Experiment for teaching economics

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Abstract

Classroom experiments are a particularly popular and powerful experiential-learning tool. Students who have participated in an experiment and have seen the resulting data are interested to discover for themselves how well (or poorly) the theory works to explain the reality that they have observed, instead of simply learning the theory as dogma to be memorized.

This paper discusses the education literature on the impacts of experiments in students' performance, engagement and enjoyment of the class. It shows that technology and newly available material drastically reduce the costs of running experiments in the classroom or online, and automatically provide the output data necessary for a fruitful discussion with students. They also blurred the differences between running experiments in-class or online. Experiments are becoming an easy way to engage students and facilitate the understanding of 'difficult' concepts without sacrificing, and most likely improving, student performance, while contributing to make teaching a more enjoyable experience.

Key words: Classroom experiments, experiential learning, student performance, student engagement, online teaching, online games, mobile devices, online platforms.

"Tell me, and I forget.
Show me, and I may remember.
Involve me, and I understand"
From the Xunzi by Xun Kuang
Confucian philosopher
(314 - 235 B.C.)

"*Homines dum docent discunt*"
Seneca (4 B.C. – 65 A.C.)

1. Introduction

Classroom experiments are a particularly popular and powerful tool that makes use of the advantages of learning from personal experience. Students who have just participated in an experiment and seen the resulting data are interested to discover for themselves how well (or poorly) the theory works to explain the reality that they have observed, instead of simply learning the theory as dogma to be memorized. They are also able to observe many aspects thar are difficult to convey in a lecture; like how heterogeneous students act or the adjustment process to equilibrium. In addition, experiments foster "social and academic integration" (Braxton, Milem, and Sullivan 2000).

Classroom experiments have been successfully pursued for many decades now. At first, they were run with the use of pen-and-paper instructions and written contracts (e.g. Frank 1997; Emerson and Taylor 2004; Dickie 2006; Durham, McKinnon, Schulman 2007, Bergstrom and Miller 2000). Then, computers in lab rooms were used, prominently by Holt and his collaborators (Holt 1996; Anderson and Holt 1996; Holt and Laury 1997; Ball and Holt 1998; Goeree and Holt 1999; Holt and Sherman 1999; Holt and Capra 2000). More recently, new technologies have introduced online platforms that make use of handheld devices (smartphones and tablets), reducing the costs of running an experiment and collecting data, increasing the popularity of experiments as a teaching tool, and allowing for both in-class and online implementation.

There is wide evidence showing that experiments have a positive impact on students' performance and increase both the teachers' and the students' enjoyment of the class. They also foster an environment where students engage with the material more comprehensively and ask more advanced questions. In my experience, most instructors get excited when introduced to the use of experiments as a teaching tool. However, the use of experiments, though growing, is not as widely spread as all this evidence and enthusiasm would suggest. The main reason deterring instructors from adopting experiments is the perception that transitioning to a different teaching methodology will be costly in preparation time and/or installations and material.[1] Although not sufficiently known, technology and newly available material have

[1] Other arguments are the quantity of material that will be covered in class-time, concerns that the game would not work or fear of losing control in the classroom (Guest 2015). In Section 3, I show how newly available material helps anticipating what might go differently and transforming the situation into an opportunity for a better lecture. The argument about the optimal coverage of content has been taking place

drastically reduced these costs and made running experiments in the classroom or online an easy way to engage students and facilitate the understanding of 'difficult' concepts without sacrificing, and most likely improving, student performance, while helping making teaching a more enjoyable experience.

The next section discusses the main findings related to the impacts of using experiments as a teaching tool. Section 3 focuses on the new available technologies and materials, and addresses several of the frequently asked questions raised by instructors considering the use of experiments. Section 4 shows that the differences between running experiments in-class or online are fading out. Section 5 concludes.

2. Why use experiments as a teaching tool? The impact of experiments in students' performance, engagement and enjoyment.

The use of active learning techniques, most commonly experiments, is now widespread in economics and other social sciences. The motivation for these techniques is ''creating memorable experiential learning events that tap into multiple senses and emotions'' (Lantis 2010, p.6). But beyond the obvious arguments for using experiments to engage students, it is also important to know whether they have a real impact on students' performance.

