Effects of classroom experiments on student learning outcomes and attendance

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Abstract: The objective of this study was to investigate the impacts of classroom experiments on students' attendance and learning achievement. Data were collected from undergraduate students in Introductory Microeconomics classes in spring and fall 2016 at a public university in the Midwest. We constructed econometric models and adopted the ordinary least squares (OLS) method to examine three hypotheses: engagement in game-play experiments in the classroom enhances students' attendance; weaker students are most likely to increase their attendance when engaged in these experiments; and classroom experiments improve students' learning outcomes. Our findings sustain these hypotheses, suggesting that classroom experiments are a fun, lively, and creative method of teaching students, increasing their motivation to learn and improving their attendance and learning outcomes. While the design and offering of these experiments may require instructors to spend less time on lectures, overall, this activity may be a worthwhile way to enhance students' attendance, participation and learning.

Keywords: classroom experiments; lecture attendance; student learning.

Reference to this paper should be made as follows: Lin, T-C. (2020) 'Effects of classroom experiments on student learning outcomes and attendance', *Int. J. Education Economics and Development*, Vol. 11, No. 1, pp.76–93.

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This paper is a revised and expanded version of a paper entitled 'The impact of classroom game-play experiments in introductory microeconomics on student learning' presented at Southern Economic Association Conference, Washington, DC, 18–20 November 2018.

1 Introduction

Although numerous studies have investigated the impact of classroom experiments (game-play experiments in classroom) on student learning (e.g., Cardell et al., 1996; Frank, 1997; Gremmen and Potters, 1997; Emerson and Taylor, 2004; Dickie, 2006; Cartwright and Stepanova, 2012; Lin and Dunphy, 2013; Emerson and English, 2016), none have explored whether classroom experiments can enhance students' lecture attendance. A number of empirical studies have demonstrated that student lecture attendance is one of the primary factors in ensuring student learning (e.g., Brocato, 1989; Cohn and Johnson, 2006; Lin, 2014). If classroom experiments can significantly improve students' lecture attendance, then engagement in classroom experiments may improve student learning as well.

The classroom experiment is an instructional method used by instructors to help students better understand an abstract model. For example, in the trading experiment, learning by doing shows students how demand and supply drive the market towards equilibrium. Overall, the classroom experiment is regarded as a fun, lively, and creative instructional method that increases student interest in game participation and ensures more frequent lecture attendance. However, some students may perceive these experiments as games (not alternatives to formal lectures), and hence miss more lectures. This raises an interesting question for investigation: can classroom experiments enhance students' lecture attendance? If the results indicate that, yes, these experiments can significantly enhance students' lecture attendance, then we need to further investigate: which students (stronger or weaker) are most likely to enhance their lecture attendance when engaged in classroom experiments? On the other hand, faced with the opposite results, the question becomes: which students (stronger or weaker) are most likely to decrease their lecture attendance when engaged in classroom experiments?

We hypothesise that classroom experiments can enhance students' lecture attendance, and that weaker students are most likely to improve their lecture attendance if offered the opportunity to engage in classroom experiments. Instructional methods that are fun, lively, and creative may attract more students' (especially weaker students') participation in games that help them learn and retain course content and inspire them to attend lectures more frequently. That is, weaker students who initially might not be interested in lectures and might be less motivated by a more traditional teaching method may become more interested in lectures and more motivated through engagement in classroom experiments. Moreover, as mentioned earlier, we hypothesise that classroom experiments may improve student learning outcome. Therefore, we investigated the veracity of our hypotheses on the impact of classroom experiments on both student lecture attendance and learning outcomes.

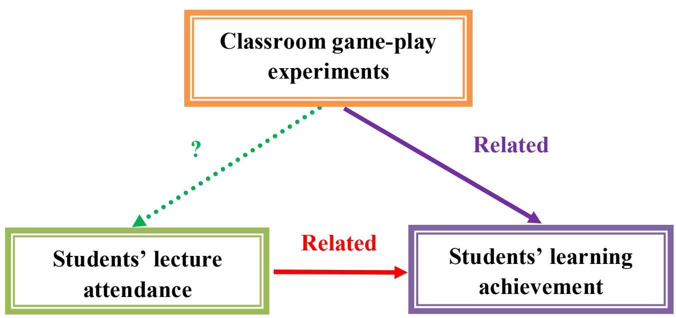
The method of analysis for this study was econometrics rather than statistical methods used by other researchers (e.g., Lin and Dunphy, 2013), because hypotheses on students' economic behaviour were being tested. Students are economic individuals who engage in economic behaviour, such as investment behaviour, in in-class effort. Thus, when the professor uses classroom experiments as an instructional method, students decide whether to invest more or less in-class effort (i.e., attending the class more or less frequently). We constructed econometric models and adopted the ordinary least squares (OLS) method to verify these hypotheses.

This paper is organised as follows. First, we briefly review selected articles related to this topic. Second, we offer details on developing a basic framework for lecture attendance and learning outcome, and data sources and measurement. Third, we present the development of our econometric models for testing hypotheses. Fourth, we show our findings and explain whether our hypotheses are supported. Fifth, we discuss an argument. Finally, we offer conclusions.

2 A brief literature review

Before offering a brief literature review, we display the following simple diagram (Figure 1) to express the theoretical foundation for the article.

Figure 1 Relationship among classroom game-play experiments, students' lecture attendance, and students' learning achievement (see online version for colours)



As Figure 1 shows, the relationship between classroom game-play experiments and students' learning achievement as well as the relationship between students' lecture attendance and students' learning achievement have been broadly investigated and discussed. However, the relationship between classroom game-play experiments and students' lecture attendance has not been verified yet. Since both classroom experiments and lecture attendance can affect learning outcomes, classroom experiments may affect students' investment in in-class effort (i.e., attendance), and thus influence their learning outcomes. Therefore, we need to verify the relationship between classroom experiments and lecture attendance. Our research links these important education concepts. Below, we briefly review the literature on these two topics.

