers and sellers haggling over commodity prices in a designated trading area in the center of the classroom.

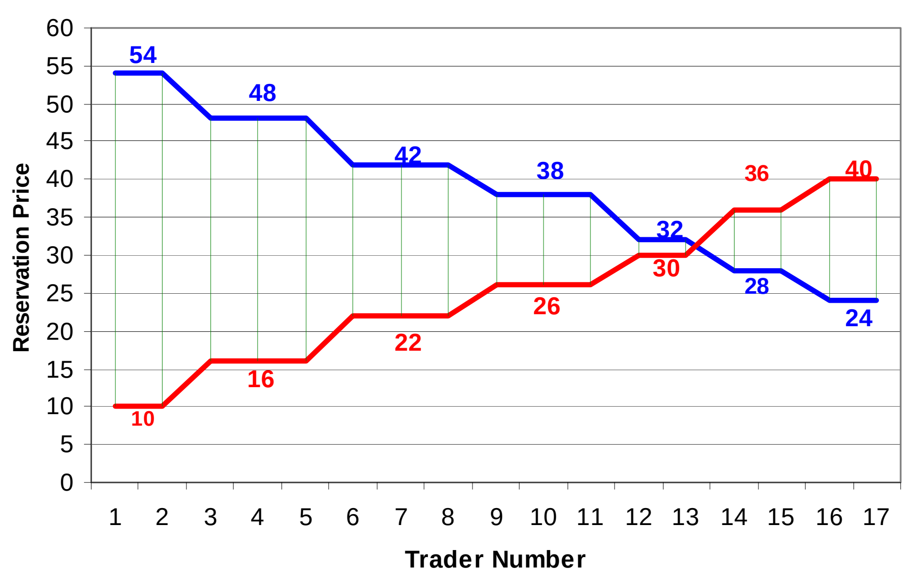
The two pit market experiments, each lasted for 50 minutes, used the following general process. Upon entering the classroom at the beginning of a session, each student is told to sit on one of the two sides of the classroom, designated for buyers and sellers, respectively. A one-page Instruction Sheet, along with a seller/buyer ID tag, is handed out to each trader, explaining the basic rules under which trading will occur. As the TAs are distributing the seller “cost cards” and buyer “value cards” that set limits on the prices at which the students will exchange during the trading session, we remind the students that in no way should they reveal their reservation prices to other traders. With their wireless transmitters, each student enters his or her ID tag number and reservation price into the ARS as the answers to the first two questions of the experiment. Eventually, students will answer another three questions over three rounds of trading, producing the data that they analyze later in the class. To reserve sufficient time for post-experiment discussion of the trading data and insights therein, each trading round is restricted to three minutes in length.

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. 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 for verification, and they are told to enter their transaction price into the ARS as the answer to the next question. The procedure is repeated for the second and third round, and traders enter their transactions prices as the answers to the subsequent questions in the ARS.

With all three rounds completed, one of the experimenters manipulates the student data generated through the ARS, creates the necessary graphs and tables, and inserts them into the instructor's PowerPoint presentation file. This step takes about five minutes, giving the instructor just enough time to prepare the students for the post-experiment discussion.

We turn now to the content of the two pit market experiments. 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. 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 indicated in the figure.[4]

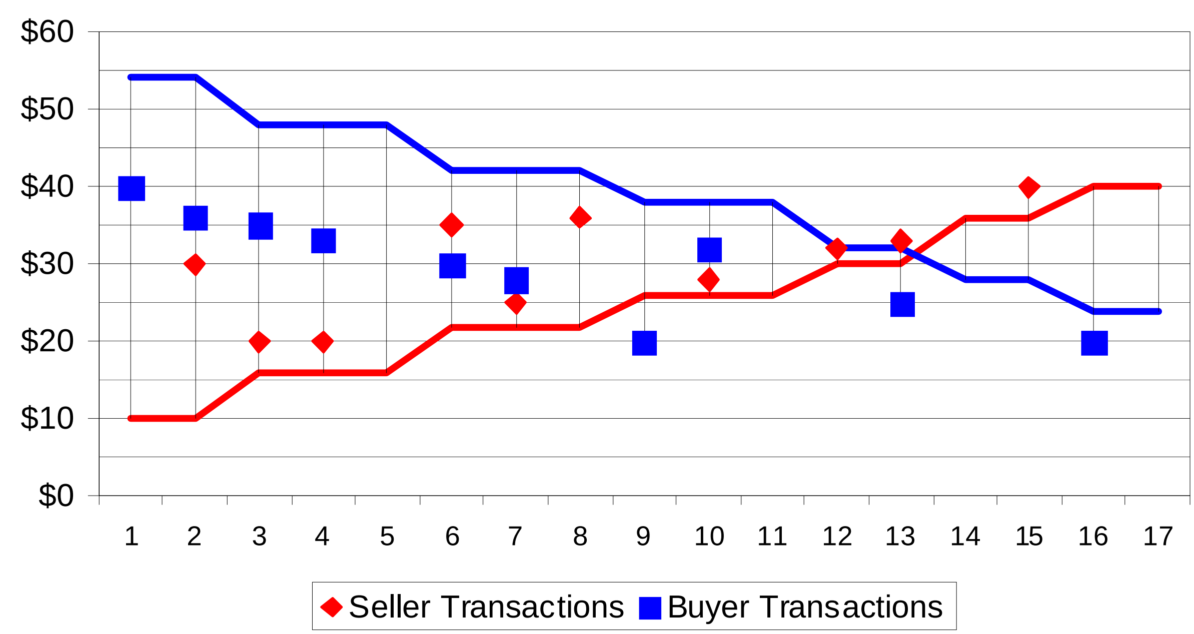
Figure 1: Reservation Prices of Buyers and Sellers



[4] 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.

