Enhancing Economics Learning using Classroom Experiments on Mobile Applications in Higher Education

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ABSTRACT

We have proposed that implementing classroom experiments is one of the strategies that optimizes the use of mobile devices. Traditionally, classroom experiments are conducted in hand-run form or in computerized, usually online, form. We have compared different means of running classroom experiments and discussed some of the pedagogical and practical concerns faced by instructors, namely the cost of pre-class preparation, in-class implementation and post-class preparation. Introducing a mobile app that implements classroom games and experiments does not only enhance active learning in economics, but it also significantly reduces the implementation costs.

Author Keywords

Economics, Classroom Experiments, Mobile Learning

INTRODUCTION

Pedagogical research has shown that active learning increases student engagement and results in better learning outcomes across different disciplines (e.g. Freeman et al., 2014), including economics (Miller and Rebelein, 2012). Numerous studies have found the benefits of classroom experiments (e.g. Emerson and Taylor 2004; Ball et al., 2006; Durham et al., 2007; Emerson and English, 2016), collaborative and problem-based learning (e.g. Yamarik, 2007; Maxwell et al., 2005), use of clickers (e.g. Salemi, 2009; Ghosh and Renna 2009), and other active learning approaches, when compared to traditional lectures. In recent years, games and simulations are also gradually being integrated in traditional education systems. Although reviews by Vlachopoulos and Makri (2017) showed that games and simulations have mixed effects on student performance, engagement, and learning motivation, other researchers (Andreu Andrés & García Casas, 2011; García Carbonell & Watts, 2012; Angelini et al., 2015; Angelini, 2016) have found that in simulations, which creates a scenario-based environment, students can interact to apply previous knowledge and practical skills to real-world problems, allowing teachers to reach their own pedagogical goals.

Despite many well-documented reasons to incorporate active learning, lecturing remains the dominant form of instruction in undergraduate economics education (Goffe and Kauper, 2014; Watts and Schaur, 2011). In the fourth national survey of teaching methods in undergraduate economic courses, Watts and Schaur (2011) found that the median respondent spent 83 percent of class time in their economics principles courses lecturing. Their results were similar or identical to those in the three prior surveys (Becker and Watts, 1996, 2001; Watts and Becker, 2008), indicating that the preferences for traditional lecturing has persisted for a long time. Goffe and Kauper (2014) found that the predominant reason why lecture was preferred over active learning were “students learn best from lecture” (33%) or “lecture is cost effective, though students do not learn best from lecture” (28%). For those who preferred lecturing, the most common explanation was course thinning. Given classroom time constraints, active learning exercises crowd out detailed coverage of important material. For those who felt lecturing to be cost effective, the high preparation and time costs involved in pedagogical change for learning was their major concern.

Thanks to the proliferation of the use of mobile devices, the concept of implementation of active learning has been made more feasible through mobile learning. For instance, mobile applications and classroom response systems that allow students to provide immediate responses to instructor questions are commonly used. It has been shown that such applications of mobile learning improve student perceptions of learning, engagement, and actual assessment scores (Denker, 2013). While it is usually agreed that mobile learning enhance student engagement through providing immediate communication and hands-on learning, some researchers also warn that mobile learning is effective in enhancing learning only when teaching and learning activities has been carefully designed to make optimal use of the technology (Cheng, Yang, Chang, & Kuo, 2016). A common concern is that students may be distracted by multitasking on devices and/or the technology use by fellow students (e.g. Dietz & Henrich, 2014; Bellur, Nowak, & Hull, 2015; Heflin, Shewmaker, Nguyen, 2017).

The current study proposes that implementing classroom experiments is one of the strategies that optimizes the use of mobile devices. Introducing a mobile application (app) that implements classroom games and experiments does not only enhance active learning in economics, but it also significantly reduces the implementation costs. In this paper, we first review the positive impacts of classroom experiments that are well documented in economics literature. We then compare different means of running classroom experiments and discuss some of the pedagogical and practical concerns. Finally, we describe the basic feature of our mobile app and how it might be applied effectively to provide solutions to the abovementioned pedagogical concerns.

