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An Empirical Investigation of the Effects of SRS Technology on Introductory Managerial Accounting Students

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ABSTRACT: To investigate whether student response system (SRS) technology increases student exam performance, we conduct a quasi-experiment using six introductory managerial accounting courses. Three courses were taught using SRS technology and three were taught without using SRS technology. The students in the SRS courses performed on average 3.15 percentage points better than students in the non-SRS courses after controlling for age, gender, prior GPA, and ACT score. SRS technology was more beneficial to students with the lowest prior GPAs. The study found evidence that SRS technology helps these low-GPA students without having a negative effect on high-GPA students.

Keywords: technology; interactive; active learning; response system; student; classroom.

INTRODUCTION

Since the turn of the century, there has been a growing body of research dealing with educational technology in accounting (Watson et al. 2003). Research has focused on three areas: how technology can be applied to accounting education, how students perceive learning with technology, and whether educational technology affects student performance. While there has been extensive coverage of the first two areas, Watson et al. (2003) specifically call for more research on how educational technologies affect student performance. This question is important because implementing educational technology is expensive. If educational technology is not affecting student performance, then some may question whether it should be implemented.

Studies that have investigated the effect of educational technologies on student performance have typically focused on content delivery technologies (i.e., presentation software packages and the Internet). However, to our knowledge there has not been any research published showing that these content-delivery technologies have had a significant effect on student exam performance (Agarwal et al. 2004; Susskind 2005; Rankin and Hoaas 2001; Russell 2001; Szabo and Hastings 2000; Agarwal and Day 1998).

A possible reason for the "no effect" results is that the focus of classroom technology has been one-sided, instructor to student. Technologies such as presentation software packages and the Internet have aided in delivering content, but have not affected the way students

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learn in the classroom. A new technology, known as a Student Response System[1] (SRS), goes beyond content delivery. SRSs use remote control devices (clickers) to enable continuous information exchange between the student and the instructor, thereby allowing students to become active participants in the learning process.

Active learning is highly relevant to accounting educators. In 1989 The Accounting Education Change Commission (AECC) was formed with the express purpose of fostering "changes in the academic preparation of accountants consistent with the goal of improving their capabilities for successful professional careers in practice ... Providing such capabilities will require both curriculum reengineering and supportive institutional changes by educational, professional, licensing, and accreditation bodies, *inter alia*, all with the ultimate goal of serving the public interest through the improved education of accountants" (Sundem 1999).

While the AECC established general objectives to foster profound changes in the education of accountants, it did not give specific recommendations on how accounting educators should change their teaching methodology. Bradford and Peck (1997) argued that the AECC objectives can be met by following the "seven principles of good practice in undergraduate education" issued by the Association of Higher Education (AAHE). Five of these principles, including encourage student-faculty contact, promote cooperation among students, encourage student participation, give prompt feedback, and emphasize time on task, are directly related to active learning as defined by Bonwell and Eison (1991). Indeed, active learning is an internationally recognized cornerstone of the accounting education change movement (Lucas 1997).

The theoretical arguments made by accounting educators are supported by a body of research suggesting that active learning promotes student performance. The objective of this study is to test the effect of an active learning environment enabled by SRS technology on student exam performance in an introductory managerial accounting course.

We recognize that passive and active learning environments exist along a continuum. There is no pure form of active or passive learning. However, some learning environments contain more or less of the characteristics that distinguish the two teaching methodologies. Our experiment compares one form of a relatively passive environment (non-SRS treatment) with one form of a relatively active learning environment (SRS treatment). Countless other possible comparisons are possible. While our experiment is limited to a particular technology and a particular application of that technology, it provides a base for future research designed to make comparisons regarding alternative treatments of SRS technology or differing educational technologies.

The remainder of the paper is organized as follows. We discuss the existing body of research associated with SRS technology and explain how SRS technology relates to active learning. The research hypotheses are developed. We describe the research approach. Then we display the empirical results of the hypothesis tests. Finally, we discuss the implications of the results for accounting education.

PRIOR SRS RESEARCH

Research on SRS technology started in the late 1960s. The first systems consisted simply of an overhead projector and index cards. Harden et al. (1968) gave students several colored index cards, each one representing a different response. Harden et al. (1968) would pose a question on an overhead projector and students would respond by raising one of

[1] For a description of SRS components and functions see the Appendix.

their index cards. Harden et al. (1968) would pace the lecture based on the student responses. During the same time period the University of Glasgow introduced an electronic system. The system hard-wired 128 student stations to an instructor's console. The instructor posed questions that the students answered by selecting one of the four switches at their station (Dunn 1969). To our knowledge, no research was published testing how SRS systems affected student learning. This research stream was not continued because of the great cost in implementing a hard-wired system.