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 Figure 2 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, however, 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.[5] 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.

Figure 2: Transaction Prices



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

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

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. 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, another experimenter opened the text data file, cleaned up any student data entry errors (e.g., via asking students to verify outlier entries), manipulated the entries, and performed calculations on the live student data using the Excel spreadsheet template created in the first stage. These calculations made it possible to generate measures such as realized surplus and efficiency level and graphs such as Figure 2.

The data display procedure described above was not without challenges. For instance, it was 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. We expect, however, that this step will be streamlined in the future as the experimenters gain proficiency.

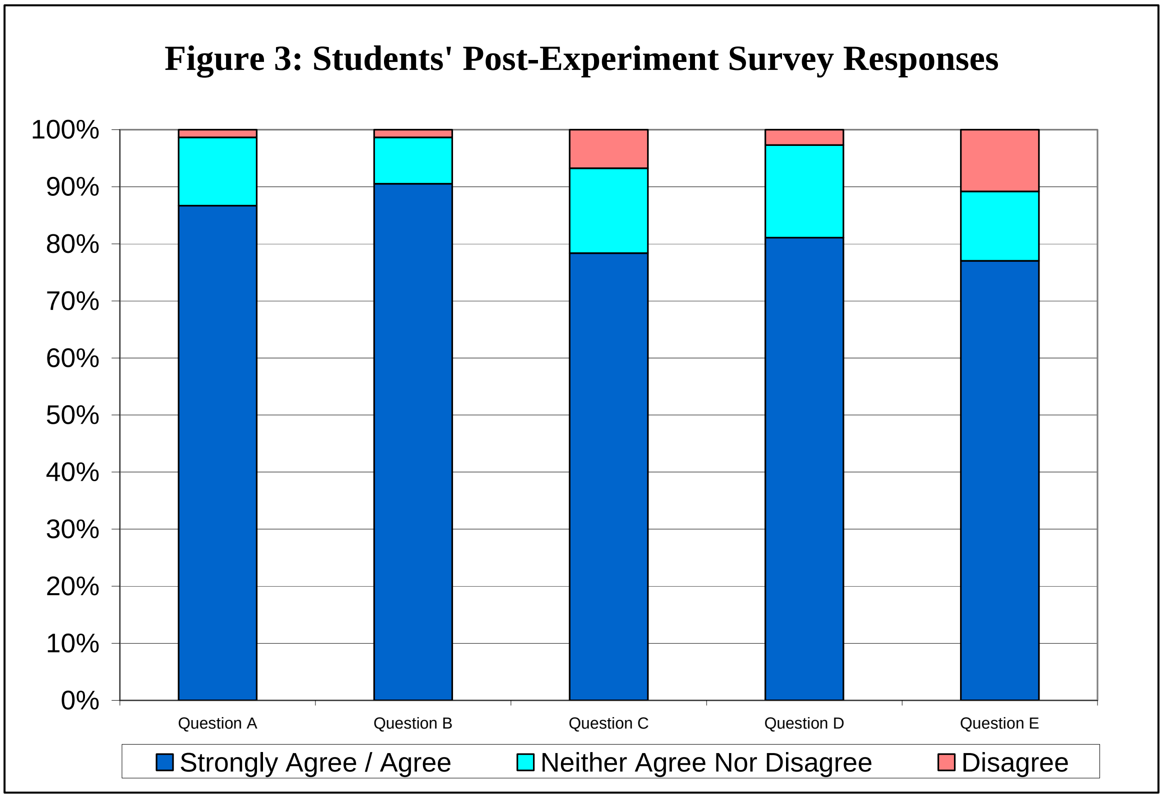
Evaluation of Student Attitudes and Learning Outcomes

In the lecture session following the first pit market experiment, a survey was conduct to gauge students' attitudes toward the usefulness of the experiment. Students used the ARS to respond to the following survey questions on a five-point Likert scale from "strongly agree" to "strongly disagree":

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". Results indicate that substantial majorities of students enjoyed the experiment and found it useful in helping them understand the economic concepts the instructor intended to convey.

In addition, preliminary findings suggest some positive impacts on learning outcomes of the experiments. When compared to a control group of about equal size, attending experiments appears to: (i) increase the post-test scores on the Test of Understanding of College Economics (TUCE) by 3.5%, (ii) boost the score of tax specific questions in the final examination by 2.4%, and (iii) heighten the overall semester score by 2.2%. However, these effects are, at best, marginally significant at the conventional confidence levels. The lack of strong statistical evidence on learning impacts could be due to several factors including: (i) a lack of proficiency on our part in implementing the experiments (our first attempt), (ii) our failure to use the appropriate performance measure for learning impact and/or to control adequately the heterogeneity among student subjects, and (iii) an insufficient number of experiments, failing to give students enough exposure to overcome the minimum threshold that is required for learning impacts.



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 their implementation. After using the ARS approach in a microeconomics principles class of 110 students, we conclude that this approach to classroom economics experiments is indeed feasible and can be made efficient.

The ARS method 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. 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.

Costs associated with the ARS method include the non-trivial amount of time required to produce the initial Excel spreadsheets that enabled real-time data displays as well as the difficulty of seamlessly processing, in front of student subjects, the generated data into a form that is conducive to post-experiment discussion. However, we believe that these costs can be significantly lessened in the future as the experimenters gain proficiency.

Overall we believe the pilot to have been successful because the results of our evaluation were encouraging and because the pilot has given us useable data that will drive a redesign of our project. Our future efforts, we believe, should lie in the areas of perfecting our experiment procedure and ways of engaging student subjects, refining our research methods on performance evaluation, and incorporating additional experiments, which involve additional topics besides pit market trading, into our teaching repertoire.

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