CLASSROOM EXPERIMENTS

Research in economics education suggested that classroom experiment is effective in improving students' learning outcomes because students are placed directly into the economic environment being studied (Holt, 1999). One of the earliest studies is Cardell et al. (1996), who studied the impact of using a small number of games in both microeconomics and macroeconomics classes. By comparing the pre- and post-course test scores drawn from the Test of Understanding College Economics (TUCE) and controlling for student characteristics and ability, they concluded that classroom experiments had improved the test scores, but the impact was insignificant. Further studies by Dickie (2006) and Emerson and Taylor (2004) adopted a similar approach but focused on paper-based games in the microeconomics only. In order to control for the instructor quality, Dickie (2006) investigated the partial effect of experiments by using identical instructor in the experimental and control groups and introducing classroom experiments separately from other innovations and found that test scores of the students in the experimental group improved by significantly more than those in the control group. He also found that the students with highest ability were benefited most using classroom experiments. On the other hand, while the similar positive results were found in Emerson and Taylor (2004), the biggest improvement in test scores were found among the least able students. Focusing on implementing games online in larger classes, Ball et al. (2006) found that, compared with traditional lectures, the students in the experimental group did significantly better in the end-of-year examination.

While the above studies focus on the overall impact of the experimental pedagogy on student achievement in the course, there are some studies emphasizing the impact of specific classroom experiments on student learning on the topics addressed explicitly. An early study by Frank (1997) focused on the effect of a basic strategy of the common experiment. He found that, by participating in or observing the experiment, students performed better on a multiple-choice test on common property concepts than those students exposed to the contents through lecture. Similar study was also conducted in the field of international economics. Gremmen and Potters (1997) evaluated the impact of an international economic relations simulation game on students' learning and it was found that classroom games and experiments had improved student performances in the subject matter significantly, compared with those who did not have such experience.

Durham et al. (2007) conducted a formal analysis by evaluating both the overall impact of the classroom experiments, as well as the effect of specific experiments on their corresponding concepts. In their treatment group, students were exposed to experiments covering concepts including resource allocation, comparative advantage, demand and supply, diminishing marginal utility, production and costs, monopoly, cartels, and public goods. While the overall impact of experimental pedagogy was significantly positive, it was found that specific experiments might not have a positive impact (or might even have a negative impact) on students learning. Also, it was found that students' preferred learning style mattered. Multimodal and kinaesthetic learners were found to be significantly benefited, while the impacts of experiments on read-write learners were insignificant. Similar results were found by Emerson and English (2016). Besides academic outcomes, various research have found experiments increase both teachers and students' enjoyment of the class, and students are engaged with the material more comprehensively and ask more advanced questions (Gremmen and Porter 1997; Ball and Eckel, 2004; Ball et al., 2006), resulting in higher student motivation (Gremmen and van den Brekel, 2013).

Apart from undergraduate economics courses, classroom experiments were found to be effective in improving the learning outcomes at different levels of economics education. Eisenkopf and Sulser (2013) found that classroom experiments improved students' economic understanding significantly at Swiss high schools. Their study also unveiled that more able students benefited disproportionately from the experiments. They suggested that the content thinning effect in the treatment group might play a role for that, as the experiments crowded out time for adequate discussion that would be helpful to less able students. Rupp (2014) attempted to convey some simple economics concepts, including the law of demand, opportunity costs and gain from trade, to fifth grade elementary school students using classroom experiments. The author found that fifth grade students demonstrated significant improvements in their understanding of these fundamental economic concepts two days after this classroom experiments.

