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An Experimental Evaluation of the Instructional Effectiveness of a Student Response System: A Comparison with Constructed Overt Responding

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Student response systems (SRSs) are increasingly being used in the classroom. However, there have been few well-controlled experimental evaluations to determine whether students benefit academically from these instructional tools. Additionally, comparisons of SRS with other interactive methods have not often been conducted. We compared SRS, Constructed Overt Response (COR), passive, and control conditions to determine their effects on learning and affect. We found that students performed better in the interactive conditions—SRS and COR—than the other conditions. Participants' gain and retention of gain scores in the SRS condition were lower than those in the COR condition. Participants in the SRS condition perceived their condition as more enjoyable than those in the passive condition and more useful than those in the control condition. Additional research questions are raised about how these interactive methods may best improve student learning.

Active learning approaches in the classroom have long been recognized as a means of promoting student acquisition of course material (Hake, 1998; Kritch, Bostow, & Dedrick, 1995; Pratton & Hales, 1986; Sivan, Leung, Woon, & Kember, 2000; Yoder & Hochevar, 2005). Teaching methods that involve student exchanges with peers, instructors, or others about the learning material – termed interactive teaching – can facilitate acquisition and retention of course material (Bonwell & Eison, 1991; Brophy, 1986; McKeachie, 2002; Sokoloff & Thornton, 1997).

An interactive teaching technique well-suited to large class sizes is the use of a student response system (SRS). With this method the instructor intermittently poses questions embedded in presentation software (e.g., PowerPoint) projected onto a screen during ongoing classroom instruction (see Banks, 2006 for more information). Students answer questions by pressing buttons on a remote response device (RRD) to transmit their encoded answers to a receiver connected to the instructor's computer. When polling is completed, the instructor advances to the next slide to display a histogram of the class responses. The data are reviewed with the class and may result in additional instruction and discussion. Student response data are saved and available for off-line analysis. Since each RRD has a unique code, the students' response data can also be used for recording attendance or tracking individual progress. Course points can be awarded based on this response data (Burnstein & Lederman, 2001).

SRSs provide an easy-to-use means of collecting student information in real-time, which may enhance the classroom environment in various ways (Collins, 2007). SRSs place students in an interactive role (Cutts, Kennedy, Mitchell, & Drapper, 2004; d'Inverno, Davis, & White, 2003; Fries & Marshall, 2006). Siau, Sheng, and Nah (2006) demonstrated that significantly greater student communication and engagement occurred following use of SRS. The active responding and immediate feedback to questions posed by the instructor may hone students' comprehension of the material, leading to greater learning (Dufresne, Gerace, Leonard, Mestre, & Wenk, 1996; Forsyth & Archer, 1997).

Topics may be broached by administering SRS opinion polling to pique student interest in the course material and gain insight into their position on controversial or sensitive issues. Because answers are provided anonymously, a more accurate measure of attitude and understanding may be obtained, and students may be less reluctant to participate in the classroom (Davis, 2003).

SRSs are not devoid of negative aspects. Instructor time is needed, both to become proficient with the computer hardware and software and to prepare challenging questions. Class time is also required for presenting questions, reviewing the histogram, and providing remediation. Technical problems can occur with these systems which may result in lost data or delay of class presentation. Additionally, the cost of purchasing the RRD (approximately $20-$40 U.S.) may be too burdensome for some students.

Given the possible advantages and disadvantages associated with SRSs, it is important to empirically address whether they are effective instructional tools. Although many studies have found that students prefer using SRSs in the classroom compared to traditional methods of instruction (Littauer, 1972; Siau et al., 2006; Teeter, Madsen, Hughes, & Eagar, 2007; Trees & Jackson, 2007), research results concerning the effect of SRSs on student performance are mixed.

Pemberton, Borrego, and Cohen (2006) compared a LearnStar® student response system to a traditional

review method with 378 undergraduate students. Condition assignment was determined by course schedules for the six classes that participated. Although no significant differences in test scores between conditions were found, students reported higher enjoyment and participation in the SRS condition compared to the traditional instruction condition.

