THE EFFECTS OF TECHNOLOGY-INFUSED INSTRUCTIONAL STRATEGIES ON STUDENT LEARNING OUTCOMES IN ECONOMICS: A COMPARATIVE STUDY

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ABSTRACT

This study investigates technology-infused teaching strategies with a view to identifying and selecting a teaching method and practice that will improve student learning in principles of macro and microeconomics. Two teaching strategies, clickers or personal response system and "just-in-time teaching", were used and compared. Each method was applied in different classes for principles of macro and microeconomics courses taught by two instructors over two semesters. This classroom research found that clickers contributed more to student learning outcome than "just –in-time teaching" even after controlling for selected observable determinants of academic performance.

INTRODUCTION

Economics is perceived by many undergraduate students as one of the most challenging disciplines in business and social sciences. An increasingly fewer number of students choose economics as their major or minor in undergraduate studies compared to related disciplines. While this phenomenon could be attributed to differences in job opportunities and other factors, at the University where the sample of this study is drawn, the perception of relative difficulty is anecdotally cited as one explanation (Knoedler and Underwood, 2003). This perception is a problem not only in recruiting students who would potentially major or minor in economics but also for those who take economics courses as part of their requirements for their chosen fields of study. At this University, principles of micro and macroeconomics courses are taken each semester by non-economics majors most of whom are students in majoring in accounting and business administration. The average level of performance of students in these courses has been worsening over the years, with a failure/withdrawal rate surpassing that in comparable courses.

To be sure, observed students' relative performance in these courses cannot be entirely attributed to perception/misperception and apprehension, although these are expected to play a part in isolation or in interaction with other factors, which may include inadequate relevant academic background, lack of motivation and effective engagement on the students' part, and perhaps inappropriate or non-adaptive teaching methods on the instructors' part.

Economics at the undergraduate level has been commonly taught using the traditional "talk and chalk" or direct instruction method (Becker & Watts, 1996, 2001). Although the use of other types of teaching methods is slowly on the rise, standard lectures and chalkboard presentations still dominated the instruction of economics by 2005 (Becker & Watts, 2007). And the way economics has been taught compared to other disciplines has been asserted as one of the factors for the relative decline in economics enrollment in the 1990s (Becker, 1997; Knoedler & Underwood, 2003). Evidently, the traditional method is becoming less and less effective for a student body with the aforesaid attributes. Given the appeal of technology to this generation of students and the technological savvy they readily display, and given the lack of active engagement asserted to be associated with the traditional method (Cooper, 1995; Schank, Berman, & Macpherson, 1999), it would be reasonable to inquire and explore what technology-infused course delivery may be better suited to the way students learn and, as a consequence, would exert a greater impact on teaching and learning effectiveness. Put differently, what instructional technology would be more effective in dealing with the problems of motivation, study habit, class attendance and engagement and thereby enhance student learning and, in the process, help change students' perception about the discipline of economics?

Needless to say, there is no single "all-cure" method that addresses observed student learning problems. Of the instructional strategies suggested in the relevant literature, we considered personal response system (PRS) and Just-in-Time Teaching (JiTT) and compared their effectiveness in teaching principles of economics. These methods have not been extensively used in teaching economics, and the empirical evidence on their effectiveness in the discipline is thus rather thin. The purpose of this study is, therefore, to compare the two technology-infused teaching strategies with a view to identifying and selecting teaching methods and practices that will improve student learning.

The remainder of the paper is organized as follows. The next section describes the instructional methods under study. The third section describes the research method and the profile of the study sample, followed by a presentation and discussion of results. The final section summarizes and concludes.

AN OVERVIEW OF THE PEDAGOGICAL TOOLS USED

This section briefly reviews the two technology-infused and potentially active learning-based instructional strategies under study, PRS and JiTT.

PRS or Clickers: PRS is a form of classroom technology that allows an instructor to ask multiple-choice or true/false questions and instantaneously receive responses individually from students on a hand-held wireless transmitter. The responses from students are aggregated and the results are anonymously displayed on a screen for them to see. This technology is asserted to have multiple benefits including the following. First, PRS helps gauge student comprehension of the course material covered, allowing the instructor to identify misconceptions or lack of understanding and address them in the subsequent lecture segment during the same class session. This is expected to have a direct favorable effect on student learning outcome. Second, the system encourages active student learning and engagement as students know that they will be quizzed on the material covered right after the lecture. Third, given that some students struggle to maintain concentration levels for the entire class period of 50-75 minutes, administering quizzes in the middle (or at some appropriately designated intervals) of the lecture provides the necessary break which will help minimize the incidence of boredom and passivity. Lastly, the system can be used to take attendance, and this may decrease unexcused absences from class.