The findings on the impact of classroom experiments on student learning achievement are mixed – either significant or no impact. For example, Cardell et al. (1996) and Cartwright and Stepanova (2012) did not find a significant relationship between classroom experiments and student learning achievement. It should be noted that Cartwright and Stepanova (2012) offered one condition: if students wrote a report on the experiment, then the experience improved students' test scores. That is, unless students wrote a report on the experiment, their test scores did not improve. On the other hand, most previous studies (e.g., Frank, 1997; Gremmen and Potters, 1997; Emerson and Taylor, 2004; Dickie, 2006; Lin and Dunphy, 2013; Emerson and English, 2016) demonstrated that classroom experiments exert a positive and significant effect on students' quiz or test scores, implying that classroom experiments are an effective instructional method in improving student learning.

The relationship between student lecture attendance and exam performance has been widely explored and discussed by numerous researchers (e.g., Anikeeff, 1954; Jones, 1984; Brocato, 1989; Park and Kerr, 1990; Van Blerkom, 1992; Gunn, 1993; Romer, 1993; Durden and Ellis, 1995; Devadoss and Foltz, 1996; Marburger, 2001, 2006; Rogers, 2001; Rocca, 2003; Chung, 2004; Stanca, 2006). Although these researchers adopted different methodologies and used different datasets to examine this issue, all came to a similar conclusion: exam performance is positively and significantly correlated with student lecture attendance. In addition, Lin (2014) focused on a different but related topic: the relationship between absence from lectures and exam 'performance progress'. Since 'performance progress' is a dynamic perspective, while performance is a 'static perspective', these two perspectives could have different effects. Lin (2014) found that missing lectures decelerated students' (especially high-performing students') exam performance progress.

Moreover, Lin (2010) demonstrated that student's preference for a teacher's instructional method/style and student lecture attendance are positively and significantly correlated, and hence positively associated with student grade performance. In addition, Lin (2016) further verified that quizzes enhance student lecture attendance, and hence in turn improve student learning outcomes. In his empirical model, grade point average (GPA) was used as a measure of a student's motivation and academic quality. He also used student work hours for pay and total credits taken in the semester as a proxy for a student's opportunity cost of taking the course. Furthermore, two additional variables (gender and living with young kids) were included in his model as control variables. We employed the same variables (i.e., GPA, work hours for pay, total credits taken in the semester, gender, and living with young kids) in our study.

Previous studies pointed to the importance of investigating the relationship between classroom experiments and student lecture attendance as well as learning outcomes. For that reason, we developed three hypotheses for this study:

Hypothesis 1 Classroom experiments can enhance students' lecture attendance.

Hypothesis 2 Weaker students are most likely to increase their lecture attendance when engaged in classroom experiments.

Hypothesis 3 Classroom experiments can improve students' learning outcomes.

3 Basic framework and data

3.1 Basic framework

To conduct this research, we need to build basic frameworks for student's lecture attendance and learning outcomes to construct econometric models. The determinants of each basic framework were mainly based upon empirical findings found in previous studies (e.g., Frank, 1997; Cohn and Johnson, 2006; Dickie, 2006; Lin, 2013, 2016, etc.) rather than just an assemblage of suppositions. Below, we show these two basic frameworks for student's lecture attendance and learning outcomes.

According to empirical findings mentioned earlier, a student's lecture attendance (*ATD*) can be influenced by the student's quality and motivation to engage in course learning (*QUM*), the opportunity cost of taking this course (*OPC*), gender (*GEN*), living with young kids (*LYK*), and the instructor's instructional method (*IMD*). A simple basic framework for a student's lecture attendance can be displayed as follows:

$$ATD = f(QUM, OPC, GEN, LYK, IMD). \quad (1)$$

Similarly, based upon empirical findings mentioned earlier, a student's learning outcomes (*OUC*) can be affected by the student's quality and motivation to engage in course learning (*QUM*), the student's effort (*EFT*), the opportunity cost of taking this course (*OPC*), gender (*GEN*), living with young kids (*LYK*), math background (*MAH*), and the instructor's instructional method (*IMD*). A simple basic framework for a student's learning outcomes can be displayed as follows:

$$OUC = f(QUM, EFT, OPC, GEN, LYK, MAH, IMD). \quad (2)$$

A student's quality and motivation to learn course material are primary factors in determining whether he or she will invest more or less effort in the classroom. The greater the student's motivation and higher their quality, the more effort he or she will be willing to invest in the classroom, vice versa. For example, a student who is very interested in learning a course and very able to learn is more likely to frequently attend lectures, and hence enjoy better learning outcomes.

A student's effort (e.g., in-class effort) toward learning course material is an important factor in determining a student's learning outcomes. As described above, the more efforts the student devoted toward studying for the course, the better his or her learning outcome will be.

A student's opportunity cost also would affect his or her decision to invest more or less effort in the classroom. The greater the opportunity cost to the student in taking this course, the less effort the student will be willing to invest in the classroom, thus affecting his or her learning outcomes. For example, if the student has a job that requires 48 hours/week, he or she may have less time for travel to campus and for rest, and therefore may skip lectures more often, negatively influencing his or her exam performance. Moreover, a student who is taking more credit hours in a semester may have less time to study for each course, leading them to skip lectures for other classes due to midterm exams or homework assignments for other classes and in turn resulting in a poor exam performance for the course.

Several empirical studies (e.g., Woodfield et al., 2006; Cortright et al., 2011; Paisey and Paisey, 2004) have demonstrated that gender may influence lecture attendance behaviour. Thus, we included this factor in the model to determine whether the hypothesis that gender may affect student lecture attendance and learning outcome is true.