Paschal (2002) also compared a traditional approach (class lectures and graded homework assignments) to lectures intermixed with SRS-delivered questions. Using a quasi-experimental research design, 132 students participated across two years in either the traditional instruction (during first year) or SRS (during second year) conditions. No significant differences in student course performance between conditions were found, although students perceived that use of the SRS contributed to their learning and time management.

Using an earlier SRS prototype, Brown (1972) compared traditional instruction to SRS conditions when teaching mathematics to first year college students. Test scores, anxiety levels, and attitude toward mathematics were not significantly different between conditions for the 73 students who participated in this experiment.

Some studies suggest that use of SRS may improve test scores. Using an AB design, Bullock et al. (2002) found 200 undergraduate students improved their attendance, participation, homework completion, and exam performance after a SRS was implemented as compared to when a traditional approach was used. Kennedy and Cutts (2005) found a significant positive association between students' use of SRSs and exam performance.

Considering that SRSs have been in use in classrooms since the 1970s, it is remarkable that relatively few well-controlled experiments have been conducted to determine their instructional effectiveness (see Fies & Marshall, 2006 for a review). Moreover, much of the past research has been conducted in the field. Although classroom research increases the generalizability of the findings, less control over confounding variables can make interpretation of the data difficult (e.g., order and difficulty of material, participant characteristics, instructor bias).

Another weakness with the past research evaluating SRSs involves the type of control/comparison condition used. In past research (e.g., Pemberton et al., 2006), SRSs were compared to a traditional instructional style which, in general, is a passive method involving little student-teacher or student-peer interaction. A comparison of SRS with a traditional method of instruction does not address whether more interactive approaches are equally or more effective.

Another interactive teaching method that fosters participation by all students in the classroom involves the use of response cards (RC). In one form of this approach, each student is given a set of cards with which to answer questions during the class. These cards display letters (e.g., A, B, C, D) for answers to multiple-choice questions or other response indicators as determined by the question format (e.g., true/false). The teacher poses a question to the class, and each student holds up the appropriate response card. The teacher then surveys the students' answers and provides remediation or continues instruction as necessary (Gardner, Heward, & Grossi, 1994). Marmolejo, Wilder, and Bradley (2004) compared RC to hand-raising with 27 psychology majors in a learning course. These researchers found that most students performed better on quizzes and participated more in class when RC was employed.

Another form of the RC method is constructed overt responding (COR) (Narayan, Heward, Gardner, Courson, & Omness, 1990). With this method the student writes an answer to a question posed by the instructor on a card, sheet of paper, or dry erase board. When requested to do so, all students hold up their answers or call out an answer (choral responding) for the instructor's review. The results of research evaluating this method are similar to the use of response cards. On average, when students used COR they performed better on quizzes, their frequency of active response increased, and they preferred response cards compared to answering in-class questions by hand-raising (Davis & O'Neill, 2004; Gardner, Heward, & Grossi, 1994; Narayan et al., 1990) or passive review (Cavanaugh, Heward, & Donelson, 1996). Although most of these studies involved elementary or high school students (e.g., Cavanaugh et al., 1996; Davis & O'Neill, 2004; Lee-Vieira, Mayer, & Cameron, 2006; Narayan et al., 1990), greater gains in a constructed response condition compared to passive conditions have also been found with college students using computer-based instructional software (Thomas & Bostow, 1991).

Requiring students to write or vocalize a correct answer to questions posed during a lesson may enhance student learning and retention of the information when compared to simply raising a letter to signify the correct answer. The COR method involves recall of the answer rather than merely recognizing or discriminating the correct answer from other items on a list, as is the case with a multiple-choice format, which may facilitate learning (Edwards & Arthur, 2007). By writing the correct answer rather than selecting a letter corresponding to that answer from a list, the student practices the desired behavior. Alba and Pennypacker (1972) compared two different types of study sessions: one in which students orally answered fill-in-the blank questions (COR) to another in which students completed individual projects. These researchers found that gain scores (post-test minus pretest scores) were

significantly higher for participants in the COR condition compared to the individual project condition.