IMPLEMENTATION OF CLASSROOM EXPERIMENTS

Regardless of the empirical evidence on the potential benefits of experimental pedagogy in economics education, most lecturers preferred lecturing because of the worry of content thinning and the concern about cost-effectiveness (Goffe and Kauper, 2014). While flipped learning might provide a partial solution to lessen the content thinning concern, it might imply a bigger concern regarding effort and costs. For implementing classroom experiments, there are three types of costs:

1. Pre-class preparation: selecting games and experiments, course planning on adaptation, preparation for specific experiments
2. In-class implementation: running the experiments in class
3. Post-class preparation: data collection and processing, results dissemination, preparation for postgame discussions

As both hand-run and computerized experiments are currently well-developed and widely available, costs such as games selection and course planning might not be significant regardless of the form of implementation. However, the administrative part of the implementation costs depend on how the experiments are run in class. Carter and Emerson (2012) compared and summarized the major pedagogical differences between hand-run and computerized experiments. The biggest disadvantage of hand-run experiments is the high implementation costs at all stages, even with manageable class sizes of 20 – 40 students. Indeed, based on our own experience of running more sophisticated games, such as Cournot oligopoly markets, in pen-and-paper form, the in-class administrative cost, including collecting and disseminating data, and transiting between game rounds, could be burdensome, even with the help of a teaching assistant. In some games involving private information, how to distribute the information and even the classroom setting requires careful planning. Data collection cost is high as it is very common that data would be lost after classes, regardless of how the experiment sessions are carefully run. However, hand-run experiment is the best way to engage students, especially in market games.

On the other hand, computerized online experiments such as VeconLab and classEx are readily available through several sources (for a fee and free of charge) and could reduce the implementation costs. Because of automated implementation, computerized experiments not only allow for larger class size, but also allow for numerous rounds of trading given limited class time, which are essential features in some experiments, such as repeated games or asset bubble games. A frequently cited disadvantage of using computerized experiments is the need of computer rooms or labs. However, this drawback is no longer relevant as experiments can be run on mobile devices such as smartphones, laptops, and notebooks, in a location with stable wireless internet connection, all of which are widely available nowadays. However, running online experiments in class is not without logistical drawbacks. A common problem is that most experiments cannot proceed to the next round until all the students have submitted their decisions. In other words, experiments tend to be bottlenecked by the slower students. Also, the use of mobile devices in a classroom might create distraction. Some students might delay the game due to off-task activities such as browsing or checking email (Balkenborg and Kaplin, 2009). Besides, there is always a risk of technical problems, which can be exogenous, such as network failure and IT-related problems, or student-related ones such as login failure and multiple accounts creation. Such problems might jeopardize the whole experiments in the middle of the class. Another major shortcoming of computerized experiments, suggested by Carter and Emerson (2012) is that hand-run experiments usually allow for more face-to-face interaction among students, which might foster a greater sense of community within the class or lead to higher levels of subsequent interaction. While technologies allow online experiments to be run inside classroom, based on our experience on running in-class experiments, we observe that students tend to be more engaged and interact better during hand-run experiments.

In terms of learning outcomes, Carter and Emerson (2012) found no difference in student achievement between hand-run and computerized experiments ran outside the classroom. However, they found that students exposed to hand-run experiments reported more favourable views of the experimental pedagogy and reported higher level of peer interaction. Given that there is no significant difference between the impacts of hand-run experiments and computerized experiments, the choice of medium should hinge on the perceived cost effectiveness, which favours computerized experiments.

MOBILE APPLICATION

Based on a meta-analysis of 110 studies published between 1993 and 2013 that investigated the impacts of mobile learning on student learning, it is found that that the overall effect of using mobile device is better than the use of desktop computers or not using devices at all (Sung, Change, & Liu, 2016). At present, most of the computerized experiments are mostly web apps, where lecturers and students log in via their browser.

The major benefit of implementing experiments using these web apps is that it only relies on the browser of the mobile device and thus supports BYOD (Bring Your Own Device) (Boulos et al., 2011; Khaddage, 2013). However, the potential implementation problems mentioned may generate negative experiences for students. It is suggested that such negative experiences derived from difficulty in using the tools may jeopardize student learning using mobile devices (Ting, 2012). Therefore, introducing a user-friendly cross-platform hybrid app, which combine the characteristics of native and web apps, provide significant benefits for students in active learning, and for educators in reducing implementation costs.

