THE EFFECTS OF STUDENT RESPONSE SYSTEM AND SINGLE STUDENT QUESTIONING TECHNIQUE ON GRADUATE STUDENTS' RECALL AND APPLICATION OF LECTURE MATERIAL

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ABSTRACT

This study was an empirical investigation of active student responding (ASR) utilizing a student response system (SRS) vs. single student questioning (SSQ) and no student responding in a graduate level special education class of 23 participants. During the SRS condition, every participant responded to questions using remotes/clickers. During the SSQ condition, the instructor randomly called upon individual participants to vocally answer a question. During the control condition, no questions were asked of participants. An alternating treatments design was used to test the effects of the three conditions on the response accuracy to a short-answer quiz at the beginning of a session, and accuracy with which participants completed a task during which they must apply the information presented during the lecture. There was statistically significant difference in student performance on application tasks, but not statistically significant difference on quiz scores. The findings diverge from the results of other SRS studies and K-12 ASR studies, but support some college level studies.

keywords: student response system, active student responding, post-secondary education

INTRODUCTION

In 21st century instructors of colleges and universities are virtually bombarded with new and exciting forms of technology that ostensibly can enhance their teaching. From putting entire courses on-line, to hybrid courses, to on-line course management software, to podcasting lectures, to electronic discussion boards, to electronic response systems and many more, there are a myriad of ways to enhance instruction through technology. However, these technologies are no more or no less than an instructional tool that functions much in the same way as a chalk, a slate board, and an eraser. In other words, the purpose of the technology is to facilitate student learning of whatever content is taught.

One of the technology enhancements that has been around for a long time is electronic student response system (SRS) (See Judson and Sawada, 2002 for an extensive historical overview of SRS). SRS is best defined as a technological response system or an input device based on a computer mediated wireless response system (Judson & Sawada, 2002). SRS is designed to encourage active participation in the classroom while creating an effective student-centered learning environment. SRS is usually comprised of three parts. The first part is the *clicker*, a small remote control device that allows students to press keys that correspond to answers. The key pressing may correspond to letters on keyboard or A-B-C-D multiple choice or True (or) False responses. The second part is a receiver designed to interact with the clicker and pick up responses encoded by students. In many SRS the student and instructor are given immediate feedback on the student's responses. Lastly, there is a computer program that the instructor uploads to his or her classroom computer to enable interface between a computer and the receiver and provides the instructor with presentation options and records all student responses in a database (Hatch, Jensen, & Moore, 2005).

In general, research does support the use of SRS in college classrooms to enhance learning (Caldwell 2007; Hatch, Jensen, & Moore, 2005). Most studies have reported positive results in terms of academic gains and personal satisfaction in the classroom (e.g., Martyn, 2007). Stowell and Nelson (2007) compared SRS to response cards and standard lecture hand-raising during simulated introductory psychology classes. The results showed that students performed well during both the SRS and response card conditions, and performed significantly better than during hand-raising conditions. Other studies have shown that SRS systems can have positive effects on student attendance (Jackson & Tress, 2003). Conversely, Bunce, VandenPlas, and Havanki (2006) found that students test scores were lower during SRS conditions as compared to WebCT conditions during chemistry classes. In addition, although they were generally positive of SRS, Hatch, Jensen and Moore (2005) reported frustration with technological glitches. Even though there is a significant and growing research base to support the use of SRS in college classrooms there are still many gaps in the literature. For example, little research has addressed how SRS affect applying lecture information to task specific activities. In addition, the authors found no studies that looked at the delayed recall of lecture information while utilizing SRS. Finally, most of the studies used undergraduate students as participants.

The purpose of the present investigation was to address these deficiencies by investigating the effects of SRS, single student questioning, and no student questioning during a post-bachelorette special education teaching methods course. The study was designed to address the question, What are the differential effects, if any, of a student response system, single student questioning, and no questioning on participants' delayed recall, application of content, or response accuracy?

Method

Participants

The participants were 23 graduate students enrolled in a graduate level special education class at a public university in the southern United States. Twenty-two participants were seeking a degree related to instruction and curriculum leadership, which includes special education. One participant was taking the course to obtain teaching certification only. Thirteen of the participants were African American, nine were Caucasian, and one was Hispanic. Thirteen were female, ten were male. The course was required for all the participants. The class met twice per week for 2 hours and 50 minutes for 10 weeks.