There have been a few studies that have compared SRS to other interactive instructional approaches. Stowell and Neilson (2007) compared SRS to RC and other traditional methods (i.e., standard lecture and polling via hand-raising) with 140 undergraduate psychology students and found no difference in performance on a post-test. Using a subjective evaluation instrument, the researchers found slightly higher enjoyment ratings for those participants in the SRS condition. Additionally, Lasry (2008), using Mazur's peer instruction approach (see Couch & Mazur, 2001), experimentally compared SRS to flashcard methods of answering questions in class. There were no learning differences between participants' scores in the two groups found in this study.

Given the increasing use of technology in classrooms in countries such as the United States and Canada, it is important to experimentally determine whether use of SRS enhances students' acquisition of instructional material. In this study we compared SRS, COR, passive, and control conditions to determine their effects on acquisition and retention of instructional material, and student preference.

Method

Participants

Eighty-four students from an introductory psychology course at a medium-size, liberal arts college in New York State participated. Participants received research credit for voluntarily participating in the study (a standard practice in colleges in the United States). There were 20 students with an average age of 19 years in the SRS condition – 13 females and 7 males, 95% Caucasian and 5% African American. There were 21 students with an average age of 19.4 years in the COR condition – 15 females and 6 males, all of whom were Caucasian. There were 21 students with an average age of 18.4 years in the passive condition – 17 females, 4 males – 85% Caucasian, 5% African American, and 5% other (one participant did not indicate race). There were 22 students with an average age of 18.7 years in the control condition--13 females, 9 males, 95% Caucasian, 5% African American. Across conditions, most participants were in their first (77%) or second year (13%) of college and majoring in Nursing (24%) or Physical Education (23%). Sixty-nine percent of the students had grade point averages (GPA) between 2.6 and 3.5 on a 0-4 scale.

Apparatus and Materials

Each of the four groups viewed one of two videos (*Sensation and Perception* or *Learning*) from Annenberg's *Discovering Psychology* series hosted by Dr. Phillip Zimbardo in a digital streaming format accessed from http://www.learner.org/resources/series138.html. A laptop computer with the TurningPoint® SRS system, response devices, and radio frequency (rf) receiver was used to project questions digitally from a PowerPoint presentation. Three PowerPoint presentations were produced based on the same content material but using different formats—10-option multiple-choice used in the SRS condition, fill-in-the blank used in the COR condition, or a statement with the main point underlined and in bold used in the passive condition. The TurningPoint® SRS system used was only capable of multiple-choice or True/False responses, thus requiring the different question formats. All participants also received a post-test consisting of 30 multiple-choice questions (70% factual and 30% conceptual) on the topic of visual perception. Note that the post-test topic only matched one of the Annenberg *Discovering Psychology* videos. The other video (*Learning*) was used as a control condition. Other materials include a demographic sheet and 3 x 5 inch note-cards.

Procedure

Participants were randomly assigned to one of four conditions—SRS, COR, passive, or control. In each condition, one of four experimenters (who alternated between conditions across sessions) escorted participants to a separate small classroom (with a capacity of approximately 20-30 students) and asked them to complete informed consent and demographic sheets. In all four conditions participants viewed an approximately 20 minute psychology video. In the SRS, COR, and passive conditions, the *Sensation and Perception* video was presented, and in the control condition the *Learning* video was shown. In the SRS, COR, and passive conditions the video was paused approximately every minute, and a PowerPoint slide displaying a key point made in that segment of the video was shown, whereas in the control condition, the video was presented without pauses. In addition to video content, the format of the PowerPoint slides and degree of student participation differed between conditions, as described below.

In the SRS condition, a multiple-choice question based on a key point addressed in the *Sensation and Perception* video was presented visually on a PowerPoint slide and read aloud by the researcher. A 10-option list of choices for each question was used to

make the discrimination between the correct and incorrect answers challenging and more similar to that in the COR condition. The content of the multiple-choice question was the same as that presented in the COR condition.