Living with young kids may impact a student's decision to invest more or less effort in the classroom. For example, if a student (especially a non-traditional student) has kids who are less than ten years of age who need more parental attention and care, the student may frequently skip lectures when these children are ill or have school-related emergencies. Missing lectures may negatively affect learning outcomes.

Learning economics requires a mathematical background, such as college algebra and calculus. A student with a stronger mathematical background is more likely to have better learning outcomes in the subject of economics.

The instructor's instructional method is also an important factor in a student's decision to invest more or less effort in the classroom. The more acceptable the instructor's instructional method to the student, the more effort the student will invest in the classroom and thus the better the learning outcomes. For example, if the student is very interested in the instructor's instructional method, say classroom experiments, and always enjoys playing each game, he or she will be more likely to attend lectures more frequently and perform better on exams.

3.2 Data

Based upon the basic study framework shown above, we divided the students in Introductory Microeconomics classes into two groups – classroom experiments and no classroom experiments. The study was done during the spring and fall 2016 semesters. Fifty-seven students who enrolled in spring 2016 were in the classroom experiments group (i.e., experimental group), while 63 students who enrolled in fall 2016 were in the no classroom experiment group (i.e., control group). Students self-selected into the classes. They did not have any knowledge before they signed up for the class.

The same instructor taught both groups. With the experimental group, the instructor used the classroom-experiment instructional method, designing three classroom game-play experiments; with the control group, the instructor used a traditional instructional method and no classroom game-play experiments. The topics of these three classroom experiments were:

1. Game 1 – production possibilities frontier
2. Game 2 – demand curve and price elasticity of demand
3. Game 3 – diminishing marginal utility and increasing total utility.

For each classroom experiment, the instructor took approximately 60 minutes to lecture on the topic. However, a lecture on the same topic using the traditional instructional method in the no-experiment group took the instructor about 20 or 25 minutes. The meeting time for each class was 75 minutes.

In both conditions, the instructor used the same grading policy and teaching materials (e.g., textbook and handouts) and gave students three exams [two midterm exams (i.e., exam 1 and exam 2), and one final exam (i.e., exam 3)]. The course grade was based upon results from these three exams (each exam weighted one-third of the course grade). These two groups' midterm exams were identical, but the final exam (which was comprehensive) was somewhat different for each class because two textbook chapters were not taught in the experiment group due to a lack of time – these two chapters were taught in the no-experiment group. All exams were collected when students submitted their answers. Therefore, students were not able to get information from a previous year's exams. Students in these two groups were given complete freedom to choose whether to attend the class. There were no mandatory attendance policies, no attendance bonus and no absence penalty.

Moreover, each semester was split into three periods (i.e., three exam periods). In the no-experiment group, period 1 (i.e., the first exam period) extended from the first to the fifth week of the semester (exam 1 was held at the end of period 1); period 2 (i.e., the second exam period), from the sixth to the tenth week of the semester (exam 2 was held at the end of period 2); and period 3 (i.e., the third exam period), the 11th to the 15th week of the semester (exam 3 was held at the end of period 3). Thus, the length of each period was five weeks in the no-experiment group, for 15 weeks in total. In the experiment group, the length of each period was different from that for the no-experiment group. It should be pointed out that Game 1 and Game 2 took place during the first exam period, while Game 3 took place during the second exam period. Without classroom experiments, the length of one exam period was five weeks. With these three classroom experiments, the length of the two exam periods was more than ten weeks for the experiment group, but still ten weeks for the no-experiment group. However, given 15 weeks in a semester, the length of the third exam period for the experiment group was less than five weeks, while the length was still five weeks for the no-experiment group.

In addition, it should be indicated that although there are some differences (the length of each period and the final exam materials) between these two groups, these differences are not likely to affect the effect of game-play experiments.

The data used in the study were instructor-reported and self-reported. Below, we describe the data source and measurement:

1 *Lecture attendance (ATD):* As described above, the length of each exam period for the classroom experiments group differed from the length of each exam period for the no classroom experiments group. To solve this problem, we adopted attendance rate (*ATR*) to proxy student lecture attendance (*ATD*). *ATR* is defined as the total number of lectures attended divided by the total number of lectures during the exam period. The instructor took daily lecture attendance in these two groups (i.e., the experiment group and the no-experiment group). Attendance was taken in the same way in both classes. Students were aware that daily attendance was being taken but they were told by the instructor that it was just for record-keeping purposes and would not affect their final grades because there were no mandatory attendance policies.

2 *Quality of learning for/motivation to learn this course (QUM):* Regardless of students' different majors, an appropriate proxy for student quality and motivation to learn may be the student's GPA. Thus, we used GPA as a proxy for students' quality and motivation to learn from the course. Each student's GPA was provided by the Registrar Office, after institutional review board (IRB) approval was received.

3 *Opportunity cost of taking this course (OPC):* Both student work hours for pay per week (*WHR*) and credit hours taken in the semester (*CRD*) can shed light on a student's opportunity cost of studying for the course. The information on each student's total credit hours taken during the semester can be obtained from the Office of the Registrar. However, the information on student work hours for pay per week requires students' self-report via a questionnaire. We describe the questionnaire later.

4 *Gender (GEN):* This was a dummy variable. We set male (*MAL*) as 1, and female as 0. The instructor identified each student's gender.

5 *Living with young kids (LYK):* This variable was also a dummy variable. We set 'yes, living with young kids whose age is below ten years old' (*KID*) as 1, while 'no, do not live with young kids whose age is below ten years old' as 0. This variable also requires students' self-report via a questionnaire. We describe the questionnaire later.