Dependent Variables

The dependent variables measured were accuracy of delayed recall of lecture material, accuracy of application of lecture material, and frequency and accuracy of student responding. Delayed recall was assessed by giving the participants a short-answer, 5-item quiz at the beginning of the next class session. The quiz items required the participants to recall key points that were presented during the lecture. The quizzes were scored by the first author, who was the instructor for the class, and by a second observer. Data are reported in terms of number of items accurately answered.

Application of lecture material was assessed by giving the participants' a task during which they must apply the information presented during the lecture. After the participants take the recall quiz, they were provided approximately 30 minutes to complete the application task (e.g., write an instructional objective). Tasks were evaluated using a rubric consisting of 3 points. In general a participant earned 3 points if they accurately completed the task, 2 points if a few elements of the task were missing, 1 point if several elements of the task were missing, and no points if all the elements were missing or if the task was incomplete. The first author evaluated the tasks, as did a second observer. Data are reported in terms of the number of points earned on the rubric.

Accuracy of responding was measured by examining the participants' responses and the correct answer for one-to-one correspondence. Data were reported in terms of percentage of correct responses. Participants' responses were collected in vivo by the student response system during the SRS condition and by the instructor for the course during the SSQ condition. Accuracy of responding data was not collected during the control condition because questions were not asked to the participants.

Independent Variables

Three experimental conditions were manipulated during the study: single student questioning (SSQ), student response system (SRS), and a control condition. In the SSQ condition, lecture information was discussed and presented using PowerPoint©. Periodically throughout the lecture the instructor randomly called upon *individual participants* to answer questions that were prepared prior to each class session. Questions were read aloud by the instructor and presented via PowerPoint©. A random number generator (http://www.random.org) generated list of numbers, corresponding to individual participants to be called upon, prior to each session. If a participant chose to "pass" the question, the instructor would provide the correct answer. Participants were informed at the beginning of the class that they would be asked to recall and apply the information after the lecture. An average of 19 questions were asked during each session of this condition.

In the SRS condition, the instructor conducted the lecture in the same manner as the previous condition. However, *every participant* used remotes/keypads with which they responded to questions posed by the instructor. Radio frequency clickers by Interwrite Personal Response System© (PRS) were utilized because the university had adopted this particular system. Interwrite PRS© provided 30 seconds to select and enter an answer and displayed the percentage of responses to each choice after the question was closed (the computer no longer accepts responses for that question). An average of 19.75 questions were asked during each session of this condition.

The control condition consisted of the instructor presenting lecture information with PowerPoint© without asking participants questions. Participants were informed at the beginning of class that they would be asked to recall and apply the information after the lecture.

Research Design

Alternating treatments design was utilized during when the experimental conditions were alternated across sessions. An alternating treatment design is a repeated measures research design in which two or more treatments are rapidly alternated to determine their effects on behavior (Cooper, Heron, & Heward, 1987). Conditions were randomly assigned with no more than 2 consecutive sessions utilizing the same condition. One experimental condition was conducted per class session.

Procedures

Each session consisted of a lecture with a corresponding PowerPoint© presentation during which the participants used guided notes. During the control condition, there were no opportunities for participants to respond to questions during the lecture. During SSQ and SRS conditions questions were presented during the lecture to which the participants responded. Feedback was provided after each question. If the majority of the responses were correct, the instructor praised or repeated the correct answer. If the responses were incorrect, the instructor repeated the correct answer with a brief explanation. After the lecture in each session, participants were provided approximately 30 minutes to complete a task that required them to apply the information from the lecture. The participants were allowed to refer to their notes during the task. At the beginning of each session, participants answered a short-answer, 5-item quiz covering content from the lecture during the previous session.

Reliability

Participants were trained how to use the clickers to ensure that response errors were less likely due to technical difficulties with the clickers. Participants were asked to respond using the clickers to 8 questions with obvious correct answers (e.g., who is the president of the United States? A. Donald trump, B. George W. Bush, C. Martha Stewart). The mean response accuracy during training was 92.7% with a mean of 22.9 responses.