One difference between the SRS and COR conditions was the format of the material. In the SRS condition, participants were instructed to individually select an answer from the list provided on the screen and answer it by pressing the appropriate buttons on their RRD. Once all the participants' answers were entered, the researcher presented a slide with a histogram depicting the percentage of participants in that group who selected each of the multiple-choice options. The researcher described the graph in terms of the percentage of participants who made each selection and then, on the next slide, read the statement with the correct word(s) filled in.

Another difference between the SRS and COR conditions was that participants were not required to write the correct answer in the SRS condition. This procedure was implemented to more realistically portray use of the SRS under typical classroom conditions. Following the answer slide, the next video segment was presented, then the next question, and so on until all 18 questions had been presented.

In the COR condition, a fill-in-the blank question based on a key point addressed in the *Sensation and Perception* video was presented visually on a PowerPoint slide and read aloud by the researcher. Participants were instructed to write down their answers to complete the statement on a 3 x 5 inch card and hold the card up at their foreheads so that other participants could not view any individual student's answer. The researcher then checked that an answer was made. To prevent an individual student from changing his or her answer, participants were instructed to place their completed cards in an envelope. A slide was presented with the correct word(s) shown to complete the statement and read aloud by the researcher. Similar to past research using the COR method (Alba & Pennypacker, 1972; Lee-Vieira, Mayer, & Cameron, 2006), which require mastery before moving to the next item, participants were instructed to write the correct answer on their answer sheet, whether or not they had previously answered correctly. Following the answer slide, the next video segment was presented, then the next question, and so on until all 18 questions had been presented.

To determine the effect of an active format on learning the material, the passive condition was implemented. In the passive condition, statements based on a key point addressed in the *Sensation and Perception* video were displayed on a PowerPoint slide and read aloud by the researcher. The key point word(s) were underlined and in bold text. As in the SRS and COR conditions, the video was paused at intervals and the slides presented. The statements were identical to the correct answer slides presented in both SRS and COR conditions. Participants were not asked to respond in any way to the information provided in this condition.

A control condition was implemented to assess participants' prior knowledge of sensation and perception. This condition differed from the other conditions by presenting, with no pauses or interspersed questions, the *Learning* video rather than the *Sensation and Perception* video which the other three groups viewed.

Following the training session, participants in each condition completed a 30-item multiple-choice post-test concerning visual perception.

Following the post-test, each participant was given a four- or six-item (depending on the condition) subjective evaluation questionnaire to complete. As applicable to the condition, participants were asked to rate, along a seven-point Likert-type scale, the degree to which: (a) information received was useful for their understanding of the material, (b) the method of instruction helped them prepare for the test administered after it, (c) their answer was carefully chosen, (d) close attention was paid to whether an answer was right or wrong, (e) they tried their best to learn the material, and (f) they enjoyed the method of instruction. Following completion of the questionnaire, a debriefing statement describing the overall study and its purpose was read aloud by the experimenter to the participants.

A measure of retention of learning was also collected approximately two weeks after the experiment. As part of a multiple-choice exam held during class, eight questions, which were variations on the questions asked in each experimental condition, were administered.

The dependent variables consisted of the post-test scores, ratings from the subjective evaluation questionnaire, and retention test scores. Learning and retention gain scores were also calculated. Learning gain is defined as the number of items participants answered incorrectly during the review session and correctly during the post-test for that matched item. Retention gain is the number of items for which both learning gain and a correct response to the matched question on the course exam occurred for each participant.

Reliability procedures were conducted with 33% of the sessions. Reliability was measured by an independent observer reviewing video-taped session procedures and scoring whether procedures were followed correctly. Procedural and interobserver reliability scores were calculated by dividing the number of researcher and observer agreements by the

number of agreements plus disagreements and multiplying by 100. Procedural reliability scores for delivery of the correct test materials, instructions, video, questions, and feedback were 100%. Interobserver reliability scores for participants' answers during training in the COR condition and subjective evaluation were 100%. Since test scores were automatically entered into the computer from machine-read scantron sheets, no reliability measures were required. Similarly, the SRS training session data were automatically collected and so did not require reliability procedures to be performed.