The existing empirical evidence on wireless classroom communications systems overwhelmingly points to its effectiveness in one or other dimension of the learning process. Some results based on classroom research conducted in a number of disciplines suggest that the use of clickers positively influences class attendance and engagement (e.g. Chemistry: Ward, Reeves, & Heath, 2003; Economics: Elliott, 2003; Biology: Ribbens, 2007; Psychology: Stowell

& Nelson, 2007; Shapiro, 2009), although there are reports who found no clear evidence for this to be the case (Morling, et al., 2008, Judson and Sawada, 2002). As well, a favorable effect on learning outcomes , as measured by exam scores and other assessment instruments, is reported by a number of researchers (e.g. Physics: Poulis, Massen, Robens, & Gilbert, 1998; Biology: Hatach, Jensen, & Moore, 2005; Economics: Ball, Eckel , & Rojas, 2006; Biology: Ribbens, 2007; Statistics: Lass, Morzuch, & Rogers, 2007; Physiology: Gauci, Dantas, Williams, & Kemm, 2009 ; Psychology: Morling et al.), while mixed or conditional results are documented by other studies [e.g. Computing Science : Kennedy & Cutts, 2007; Psychology: Stowell & Nelson, 2007).

Just in-Time Teaching Method: As described by Novak, Patterson, Gavrin,& Wolfgang (1999), the original developers of this teaching technique, Just-in-Time Teaching is a strategy that comprises of classroom activities that encourage active learning and web-based activities designed to enhance the former (see also Simkins & Maier, 2010). The JiTT strategy involves completing and electronically submitting appropriately designed exercises on material that will be covered in the next class, requiring students to read ahead on their own prior to class coverage. The instructor reviews students' responses prior to class and uses them to modify the next lecture and classroom activities that will overcome students' misunderstanding, or lack of understanding, of concepts. This strategy's in-class component complements the out-of-class pre-lecture activity component, creating a positive "feedback loop" that enhances student learning by (1) encouraging students to come to class better prepared, (2) allowing immediate feedback on students' comprehension of course material, and (3) enabling "just-in-time" modifications of class activities and discussion on the basis of their performance on the outside-of-class activities. The modification of lectures informed by students' work heightens their sense of ownership of their learning, motivating them to complete assignments and to engage actively in classroom activities and discussions.

There are classroom experiment reports suggestive of the effectiveness of this strategy. Simkins and Maier (2004) find that it exerted a statistically significant effect on student learning in introductory economics. As well, research findings reported by authors in various disciplines (biology, geosciences, physical sciences, history, and in a course on critical thinking in humanities) show that this pedagogical tool contributed to student learning outcomes (Simkins & Maier, 2010). Likewise, completing online homework assignments, even without the other components of JiTT, is reported to have improved exam scores in statistics classes (Lass et al., 2007).

RESEARCH METHOD AND STUDY SAMPLE

The classroom research for this study was carried out for two economics courses: Principles of Macroeconomics (Macro) and Principles of Microeconomics (Micro). Most of the students in these courses were non-economics business majors. One section of each course was taught by the authors over two semesters (Fall 2009 and Spring 2010). However, both sections of each course over the two semesters were otherwise similar in terms of course content, instructor, exams, and in the use of PowerPoint presentations. The experiment was run by assigning alternately the two forms of instructional technology over the two semesters. The PRS method involved administering clicker quizzes before, in the middle, or at the end of a lecture as deemed appropriate by the instructor who subsequently reviewed concepts in light of feedbacks received from the class. At the outset, students were informed that performances in these quizzes would constitute part of their final grade.

The JITT method was implemented by assigning problem sets from a textbook based online homework software on a section/chapter covered or to be covered in the lecture. Students' responses were reviewed and used as needed to modify lectures and classroom activities. In both interventions, points were awarded for correctness of answers as well as for participation in online homework or clicker-based activities. The impacts of the two forms of instructional technology on student learning are compared on the basis of scores on a cumulative final exam, which accounted for a quarter of the final grade. The final exam, as opposed to other evaluation instruments, such as tests and quizzes, was preferred because of its comprehensiveness, relative weight and the seriousness with which it may be taken by the student.

The study sample comprises of145 students who sat for the final exam of whom 76 attended Micro and 69 Macro, and 76 were in JiTT and 69 in PRS classes. The methodology employed for comparing the two strategies is multiple regression analysis. A regression model that controls for some observable determinants of academic performance is specified. The estimation equation takes the following form:

$$log Y_i = \beta_0 + \beta_1 PRS + \beta_2 Z_i + \varepsilon_i \quad (1)$$

where Y = Final exam score, Z = A vector of controls; PRS=1 if the student is in a class where PRS was used, zero if the student was in the JiTT class (which is taken as the base category).

Using this specification, we were able to compare the two instructional technologies under study on student learning by examining differences in students' performance on final exams.