Interrater agreement was calculated for 29% of the sessions. The instructor and an independent grader scored all quizzes and application tasks. The total agreement was calculated through dividing the number of items in which the graders agreed upon by the number of agreements plus disagreements and multiplying by

100. The mean agreement on delayed recall quizzes was 98%. Mean agreement on the application tasks was 83%.

Treatment integrity was calculated by a second observer by counting the number of questions asked during a session and the type of feedback provided for responses during 14% of sessions. A question and answer were scored accurate if the correct question was asked and the proper type of feedback was given. Feedback was considered accurate if a praise statement or restatement of the correct answer was provided based on the accuracy of the group or individual response. An incorrect answer in the majority of the group resulted in the instructor providing the correct answer and giving a brief explanation. Treatment integrity was calculated by counting the number of accurate questions and feedback completed divided by the number of accurate and inaccurate questions and feedback completed multiplied by 100. Treatment integrity was eighty-three percent across all observations.

Results

Participants scored slightly higher on quizzes during the SSQ condition ($M = 4.8$; $SD = 0.28$) than the SRS ($M = 4.5$; $SD = 0.54$) or control conditions ($M = 4.5$; $SD = 0.68$). Figure 1 displays the average score per quiz in each condition. A one-way analysis of variance (ANOVA) was used to assess the differences between the quiz score means in each condition for significance. The ANOVA did not reveal statistically significant difference in quiz scores for each condition (F (2, 66) = 2.96, $p < 0.06$). However, post hoc comparison using Tukey procedures revealed SSQ differed from SRS by 0.73 standard deviations and from the control condition by 0.65 standard deviations. While the findings may not be statistically significant, it could be argued that they are conceptually different.

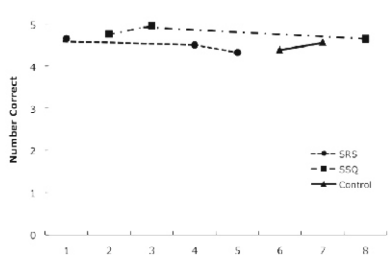

Figure 1. Mean number of points earned on delayed 5-item quizzes during SRS and SSQ.

Figure 2 shows the average application task score per session in each condition. Participants earned approximately the same amount of points on the tasks during the SSQ condition ($M = 2.6$; $SD = 0.21$) and SRS condition ($M = 2.7$; $SD = 0.23$). Both the SSQ and SRS conditions were superior to the control condition ($M = 2.3$; $SD = 0.58$). An ANOVA of application task scores revealed there was a statistically significant difference between task scores in the conditions ($F(2, 65) = 4.78$, $p < 0.01$). A post hoc comparison using Tukey procedures revealed no statistical difference between SRS and SSQ application task scores ($q = 1.25$; $p < 0.05$) but did reveal statistically significant differences between SRS and control conditions ($q = 5.02$; $p < 0.05$) and SSQ and control conditions ($q = 3.77$; $p < 0.05$). There was a large effect size in favor of application task scores during the SRS condition when compared to the control (Cohen's $d = 0.89$) and also of the SSQ condition when compared to the control (Cohen's $d = 0.67$).

Differences in response accuracy during SRS and SSQ were evaluated for significance using a T-test. There was no significant difference in response accuracy between the conditions (t (-0.13) = 2.02, $p = .89$, two-tailed). Figure 3 depicts the average accuracy of responses during the SSQ and SRS conditions. Responses were more accurate during SSQ (M =78%; SD = 0.35%) than during the SRS condition (M = 77%; SD = 0.07). More total responses were made during the SRS condition ($M = 21.5$; Range = 20.4 - 22.5) than the SSQ condition ($M = 18$; Range = 17-19).

At the end of the study, participants (n = 22) completed a questionnaire that contains 12 social validity question to which they responded strongly agree, agree, disagree, strongly disagree, or not sure. Several items addressed

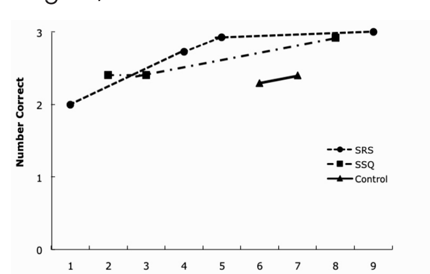

Figure 2. Mean number of points earned on application tasks during SRS and SSQ.