SRS research was revived during the late 1990s with the introduction of cost-effective wireless student response systems. Recently, there has been considerable research on the implementation of these systems (Elliott 2003; Hall et al. 2002; Burnstein and Lederman 2001). This research covers the implementation of SRS technology into economics, physics, and engineering classrooms. To our knowledge there is no published research on whether SRS technology affects student learning. The primary objective of this study is to test the potential link between SRS technology and student learning in an introductory accounting setting.

SRS TECHNOLOGY AND ACTIVE LEARNING

We believe SRS technology will affect student learning because it enables an active learning environment. Bonwell and Eison (1991) associate active learning with the following seven characteristics: (1) students are involved in more than passive listening; (2) students are engaged in activities; (3) there is less emphasis placed on information transmission and greater emphasis placed on developing skills; (4) there is greater emphasis placed on the exploration of attitudes and values; (5) students can receive immediate feedback from their instructor; (6) student motivation is increased; and (7) students are involved in higher order thinking. The SRS treatment used in this study embraces Characteristics 1, 2, 3, 5, and 6.

SRS technology enables two-way communication between the student and the instructor. More specifically, students communicate with the instructor using wireless response pads. The instructor can pose questions to the class and receive an immediate student response. Every time a student responds, active learning Characteristics 1 and 2 are satisfied.

SRSs motivate information exchange between students. For example, students strive for consensus when SRS data indicate diverse responses to an instructor query. Verbal communication and team-building skills are promoted as students strive to explain and justify their particular answers to one another. This condition satisfies active learning Characteristic 3.

SRS technology provides immediate student response feedback. When students respond to a question, the SRS server compiles all responses and displays class performance statistics. The results not only inform the students as to whether they answered the question correctly but also as to how well they are performing in relation to their peers. This immediate feedback satisfies active learning Characteristic 5.

Edmonds and Edmonds (2007) surveyed managerial accounting students and found that the presence of SRS technology increases students' motivation to attend class and to pay attention during class. An increase in student motivation satisfies active learning Characteristic 6.

Certain applications of SRS technology could be linked to active learning Characteristics 4 and 7. For example, SRSs could motivate students to exchange information about their attitudes and values thereby satisfying Characteristic 4. The SRS treatment used in this study contain the majority of characteristics that define an active learning environment.

ACTIVE LEARNING AND STUDENT PERFORMANCE

There is a body of research that ties active learning to student performance. Benware and Deci (1984) investigated the differences in active versus passive learning. They compared students who "learned to teach" with students who "learned to be examined." The students who actively participated in the learning process, "learned to teach," scored 33.7 percent ($p < .001$) higher on a conceptual learning test than students who "learned to be examined." The "learned to teach" students were also more intrinsically motivated and viewed themselves as being more actively engaged in the learning environment (Benware and Deci 1984).

Felder et al. (1998) conducted a longitudinal study that tracked two groups of engineering students over five courses. The active group was exposed to active and cooperative learning (including "open-ended questioning, multidisciplinary problem formulation and solution exercises, criterion-referenced grading, and other features designed to address a full spectrum of student learning styles"). The traditional group was taught using traditional methods. The overall performance of the active group was significantly better ($p < .008$), with 43 percent of the students receiving an A compared to only 20 percent for the traditional group. The active group's mean grade was five percentage points higher than the traditional group ($p < .01$). The active group also had a higher retention rate, graduation rate, and number of students choosing to pursue advanced study in chemical engineering (Felder et al. 1998).

Active learning has also been shown to significantly affect student performance in accounting. Berg et al. (1995) implemented a computerized market simulation in an introductory financial accounting course. In the simulation, students functioned as traders where they were actively involved in establishing security prices. Students who participated in the simulation scored significantly higher ($p < .0001$) on examinations after controlling for GPA (Berg et al., 1995). Overall, there is a research consensus that students perform better in an active learning environment.