6 *Math background (MAH):* Both college algebra (*ALG*) and calculus (*CAL*) were used to reflect a student's math background. These two were dummy variables. We set 'yes' as 1 and 'no' as 0. The information on whether or not each student has completed college algebra and calculus can be obtained from the Office of the Registrar.

7 *Instructional method (IMD):* In this study, there were two instructional methods – classroom game-play experiments (*GAM*) and traditional method with no classroom game-play experiments. This was a dummy variable as well. We set 1 as 'students in the classroom experiments group' and 0 as 'students in the traditional instructional method group'.

As mentioned above, information on total work hours for pay per week (*WHR*) and living with young kids (*KID*) requires self-report via a questionnaire. We designed a questionnaire that could take students approximately one minute to complete (see below):[1]

1 Do you work for pay? Yes: ____; No: ____. If you answer 'yes', approximately how many hours a week do you work for pay? _____

2 Do you live with young kids (below ten years old)? Yes: ____; No: ____.

4 Econometric models

For the illustration provided in the previous section, the initial basic framework [equation (1)] for a student's lecture attendance rate shown above can be rewritten as follows:

$$ATR = f(GPA, WHR, CRD, MAL, KID, GAM). \tag{3}$$

Based upon the basic framework, we assumed that the attendance rate (*ATR*) was modelled as a transcendental function, which can be shown as below:

$$ATR = a_0 (GPA)^{\alpha_1} (WHR)^{\alpha_2} (CRD)^{\alpha_3} e^{\alpha_4 (MAL) + \alpha_5 (KID) + \alpha_6 (GAM)}. \tag{4}$$

Hypothesis 1 Classroom experiments can enhance students' attendance rate.

To verify Hypothesis 1, we constructed a regression model by taking natural logarithms of both sides of equation (4); the attendance rate function becomes linear, and hence the regression model can be developed as follows:

$$\begin{aligned} \ln ATR_t = {} & \alpha_0 + \alpha_1 \ln GPA + \alpha_2 \ln WHR + \alpha_3 \ln CRD + \alpha_4 MAL + \alpha_5 KID \\ & + \alpha_6 GAM + \varepsilon_1 \end{aligned} \tag{5}$$

where $\alpha_0 = \ln a_0$, $t = 1, 2, 3$, and whole semester, ATR_t = attendance rate during the period of exam t, *GPA* = grade point average, *WHR* = total work hours for pay per week, *CRD* = total credits taken in the semester, *MAL* = male students (dummy variable), *KID* = living with young kids (dummy variable), *GAM* = students in the classroom game-play experiments group (dummy variable), and ε_1 = stochastic disturbance with a mean 0 and a variance σ^2.

In this formulation, the null hypothesis was that the parameter (α_6) was zero, while the alternative hypothesis was that the parameter (α_6) was not zero. That is, if classroom experiments enhanced students' lecture attendance rate, then $\alpha_6 > 0$ and the effect should be significant.

Hypothesis 2 Weaker students are most likely to increase their attendance rate when engaged in classroom experiments.

To verify Hypothesis 2, we first split data on stronger and weaker students based on GPA. We did not use a dyadic approach to identify weaker and stronger students. Instead, we created three groups based upon GPA, measuring the top versus the bottom and ignoring the middle group. This approach was also used by Lin (2013), and allowed us to avoid students whose GPA was at the margin (e.g., GPA = 2.96, which is very close to 3.00). Students whose GPA was higher than or equal to 3.0 were in the group of stronger students, while students whose GPA was lower than or equal to 2.6 were in the group of weaker students. Students whose GPA was between 3.0 and 2.6 (not including 3.0 and 2.6) were in the group of mediocre students. Based upon this approach, the 'mediocre' students were not included in the analysis. Nineteen students were referred to as stronger students and 26 students were referred to as weaker students in the experiment group; while 27 students were referred to as stronger students and 24 students were referred to as weaker students in the no-experiment group.

Second, we constructed the regression model by modifying equation (5). We used an interactive dummy variable (i.e., *GAM* × *STG* or *GAM* × *WEK*) to identify students who were stronger (or weaker) in the classroom game-play experiments group. *STG* was set as 1 if students' GPA ≥ 3, while *STG* was 0 if students' GPA < 3. *WEK* was set as 1 if students' GPA ≤ 2.6, while *WEK* was 0 if students' GPA > 2.6. As a result, the regression model was as below:

$$\begin{aligned}\ln ATR_t &= \beta_0 + \beta_1 \ln GPA + \beta_2 \ln WHR + \beta_3 \ln CRD + \beta_4 MAL + \beta_5 KID \\ &\quad + \beta_6 GAM \times STG + u_1\end{aligned} \tag{6}$$

$$\begin{aligned}\ln ATR_t &= \gamma_0 + \gamma_1 \ln GPA + \gamma_2 \ln WHR + \gamma_3 \ln CRD + \gamma_4 MAL + \gamma_5 KID \\ &\quad + \gamma_6 GAM \times WEK + u_2\end{aligned} \tag{7}$$

where *STG* = stronger students whose GPA 3 (dummy variable), *WEK* = weaker students whose GPA 2.6, and u_1, u_2 = stochastic disturbance with a mean 0 and a variance σ^2.

In this formulation, the null hypothesis was that the parameter (γ_6) was zero, while the alternative hypothesis was that the parameter (γ_6) was not zero. That is, if classroom experiments enhanced weaker students' lecture attendance rate, then $\gamma_6 > 0$ and the effect should be significant.

