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Teaching Educational Psychology: Using a Classroom Response System for Summative Group Assessments and to Enhance Interactivity

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Abstract

A classroom response system (CRS) was adopted in a small undergraduate educational psychology course in an effort to enhance interactivity, maintain student interest, and provide real-time, formative feedback to both students and instructors. Approximately 10 weeks after introduction, students' attitudes toward the technology were assessed using quantitative and qualitative data sources. Students positively endorsed our use of the technology, which encouraged us to use the CRS for an in-class, summative, group assessment. This innovative assessment method was designed to mitigate test anxiety and make assessment a more positive educational experience. Student feedback suggested that this alternative assessment was more enjoyable, and that it may have been as effective as a traditional assessment. Our findings are primarily descriptive. We discuss the pedagogical affordances of a CRS based on student data and our recollections (as the instructors of the course). Educational implications and future directions are also discussed.

Teaching Educational Psychology: Using a Classroom Response System for Summative Group Assessments and to Enhance Interactivity

Conventional lecture styles hold significant pedagogical limitations, mainly due to lack of classroom interactivity and inadequate opportunities for feedback (American Psychological Association, 1997; Bransford, Brown, & Cocking, 2000). Simply stated, transmitting information from the teacher to the learner in a lecture does not sufficiently ensure that every student will have the opportunity to learn the material (King, 1993; Mayer, 1996). Research in the field of educational psychology has shown that engaging students in *active learning* is a more effective teaching strategy (Anderson, 1987; Glaser, 1990; Jonassen, 1995). For our purposes, active learning simply means that students become *cognitively* engaged with the information presented; that is, they select, organize, and integrate new information into their existing knowledge structures, rather than just passively listening to someone else's version of the way things are (Mayer, 2002, 2004). Furthermore, from a social constructivist perspective, we assume that knowledge construction and understanding is significantly enhanced through human interaction (Brown, Collins, & Duguid, 1989; Driscoll, 2005; Lave & Wenger, 1991; Vygotsky, 1978). In the classroom, this type of interaction includes both instructor-learner and learner-learner communication and collaboration.

Recently, classroom response systems (CRSs) have received considerable attention in the educational technology literature, and their use in college classrooms has increased dramatically (MacGeorge et al., 2007). In several empirical studies, CRSs emerged as useful tools for engaging students in active learning during lectures, enhancing students' overall communication, and helping instructors create a more learner-centered classroom (see, for example, Beatty, 2004; Caldwell, 2007; Draper & Brown, 2004; MacGeorge et al., 2007; Siau, Sheng, & Nah, 2006). In

the spirit of creating a more learner-centered classroom, we (the instructors) adopted a CRS for our educational psychology undergraduate course in an effort to enhance interactivity, maintain student interest, and provide real-time, formative feedback to students and instructors. Students positively endorsed our use of the technology, which encouraged us to use the CRS for an in-class, summative, group assessment. Thus, in this study, our goal is twofold: (a) to discuss the pedagogical affordances of CRSs as they relate to enhancing interactivity, maintaining student interest, and providing real-time, formative feedback; and (b) to speculate on the efficacy of CRSs to support group test-taking, which may help to mitigate test anxiety and make assessment a more enjoyable activity. We base our discussions on qualitative and qualitative data from our students, as well as on our own experiences as instructors.

Review of the Literature

Classroom response systems appear in the literature under different names, including classroom communication systems, classroom performance systems, electronic response systems, personal response systems, electronic voting systems, clickers, and polling systems (Fies & Marshall, 2006). The classic CRS consists of transmitters that students use to send responses, a receiver that collects these inputs, and computer software that collates responses and displays results. Typically, students respond to an instructor's multiple-choice questions and then histograms, representing students' answers, can be produced and viewed by instructors and students. Moreover, the software allows instructors to easily keep records of their questions, as well as their students' answers. When a CRS is used in anonymous mode, it allows students to confidentially enter responses without fear of failure. When used in named mode, instructors have the ability to analyze and grade the in-class activity and to generate detailed reports for each individual.