Since the popularization of experiments in the classroom in 1990s, the economic education literature has tried to study the impact of introducing experiments in the classroom, with a particular focus on their effect on students' achievements. The standard analysis uses an experimental design with a control group that receives more traditional chalk-and-talk lectures, and a treated group exposed to the experimental treatment. Performance is measured by grades and, more commonly, test scores, usually based on multiple-choice questions. Several controls are used to control for a number of student characteristics.

Emerson and Taylor (2004) is a representative example. They collected data in a sample of 9 sections of micro principles, two of which used extensive experimentation (11 experiments from the well-known Bergstrom and Miller (2000) textbook) and tested students using the Test of Understanding in College Economics (TUCE). They find that the two sections using experiments performed better than the control group in the TUCE scores, showing evidence that experiments improve student achievement and retention in economics principles classes. These findings are ratified by several other studies, like Dickie (2006), Durham et al. (2007), Emerson and English (2016a) and, more recently, Tila (2021).[2] Tila (2021) finds that not only did students obtain higher scores but they also recognized improvements in understanding the material and boosted their attitudes towards the subject. Similar results also show up in more advanced courses (Frank 1997)[3], and are common to other disciplines and other active learning

for a long time and will remain an issue independently of the teaching methodology. As a general principle, I believe that instructors should focus on what students learn rather than on what they have covered in their lectures (Hansen, Salemi and Siegfrid 2002), but this topic is complex and falls outside the scope of this paper.

[2] Refer to Guest (2015) and Tila (2021) for a more exhaustive list of references.

[3] Frank (1997) tested the impact of using an experiment in explaining the tragedy of the commons for environmental economics and public finance courses.

methodologies.[4] For instance, in a meta-analysis of 225 published papers, Freeman et al (2014) study the effects of introducing active learning and interactive classroom in science, technology, engineering, and mathematics (STEM) courses. They find that students' scores increased by 6%, on average, in active learning sections, while students in more traditional sections where 1.5 times more likely to fail.[5]

The literature has also studied the drivers behind these general positive impacts. Durham et al. (2007) used a similar control-and-treated-groups design, but created their own specific multiple-choice questions to test the students' understanding of the specific concepts associated with each experiment. They discovered that making several decisions in a series of rounds, compared to making just one decision, and participation, compared to observing the actions of a few volunteers, were more effective and had a larger positive impact. Experiments are also more effective when students are required to perform follow-up work, such as homework after the experiment (Cartwright and Stepanova, 2012), and when students participate in more than one experiment. Emerson and English (2016b) find that additional experiments during a course have a positive, but diminishing marginal benefit, with the maximum benefit being obtained between the fifth and seventh experiment. So, "more is more" but up to a limit. Finally, experiments have also been shown to be beneficial in large principles courses, even when the technology for a proper implementation was not yet widely available (Ball et al., 2006).

Another important question is how the benefits are distributed among different groups of students and if the benefits are higher for more needed groups, since active learning techniques may engage different types of learners and help some students more than others. The general view is that while the overall effect is neutral or beneficial, classroom experiments may help to bridge some achievement gaps. Positive impacts tend to be higher for low achievement groups, females (Emerson and Taylor 2004), freshmen (Ball et al. 2006), and multimodal and kinesthetic learners compared to read-write learners (Durham et al., 2007). A common conjecture is that the experimental approach has the highest impact on students who tend to benefit from experience and examples, but being time intensive, may be less effective on students with less time to devote to class.

Other than the cognitive impacts of experiments in teaching, it is also important, as for any other pedagogical approach, to study their effectiveness on a wide variety of outcomes (Becker and Powers 2001). First, a direct side effect of participating in experiments in the classroom is that students may learn about conducting experiments and testing theories. Secondly, educational psychology and gamification research highlight that games activate motivation which improves learning outcomes, including cognition, creative problem solving, teamwork, and social-emotional abilities (Dichev and Dicheva, 2017). Thirdly, students also seem to enjoy participating and recognize the learning impact, improving their attitudes toward the subject and towards economics in general (Dickie 2006; Durham et al. 2007; Tila 2021). Increased

[4] Although there are studies that find no impact on student performance (like Cardell 1996), I know of no study that finds a negative impact.