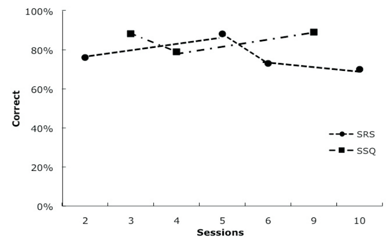

Figure 3. Mean accuracy of participant responses during SRS and SSQ.

engagement and on-task behavior. Forty-five percent of the participants said that they paid better attention during SRS condition and 59% thought that they have participated more with SRS. However, participants said SRS aided with their on-task behavior (68%) and that there was more class participation during SRS (82%). Regarding the effect of SRS on learning, participants said that they had more time for questions and comments during SRS (50%), spent more time listening and thinking about concepts with SRS (64%), learned more with SRS (64%), and retained more information with SRS (59%). Similarly, 45% of participants were not sure if their quiz scores were better when utilizing the SRS. As for personal preferences, 91% of participants said that they had a positive experience with SRS. Seventy-seven percent of participants preferred SRS to SSQ and 86% recommend using SRS in future classes. Space was provided on the questionnaire for additional comments. There were 15 additional comments. Generally the comments addressed four areas: elements of pacing such as feedback delay and intertrial interval, feedback on percent accuracy across all questions not just individual questions, closer relation between questions and quizzes, and use of SRS for assessment.

Discussion and Conclusion

In general, regardless of the conditions, participants performed well during this study. In terms of letter grades (i.e., what the students really care about), there was only an average of a difference of half a letter grade on quiz scores and application tasks between SRS and SSQ conditions. However, there was a full letter and a half grade difference between SRS and the control condition and a full letter grade difference between SSQ and the control conditions on application tasks. In other words, the differential effects between the SRS and SSQ technologies were minimal and both were better than no questioning at all. These results are congruent with Stowell and Nelson (2007) and similar to Shabani and Carr (2004) who investigated a low-tech form of active student responding. The results stand in contrast to those of Bunce, VandenPlas and Havanki (2006). However, there is a major limitation to this study that must temper any conclusions. First, the researchers had to balance the need to increase the likelihood that students learned the material for the class with wanting to get “clean” results from this study. Therefore guided notes were chosen to use in all conditions. Guided notes are a standard technology used to increase active student responding during lectures. Guided notes are instructor prepared handouts that contain cures to write important information presented in class (See Heward, 1994 for a review of guided notes research). Studies have shown that guided notes alone increase college student's quiz scores (Austin, Lee, & Carr, 2004; Austin et al., 2002; Lazarus, 1993). Although the guided notes were optional almost all the students chose to use them and they were consistently provided across conditions. The use of guided notes may have confounded the results of this study because the students were given important information from which to study for the next class quizzes. This may be the reason for why test scores were not significantly different across all conditions. In addition, the low number of quiz questions could have impacted differences as well. A ceiling effects was seen on quiz scores in this study. A future study would be well served to include more questions than the present study did per quiz. An interesting topic for a future study may be to include higher order comprehension questions along with higher order application tasks. However, a limitation of the SRS technology is the ability of the clicker devices to allow students to produce sophisticated answers, which is discussed in the later section of this paper.

A second limitation to the investigation was the method chosen to implement the SSQ conditions. Instead of allowing students to voluntarily answer questions or choosing students in a predictable manner the researchers chose to use an indiscriminable contingency during SSQ conditions. Participants were randomly selected to answer questions. Although participants were allowed to "pass" the question, only one participant ever did this. The reason for choosing to use this method was it was more likely to keep participants "on their toes" during SSQ conditions (Brame, 2001). The researchers also wanted to provide every participant with an opportunity to respond at least once during SSQ. Yet, by doing so it might have inadvertently elevated participant learning. So, again the researchers had been trying to balance the dual goals of fostering learning and investigating teaching methods in the classrooms. Future investigators may want to try to disentangle aspects of the method that may yield clearer results.