CRSs have been used in college classrooms since at least the mid-1990s, although the popularity of these systems has recently increased dramatically (MacGeorge et al., 2007). Past research on the use of CRS technology in the classroom has focused on (a) its effects on student achievement, attitude, and motivation, and (b) effective pedagogical practices in CRS-enhanced classrooms. For example, the *ClassTalk* program pioneered the effective use of CRSs in physics classrooms at the University of Massachusetts. Dufresne, Gerace, Leonard, Mestre, and Wenk (1996) used ClassTalk in four different introductory physics courses over a three-year period to create a more interactive, student-centered classroom. During a CRS-facilitated lecture, the following activities occurred: (a) the instructor presented questions, (b) students worked in groups to reach a solution, (c) students voted either individually or in groups, (d) a histogram of the results was displayed, and (e) a class-wide discussion followed until consensus was reached. Data collected in the form of student and instructor interviews, as well as end-of-semester student questionnaires, favored the use of the CRS. The vast majority of students expressed a high degree of satisfaction with the way the CRS was used in the classroom; they found CRS-facilitated lectures more enjoyable and believed that they had learned more. The instructors reported that the CRS helped them engage students in active learning and improved classroom communication (Dufresne et al., 1996).

Since the pioneering study of Dufresne et al. (1996), many others have examined the effectiveness of CRSs in the classroom, predominately in large enrollment courses. For instance, Fies and Marshall (2006) conducted a review of 24 selected publications[1] concerned with CRSs and their instructional use. The authors found that the most commonly-stated student benefits of CRSs were improved attendance and participation, as well as enhanced perceptions of classroom

[1] The *ClassTalk* study (Dufresne et al., 1996) was included in the 24 investigations selected for the review by Fies and Marshall (2006).

interactivity (i.e., the students felt the class was more interactive, more engaging, and more enjoyable). Moreover, a number of researchers indicated that CRSs helped students and instructors become more aware of students' understanding, which ultimately improved instruction. The capability of CRSs to provide anonymous participation was also perceived as a critical feature that allows even shy students to become actively engaged in classroom activities (Fies & Marshall, 2006). Additionally, the review revealed that most of the studies of CRS use in the classroom followed a stimulus-response, behaviorist approach, where students responded to multiple-choice questions and then received appropriate feedback. Only a limited number of studies were found that employed CRSs using constructivist pedagogy, with emphasis on instructor-learner and learner-learner interactions (Fies & Marshall, 2006). Finally, most of the CRS research was done in science courses, especially undergraduate physics courses (Fies & Marshall, 2006), which might suggest that CRSs have yet to be shown beneficial (or at least are not widely used) in social science, psychology, and education classrooms.

In a noteworthy study conducted by Siau et al. (2006), the researchers followed a pretest-posttest, quasi-experimental design to explore whether CRSs improved classroom interactivity in a systems analysis and design course. In this study, students received lecture-based instruction for the first half of the semester and then received CRS-enhanced instruction until the end of the semester (about eight weeks). Prior to introducing the CRS, the instructor used oral questioning and answering as a mechanism for facilitating instructor-learner interaction. This practice was considered problematic since not all students were willing to express their opinions in front of the class, and there was no way for the teacher to know whether all students were keeping pace with the instruction (Siau et al., 2006). A pretest was administered to the students just before the

CRS was introduced, and a posttest was given at the end of the semester. Results suggested that interactivity, at both the individual and class levels, increased significantly after CRS use.

In a more recent review, Caldwell (2007) examined the literature on applications and classroom outcomes of CRS use in large-enrollment classes. The author found that CRSs have been successfully used primarily to (a) increase classroom interactivity, (b) assess student preparation, (c) find out more about students (e.g., their thoughts and attitudes), (d) conduct formative assessments, and (e) review materials and practice problems. Overall, the use of a CRS was found to increase classroom interactivity (learner-learner and learner-instructor interaction) and engagement in class activities, to improve student understanding and learning, to improve achievement on exams, to increase attendance, to provide real-time feedback to instructors about student misconceptions, and to promote a more positive, active, and fun atmosphere in the large classroom (see Caldwell, 2007).