[5] They performed several tests to assess that the results did not suffer from publication bias.

motivation is perhaps the most robust of all impacts (Gremmen and van den Brekel 2012). Finally, in a recent paper, Bartels et al. (2022) ran a case study in India and found some evidence that participating in the experimental game induced real-world changes, opening the possibility that participation in experimental games may change real life behavior (a transfer from in-game to out-game behavior as a learning outcome).

Studying the effectiveness of different teaching methods faces several difficulties: attaining sufficient instruction time to make a difference, selection bias, measurement of outcomes, institutions and instructor's differences, students' strategic reactions, and barriers to data collection by IRBs (Allgood et al. 2015). The empirical studies in this section have been carefully designed to overcome many of these obstacles, and they show that game experiments in the classroom have a robust and positive effect on student learning achievement, on retention of economic material in the course, and on a more favorable impression of economics, as compared with the traditional chalk-and-talk pedagogy. Experiments also have a positive impact on students' evaluations and motivation, and on instructors' satisfaction.

3. Running experiments in the classroom.

Economics is especially well suited for the use of experiments since it studies the behavior and interactions of people in economic situations. Students, acting as interacting economic agents, are able to experience first-hand the problem faced by such agents, making economic ideas come to life in the classroom.

This section addresses several issues frequently raised by instructors considering to incorporate experiments in their teaching. I start by describing available resources, more specifically the advantages of online platforms and their companion material.

Online platforms

Running classroom experiments with pen-and-paper is a time and resource consuming approach. Many instructors who are intrigued by the idea of running classroom experiments are deterred by the organizational burden of running them. Running experiments in a lab is also possible but it requires expensive installations and a reduced number of students. These drawbacks disappear when experiments are run in the classroom or online using a web-based platform and mobile devices such as smartphones, tablets and personal computers.

There exist several web-based online tools for running classroom experiments.[6] Currently, the dominant platforms are *classEx*, *MobLab*, and *VeconLab*.[7] All three offer a broad range of pre-programmed games for teaching microeconomics, macroeconomics, game theory, public economics, environmental economics, psychology, and other subjects (Table 1). classEx and veconLab are available free of charge to any lecturer and participant (unlike MobLab that

[6] A longer list includes, among others, *Aplia*, ARS, *classEx*, *MobLab*, *VeconLab*, LIONESS, *oTree*, and *zTree*. The last three programs are research-oriented, while *classEx* and, to a lesser extent, *VeconLab* can be used both for teaching and for research.

[7] *classEx*: https://classex.de; *MobLab* https://moblab.com; *VeconLab*: https://veconlab.econ.virginia.edu.

requires a subscription fee). classEx and MobLab are platform-independent and are optimized for the use of mobile devices (smartphones, tablets, notebooks, and personal computers). classEx and MobLab are friendlier to use than veconLab. Unlike MobLab, classEx also offers the possibility to create your own games and modify existing ones, providing the flexibility to adapt any game to your needs, or use existing games as a starting point for the design of new ones. Instructors may also share their games and outcomes. Because it is free, user-friendly, and flexible, I have been using and collaborating with *classEx* for over a decade now. Hence, I will refer to its features when describing specific details about the platforms. Nevertheless, most of what I have to say, if not all, is common to all three platforms.

classEx (Giamattei and Lambsdorff 2015, 2019) runs as a centralized application and only requires an internet connection and a standard (up to date) browser.[8] Instructions, any public information, and the output from running the experiment can be projected to all students. Private information and decisions are displayed on the students' mobile devices. Experiments can be run completely anonymously or require an identifying code or alias in case you want to keep personal records. The graphical output and the data obtained in previous sessions is easily accessible withing a game and can also be downloaded prior to the session. This feature provides an insight on the expected results prior to running the experiment, facilitating the preparation of the lecture, and can be used as a backup in case there are unusual outcomes or unexpected problems emerge, for example the loss of internet connection. Experiments can be run online as well as in-class with face-to-face interaction, even with very large groups.