Finally, it is important to note that although the participants generally were favorable to the SRS system there were some complaints about the length of the response times (many thought that the response times were too long). Additionally, there was somewhat of a steep learning curve in learning to integrate the technology into the PowerPoint© presentations and in learning to transfer the data from the system to a spreadsheet.

Despite the limitations, it is important to discuss the possible reasons why the two questioning conditions were better than the no questioning condition. The difference between the questioning conditions and the control condition was active student responding. Active student responding refers to when a student emits an observable, measureable response to an instructional antecedent, such as instructor presented questions (Heward, 1994). Research shows that the more actively engaged a student, the better their performance (e.g., Austin, Lee, & Carr, 2004; Austin et al., 2002; Greenwood, Delquadri, & Hall, 1984; Narayan et al, 1990; Neef, McCord, & Ferreri, 2006; Randolph, 2007; Saville, et al., 2006). During the SRS condition students were actively responding to instructional antecedents, the questions. During the SSQ condition, although the participants did not make as many responses as during SRS, they had to remain on-task because they did not know when they would be called upon to answer a question and they had to respond when it was their turn to answer; whereas during the control condition, there was no contingency for the students to remain on task or engaged during the lecture. An instructor can improve student performance simply by increasing active student responding regardless of the mode of technology. As a case in point, Stowell and Nelson (2007) found no differences between SRS and response cards (a high tech and low tech version of active student responding). This leads us to believe that using technology for technology's sake does not improve instruction. There should be a specific purpose for effective use of technology. For example, an instructor may wish to receive immediate feedback on the accuracy of a large group of student responses. In this case, SRS would meet that goal. Another instructor may wish to increase the engagement of students in the class. In this case a further analysis of the type of engagement would reveal a better perspective of the type of high - tech or low-tech device that should be used. If the goal was to provide more practice a low-tech method such as response cards may be a more reasonable option than SRS. SRS may be preferable to other low-tech forms of active student responding when teaching a large group of students, immediate feedback on the precise average student performance is important, recording and scoring individual performances during class is desired, and privacy of students' responses is important (i.e., assessment). Response cards and choral responding may be appropriate when teaching small groups of students, presentation pace of questions is important (e.g., less than 30 second thinking time, short intertrial interval), privacy of student responses during the activity is not important (i.e., practice), funding for materials is limited, and instructor needs immediate feedback on an individual student performance or the general overall impression of group performance. However neither option provides for complex student responses. SRS, response cards and choral responding are appropriate for one correct short answer. Although SRS has been used to provoke student discussions (Judson & Sawada, 2002), the system itself does not allow for students to submit the discussions or independent thoughts via the clicker to be scored, recorded, and have feedback provided.

There are still many questions related to the efficacy of SRS in classrooms. For example, some types of SRS that allow the instructor to control the presentation of the question and length of thinking time and response time lends itself to investigations of instructional pacing. Instructional pacing incorporates instructor controlled elements such as simplicity or complexity of the question, time allotted for students to think about their answer, response prompts provided to students (if any), length of student response, time between the response and feedback, feedback itself, and the time between the end of feedback on one question and the presentation of another question (intertrial interval) (Tincani, et al., 2005) that make up a learning trial. For example, Robertson (2000) suggests 15-20 seconds per question for a group of 0 to 30 students, 30 seconds per question for 30-100 students, 1 minute per question for 100 or more students. The pace in this study during the SRS condition was 30 seconds per questions with 23 participants. The optimal presentation rate of a learning trial through SRS is an empirical question that has not been addressed.

Similarly, issues related to the presentation of questions should be investigated. For example, the manner in which questions are presented, interspersed throughout the lecture or massed presentation of questions, may impact student learning. Likewise, what is the optimum number of questions that should be presented during a lecture to improve student learning? In a review of SRS research Caldwell (2007) found that a range of two to five questions was typical for 50-minute class session. However, eight to ten questions or more are presented during response card studies (Heward, 1994; Randolph, 2007). Perhaps once these empirical questions are addressed, more differential effects of SRS on student learning will be seen.

In conclusion, the results of this study suggest, that no matter what form of technology one chooses to use from high to low tech, the most important variable is to get the students to make active responses in the classroom. Students will appreciate the teachers efforts and it will likely make the teachers to get more learning out of students.

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