The framework or platform shall host multiple games and simulations to address various economic topics that will be taught in class. The use of such a framework or platform allows for the deployment of either a single-student or a multi-student game or simulation. These practical scenarios may be carried out individually or within a team (Robertson et al., 2009), leading to collaboration and knowledge sharing. And as cost effectiveness remains the major concern for economics instructors to adopt more active learning approach, our project aims to reduce the costs further by designing a mobile application to run classroom games and experiments for economics. The use of app allows instructors to start right away choosing from of a broad range of pre-programmed games. Instructors can also modify existing ones by manipulating the parameters and choosing among different types of matching, role assignments and treatments. There are some advantages that mitigate many of the abovementioned shortcomings in using the readily available web apps.

Firstly, a hybrid app that contain the feature of native app that interface with the device’s features and hardware, such as the camera, GPS location, and so on. By leveraging the device’s capabilities, it is possible to significantly enhance the efficiency of classroom experiments. For example, push notification messages and device vibration can be used to remind students of next course of action in the middle of a game round and lessen the holding up problem when computerized experiments are run in class. These device features can also offer an opportunity for instructors to explore another inferior option of experiment implementation: out-of-class experiments. While no significant difference in learning outcomes were found empirically, Carter and Emerson (2012) argued that delayed instructor feedback and discussion was a pedagogical shortcoming for out-of-class experiments. With the features of mobile app, push notification sent out in a timely manner could mitigate game delay. As soon as the session is complete, feedback could be sent to students outside the classroom.

Mobile apps also address the concerns regarding lack of interaction for computerized experiments. Chat rooms could be programmed into specific games and experiments that allow interaction or communications between the group members, who are usually assigned randomly in the game. Another important advantage of running games via mobile apps is that it offers users a personalized experience, such as tracking personal records in different experiments, student engagement, or even personalized comments to the users. It is believed that it would increase student engagement through active learning, which is an important ingredient for learning that has many educational benefits for students (Berman, 2014; Kuh, 2009; Lippmann, 2013, Rocca, 2010).

Lastly, although the app requires internet connectivity to perform its critical task, i.e. running experiments, mobile apps can still operate while the mobile device is offline. Useful content and functionality can be offered to students while the device is in offline mode. It might allow students to read experiment instructions, work on pre- or post-game exercises, reading the findings of some classic experiments and so on. A novel concept is to allow users to participate in some classic economic experiments with the artificial intelligence programmed based on actual participants' responses in the corresponding games. While it is pedagogically inferior to experiments with actual human subjects participating in classroom experiments, it might incentivise teachers who are reluctant to switch away from traditional lectures due to prohibitively high cost to include some active learning elements in their courses. Nonetheless, previous study has shown game-based learning can help improve student learning by reducing their anxiety in learning. It also improves deep-learning and higher-order thinking for some students (Crocco, Offenholley, & Hernandez, 2016). More importantly, it leverages on the major potential of mobile learning: its ability to provide timely and on-demand learning (Crompton, 2013; Herrington, Ostashewski, Reid, & Flintoff, 2014).

Park (2011) developed a framework, which includes a four-level mobility hierarchy, for understanding different types of mobile learning. Under the framework, level 1 is content intensive and focuses on production. Level 2 focuses on flexible physical access and includes local databases and interacting prompting. Level 3 uses mobility applications that capture and integrate data. Level 4 applications of mobile learning allow for communication and collaboration. Implementing economics experiments using mobile apps achieve all the levels of mobile learning in the mobility hierarchy. Researchers suggested that the use of mobile devices in general is most effective when teachers are able to design the learning experience to match the device, program, and/or software with the learning outcome goals of the educational experience (Sung, Change, & Liu, 2016). Implementing classroom experiments on mobile devices could be one of the optimal strategies that maximize mobile learning of students.

CONCLUSIONS

We have proposed that implementing classroom experiments is one of the strategies that optimizes the use of mobile devices. Traditionally, classroom experiments are conducted in hand-run form or in computerized, usually online, form. We have compared different means of running classroom experiments and discussed some of the pedagogical and practical concerns faced by instructors, namely the cost of pre-class preparation, in-class implementation and post-class preparation. Introducing a mobile app that implements classroom games and experiments does not only enhance active learning in economics, but it also significantly reduces the implementation costs. The paper is exploratory, further studies would be conducted to evaluate the effectiveness of mobile learning in the form of classroom experiments.

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