Finally, the number of resources with instruction on how to run the most common experiments in these platforms is rapidly growing. They include fully detailed student's and instructor's manuals, exercises that help testing students understanding of the rules, and questions and problems sets to reflect on the outcome of the experiment. A good example include the e-book *Experiencing Economics* (The CORE team 2019b) with experiments linked to specific units of *The Economy* (The CORE team 2017) and *Economy, Society, and Public Policy* (The CORE team 2019a). Nevertheless, because experiments are self-contained, they can be used alongside other textbooks. Other examples include Lambsdorff and Giamattei (2020), a macroeconomic textbook with an extensive use of experiments, or the webpage *Experiments with Economic Principles* (http://econclassexperiments.com), that adapts several market experiments from Bergstrom and Miller (2000) to be used with personal devices.

How to incorporate experiments to the classroom

As seen in Section 2, there is ample evidence that running experiments engages students and improves performance. But running an experiment and showing the outcomes do not make experiments a meaningful part of the learning experience. Students must be actors, and not mere spectators, reflect on the experiment and analyze the data.

I favor a common approach that combines elements of a flipped-classroom and of experiential learning. The approach emphasizes the importance to furnish classroom experiments with

[8] A complete documentation of *classEx* can be found at https://classex-doc.readthedocs.io.

constructive homework, making students reflect on the experiment and analyze the data. This is, for example, the structure built in Bergstrom and Miller (2000).[9]

Each experiment is structured in three stages.

1. First, students prepare for the experiment by reading the instructions and working on some warm-up questions that should get them thinking about how to behave in the experiment for all possible roles (like sellers and buyers or proposers and responders). Students can work on this preparation before coming to the classroom or at the beginning of the session, depending on the complexity of the experiment and the time available during the session. Then, the instructor runs the experiment with a discussion during and after the process, inviting students to come up with possible explanations for the observed results and to work on their economic intuitions.
2. Next, a series of questions and tasks help them reflect on their experience and understand their and others' behavior in the experiment. Many places (like Bergstrom and Miller (2010) or The CORE team (2019b)) provide questions and constructive homework that uses the data from your session; and most online platforms let you download the data from your experiment in a format that can be read by popular spreadsheets.[10]
3. Later, during the lecture, the instructor generalizes the results by presenting the mathematical, more abstract analysis, provides applications, and solves the doubts that students had while working on the questions and tasks.
4. Finally, students test practice their recently acquired knowledge in assignments.

Observe the similarities with the four stages in Kolb's (1984) experiential learning theory: Concrete experience → Observation and reflection on that experience → Abstract conceptualization → Active experimentation and testing the new concepts. Evidently, you may have to adapt this general structure to your study plans, schedule, size of the class, and the particular characteristics of the experiment.

Time required

The use of online platforms leaves enough time for a fruitful discussion in a regular session. Many of the most popular experiments can be run in 15-20 minutes or less, plus instructions, which could also be sent to students before the class if necessary. In a trading-pit market where participants need to find a buyer or seller and negotiate a price, we find that students quickly understand the dynamics of the experiment and each round requires no more than four minutes to be completed (Giamattei and Llavador 2020). A more involved experiment of voluntary contributions to a public good with penalties can be easily run in less than 15 minutes (see

[9] Several of their experiments have been updated and complemented with classEx packages, which can be found, as well as their companion material, in the webpage http://econclassexperiments.com (Bergstrom et al. 2019) and in the *Experiencing Economics* e-book (Giamattei and Llavador 2020).

[10] In addition, Bergstrom et al (2019) provide Excel files that read the output files from classEx and automatically generate solutions to the exercises and report participation, profits and the number of correct answers to the warm-up quiz (in case you want to keep records).

chapter 1 in *Experiencing Economics* (Giamattei and Llavador 2022)). Simple games, like the prisoner's dilemma, the dictator game, or the beauty contest, require as little as 5-10 minutes for the whole activity.