RESULTS AND DISCUSSION

The table below presents the OLS estimates of the various versions of this model. The explanatory variables in the multiple regression models are jointly significant, explaining 30-34% of the variation in the log of final exam scores around its mean. Consider first column I where the results obtained with no controls are presented. Assuming that the two groups of classes are otherwise similar, these results suggest that the average score in the PRS group was higher (around 10 percentage points) than that in the other classes; and the difference is statistically significant at the one percent level.

However, the PRS and JiTT groups are far from otherwise homogeneous, as student survey results show (A survey was administered during the last three weeks of each semester to collect relevant individual-specific information. The overall participation rate in the survey for these classes was 84%, with 122 students completing it). There appear to be differences in such attributes as GPA, SAT, course load, and work hours, which could partly explain the observed inter-group score differential. Controlling for such factors would improve the validity of the results, although doing so would exclude 16% of the sample. Despite the resulting reduction in sample size, an expanded set of controls was included and the results compared. The set includes college grade point average (GPA), scholastic aptitude test (SAT), absences from class (ABS), living arrangements—whether the student lives on-campus or off-campus (RES), the semester the course was offered (SEM), and whether the student previously took an economics course (ECO). The semester when the courses were offered was included to capture the possible effects of differences in the cohorts of students enrolled between the two semesters. Other controls, namely, gender, whether the student owned a textbook, work hours, course load, study hours, were included, but all of them were found highly insignificant with little contribution to the explanatory power of the model and with no effect on the parameter estimate of PRS.

The estimated coefficients of the individual-specific control variables are generally consistent with a priori expectations in terms of their signs (column II). A clear case in point is GPA, which is included as a measure of effort, and as a proxy for intellectual capability developed, by the student in college (e.g. Park and Kerr, 1990). This variable enters the regression positively and highly significantly. Likewise, SAT, representing student's intellectual ability before matriculation, is found to influence academic performance positively. Given the analytical nature of the courses, the math portion of the SAT score was used. Similar results were obtained when the overall SAT score was used instead.

As well, class attendance and staying on campus appear to contribute to improved student learning, their lack of statistical significance notwithstanding. Unexpectedly, taking an economics course before enrolling for the current course exerted a negative effect, albeit imperceptibly.

Regression Results

Dependent variable: logFINAL

Explanatory Variables	I	II	III	IV	V	VI
Constant	4-04 (129)***	3.57 (26.29)***	3.79 (31.87)***	3.79 (34.65)***	3.87 (38.59)***	3.93 (41.29)***
PRS	0.1579 (3.68)***	0.1687 (4.08)***	0.1572 (3.66)***	0.1687 (4.08)***	0.1412 (4.15)***	-0.0058 (0.09)
GPA	---	0.0780 (3.20)***	---	0.0780 (3.20)***	0.0595 (2.51)**	0.0590 (2.57)**
SAT_math	---	0.0577 (2.28)**	0.0681 (2.50)**	0.0679 (2.68)***	0.0555 (2.35)**	0.0573 (2.65)***
ABS	---	-0.0204 (0.78)	-0.0371 (1.26)	-0.0380 (1.49)	-0.0464 (1.80)*	-0.1245 (3.02)***
SEMESER	---	0.0525 (1.07)	0.0634 (1.23)	0.0525 (1.07)	0.0657 (1.60)	0.0767 (1.71)*
RES	---	0.0754 (1.70)*	0.1069 (2.17)	0.1096 (2.33)**	0.0805 (2.01)**	0.0932 (2.37)**
ECO	--	-0.0632 (1.47)	-0.0574 (1.29)	-0.0632 (1.47)	-0.0397 (1.04)	-0.0289 (0.78)
PRS X ABS	---	---	---	---	---	0.1213 (2.43)**
N	145	122	122	122	118	118
F stat	0.09	0.310	0.243	0.310	0.297	0.330

R^2	13.5***	7.58***	7.11***	7.58***	7.95***	8.03***

Notes:

1. PRS=1 if the student was in classes where clicker was used, zero in classes where JiTT was implemented.
2. SEMESTER= 1 if the courses were taken in Spring 2010, zero if in Fall 2009.
3. RES= 1 if the student stayed on campus, zero otherwise.
4. ECO=1 if the student successfully completed another Principles course (Micro, Macro, or a one-semester general principles course offered at the University) before taking the current course, zero if the student did not take, failed, or withdrew from, another Principles course.
5. Estimates in columns IV-VI, GPA is replaced by the residual series derived from equation (2).
6. Estimates in columns V&VI are based on data that exclude extreme observations on both ends of the distribution.
7. Figures in parentheses are t ratios that are based on robust standard errors, and the asterisks *, **, and *** denote, respectively, significance at the 10, five, and one percent level.