Moreover, according to the illustration provided in the previous section, the initial basic framework [equation (2)] for a student's exam performance shown above can be rewritten as follows:

$$EXA = f(GPA, ATR, WHR, CRD, MAL, KID, ALG, CAL, GAM). \tag{8}$$

Based upon the basic framework, we assumed that the student's exam performance (*EXA*) was modelled as a transcendental function, which can be shown as below:

$$EXA = d_0 (GPA)^{\delta_1} (AHR)^{\delta_2} (WHR)^{\delta_3} (CRD)^{\delta_4} e^{\delta_5 (MAL) + \delta_6 (KID) + \delta_7 (ALG) + \delta_8 (CAL) + \delta_9 (GAM)}. \tag{9}$$

Hypothesis 3 Classroom experiments can improve students' exam performance.

To verify Hypothesis 3, we constructed a regression model by taking natural logarithms of both sides of equation (9); the exam performance function became linear, and hence the regression model can be developed as follows:

$$\begin{aligned} \ln EXA_t &= \delta_0 + \delta_1 \ln GPA + \delta_2 \ln ATR_t + \delta_3 \ln WHR + \delta_4 \ln CRD + \delta_5 MAL \\ &+ \delta_6 KID + \delta_7 ALG + \delta_8 CAL + \delta_9 GAM + \varepsilon_2 \end{aligned} \quad (10)$$

where $\delta_0 = \ln d_0$, $t = 1, 2$, EXA_t = scores on exam t, and ε_2 = stochastic disturbance with a mean 0 and a variance σ^2.

In this formulation, the null hypothesis was that the parameter (δ_9) was zero, while the alternative hypothesis was that the parameter (δ_9) was not zero. That is, if classroom experiments enhanced students' lecture attendance rate, then $\delta_9 > 0$ and the effect should be significant.

Table 1 Mean and standard deviations for variables

Variables	*Mean*		*Standard deviation*	
	N = 57 *Game*	*N = 63* *No game*	*N = 57* *Game*	*N = 63* *No game*
Lecture attendance rate in period 1	0.93	0.89	0.10	0.15
Lecture attendance rate in period 2	0.88	0.83	0.14	0.21
Lecture attendance rate in period 3	0.87	0.82	0.15	0.23
Lecture attendance rate for the whole semester	0.89	0.85	0.11	0.19
Hours of work for pay per week	26.77	28.81	15.41	12.85
Hours of credit taken over the whole semester	12.79	13.38	2.88	3.27
Student grade point average (GPA)	2.65	2.76	0.58	0.61
Dummy variable – male	0.58	0.54	0.50	0.50
Dummy variable – kids	0.32	0.25	0.47	0.44

5 Results

5.1 Hypothesis 1

We present the results for equation (5) in Table 2. The null hypothesis that the instructional method of classroom experiments is not related to student lecture attendance rate was rejected, because the classroom experiment (*GAM*, dummy variable) exerted a positive and statistically significant effect on the lecture attendance rate at the 5%, 10%, 5%, and 5% levels, for the first exam period, second exam period, third exam period, and whole semester, respectively.

In addition, as predicted, the variable of GPA exerted a positive and statistically significant effect on lecture attendance rate at the 1% level in all periods, implying that a student with greater motivation and of higher quality will invest more effort in the classroom, and thus attend more lectures. However, unexpectedly, the other variables [such as work hours for pay (*WHR*), credit hours taken in a semester (*CRD*), gender (*MAL*), and living with young kids (*KID*)] did not provide a statistically significant effect on lecture attendance rate at the 1%, 5%, or 10% levels in all periods.

Table 2 Regression results for Hypothesis 1 (experiments vs. no experiments)

Explanatory variables	*Explained variable: ln ATR*			
	Period 1 *(1)*	*Period 2* *(2)*	*Period 3* *(3)*	*Whole semester* *(4)*
Constant	–0.48***	–0.76**	–1.11***	–0.73***
	(–2.70)	(–2.34)	(–2.99)	(–2.98)
ln *GPA*	0.17***	0.362***	0.361***	0.285***
	(2.70)	(3.11)	(2.73)	(3.28)
ln *WHR*	0.004	–0.014	–0.009	–0.005
	(0.35)	(–0.58)	(–0.34)	(–0.29)
ln *CRD*	0.06	0.07	0.198*	0.098
	(1.18)	(0.72)	(1.71)	(1.29)
MAL	–0.03	0.007	–0.01	–0.011
	(–0.82)	(0.12)	(–0.17)	(–0.27)
KID	0.04	0.06	0.09	0.07
	(0.95)	(0.96)	(1.20)	(1.30)
GAM	0.074**	0.106*	0.138**	0.096**
	(2.40)	(1.88)	(2.14)	(2.28)
R^2	0.102	0.117	0.115	0.133
$\bar{R}^2$	0.055	0.07	0.068	0.087
F-statistic	2.14	2.49	2.45	2.89
Observation	120	120	120	120

Notes: Number in parentheses is *t*-value, *GPA* = grade point average, *WHR* = working hours per week, *MAL* = dummy variable (male student = 1), *KID* = dummy variable (living with kids = 1), and *GAM* = dummy variable (game-play experiment = 1).
***$p < .01$, **$p < .05$ and *$p < .10$.

As a result, Hypothesis 1 was supported. Classroom experiments can enhance students' attendance rate.

5.2 Hypothesis 2

We report the results for equations (6) and (7) in Table 3. Comparing stronger students with weaker students, the interactive dummy variable (*GAM* × *WEK*) exerted a positive and statistically significant effect on lecture attendance rate at the 1%, 5%, 1%, and 1% levels in the first exam period, second exam period, third exam period, and whole semester, respectively. Nevertheless, the other interactive dummy variable (*GAM* × *STG*) did not provide any statistically significant effect on lecture attendance rate at the 1%, 5%, or 10% levels in all periods.