Number of participants

Another advantage introduced by online platforms is that experiments can be run with groups of many different sizes, though some experiments work better than others with very small and very large groups. Groups with few students are more susceptible to outliers and, in market experiments, to collusion among roles who benefit from reducing competition. When students do not need to interact directly (e.g. in the beauty contest, auction games, or the Keynsian multiplier) or when they are matched in pairs or groups (e.g. in any standard 2x2 game, the public good, or the tragedy of the commons), experiments can be conducted synchronously even with large groups of hundreds of students with life streaming (Lambdorff and Giamattei 2019; Li et al. 2021). Nevertheless, it is always possible to run several parallel sessions or to get students to make their decisions in groups. This last option may have key advantages, even in smaller classes: It allows them to discuss the decisions as the game progresses, helping to obtain a better understanding of the issues involved; and may increase the engagement with the game, reducing the risk of unmotivated students and their impact on the result of the game (Guest 2015).

Incentives and payoffs

Experimental economics have put much emphasis on the relevance of incentives when running experiments (Davis and Holt 1993). Monetary incentives improve outcomes (Bettinger 2012), and so does reputational incentives (Filsecker and Hickey 2014) or external rewards (Madan 2013). And there is also evidence of no substantially different outcomes from field games with and without performance-based individual payoffs (Bartels et al 2022).

In teaching, grade incentives help experimental outcomes to match between theoretical predictions, making easier to use experiments in the classroom, but there is the risk that "the effort students devote to earning grade credit crowds out the attention they would otherwise pay to the economic lessons conveyed by the experiments" (Dickie 2006). In my own experience, reputation is a powerful enough incentive for most students, while very small grade incentives are sufficient to enlist those who require a bit of an extra motivation. It is important, when designing incentive rules, that they do not promote cunning behavior and that they are perceived as fair. Helpful tips include using simple normalizing formulas and choosing the payoffs from only some ex-post chosen rounds or sessions. You should be careful to make the choice non-foreseeable, treat different roles fairly, and consider eliminating outliers.

What if something goes differently from expected?

Another common concern among potential adopters of experiments is that the game may not work. This is, however, a fear easily overcome. Most teaching experiments have been widely tested and deviations from expected outcomes are clearly identified. In any case, unusual outcomes should not be automatically discarded, but transformed into teaching opportunities. Understanding what generated those results usually provides excellent opportunities for an enriched debate.

Online platforms usually provide outcomes from previously run sessions that can be used as an easy backup for the discussion. And additional material for the instructor, like in *Experiencing Economics* (The CORE Team 2019b), explicitly addresses possible deviations, and offer tips on how to conduct the discussion.
Once again, it is important to ask students to reflect on why their session differed from the predicted results, not only because it is a good tool to discover the mechanisms working behind the economic theory, but also to avoid leading them to think that one or the other is false.

4. Using experiments in online teaching. What is different? Challenges and benefits.

Most of what I wrote in the previous sections applies to both in-class and online teaching. On the other hand, there is little written on whether experiments work better in-class or online. Carter and Emerson (2012) is, to my knowledge, the first, and perhaps the only, formal study in the literature. They compare students in sections with manually administered in-class experiments and those in sections with computerized online experiments and find no significant differences in student achievements or overall views of the course or the instructor. They find, however, that students report greater satisfaction with in-class experiments, more interactions with their classmates, and direct contact with a larger number of them. In my experience, these interactions may foster a greater sense of community and lead to out of class interactions, like study groups or even long-term friendships. One of the reasons why students come to class is (or should be) to relate with other students. Experiments work as a good instrument for this purpose. Sharing experiences while bargaining, making exchanges, or thinking together foster relationships that in some cases can extend beyond the classroom. This *disadvantage* of online experiments is not specific to them but shared with the broad concept of online teaching. And avatar-based meeting platforms may perhaps allow for a smoother communication among students in online sessions, lowering some barriers to personal interactions among students.