Although GPA and SAT scores enter the model each representing a distinct measure of intelligence, the two variables are expected to be correlated— a pairwise correlation coefficient significant at the 10% level is observed. Dropping the GPA variable and estimating the model increases the estimates of the coefficients on SAT, ABS and RES in absolute value (column III). On the other hand, the explanatory power of the model decreased, apparently pointing to the relevance of GPA in explaining variations in exam scores independently of the included variables. The data show the presence of association between GPA and the aforementioned three variables. The pairwise correlation coefficients and the associated probabilities are: GPA and SAT (0.17, 0.067), GPA and ABSENCE (-0.22, 0.015), and between GPA and RESIDENCE (0.25, 0.005). To obviate multicollinearity and be able to determine both the direct and indirect effects of the said variables, their combined effects on GPA was removed using the following estimated equation (Park and Kerr, 1990).

$$GPA = 2.87 + 0.132SAT - 0.226ABS + 0.438RES + Residual \quad (2)$$

$$(7.40)^{***} \qquad (1.55) \qquad (1.94)^{*} \qquad (2.70)^{***}$$

N=122, F=5.2***, R^2=0.12.

Figures in parentheses are absolute values of t ratios based on robust standard errors.

The residual series of this regression was entered into the estimating model representing the variation in GPA independently of the three variables in question (using ordered probit model to generate the residuals (given that the data on GPA are ranges) made little difference for the results reported in the relevant columns in table 4). The estimates of the model thus obtained are reported under column IV where, relative to column II, the parameter estimate of GPA remained unaltered, while, as expected, those of SAT, ABS, and RES increased in absolute value with improved efficiency.

Final exam scores in the sample range widely between 18 and 96%, possibly engendering outlier effects on the regression coefficients. To mitigate this potential problem, extreme values below the one and above the 99 percentile (4 observations) were dropped and the model re-estimated (column V). Consequently, the magnitude of the majority of the estimated slope coefficients somewhat decreased in absolute value with the exception of ABS and SEM whose parameter estimates emerged slightly higher with lower standard errors. Signed positive, the coefficient on PRS decreased but remains significant at the one percent level.

The data seem to suggest that in the context of the sample under study the clicker-based instructional method was more effective than the JiTT approach. Plainly, the effectiveness of JiTT hinges critically on students' participation in completing online homework assignments as well as their class attendance. The implication of the latter is explored by interacting ABS with PRS, and the coefficient estimate on the interaction term emerges significantly positive, while that of PRS becomes negative, although it is statistically zero (column VI). Taken together, these estimates suggest that class attendance is important for the JITT strategy to have the desired effect (Interacting the degree of participation in completing online assignments with JiTT made little difference on the coefficient of JiTT, and the interaction term enters highly insignificantly (not shown in the table). In other words, the JITT strategy is expected to enhance student learning, in part, by enabling "just-in-time" modifications of class activities and discussion on the basis of their performance on the outside-of-class (web-based) activities. Plainly, class attendance is necessary, albeit insufficient, for students to avail themselves of this component of the strategy in question. However, unlike PRS, this strategy, as implemented, lacked a built-in direct incentive for attendance.

An inspection of the average marginal effects of the two interaction terms suggests that the two forms of intervention would have statistically the same effect if class attendance was perfect (Given that $\partial logFinal/\partial PRS = -0.0058 + 0.1213ABS$, a district change from JiTT to PRS would leave final exam scores essentially unchanged if ABS was zero). Evaluated at the means of the relevant variables, the marginal effect of a change from JiTT to PRS, as it were, would be 0.1422. Significant at the one percent level, this figure indicates a15% score differential in favor of PRS. The negative marginal effect of absences from class is significant and stronger in the JiTT classes [-0.124 (prob.=0.002) in JiTT versus -0.003 (prob.=0.913) in PRS classes].

Overall, the regression results seem to suggest that for the sample under study, PRS was found to exert greater favorable effect on final exam performance than JiTT. The differential effect was moderate but significant and was found robust to the inclusion of various controls most of which exerted perceptible effect on student learning in the way they were expected.

SUMMARY AND CONCLUSION

The purpose of this paper has been to investigate technology-infused teaching strategies for principles of macro and microeconomics courses. A classroom research of two forms of instructional technology, PRS and JITT, was conducted and student's end-of-semester performance compared employing multiple regression analysis with different sets of controls.

The results appear to suggest that PRS outperformed JiTT in terms of improving learning outcomes in the study sample. The results are robust to including various determinants of academic performance, such as students' ability and effort as represented by SAT, GPA and class attendance. The relative effectiveness of PRS in this study seems to emanate from its greater built-in incentive to induce class attendance than JiTT provided.

Needless to say, however, these results are preliminary and tentative, and further investigation of the effects and potentials of using these strategies in economics courses would be needed to provide a definitive assessment. This requires applying them in multiple sections of the same course overtime so as to build the database necessary to conduct more robust comparisons.

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