HYPOTHESIS DEVELOPMENT

Previous research has not found an association between classroom technology and student exam performance (Agarwal et al. 2004; Susskind 2005; Rankin and Hoaas 2001; Russell 2001; Szabo and Hastings 2000; Agarwal and Day 1998). However, the technologies tested were designed to aid in content delivery and not in improving student learning. SRS technology may enhance student learning because it is designed around active learning. As previously discussed, teaching with SRS technology satisfies five of Bonwell and Eison's (1991) seven active learning characteristics. Students also believe that learning in an SRS classroom is more active than learning in a non-SRS classroom (Edmonds and Edmonds 2007). Since research has found that active learning is associated with increased student exam performance, the following hypothesis is proposed in the alternative form:

H1: Students learning in an SRS classroom will score higher on examinations than students learning in a non-SRS classroom.

Hypothesis 1 predicts that, *ceteris paribus*, an SRS class will perform better than a non-SRS class. This hypothesis is the key focus of this study. The next hypothesis is more exploratory and investigates how SRS technology affects low- and high-performing students within the class. We define students with a prior GPA in the bottom (top) quartile as low (high) performers. The traditional learning environment is obviously working for students classified as high-performers and not working for students classified as low-performers.

Even if H1 is accepted, it is still unknown which students, within the SRS classroom, benefited. It is possible that the system increased the performance of certain students and decreased the performance of others. To explore this issue, the following exploratory hypothesis is proposed:

> **H2:** Low-GPA students will receive more benefit using SRS technology than high-GPA students.

RESEARCH APPROACH

To test H1 and H2 a quasi-experiment was implemented using six introductory managerial accounting courses that were offered at a mid-sized, AACSB-accredited urban university. The control group consisted of three classes, two of which were taught in the fall semester and one in the spring semester of the 2003/04 academic year. The experimental group consisted of three classes, two of which were taught in the fall semester and one in the spring semester of the 2004/05 academic year. Since the treatment was separated by a summer session, the potential for a Hawthorn effect was minimal. SRS technology[2] was introduced as a routine approach in only the experimental group. All classes were taught by the same professor. All classes meet for an hour and 15 minutes two times per week. The same syllabus, course content, homework, and tests were used in all classes.

Instruction was administered via brief lectures that were interspersed with short multiple-choice questions. More specifically, relevant questions were administered immediately after related topics were discussed. The same questions were used for both SRS and non-SRS groups. The questions were displayed on a screen using computer projection equipment. Students were encouraged to answer questions through the implementation of a bonus system.

Students in the SRS group answered all the questions electronically by entering data through SRS remote control devices. Student in the non-SRS group submitted answers to selected questions (usually one per class) on hard copy paper that were taken up randomly by the professor. Both the SRS and non-SRS groups were assigned bonus points on a pass/fail basis. Students in the SRS group were required to answer 60 percent of the questions correctly to earn the bonus points. Students in the non-SRS group were required to correctly answer 60 percent of the questions collected by the instructor to obtain the bonus points. In the SRS group, the SRS system electronically graded all questions that were asked in class (five or six per class). In contrast, the manual approach applied in the non-SRS group limited the number of questions graded to the question that was collected by the instructor. The collection and grading process was burdensome even when collection was limited to a single question per class.

In the SRS group the answer along with summary results of the students' answers were provided instantaneously through the SRS system. Students and the instructor were able to see the distribution of responses for each question immediately after the answers were submitted. In contrast, answers were provided to the control group verbally by the instructor. There was no opportunity for the instructor or the students to know how many students answered the questions correctly during the class. The instructor graded the take up question after class.

In summary, both groups received instructor provided answers to each of the questions. The primary difference is that only one of the questions was collected randomly and graded

[2] We specifically used McGraw-Hill's Classroom Response System (CPS).

in the non-SRS group, while the entire question set was graded for the SRS group. Even so, the nature of the feedback was significantly different between the two groups.

The non-SRS group received one-way communication. Specifically, the instructor provided students with the correct answers (instructor-to-student feedback). In contrast, the SRS technology enabled three-way feedback. First, the instructor provided the correct answers for the questions (instructor-to-student feedback). Second, the SRS provided summary statistics for the class thereby enabling students to compare their performance with that of their classmates (student-to-student feedback). Third, the instructor received feedback regarding the performance of the class as a whole, thereby enabling the instructor to focus on the areas where students were most in need of help (student-to-instructor feedback). Student interactions among themselves and with the instructor are recognized factors that contribute to the formation of an active learning environment.

Feedback is only one of several features of SRSs that facilitate the formation of an active learning environment. For example, SRS technology enabled students in the experimental group to affect the pace of the lecture, while there was no comparable influence in the control group. Each of these differences strengthens the degree of active learning opportunities available to the SRS experimental group. Table 1 summarizes the key active learning differences in the SRS experimental group and the non-SRS control group created by the implementation of SRS technology.

