IMPACT OF AUTOMATED RESPONSE SYSTEMS ON STUDENTS' PERFORMANCE IN PRINCIPLES OF MICROECONOMICS

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ABSTRACT

In this paper we examine if automated response systems (ARSs) improve the exam performance of students when introduced as part of active learning assignments in Principles of Microeconomics classes. Active learning assignments are designed to improve student engagement and interaction during classes and thus improve the grades of students. However, ever increasing class sizes make it more complicated to get every student to participate in these assignments. The use of the ARS allows us overcome the problem of increasing class sizes. We show that the use of ARS as part of active learning assignments lead to higher exam scores.

INTRODUCTION

While higher education administration pushes colleges to ever increase class sizes, research in economic education challenges economics instructors to move away from pure chalk and talk lectures and give more individualized attention to every student in the classroom by introducing more active learning assignments (Becker and Watts 2001). Active learning strategies are being promoted because they improve the levels of participation, peer instruction, satisfaction with the learning experience, student attitudes, and engagement in general (Armbruster et al, 2009; Johnson et al., 1998; Marbach-Ad et al., 2001; Prince, 2004; Preszler et al., 2007; Yamarik, 2007)

In recent years, automated response systems (ARSs) have become a widely used tool to address the challenges of implementing active learning in large classrooms. With an ARS all students can respond to questions posted by the instructor and receive immediate feedback about their level of understanding; using this system also provides the instructor with the possibility to identify potential areas of weakness and immediately review these areas in class. Many studies show that ARSs positively affect student attitude and student engagement (Elliott, 2003; Ghosh and Renna, 2006 ,Duncan, 2006; Freeman and Blayney, 2005; Kay and LeSage, 2009; MacArthur and Jones, 2008; Wood, 2004, Lucas, 2009; Evans et al, 2008).

While active learning has been shown to improve exam scores (Dickie, 2006; Doorn and O'Brien, 2007; Emerson and Taylor 2004; Hake, 1998; McCarthy and Anderson, 2000; Nguyen and Trimarchi, 2009; and Salamonson, Andrew, Everett, 2009), research findings on the impact

of ARSs on the grades of students are mixed: some authors find that an ARS technology improves the grades of students, while others do not find any effects.

In our study we continue this important research and contribute to the literature by using an ARS over the course of the entire semester to allow students to get comfortable with the technology[1]; by using the ARS only with active learning assignments; by limiting the difference between control and treatment classes to ARS exclusively; and by tracking the ARS impact over several exams during the semester. As a result, we are able to provide a unique way of showing the effectiveness of an ARS as a teaching tool for improving students' grades.

ACTIVE LEARNING, ARS, AND GRADES

The term "active learning" summarizes the methods of active student engagement in the class. Since active learning methods address different learning styles of students and help students to take ownership of material covered in the classroom, several authors have suggested and shown that active learning over the course of an entire semester positively influences the exam scores of students (Dickie, 2006; Doorn and O'Brien, 2007; Emerson and Taylor 2004; Hake, 1998; McCarthy and Anderson, 2000; Nguyen and Trimarchi, 2009; and Salamonson, Andrew, Everett, 2009).

While active learning methods have shown to improve teaching outcomes, these methods can be rather challenging to implement. One major challenge is getting all students in the classroom involved: effective active learning relies on engaging everyone in the classroom, while growing class sizes make it next to impossible to engage everyone in the classroom.

ARS

An ARS provides a solution to the problem of introducing active learning strategies in large classroom settings. An ARS is a device that usually looks like a remote control. Each student receives such a remote control to answer questions during class. The answers are submitted to a receiver, which is connected to the classroom computer. Each ARS has a unique number to identify the responses of each student. Responses are saved in a spreadsheet together with students' names and ARS numbers. Once students submit their answers, the cumulative results together with the correct answer can be displayed on the classroom computer screen. The responses of students can then be used as a starting point for the review of material.

Beatty (2004), Judson and Sawada (2002), and Caldwell (2007) show that ARS make it possible to transfer active learning methods from small classrooms to large classrooms. Thus, an ARS allows instructors to "interact" with every student in the classroom, and all students now receive instant feedback for their responses to the active learning assignments.