Modern technology is blurring the differences between administering experiments face-to-face in the classroom or online. Thanks to online platforms and hand-held devices in-class sessions can take advantage of computerized experiments and run experiments with very large groups. Hence, while sitting in the classroom students can participate in experiments administered purely on-line (where students receive private information in and submit their responses from their personal devices, while public information is projected for the whole class), in a hybrid format (where students interact off-line and then submit their input through their handheld devices), or purely hand-held, with all the costs associated to distributing collecting information. For example, in a market experiment, where buyers and sellers need to meet and negotiate a price, online trading let students send buying and selling offers on their devices, and transactions result from accepting standing offers; while, in a hybrid format, negotiations are done verbally, and transactions formalized once students input and submit the agreed price on their devices (Bergstrom et al. 2022). Both approaches enjoy automatized data collection and immediately available output to use in the discussion. Online experiments may face a higher risk that less engaged students hold up the game, since peer pressure is reduced, and students can become more easily distracted and lose focus (Guest 2015). However, this runs contrary to my experience. The blogpost of Jenkins (2021) recounts a very successful implementation with a very large group of more than 350 students. In any case, more experiences and research are needed.

5. Conclusions

Experiments let students experience the situation the will study, playing a role as an economic agent or a decisionmaker (experiential learning). Economic reasoning and motivation are encouraged by the discussion during and after experiments, and students get to exercise their economic intuition. The outcome of the experiment can be used to create homework and constructive problems, which get automatically renewed from year to year, challenging students to discover the main concepts by themselves. During the lecture, the instructor can more efficiently focus on generalizing the findings, presenting applications, and solving doubts, since students have already grasped the intricacies and the intuition.

In this chapter I have discussed the impacts of experiments in students' performance, motivation, and satisfaction, and elaborated on the general principles and guidelines on using experiments for teaching economics. If you are searching for a concrete example and step-by-step instructions on how to run an experiment, I recommend reading any of the chapters in *Experiencing Economics* (The CORE team 2019b). The first scenario of An Excise Tax in the Apple Market, in essence a simple trading-pit experiment, is a good starting point.

A final comment. When designing a course, we tend to have only the students in mind. We focus on the relevance of the content and the attractiveness of the material. However, we often forget that the course must also be interesting to teach, even after having taught it several times. In my experience, instructors get excited when introduced to the use of experiments in the classroom, resulting in increased motivation and more effective teaching. Experiments not only engage students but also may help us to discover or to recover the joy of teaching.

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Table 1. Representative experiments available in online platforms.
All experiments are implemented in either classEx, Moblab or VeconLab, with many of them available in more than one platform. References indicate the source for the experiment, as reported in the platform.

Markets and competition	**Standard games**	**Macro and finance**	**Cognition and decision making**	**Externalities and public goods**	**Auctions**	**Experimental ethics**
• Pit market[†§] • Taxation[†§] • Entry and exit[†] • Cournot • Bertrand • Stackelberg • Monopoly and Cartels[†] • Price discrimination	• 2x2 games: Prisoners' dilemma; Stag-Hunt; Dictator game; Ultimatum • Trust game (Camerer 2003) • Coordination and Focal points (Mehta et al. 1994) • Gift-exchange (Falk and Kosfeld 2006)	• Comparative advantage • Beauty contest • Phillips curve and Fisher effect • Bubbles and crashes • Calvo pricing • Life cycle consumption (Carbone and Duffy 2014) • Keynesian multiplier • Coordination game[§] • Gains from trade • Exchange rate and PPP (Lambsdorff and Giamattei 2020) • Interest rate parity (Lambsdorff and Giamattei 2020)	• Nudging • Anchoring effects[‡] • Halo effect[‡] • Linda problem[‡] • Framing effect[‡] • Money illusion	• Pollution game[†§] • Tragedy of the commons • Public good contributions (Herrmann et al. 2008)[§] • Network externalities and competition of standards[†]	• Dutch • English (Private value) • English (Common value) • Sealed bid (private value) • Sealed bid (common value)	• Trolley experiment (Hauser et al. 2007) • Ambiguity (Dana et al. 2007) • Gneezy game (Gneezy 2005)

[†] Bergstrom and Miler (2000)
[‡] Kahneman (2011)
[§] Companion material in *Experiencing Economics* (The CORE team 2019b)