Descriptive Statistics

Descriptive statistics[3] for the entire sample are presented in Table 2. Panel A shows that the average student in the study is 24.13 years old, enrolled in 10.89 credit hours, had a GPA of 2.7, and an ACT score of 22.16.[4] The average student also had a test average of 74.3 percent (69.1/93). Panels B and C divide the sample into the experimental group (hereafter, the SRS group) and the control group (hereafter, the non-SRS group). The SRS group contained 279 students. The non-SRS group contained 275 students. Panel D compares the mean differences of the SRS and non-SRS groups. The groups are not significantly different with respect to age, hours, and PGPA. The SRS group has a slightly lower ACT score than the non-SRS group ($p = .1001$). The groups are also significantly different ($p = .0043$) with respect to gender (see Panel E). The SRS class is approximately 55 percent female and the non-SRS class is approximately 43 percent female.

Model Development

To test whether SRS technology affects student exam performance we pooled the three SRS classes and the three Non-SRS classes into the following OLS regression model.

$$TTP_i = \alpha_0 + \alpha_1 SRS_i + \alpha_2 Gender_i + \alpha_3 Age_i + \alpha_4 PGPA_i + \alpha_5 ACT_i + \varepsilon_i$$

where TTP is the sum of the student's test scores on three 31-point objective multiple-choice examinations (a student could earn a total of 93 possible points). SRS is an indicator variable that is 1 for students in the SRS classes, and 0 for students in the non-SRS classes. Gender is 1 for male students, and 0 for female students. PGPA is the student's GPA at the beginning of the semester. ACT[5] is the student's ACT score out of a possible 36 points.

[3] Data was collected from student transcripts.
[4] All measured at the beginning of the semester.
[5] SAT scores were converted to ACT scores by the university admission office's converting system.

TABLE 1
Implementation of SRS
Differences in the Experimental Group and Control Group

	SRS Classes	Non-SRS Classes
Actively Engaged	The professor asked the students to answer/work 5 to 6 problems per class.	The professor asked the students to answer/work 5 to 6 problems per class.
Student Response	Since student responses were solicited for every question, the majority of students responded to every question.	Since only one problem was collected in each class, it is perceived that not all of the students answered/worked all of the problems.
Assessment	Students were assessed on every question answered.	Students were assessed only on the question collected by the instructor.
Feedback	The answers were supplied immediately after each answered question. Results were displayed via computer projection equipment. Students were supplied with the correct answer as well as summary class statistics.	The answers were supplied verbally after each question. Students received the answer to the collected question during the next class period. The students received no summary statistics on class performance.
Lecture Pace	The lecture pace was adjusted on a real-time basis when assessment showed that students did not understand a concept.	The lecture pace was not adjusted.

The coefficient on SRS is of primary interest. Hypothesis 1 predicts the SRS coefficient to be significant and positive. This result would indicate that SRS is positively associated with student exam performance. The other independent variables are included in the model to control for gender and ACT differences between the SRS and non-SRS group. Since the instructor was male, the coefficient on Gender is expected to be significant and positive (Lipe 1989). Based on previous research the coefficient on ACT is predicted to be significant and positive (Jones and Fields 2001; Wooten 1998; Doran et al. 1991; Eskew and Faley 1988). We also include Age and PGPA in the model even though there are no significant differences for these variables between the SRS and non-SRS groups. The variables are included because previous research has found them to be significant predictors of student exam performance (Jones and Fields 2001; Wooten 1998; Doran et al. 1991; Eskew and Faley 1988). Including Age and PGPA in our model gives us a way to validate our results by comparing them with the prior research. Based on this research we expect both coefficients to be positive.