Table 3 Regression results for Hypothesis 2 (experiments vs. no experiments)

Explanatory variables	*Explained variable: ln ATR*							
	Period 1		*Period 2*		*Period 3*		*Whole semester*	
	Stronger (1)	*Weaker (2)*	*Stronger (3)*	*Weaker (4)*	*Stronger (5)*	*Weaker (6)*	*Stronger (7)*	*Weaker (8)*
Constant	–0.33*	–0.51***	–0.56*	–0.78**	–0.84**	–1.15***	–0.54**	–0.76***
	(–1.95)	(–2.95)	(–1.78)	(–2.44)	(–2.36)	(–3.17)	(–2.30)	(–3.20)
ln *GPA*	0.17**	0.28***	0.34***	0.50***	0.34**	0.56***	0.28***	0.42***
	(2.39)	(3.85)	(2.69)	(3.72)	(2.34)	(3.61)	(2.89)	(4.23)
ln *WHR*	–0.003	0.003	–0.023	–0.016	–0.021	–0.012	–0.014	–0.007
	(–0.20)	(0.26)	(–0.97)	(–0.70)	(0.80)	(–0.46)	(–0.78)	(–0.40)
ln *CRD*	0.031	0.041	0.028	0.038	0.14	0.152	0.05	0.066
	(0.55)	(0.77)	(0.27)	(0.39)	(1.19)	(1.37)	(0.72)	(0.92)
MAL	–0.02	–0.04	0.01	–0.01	–0.002	–0.037	–0.006	–0.03
	(–0.68)	(–1.31)	(0.25)	(–0.21)	(–0.03)	(–0.57)	(–0.14)	(–0.71)
KID	0.04	0.03	0.07	0.06	0.098	0.09	0.069	0.06
	(1.02)	(0.92)	(1.00)	(0.94)	(1.25)	(1.18)	(1.36)	(1.28)
GAM × *STG*	–0.02		–0.01		–0.021		–0.023	
	(–0.51)		(–0.11)		(–0.22)		(–0.37)	
GAM × *WEK*		0.14***		0.18**		0.24***		0.17***
		(3.27)		(2.31)		(2.76)		(3.03)
R^2	0.058	0.138	0.089	0.130	0.080	0.137	0.094	0.161
$\bar{R}^2$	0.008	0.092	0.041	0.084	0.031	0.092	0.046	0.117
F-statistic	1.17	3.01	1.85	2.82	1.63	3.00	1.96	3.63
Observation	120	120	120	120	120	120	120	120

Notes: Number in parentheses is *t*-value, *GPA* = grade point average, *WHR* = working hours per week, *MAL* = dummy variable (male student = 1), *KID* = dummy variable (living with kids = 1), *GAM* = dummy variable (game-play experiment = 1), *STG* = dummy variable (stronger students = 1), and *WEK* = dummy variable (weaker students = 1).
***$p < .01$, **$p < .05$ and *$p < .10$.

These results imply that weaker students, relative to stronger students, are most likely to improve their lecture attendance if engaged in classroom experiments. This is because classroom experiments are a fun, lively, and creative way to teach students. Therefore, weaker students participated in these experiments and attended lectures more frequently. However, stronger students always attend lectures no matter which instructional method the instructor adopted. Thus, the effect was not significant for stronger students.

Consequently, Hypothesis 2 was also supported. Weaker students are most likely to enhance their in-class effort when given the opportunity to engage in game-play experiments in the classroom.

Table 4 Regression results for Hypothesis 3 (experiments vs. no experiments)

Explanatory variables	*Explained variable: ln EXA*			
	Period 1 *(1)*	*Period 2* *(2)*	*Period 1* *(3)*	*Period 2* *(4)*
Constant	3.42***	3.76***	3.17***	3.60***
	(12.43)	(18.46)	(11.38)	(17.13)
ln *GPA*	0.48***	0.29**	0.56***	0.36***
	(4.97)	(4.00)	(5.65)	(4.86)
ln *ATR*	0.49***	0.212***		
	(3.49)	(3.70)		
ln *WHR*	0.008	0.002	0.011	–0.001
	(0.43)	(0.15)	(0.56)	(–0.04)
ln *CRD*	0.087	0.102	0.12	0.12*
	(1.05)	(1.65)	(1.39)	(1.78)
MAL	0.07	0.03	0.055	0.03
	(1.47)	(0.74)	(1.15)	(0.76)
KID	–0.013	–0.016	–0.001	–0.01
	(–0.24)	(–0.41)	(–0.02)	(–0.14)
ALG	0.01	0.031	0.05	0.05
	(0.22)	(0.85)	(0.94)	(1.42)
CAL	0.06	0.05	0.06	0.05
	(1.19)	(1.26)	(1.11)	(1.38)
GAM	0.088*	0.045	0.12**	0.062*
	(1.89)	(1.29)	(2.41)	(1.69)
R^2	0.394	0.379	0.327	0.302
$\bar{R}^2$	0.344	0.328	0.279	0.251
F-statistic	7.95	7.47	6.74	6.00
Observation	120	120	120	120

Notes: Number in parentheses is *t*-value, *GPA* = grade point average, *WHR* = working hours per week, *MAL* = dummy variable (male student = 1), *KID* = dummy variable (living with kids = 1), *ALG* = dummy variable (algebra = 1), *CAL* = dummy variable (calculus = 1), and *GAM* = dummy variable (game-play experiment = 1).
***$p < .01$, **$p < .05$ and *$p < .10$.

5.3 Hypothesis 3

We present the results for equation (10) in columns 1 and 2 of Table 4. As displayed in columns 1–2 of Table 4, the null hypothesis that the classroom experiment instructional method is not related to student learning outcomes was rejected in the first exam period. This was because classroom experiments (*GAM*, dummy variable) provided a positive and statistically significant effect on exam performance at the 10% level. Unfortunately, the null hypothesis that the classroom experiment instructional method is not related to student learning outcomes was not rejected in the second exam period, because classroom experiment (*GAM*, dummy variable) did not exert a statistically significant effect on exam performance at the 1%, 5% or 10% levels.