Results

Training Scores

There were differences between experimental conditions in percent correct responding during the training session. Participants' mean scores (percent correct) during the training session were higher in the SRS condition compared to that in the COR condition (SRS n = 15, M = 63%, SD = .37; COR n = 21, M = 32%, SD = .35. $t(8) = -3.565$, $p < .05$). Participants performed better on the recognition task (SRS) than on the recall task (COR). No training session scores were collected in the passive or control conditions due to the nature of those conditions.

Post-Test Scores

Participants' post-test performance was examined to determine the effects of review format on learning. Mean post-test scores for participants in the SRS condition (M = 64.3%, SD = .14, SE +/- .03) were significantly different from those in the passive (M = 55.9%, SD = .11, simple contrasts, $F(1,80) = 6.0$, p = .01) and control conditions (M = 41.1%, SD = .11, $F(1,80) = 46.3$, $p < .001$). Moreover, mean post-test scores for participants in the COR condition were significantly different from those in the passive (simple contrasts, $F(1,80) = 5.0$, $p < .05$) and control conditions ($F(1,80) = 44.2$, $p < .001$). Mean scores in the SRS condition did not significantly differ from those in the COR condition $F(1,80) = 0.06$, p = ns). These results suggest that participants performed better in the more interactive conditions (SRS and COR) compared to passive and control conditions.

Gain Scores

Participants' learning gains in the SRS and COR conditions were compared (see Figure 1). Learning gain is defined as the number of items participants answered incorrectly during the review session and correctly during the post-test for that matched item. The mean learning gain scores for participants in the SRS

Figure 1
Participants' Gain Scores in the SRS and COR Conditions

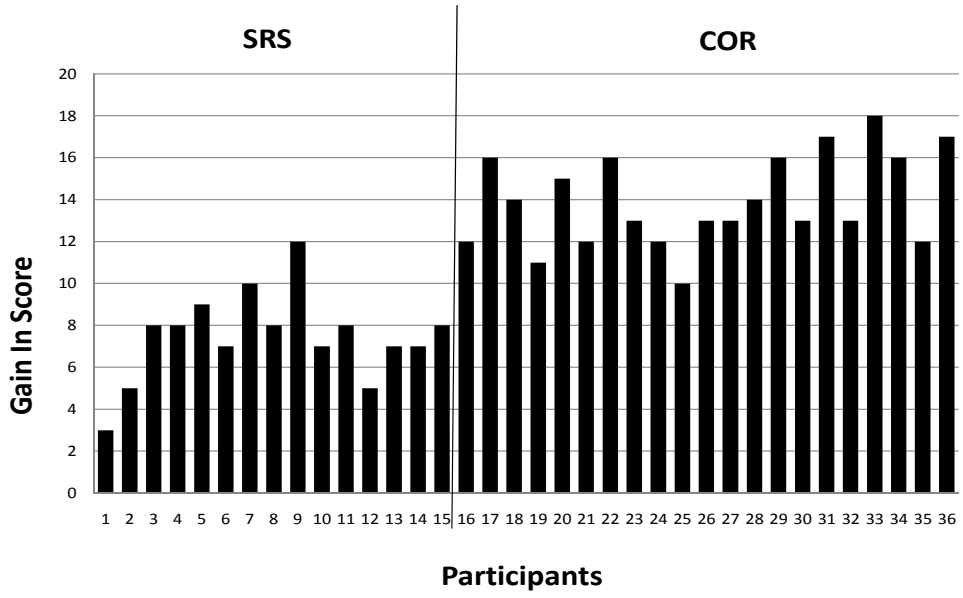
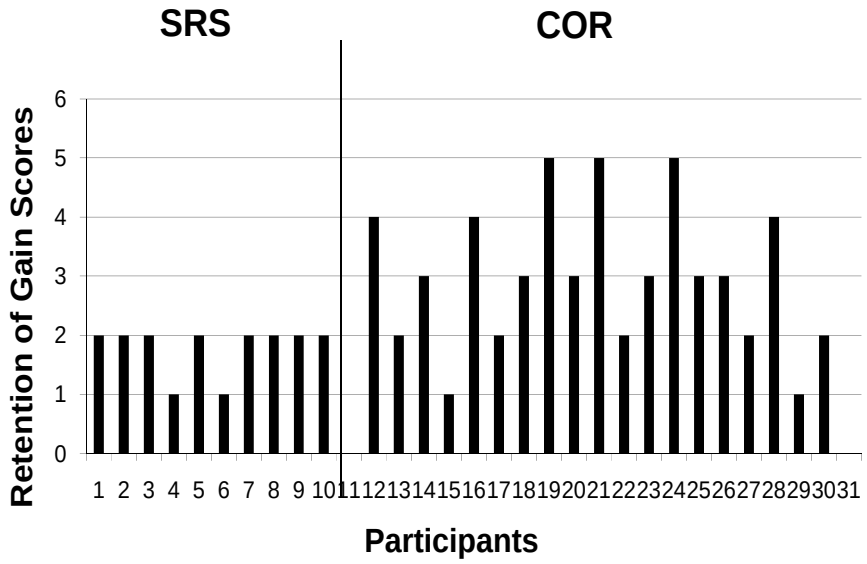