RESULTS

Univariate Analysis

Table 2, Panel D, shows the mean differences in total test points (TTP) between the SRS and non-SRS groups. Panel C provides evidence in support of H1. Students in the SRS group performed on average 2.1 (1.94/93) percentage points higher than the non-SRS group. This result is significant at $p = .0157$. Since the two groups are not

TABLE 2
Descriptive Statistics and Univariate Analysis

	TTP	Age	Hours	PGPA	ACT
Panel A: Full Sample (n = 554)[a]					
Mean	69.10	24.13	10.89	2.70	22.16
Median	69	22	12	2.68	22
Standard Deviation	10.6014	6.0360	3.7648	0.5311	3.9328
Minimum	37	17	3	1.31	14
Maximum	92	58	19	4	34
Panel B: SRS Group (n = 279)					
Mean	70.06	23.94	10.89	2.71	21.84
Median	70	22	12	2.65	21
Standard Deviation	10.66	6.25	3.76	0.54	4.02
Minimum	37	17	3	1.31	14
Maximum	92	58	19	4	34
Panel C: Non-SRS Group (n = 275)					
Mean	68.12	24.32	10.89	2.69	22.55
Median	68	22	12	2.70	22
Standard Deviation	10.4743	5.8132	3.6422	0.5208	3.8065
Minimum	39	19	3	1.52	15
Maximum	92	51	18	4	32
Panel D: Mean Differences between SRS and Non-SRS Groups					
Difference	1.9400	−0.3737	−0.0056	0.0154	−0.7126
p-value[b]	0.0157	0.4655	0.9858	0.7328	0.1001

Panel E: Percentage Female[c]

SRS	Non-SRS	Difference	p-value
0.5504	0.4291	0.1213	0.0043

SRS defines all students taught in SRS class. Non-SRS defines all students taught in the traditional class. TTP is the sum of the student's test scores on three examinations out of a possible 93 points. Age is the age of the student at the beginning of the semester. Hours is the number of credit hours the student was registered for during the semester. PGPA is the student's GPA at the beginning of the semester. ACT is the student's ACT score out of a possible 36 points.

[a] ACT only contains 329 observations.
[b] One-tailed t-test for TTP. All other tests are two-tailed t-tests.
[c] Sex was missing for one observation in the SRS group.

identical, it is possible that the difference in TTP can be better explained by controlling for the differences in Gender and ACT. We implement our model, described above, to control for these covariates.

Regression Analysis

Table 3 displays the results of the regression. The sample is reduced to 329 due to the unavailability of ACT data for transfer students. Hence, the results apply specifically to

TABLE 3
Regression Analysis Testing H1

$$TTP_i = \alpha_0 + \alpha_1 SRS_i + \alpha_2 Age_i + \alpha_3 Gender_i + \alpha_4 PGPA_i + \alpha_5 ACT_i + \varepsilon_i$$

Model Estimates (n = 329)[a]

Source	DF	Sum of Squares	Mean Square	F-value	p-value
Model	5	15618	3123.5569	58.82	<.0001
Error	323	17151	53.0093		
Correlated Total	328	32769			
Adj. R^2	0.4685				

Variable	Expected Sign	Coefficient	Standard Error	t-value	p-value
Parameter Estimates					
Intercept		12.12394	5.00625	2.42	0.016
Explanatory Variables					
SRS	+	2.89926	0.81605	3.55	0.0004
Age	+	0.45168	0.17562	2.57	0.0106
Gender	+	1.93587	0.83049	2.33	0.0204
PGPA	+	8.93837	0.90106	9.92	<.0001
ACT	+	0.91179	0.11656	7.82	<.0001

TTP is the sum of the student's test scores on three examinations out of a possible 93 points. SRS is 1 for students taught in an SRS classroom, and 0 otherwise. Age is the age of the student at the beginning of the semester. Gender is 1 for male students, and 0 for female students. PGPA is the student's GPA at the beginning of the semester. ACT is the student's ACT score out of a possible 36 points.
[a] The sample was reduced to 329 because 225 observations had missing ACT data.

non-transfer students.[6] After controlling for covariates, SRS is found to be a significant predictor of student exam performance (p = .0004). This evidence further supports H1. The magnitude of the SRS coefficient increased after controlling for the covariates. The model predicts that SRS students on average perform 3.12 (2.89926/93) percentage points higher than non-SRS students after controlling for Age, Gender, PGPA, and ACT. All covariates in the model were significant and positive as predicted. Also as predicted, PGPA and ACT were the most significant predictors and had the largest impact on student exam performance.

Analysis by PGPA Quartiles and Top Deciles

To test H2, we divide students into quartiles based on their PGPA. Students with the lowest PGPAs were placed in the bottom quartile and students with the highest PGPAs were placed in the top quartile. The regression model used in Table 3 was run on each of the quartiles. Table 4 displays the results of the analysis. Panel A shows that the model was significant for each of the four quartiles.

[6] The results hold when we eliminate ACT from the model. However, the SRS coefficient is reduced to 2.14. This is expected since ACT is positively related to exam performance and the SRS group had a lower average ACT score than the non-SRS group.