We believe that the multicollinearity problem in equation (10) is the main reason for the insignificant effect in the second exam period because classroom experiment positively affects class attendance rate, as shown in Hypothesis 2, meaning that *ATR* and *GAM* are positively correlated. Due to the simultaneous coexistence of these two variables in equation (10), the problem of multicollinearity could occur. For that reason, the variable of attendance rate (*ATR*) was dropped from equation (10) to fix the problem.

As a result, as shown in columns 3 and 4 of Table 4, the null hypothesis that the classroom experiment instructional method is not related to student learning outcomes was rejected in both exam periods, because *GAM* (dummy variable) exerted a positive and statistically significant effect on exam performance at the 5% and 10% levels in the first and second exam period, respectively.

Consequently, Hypothesis 3 could be supported after the multicollinearity problem was fixed. Classroom experiments can improve students' exam performance.

6 Discussion

Although our empirical evidence (shown in Table 3) demonstrated that weaker students are most likely to increase their attendance rate when engaged in classroom experiments, one could argue that the positive effect of GPA on attendance rate shown in Table 2 implies that students with higher GPAs attend more frequently, controlling for other factors, indicating that more room for increased attendance by stronger students than by weaker students.

As a matter of fact, this argument is incorrect. The positive effect of GPA on attendance rate shown in Table 2 only verifies that students with higher GPAs are more likely to attend the class more frequently. It does not demonstrate that students with higher GPAs attend the class more frequently and hence attendance would be higher for stronger students than for weaker students.

Let us take a look at the following example to better understand why the argument shown above is incorrect. Suppose that there are two students. One has a high GPA (say, 4.0), while the other one has a low GPA (say, 2.0). The student with a high GPA always attends the class (attendance rate = 100%) no matter which instructional method (classroom experiments or no classroom experiments) has been adopted by the instructor. However, the student with a low GPA did not attend all of the classes (say attendance rate = 70%) when the instructor adopted the no classroom experiment method but increased his attendance rate to 80% when the instructor adopted the classroom experiment method. The attendance rate for the high-GPA student did not change at all (additional attendance rate = 0), while the attendance rate for the low-GPA student significantly increased by 10% (additional attendance rate = 10%).

This example indicates that stronger students have greater motivation to learn, so they attend the class all of the time (or do so more frequently) no matter which method has been adopted by the instructor. On the other hand, weaker students may have low motivation to learn, so they may not attend the class all of the time (or do so less frequently) when they do not like the way the instructor lectures and feel the class is boring. Therefore, when the instructor adopts a method designed to motivate students and increase their interest in learning (say, classroom game-play experiments), those students would be more likely to attend the class more often. This is because game-play experiments in classroom are a fun, lively, and creative way to teach students. As shown in this study, weaker students participated in these experiments and attended lectures more frequently. However, stronger students always attended lectures no matter which instructional method had been adopted by the instructor, and hence did not increase their attendance. For that reason, the effect in Table 3 was not significant for stronger students.

Finally, in comparison with previous studies regarding the relationship between game-play experiments in the classroom and student learning achievement, our empirical finding in this study was consistent with those of other researchers, such as Frank (1997), Gremmen and Potters (1997), Emerson and Taylor (2004), Dickie (2006), Lin and Dunphy (2013) and Emerson and English (2016). We all suggested that game-play experiments exerted a positive and significant effect on student learning outcomes. Although researchers such as Cartwright and Stepanova (2012) offered a somewhat different finding (insignificant) initially, they eventually also supported the conclusion that classroom experiments improved students' test scores if students wrote a report on the experiments. Moreover, our result is consistent with Lin's (2010) that a student's preference for an instructor's instructional method/style positively influences the student's lecture attendance.

7 Conclusions

Our empirical findings offer bountiful evidence that game-play experiments in the classroom can enhance students' learning outcomes (i.e., exam performance) and lecture attendance, and show that weaker students are most likely to increase their lecture attendance when engaged in classroom experiments.

The main contributions of this study can be briefly described as below:

1. We verified a positive relationship between classroom experiments and student learning outcomes, which was consistent with most previous studies.
2. We verified a positive relationship between classroom experiments and student lecture attendance, which had not been demonstrated before by previous studies. That is, our research bridges this important void in the education literature.

This research has one limitation. The work of classroom experiments was carried out for a single spring semester (2016) and in one course (Introductory Microeconomics), so we did not have more and different course samples to compare. In other words, due to the lack of diversified samples and a larger sample size, the students' attitude toward attendance could be misleading. Therefore, after future further research in other semesters and different economics courses, we could compare the outcomes.

Although our results suggest that the classroom experiments are a fun, lively, and creative method of teaching economics to students and motivates them to participate in game-play experiments, and hence improve their lecture attendance and learning outcomes, the main issue for game-play experiments is the time needed to design games and use them to teach students. For that reason, the professor in the game-play group would have less time to teach all planned topics taught to the no-game-play group. If the professor in the game-play group insisted on teaching all initial planned topics taught in the no-game-play group, he or she might have to rush through every topic to cover all initially planned topics. As a result, students could be confused about the rushed topics, which could negatively influence students' learning.

In conclusion, while the design of classroom experiments may take time from class lectures during the semester, if instructors' goal is to enhance students' attendance/participation and learning outcomes, the classroom experiment method may be an effective pedagogical alternative.

References

Anikeeff, M. (1954) 'The relationship between class absences and college grades', *Journal of Educational Psychology*, Vol. 45, No. 4, pp.244–249.

Brocato, J. (1989) 'How much does coming to class matter? Some evidence of class attendance and grade performance', *Educational Research Quarterly*, Vol. 13, No. 3, pp.2–6.