Generally ARSs are also viewed as helpful tools for achieving the goals of active learning through increasing the levels of interest, interaction, and concentration among students (Elliott,

2003; Ghosh and Renna, 2006). Furthermore, recent research shows that the use of ARSs increases student collaboration, encourages anonymous responses, improves attendance, and encourages peer instruction (Duncan, 2006; Freeman and Blayney, 2005; Kay and LeSage, 2009; MacArthur and Jones, 2008; Wood, 2004, Lucas, 2009; Evans et al, 2008).

While consensus exists about the positive effects of ARSs on student collaboration, attendance, and peer instruction, there is a lack of consensus about the effect of ARSs on grades No statistically significant improvement of grades through the use of ARSs was observed by Bunce et al. (2006), Johnson and Robson (2008), and Paschal (2002). On the other hand studies by Ball et al. (2006), Crossgrove and Curran (2008), Hall et al. (2005), Kennedy and Cutts (2005) and Lucas (2009) show that the use of an ARS improves the performance of students on exams.

Our study differs from these papers in the way we can directly link changes in grades to the use of the ARS. Treatment and control classes in our study use identical active learning assignments and classes only differ by the use of the ARS. Furthermore, we control for a wide range of student characteristics when analyzing the impact of the ARS on exam scores. Thus, this approach allows to identify the impact of ARSs on students' exam scores more clearly than previous studies. Finally, our paper will contribute to the general literature by producing additional quantitative results about the effect of ARSs on students' exam scores and document the use of ARSs in economics. In addition, this study is unique among research about the effectiveness of ARSs in economics in the number of classes that are included and its focus particularly on the ability of ARSs to enhance the effect of active learning assignments during class.

STUDY METHODOLOGY AND DATA

The study was performed in several sections of Principle of Microeconomics classes at a regional public university in the Midwest of the United States. The class is mandatory for Business and Economics majors, it is part of the curriculum of several other social science majors, and it can be used as a social science general degree requirement for other majors on campus. The objective of the study was to determine if the use of ARSs would positively affect students' exam scores.

The instructor in this study used an ARS called iClicker™ to enhance active learning assignments during 75 minute classes, which were separated into two periods of about 20-30 minutes, followed by 5-10 minute long active learning assignments. During each of these active learning assignments students were given a situational problem with several comprehensive questions that could be answered in a multiple choice format. Once all answers were submitted with the help of the ARS, the percentage of multiple choice variants together with the correct answer were displayed. If not all students answered the questions or students struggled with the assignment, the time limits for the assignment were extended. However, a timer was used for

each assignment to stay within the time limits of classes. The instructor then reviewed correct and incorrect answer options, depending on the percentage with which each answer option was selected by the students. Therefore, in the classes where ARS was used the students received a targeted and focused review based on their individual response, whereas in the classes without ARS a few students were asked to present their results in front of the class and a more general review of the assignments was provided.

The study was performed during three semesters: Spring 2008, Fall 2008, and Spring 2009. Each student who was part of this study took three exams. Scores from each exam were used to evaluate the effectiveness of the ARS. During the study the professor, the course content, the grading scale, and the course assignments stayed the same. Measures were taken to prevent course assignments from becoming public knowledge.

Students were randomly assigned into treatment (ARS use) and control classes (no ARS use). Both groups did the same active learning assignments during classes. The treatment group had the possibility to respond to the active learning assignments using the ARS, whereas in the control group only a few students had the possibility to respond to the posed question. Before selecting classes students were not aware of the use of ARS during class.

A total of 220 students took part in the study. The treatment group consisted of 105 students and the control group consisted of 115. The majority of students in the classes were Freshmen (32%) and Sophomores (33%), with a mean ACT[2] (American College Testing) comprehensive score of 20.7 and a mean ACT math score of 21.2. However, ACT scores were only available for 154 students. Students in the sample were 61% male and 49% of the students were registered as Business or Economics Majors/Minors. The control (no ARS use) and treatment (ARS use) groups were randomly selected; however, students voluntarily entered in classes, so it was not possible to randomly assign students to control and treatment groups. Thus, the data was carefully analyzed to detect possible biases among the two groups. Students in the control group had statistically significant higher ACT math scores. Furthermore, in the treatment group 40% of the students were sophomores and 15% junior, while in the control group 26% of the students were sophomores and 32% juniors. There were no other statistically significant differences among the treatment and control group. See Table 1 for further information.