TABLE 4
Analysis By PGPA Quartiles and Top Deciles Testing H2 and H3

$$TTP_i = \alpha_0 + \alpha_1 SRS_i + \alpha_2 Age_i + \alpha_3 Gender_i + \alpha_4 PGPA_i + \alpha_5 ACT_i + \varepsilon_i$$

Panel A: Model Estimates

Quartile	n	Adj. R^2	F-value	p-value
0–25%	82	0.3526	9.82	<.0001
26–50%	81	0.1937	4.84	0.0007
51–75%	84	0.1895	4.88	0.0006
76–100%	82	0.2868	7.51	<.0001

Panel B: SRS Parameter Estimates

Quartile	Coefficient	Standard Error	t-value	p-value
0–25%	5.3740	1.6902	3.18	0.0021
26–50%	3.0589	1.8690	1.64	0.1059
51–75%	4.2035	1.8464	2.28	0.0256
76–100%	0.8164	1.4087	0.58	0.5640

TTP is the sum of the student's test scores on three examinations out of a possible 93 points. SRS is 1 for students taught in an SRS class, and 0 otherwise. Age is the age of the student at the beginning of the semester. Hours is the number of credit hours the student was registered for during the semester. PGPA is the student's GPA at the beginning of the semester. ACT is the student's ACT score out of a possible 36 points.

Panel B shows the SRS parameter estimates for each of the quartiles. The evidence provides some support for H2.[7] While SRS appears to be more beneficial for low-performers the relationship is not perfectly linear. SRS has the biggest impact on exam performance for the low-GPA students and no impact on the high-GPA students. For the bottom (0–25 percent) GPA quartile students, the SRS group performed on average 5.78 (5.374/93) percentage points higher on examinations than the non-SRS group. For the top (76–100 percent) GPA quartile there was no significant difference in exam performance between the SRS and non-SRS groups.

The results for the second and third quartiles were unexpected. The 26–50 percent GPA quartile performed on average 3.29 (3.0589/93) percentage points higher on examinations than the non-SRS group; however, this result is only significant at $p = .1059$. The 51–75 percent GPA quartile performed on average 4.52 (4.2035/93) percentage points higher on examinations than the non-SRS group. We expected the results in these quartiles to be reversed. We are unable to formulate a plausible explanation for this anomaly. Perhaps it is simply due to random error or some intrinsic differences between these two groups. We encourage future researchers to examine this issue.

[7] We presented the results using GPA quartiles because it allows the reader to see exactly where SRS is having the greatest effect. We also tested H2 using the following model:

$$TTP_i = \alpha_0 + \alpha_1 SRS_i + \alpha_2 Gender_i + \alpha_3 Age_i + \alpha_4 PGPA_i + \alpha_5 ACT_i + \alpha_6 (SRS{*}PGPA) + \varepsilon_i.$$

The coefficient on the interaction of SRS and PGPA was significantly negative ($p = .05$) indicating that the benefits of SRS decline as PGPA increases. All other possible interactions with SRS were tested and found insignificant.

Based on our teaching experience and talking with students in both SRS and non-SRS classes, we believe that a possible reason the lowest performers get more benefit from SRS is that in a traditional classroom students do not realize that they do not understand the material until the first exam and by this time it is too late. SRS feedback allows students to evaluate their understanding on a daily basis. Students are also able to evaluate their performance in relation to their peers' performance before the first exam. The system alerts low-performers that they have a problem starting the first day of class. This immediate feedback is particularly important to low-performers because it gives them the opportunity to change study habits and/or seek additional help prior to first exam.

It is also reasonable that the top performers do not receive a benefit from using SRS technology. These students are already performing well in the traditional environment and in many cases there is little room for improvement. For example, if a student scored 100 percent in a traditional classroom there is no room for improvement in an SRS classroom. While there is no evidence that SRS technology benefits top performers, it does not appear to hurt the group. The top quartile group does not appear to perform any worse in an SRS classroom. The results indicate no significant difference in performance.[8]

DISCUSSION AND CONCLUSION

The primary result of this study is that students in the SRS classroom perform on average 3.15 percentage points better than students in the non-SRS classroom. Further investigation provides evidence that SRS technology has a stronger positive performance affect on students with the lowest prior GPAs. The study finds no evidence that SRS technology has any negative effects on student exam performance.