Cardell, N.S., Fort, R., Joereding, W., Inaha, F., Lamoreaux, D., Roseman, R., Stromsdorfer, E. and Burlett, R. (1996) 'Laboratory-based experimental and demonstration initiative in teaching undergraduate economics', *American Economic Review*, Vol. 86, No. 2, pp.454–459.

Cartwright, E. and Stepanova, A. (2012) 'What do students learn from a classroom experiment: not much, unless thy write a report on it', *Journal of Economic Education*, Vol. 43, No. 1, pp.49–57.

Chung, C.J. (2004) 'Impact of attendance, instructor contact, and homework completion on achievement in a developmental logic course', *Research & Teaching in Developmental Education*, Vol. 20, No. 2, pp.48–57.

Cohn, E. and Johnson, E. (2006) 'Class attendance and performance in principles of economics', *Education Economics*, Vol. 14, No. 2, pp.211–233.

Cortright, R., Lujan, L.H. Cox, J.H. and DiCarlo, S.E. (2011) 'Does sex (female versus male) influence the impact of class attendance on examination performance?', *Advance in Physiology Education*, Vol. 35, No. 4, pp.416–420.

Devadoss, S. and Foltz, J. (1996) 'Evaluation of factors influencing student class attendance and performance', *American Journal of Agricultural Economics*, Vol. 78, No. 3, pp.499–507.

Dickie, M. (2006) 'Do classroom experiments increase learning in introductory microeconomics?', *Journal of Economic Education*, Vol. 37, No. 3, pp.267–288.

Durden, C. and Ellis, V. (1995) 'The effects of attendance on student learning in principles of economics', *American Economic Review*, Vol. 85, No. 2, pp.343–346.

Emerson, T.L.N. and English, L.K. (2016) 'Classroom experiments: Teaching specific topics or promoting the economic way of thinking?', *Journal of Economic Education*, Vol. 47, No. 4, pp.288–299.

Emerson, T.L.N. and Taylor, B.A. (2004) 'Comparing student achievement across experimental and lecture-oriented sections of a principles of microeconomics course', *Southern Economic Journal*, Vol. 70, No. 3, pp.672–693.

Frank, B. (1997) 'The impact of classroom experiments on learning economics: an empirical investigation', *Economic Inquiry*, Vol. 35, No. 4, pp.763–769.

Gremmen, H. and Potters, J. (1997) 'Assessing the efficacy of gaming in economic education', *Journal of Economic Education*, Fall, Vol. 28, No. 4, pp.291–303.

Gunn, P. (1993) 'A correlation between attendance and grades in a first-year psychology course', *Canadian Psychology*, Vol. 34, No. 2, pp.201–202.

Jones, H. (1984) 'Interaction of absences and grades in a college course', *Journal of Psychology*, Vol. 116, No. 1, pp.133–136.

Lin, T-C. (2010) 'Does a student's preference for a teacher's instructional style matter? An analysis of an economic approach', *Economics Bulletin*, Vol. 30, No. 2, pp.1320–1332.

Lin, T-C. (2013) 'Student performance and subsequent effort increment investment: do students behave like producers?', *International Journal of Education Economics and Development*, Vol. 4, No. 3, pp.219–232.

Lin, T-C. (2014) 'Does missing classes decelerate student progress on exam performance? Empirical evidence and policy implications', *Journal of Education for Business*, Vol. 89, No. 8, pp.411–418.

Lin, T-C. (2016) 'Effects of different types of quizzes on student effort investment behavior and learning outcomes', *International Journal of Education Economics and Development*, Vol. 7, Nos. 1/2, pp.33–52.

Lin, T-C. and Dunphy, S.M. (2013) 'Using the crossword puzzle exercise in introductory microeconomics to accelerate business student learning', *Journal of Education for Business*, Vol. 88, No. 2, pp.88–93.

Marburger, R. (2001) 'Absenteeism and undergraduate exam performance', *Journal of Economic Education*, Vol. 32, No. 2, pp.99–110.

Marburger, R. (2006) 'Does mandatory attendance improve student performance?', *Journal of Economic Education*, Vol. 37, No. 2, pp.99–110.

Paisey, C. and Paisey, N. (2004) 'Student attendance in an accounting module – reasons for non-attendance and the effect on academic performance at a Scottish University', *Accounting Education*, Vol. 13, No. 1, Sup. 1, pp.39–53.

Park, H. and Kerr, P. (1990) 'Determinants of academic performance: a multinational logit approach', *Journal of Economic Education*, Vol. 21, No. 2, pp.101–111.

Rocca, K. (2003) 'Student attendance: a comprehensive literature review', *Journal on Excellence in College Teaching*, Vol. 14, No. 1, pp.85–107.

Rogers, R. (2001) 'A panel-data study of the effect of student attendance on university performance', *Australian Journal of Education*, Vol. 45, No. 3, pp.284–295.

Romer, D. (1993) 'Do students go to class? Should they?', *Journal of Economic Perspectives*, Vol. 7, No. 3, pp.167–174.

Stanca, L. (2006) 'The effects of attendance on academic performance: panel data evidence for introductory microeconomics', *Journal of Economic Education*, Vol. 37, No. 4, pp.251–266.

Van Blerkom, L. (1992) 'Class attendance in an undergraduate course', *Journal of Psychology*, Vol. 126, No. 5, pp.487–494.

Woodfield, R., Jessop, D. and McMillan, L. (2006) 'Gender difference in undergraduate attendance rates', *Studies in Higher Education*, Vol. 31, No. 1, pp.1–22.

Notes

1 We asked a proctor to administer the survey; the proctor came to the class two minutes before the first exam started. The instructor was asked to leave the classroom while the survey was being administered. The proctor told students that they could choose whether or not to participate in the study, and that the survey did not count towards their final course grade. There was no interview and no audio or video-taping during the survey.