Figure 2
Participants' Retention of Gain Scores in the SRS and COR Conditions



condition (M = 7.5, SD = 2.1, SE +/- .6) and COR condition (M = 14.0, SD = 2.2, SE +/- .5) differed significantly ($t(34) = 8.8$, $p < .001$). As seen in Figure 1, only one participant's score in the SRS condition overlapped with all participants' scores in the COR condition.

Retention Scores

A measure of retention was calculated based on students' answers to eight matched test items during a course exam administered approximately two weeks after the review session. There were no significant differences in overall retention scores between SRS (M= 5.9, SD = 1.5, SE = 0.4, N = 15), COR (M= 5.7, SD = 1.7, SE = 0.4, N = 19), passive (M= 6.0, SD = 1.4, SE = 0.3, N = 21), and control (M= 6.2, SD = 1.2, SE = 0.2, N =21) conditions ($F(3, 75) = 0.4$, p = ns).

We also examined retention of gain scores as a more sensitive measure of the individual's acquisition of learning material when compared to the overall retention score (see Figure 2). The participant's retention of gain scores refers to the number of items in which both learning gain (i.e., items incorrect during the review session and correct during the post-test) and a correct response to the matched question on the course exam occur. Participants' mean retention of gain scores in the SRS condition (M = 1.8 SD = .94, SE +/- .27) ($t(29) = 2.09$, $p < .05$) were inferior to those in the COR condition (M = 2.79 SD = 1.39, SE +/- .32).

Subjective Evaluations

Participants' subjective evaluations of their experiences in each condition were examined (see Table 1). A significant difference was found in participants' mean ratings between conditions regarding whether they *received useful information* ($F(3, 75) = 8.3$, $p < .001$). A Scheffé post hoc test showed that participants in the SRS ($p < .01$) and COR ($p < .01$) conditions rated that they received more useful information than those in the control condition.

Participants' mean ratings regarding whether *the method of instruction used in this session helped them prepare for the test given after it* significantly differed between conditions ($F(3, 75) = 7.84$, $p < .01$). A Scheffé post hoc test revealed that participants' mean ratings in the SRS ($p < .01$) and COR ($p < .05$) Conditions significantly differed from those in the control condition. Participants' mean ratings in the SRS condition were also significantly different from those in the passive condition ($p < .05$).

Participants' mean ratings showed a significant difference in *enjoyment of the method of instruction* between conditions ($F(3, 75) = 4.76$, $p < .01$). A Scheffé post hoc test showed that participants' in the SRS condition rated their session as more enjoyable compared to those in the passive condition ($p < .01$).