Table 1: descriptive statistics

	Variable description	Percent	Mean	Standard Deviation
Dependent Variables				
Exam 1	Percentage Score of Exam 1		67.97	13.96
Exam 2	Percentage Score of Exam 2		73.43	14.57
Exam 3	Percentage Score of Exam 3		58.70	16.67
Independent Variables				
HWComp	Percentage of Homework Assignments Completed by each Student		91.89	14.3

Table 1: descriptive statistics				
	Variable description	Percent	Mean	Standard Deviation
BusEcon	Dummy variable Business of Economics Major/Minor = 1		0.493	0.50
ACTComp	ACT - American College Testing Comprehensive Score		20.74	3.72
ACT Math Score	ACT - American College Testing Math Score		21.21	4.33
Gender	Male = 1, Female = 0		0.58	0.50
SLevel	Level of Studies; Freshmen = 1, Sophomores = 2, Juniors = 3, Seniors = 4, others = 5		2.06	1.04
Freshmen		32.27%		
Sophomores		32.73%		
Juniors		24.09%		
Seniors		8.18%		
Others		2.73%		

EVALUATION

The objective of this study is determining if the use of ARSs in the classroom improves student performance on exams as determined by grades. Other research has looked at the relationship between ARS and exam performance; however, this study is unique in its length (three semesters) and its focus directly on using ARS as part of active learning assignments only. This study provides a unique perspective on the effectiveness of ARS, because the ARS is the only difference between the treatment and control group classes. The impact of an ARS on exam performance is tested by applying an educational production function setup (Hanushek, 1979). The approach from Hanushek suggests that student performance is affected by background (GENDER, LEVEL OF STUDIES), motivation (HOMEWORK COMPLETION, MAJOR) and ability (ACT). We use the log of percentage exam scores of students from three separate exams as the dependent variable for the study and estimate the following function:

log(exam scores) = f (ARS, log(HOMEWORK COMPLETION, GENDER, MAJOR, LEVEL OF STUDIES, ACT SCORES))

We use a standard OLS regression to estimate the educational production function. We expect to find a positive correlation between the general ability level of students (ACT) and examination scores. Furthermore, following the literature (Ballard and Johnson, 2005; Walstad and Robson, 1997), we expect to find that female students have lower exam scores than their male counterparts; we expect the sign on our gender variable to be positive (gender dummy male=1). Furthermore, it may be possible that students develop better study and test taking strategies as they have taken more classes. Thus, we would expect the sign of level of studies coefficient to be positive. However, it is possible that students may participate in the class at a later stage (junior/senior year) of their university career if they are not interested in the class and

take the class to fulfill a general education requirement. Thus, the potential lack of interest might cause the level of studies coefficient to be negative. Hence, we might have two opposing influences, ultimately causing the coefficient to be insignificant altogether. Furthermore, it is likely that students who are enrolled in a business/economics major/minor exercise more effort and thus have higher exam scores. The positive influence of a students' major/minor on exam scores might also be caused by simple selection. Students who know their academic performance in Principles of Microeconomics will likely be strong, are more likely to enroll into a Principles of Microeconomcis, because they expect to get better grades; this then leads to a positive coefficient on the major/minor. Therefore, we expect the sign of the major/minor coefficient to be positive. Finally, we expect examination scores to be positively correlated with homework completion rates. This effect might either result from a practice effect or simply identify students who are more engaged and interested in course content. Due to university regulations no additional explanatory variables were available to the researchers.

The results for the estimation can be found in table 2. Overall the results suggest a mild positive effect of using ARSs on students' grades. We only find a statistically significant positive effect of the ARS on scores of the final (third) exam. Students in the treatment group have 5% higher scores in exam 3 compared to students in the control group. This result is significant at the 99% level[3]. We suspect that it took some time for students to appreciate the immediate feedback the ARS provided. It is possible that the use of an ARS causes students to alter their study behavior over time and thus the ARS use does not immediately have an effect on exam performance.