Some readers may question whether SRSs constitute an efficiency tool (such as a calculator) or a teaching innovation that stimulates greater learning. Our review of the literature and test results suggests that SRSs can be used to stimulate greater learning. A pure efficiency variable such as a calculator will improve speed and accuracy, but is not expected to stimulate greater learning. Based on this definition, the efficiency variable must be present to have an impact. Consider an experiment during which students are encouraged to use calculators to study for an exam but are barred from using them while taking the exam. Under these circumstances, removing the calculator from the testing environment eliminates the efficiency opportunity and no impact on performance is expected. Applying this logic to our study, we note that SRS technology could not have had an efficiency impact on student performance because it was not used when students were tested.

There is a possibility that an efficiency variable could impact the learning environment in a fashion that does offer the opportunity for greater learning. For example, calculators could be used to increase efficiency thereby providing more time for coverage of content. However, in our study the non-SRS group and the SRS group were exposed to the exact same in-class question set and provided the same amount of time to answer the questions. The grading time was virtually zero for both classes. Grading was accomplished electronically in the SRS group and was accomplished outside class for the non-SRS group. Any difference in time allotted for the administration and grading of in-class quizzes was randomized and minimal. Further, the SRS technology was used solely to capture student input

[8] To investigate this further, we divided the sample into PGPA deciles and tested whether the coefficient on SRS was negative in the top decile. The coefficient on SRS was insignificant. The insignificant result indicates that SRS is not detrimental to top performers. However, given the small sample size used in the top decile this was a low-powered test.

and report results. It had no bearing on how students arrived at their answers and, therefore, could not have affected accuracy. As a result, the significantly higher test scores generated by the SRS group in our study cannot be explained by an SRS efficiency variable. Instead, a greater learning effect is a more plausible explanation.

This study contributes to the accounting literature by providing evidence that SRS technology can be used to improve student performance. This finding will hopefully encourage further experimentation and move the profession further toward the discovery of the optimal learning environment. Certainly, SRS could have been implemented differently. For example, SRS data could have been a required component of a student's grade as opposed to the bonus system we used. SRSs could be used to take roll before, after, and during class. SRSs offer the opportunity to call on students randomly, which we did not do. Feedback can be withheld or the number of questions could have been more or less. The possibilities are virtually limitless.

While our results are limited to a particular technology and a particular application of that technology, they provide a base for future research designed to make comparisons regarding alternative treatments of SRS technology or differing educational technologies such as computer-graded homework assignments or learning software that uses artificial intelligence to facilitate learning.

Our results also provide insight as to which student sectors are more likely to benefit from SRS technology, thereby enabling existing and potential SRS users to develop new implementation strategies that target particular student groups.

The study does have several limitations. First, our results do not justify the cost of using SRS technology. A full cost/benefit analysis would require extensive research. Issues regarding who bears the cost (student, instructor, and/or institution) and the measurement of the benefits would require in-depth analysis that extends beyond the scope of our study.

Second, our study does not control for student attendance. The study attributes the performance differences in SRS and non-SRS classes to the active learning environment created by SRS technology. There are other theories that could explain this result. Specifically, increased student attendance could explain why SRS technology positively affects student exam performance. If student attendance was higher in the SRS group, then students may have performed better because they were exposed to the material on a more frequent basis. If this was the case, then it would be difficult to distinguish between whether SRS technology improved performance by increasing learning or increasing attendance.

In summary, we believe that our paper demonstrates how SRS technology can be used to stimulate greater learning in introductory accounting. The road to the discovery of the optimum teaching environment is long and winding. However, we believe that our contribution provides immediate insight as well as a foundation for further experimentation.

APPENDIX
SRS COMPONENTS AND FUNCTIONS

A typical SRS includes the following components:

- Response pads: one for every student
- Receiver units: single or multiple depending on class size and type of response pads used
- SRS server software: interface and functions vary depending on vendor

The SRS software is loaded onto a notebook or desktop computer that is located in the classroom. Depending on the vendor, SRS software runs on either Windows or MAC operating systems. The receiver unit(s) is connected to the computer through a serial or USB port and the computer is connected to projection equipment in the classroom.

Instructors using SRSs may use lectures, small group discussions, text materials, videos, DVDs, PowerPoint® slides, or other means to deliver content. Regardless of the delivery method, instructors using SRSs engage students by asking questions verbally, in writing, or on projection screens. Questions may be asked at anytime during a class session. Students respond to questions by keying in alpha or numeric data on response pads that operate similar to a TV remote control. The response pad data is transmitted to a receiver unit that collects the data and transfers it to a computer storage device. SRS software is then used to sort, analyze, and report data to the instructor. The data can be instantaneously displayed to the class in a variety of forms and/or saved for later analysis and grading. Student response pads can also be used for class management functions such as taking attendance, determining tardiness, and assessing student participation.