On the subjective evaluation questionnaire, participants were asked in the SRS and COR conditions whether they *carefully chose their answer* and *paid*

Table 1
Mean (Standard Error) Agreement Ratings of Subjective Evaluation Questions Along a 7-point Rating Scale Labeled 1 = *Agree completely*, 4 = *Neither agree nor disagree*, and 7 = *Disagree completely* for each condition

Evaluation Question	Condition			
	SRS	COR	Passive	Control
1. I received useful information concerning my understanding of the material being taught during this instructional session	2.5(0.2)	3.0(0.3)	3.6(0.3)	4.5(0.3)
2. The method of instruction used in this session helped me prepare for the test given after it	3.3(0.4)	4.1(0.3)	4.7(0.3)	5.6(0.4)
3. I enjoyed the method of instruction I received during this session	3.3(0.4)	4.6(0.4)	5.2(0.3)	4.4(0.4)
4. I carefully chose my answer to each question presented during the instructional session	2.3(0.3)	3.3(0.3)	n/a[1]	n/a[1]
5. I paid close attention to whether my answer to a question was right or wrong during the instructional session.	1.9(0.3)	2.8(0.3)	n/a[1]	n/a[1]

Note. [1.] Passive and control conditions did not include an instructional session.

close attention to their answer during the instructional session. These two questions were only applicable in the SRS and COR conditions. Participants in the SRS condition indicated that they took more care in answering questions than those in the COR condition ($t(36) = -2.44$, $p < .05$). There was no significant difference for participants' ratings of whether they *paid close attention* between the two conditions (p = ns).

Discussion

Students performed better in the interactive conditions – SRS and COR – than in passive and control conditions. This superiority of interactive conditions over the other conditions was replicated across three learning measures: post-test, learning gain, and retention of gain scores. When comparing interactive conditions, participants' mean scores in the SRS condition were surpassed by those in the COR condition both in terms of learning gains and retention of learning gains, although not for post-test scores. Despite inferior gain and retention of gain, participants perceived instruction in the SRS condition as more enjoyable than those in the passive condition and more useful than those in the control condition.

In general, the results of this study are consistent with the past research in several respects. Interactive teaching methods produce higher participant post-test scores than passive conditions (Davis, Bostow, & Heimisson, 2007; Dufresne et al, 1996; Sokoloff & Thornton, 1997; Thomas & Bostow, 1991; Tudor, 1995; Yoder & Hochevar, 2005). A few studies have found that outcomes from some interactive methods (e.g., response cards, flashcards) may be similar to those produced using SRS (Lasry, 2008; Stowell & Nelson, 2007). Moreover, past research suggests that the COR method produces superior gain scores compared to a multiple-choice format (Alba & Pennypacker, 1972; Edwards & Arthur, 2007). In addition, the results support the observation that SRS methods are generally preferred by participants, regardless of actual outcomes (Beekes, 2006; Davis & O'Neill, 2004; Dufresne et al, 1996).

Our results build on past research. We experimentally evaluated the instructional effectiveness of SRS, which has been infrequently done by

researchers in the past. Furthermore, we compared participants' performance in the SRS condition to that in the passive and control conditions as well as to COR, another interactive method.

Post-Test Scores

Participants' post-test scores in the SRS and COR conditions did not significantly differ from one another, although both differed from those in the passive and control conditions. This result may have occurred for a number of reasons. Interactive methods require participants to respond to the instructional material which may by itself or, in combination with increased attention to the relevant information, contribute to improved performance. Moreover, by providing the participants with feedback for their answers, the correct answer is reinforced. Passive conditions make no such demands on participants, allowing them to choose whether to attend to the instructional material. Passive conditions also fail to assess student understanding of the instructional material.