In addition to the ARS findings, our results show that ACT scores are positively correlated with performance on exams in economics. This result is significant at the 99% level for all three regressions. A one point increase in ACT scores is related to a 1.6% to 2% higher scores in exams. Moreover, we find with a significance level of 99% that students homework scores are positive related with exam scores: increase in the HOMEWORK COMPLETION rate by 1% is related to an increase in exam scores by 0.16 to 0.26%. Different to other studies in economics classes (Johnson and Robson, 2008; Ballard and Johnson, 2005; Walstad and Robson, 1997), we do not find that female students perform worse than male students in this study. Furthermore, it does not appear that MAJORS IN BUSINESS OR ECONOMICS perform better in exams. Finally, the results show that one extra year of schooling (LEVEL OF STUDIES) is positively correlated with performance on exam 2. The coefficient for level of studies is significant at the 95% level.

We use a variety of interaction terms of students' characteristics and the ARS dummy to determine if the rate of HOMEWORK COMPLETION, the GENDER, the MAJOR of the student, or the LEVEL OF STUDIES influences the impact of ARS on exam scores. Using these interaction terms, we find that the effectiveness of ARS is not influenced by student characteristics.

Table 2: OLS Regression Results			
	Exam 1	Exam 2	Exam 3
ARS	2.051 (1.08)	-2.094 (-0.98)	5.301** (2.33)
HWComp	0.169** (2.82)	0.261** (3.87)	0.234** (3.26)
BusEcon	1.142 (0.60)	-0.016 (-0.01)	-0.857 (-0.38)
ACTcom	1.642** (6.38)	1.717** (5.90)	2.000** (6.45)
SLevel	1.201 (1.32)	2.061* (2.00)	1.752 (1.60)
Gender	2.125 (1.11)	2.001 (0.92)	1.111 (0.48)
Constant	12.594 (0.385)	8.090 (0.83)	-11.840 (-1.15)
N	154	154	154
Adj R-square	0.222	0.240	0.244
F-test (p-value)	0.000	0.000	0.000
Breusch-Pagan (p-value)	0.733	0.619	0.314
Note: Parentheses contain t-values; dependent variables are logarithms of percentage exam scores; F-test H0: all of the model coefficients are jointly = 0;Breusch-Pagan test for heteroscedasticity H0: constant variance; Significance level is indicated * = 5%, and ** = 1 % Clustering of standard errors by classes did not alter results; using White's heteroscedastic-consistent standard errors did not drastically alter results; using a SURE setup did not provide further insights			

CONCLUSION AND DISCUSSION

In this study we evaluate the effectiveness of implementing an ARS as a teaching tool in Principles of Microeconomics classes. We use ARSs to accompany active learning assignments during lectures. Generally, the literature on active learning has shown that active learning assignments benefit students, but it can be hard in large classrooms to get every student to participate in active learning assignments. An ARS allows instructors to overcome problems of participation and engagement.

We find that the use of an ARS positively affects students' exam scores. Therefore, we show that ARSs are an important addition to active learning assignments in large classrooms. However, the positive effect of the ARS was not observed until the third exam of the semester. Thus, it is likely that students need a certain period of time to get used to the changed mode of instruction. Students may need time to benefit from the ARS because they may not be used to such a direct interaction during class and may need to adapt their learning styles to fully benefit from this new teaching format. Thus, even though the benefits from ARS take time to be realized through improved exam scores, in the end, introducing this technology into the classroom paid off. Hence, the research presented in this paper is an important addition to the existing literature

on the use of ARS, since it provides insights into the use of ARS in economics and further supports for the positive impacts of ARS.

AUTHOR'S NOTE

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ENDNOTES

[1] None of the students that participated in this study had every taken a class that used an ARS

[2] College entrance exam with a max score of 36

[3] It needs to be taken into account that the average score for exam 1 and 2 was much higher than the average score for exam 3 and that the standard deviation of scores for exam 1 and 2 was higher than for exam 3.

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