REFERENCES

Agarwal, R., and E. Day. 1998. The impact of the Internet on economic education. *Journal of Economic Education* 29 (2): 99–110.

———, R. L. Bartlett, B. J. Blecha, J. I. Daniel, and K. Sosin. 2004. Efficiency in the use of technology in economic education: Some preliminary results. *American Economic Review* 94 (2): 253–258.

Benware, C. A., and E. L. Deci. 1984. Quality of learning with an active versus passive motivational set. *American Educational Research Journal* 21 (4): 755–765.

Berg, J. D., J. Hughes, J. McCabe, and K. Rayburn. 1995. Capital market experience for financial accounting students. *Contemporary Accounting Research* 11 (2): 941–958.

Bonwell, C. C., and J. A. Eison. 1991. *Active Learning: Creating Excitement in the Classroom.* ASHE-ERIC Higher Education Report No. 1. Washington, D.C.: The George Washington University.

Bradford, B. M., and M. W. Peck. 1997. Achieving AECC outcomes through the seven principles for good practice in undergraduate education. *Journal of Education for Business* 72: 364–368.

Burnstein, R. A., and L. M. Lederman. 2001. Using wireless keypads in lecture classes. *The Physics Teacher* 39: 8–11.

Doran, M. B., M. L. Bouillon, and C. G. Smith. 1991. Determinants of student performance in Accounting Principles I and II. *Issues in Accounting Education* 6: 74–84.

Dunn, W. R. 1969. Programmed learning news, feedback devices in university lectures. *New University* 3 (4): 21–22.

Edmonds, C. T., and T. P. Edmonds. 2007. Student perspectives on the effectiveness of student response system technology. Working paper, The University of Alabama at Birmingham.

Elliott, C. 2003. Using a personal response system in economics teaching. *International Review of Economics Education* 1 (1): 80–86.

Eskew, R. K., and R. H. Faley. 1988. Some determinants of student performance in the first college-level financial accounting course. *The Accounting Review* 63 (1): 137–147.

Felder, R. M., G. N. Felder, and E. J. Dietz. 1998. A longitudinal study of engineering student performance and retention v. comparisons with traditionally taught students. *Journal of Engineering Education* 87 (4): 469–480.

Hall, S. R., I. Waitz, D. R. Brodeur, D. H. Soderholm, and R. Nasr. 2002. Adoption of active learning in a lecture-based engineering class. *Frontiers in Education* 32 (1): T2A-9–T2A-15.

Harden, R. McG., Sir E. Wayne, and G. Donald. 1969. An audio-visual technique for medical teaching. *Journal of Medical and Biological Illustration* 18 (1): 29–32.

Jones, J. P., and K. T. Fields. 2001. The role of supplemental instruction in the first accounting course. *Issues in Accounting Education* 16 (4): 531–547.

Lipe, M. G. 1989. Further evidence on the performance of female versus male accounting students. *Issues in Accounting Education* 4 (1): 144–152.

Lucas, U. 1997. Active learning and accounting educators. *Accounting Education* 6 (3): 189–190.

Rankin, E. L., and D. J. Hoaas. 2001. The use of PowerPoint and student performance. *Atlantic Economic Journal* 29 (1): 113.

Russell, T. 2001. The no significant difference phenomenon. Available at: http://www.nosignificantdifference.org/.

Sundem, G. L. 1999. The Accounting Education Change Commission: Its history and impact. *American Education Series* 15.

Susskind, J. E. 2005. PowerPoint's power in the classroom: Enhancing students' self-efficacy and attitudes. *Computers & Education* 45: 203–215.

Szabo, A., and N. Hastings. 2000. Using IT in the undergraduate classroom: Should we replace the blackboard with PowerPoint? *Computers and Education* 35: 175–187.

Watson, S. F., B. Apostolou, J. M. Hassell, and S. A. Webber. 2003. Accounting education literature review (2000–2002). *Journal of Accounting Education* 21 (4): 267–325.

Wooten, T. C. 1998. Factors influencing student learning in introductory accounting classes: A comparison of traditional and nontraditional students. *Issues in Accounting Education* 12 (2): 357–373.