Gain Scores

Participants' gain scores (the difference between initial correct answers during the instruction phase and correct answers on the post-test) in the SRS condition were significantly lower than those in the COR condition. This difference in gain scores may be an artifact of the training approach. It is also possible that the multiple-choice questions in the SRS condition cued or prompted the selection of the correct answer (a recognition task) while participants in the COR condition were not given any cues (a recall task). Past research has shown better performance on recognition tasks compared to recall tasks (Arthur, Bennett, Stanush, & McNelly, 1998). In our study, an attempt to mediate this inequality in task performance between conditions was made by including 10 possible options for each multiple-choice question in the SRS condition instead of the usual four or five.

The response entry procedure may have also contributed to the difference in gain scores between interactive conditions. Participants in the COR condition wrote the correct answer at least once, whereas participants in the SRS condition were never required to write the correct answer. Writing an answer, as opposed to selecting a letter, provides practice with emitting the correct response. The COR methodology requires that participants write the correct answer to facilitate learning (Alba & Pennypacker, 1972; Lee-Vieira, Mayer, & Cameron, 2006), and to avoid reinforcing an incorrect response. Thus, in the COR condition participants initially had fewer correct answers, but on the post-test their performance was more similar to those in the SRS condition. Typical classroom use of the SRS does not require students to write down the target word or phrase.

Subjective Evaluation

Our results found that participants perceived the SRS condition as more enjoyable compared to those the passive condition. Favorable opinions of an instructional method may lead to increased attendance, exposure to the learning material, and better grades compared to unfavorable views (Marmolejo, Wilder, & Bradley, 2004).

Participants in both SRS and COR conditions rated their condition as more useful and helpful than those in the control condition. This result was possibly due to the features of the SRS and COR conditions--feedback and active responding to the learning material were present in the interactive conditions and not in the control condition. Additionally, those in the control condition saw a video unrelated to the post-test.

Participants in the SRS condition reported taking more care in arriving at their answers than in the COR condition. Selecting one of the ten multiple-choice answer options in SRS condition may have required more attention to details than simply producing an answer, as was the case in the COR condition.

Future Research

Several interesting questions remain to be answered in future research. For example, how well do the results of this study generalize in terms of context, testing approach, and type of response input? To evaluate the effectiveness of SRSs we arranged a more controlled environment than typically is present in classroom instruction (i.e., by using a video-taped lecture and collecting subjective evaluations). Whether our results are replicable in an actual classroom situation where instruction is more free-flowing and guided by students' responses should be tested.

Another unanswered research question concerns the type of test administered. Would the same results occur if questions on the post-test and retention test consisted exclusively of fill-in the blank versus multiple-choice? How much did use of multiple- choice questions contribute to participants' performance in the SRS condition versus the COR condition? The present experiment used only a multiple-choice test to standardize and simplify the administration. Perhaps the results would differ if test format were matched to condition (e.g., if the COR condition participants completed a fill-in-the-blank test).

An important question is whether technology is necessary in training situations for optimal student learning. Moreover, if technology does make a

difference, would an SRS that allows word input via the RRD provide greater learning gains than either a manually constructed response or a system that requires multiple-choice letter selection? The SRS utilized in our experiment does not allow users to input specific words, thus limiting the form of the response to multiple-choice format. The selection of a letter via multiple-choice format may lessen the learning value compared to inputting the answer in actual word form.

The role of anonymity in encouraging interactive participation also requires exploration. The lack of individual identification inherent in a SRS may contribute to honest and uninhibited answering when compared to other interactive methods which may preclude anonymity by virtue of their design. In the COR condition participants revealed their answers to the researcher in a way that made it difficult for others to see. The experimenter, however, was required to check that everyone had made some response, thus forcing participants to expose their personal answers to another person. SRS technology that allows word input would allow for participant response anonymity in recognition and recall conditions.

The use of SRS technology is a fairly costly approach compared to other interactive classroom methods. The results of this research suggest that an alternative (i.e., COR) is as effective as the SRS method in terms of participants' learning. Additional research will help to clarify the extent to which these instructional methods can be successfully added to the interactive teaching toolbox.

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