Based on our review of the literature, there appears to be no consistent evidence that a CRS-enhanced lecture can actually facilitate greater learning gains than traditional lectures or other types of instruction. Although some researchers have asserted that CRSs favor learning gains over other traditional forms of instruction (e.g., Beatty, 2004; Roschelle, Penuel, & Abrahamson, 2004), others have found that the CRS learning effect is variable (e.g., Crossgrove & Curran, 2008; Duggan, Palmer, & Devitt, 2007; Judson and Sawada, 2002). That said, there does seem to be convincing evidence across studies regarding other positive CRS outcomes, such as those reported by Caldwell (2007) and Fies & Marshall (2006). Moreover, our review revealed that the use of CRSs for summative group assessments—or even for individual summative assessments (see Caldwell, 2007)—are relatively rare.

Collaborative Testing

Collaborative test-taking has been found to promote retention of material (e.g., Cortright, Collins, Rodenbaugh, & DiCarlo, 2003; Zeilik & Morris, 2004), critical thinking (e.g., Shindler, 2004), and overall enjoyment (e.g., Shindler, 2004; Stearns, 1996; Yuretich, Khan, & Leckie, 2001). Furthermore, it appears to be a fair and sound method of assessment (e.g., Shindler, 2004). At the same time, CRSs have been successfully used to promote collaborative learning during class activities (e.g., Dufresne et al., 1996; Lucas, 2007). Yet, studies examining the potential combined effect of CRS-enhanced, summative group assessments are almost non-existant. We managed to identify only one study (Bali & Keaney, 2007) experimenting with such innovative forms of assessments using clickers. Bali and Keaney (2007) implemented a CRS-enhanced group exam in a history class at an American institution of higher education in Egypt. During the exam (consisting of 30 multiple-choice questions) students answered each question twice, using their clickers: one time individually and a second time after a discussion with their pre-specified teammates (consisting of five students). To discourage "free-riding", the instructor assigned 70% of each student's grade on the initial individual response, and 30% of his/her grade on the second team response. Overall students' responses improved after team discussions. Moreover, the instructor observed that the exam was not only enjoyable for students, but actively engaged them in discussions. In fact, 95% of the students reported that they would like to participate in a similar activity again.

Purpose of the Study

The purpose of this small-scale, descriptive study was twofold:

1. To examine the pedagogical affordances of a CRS as they relate to enhancing interactivity, maintaining student interest, and providing real-time, formative feedback to students and instructors in a small educational psychology course; and

2. To evaluate the efficacy of a CRS to support collaborative test-taking, in an effort to mitigate test anxiety and make assessment a more positive educational experience for students.

Our study differs from previous CRS studies in at least three important aspects: (a) we used a CRS in an educational psychology course; our review of the literature failed to uncover any studies of CRS use in educational psychology courses; (b) we used a CRS in a relatively small enrollment class ($N = 33$); previous CRS studies were conducted predominately in large enrollment courses[2]; and (c) we experimented with innovative forms of assessment using a CRS; to the best of our knowledge, such efforts have been extremely limited.

Method

Participants

Thirty-three undergraduates were enrolled in our introductory educational psychology course. Students came from a variety of disciplines, including psychology, communications, English, and business. We obtained demographic information from 27 students during the first survey (see Instrumentation section). In particular, the sample consisted of 24 females (89%); 20 participants (74%) were seniors and 7 (26%) were juniors.

Procedures

The 75-minute class met in a traditional classroom for 16 weeks, twice per week, and was predominately lecture based. The class was taught by two instructors. On average, each instructor taught once per week. Both instructors attended all lectures. The CRS was introduced in the second week of classes and was used in the majority of the lectures throughout the remainder of the semester.

[2] In our review of the literature, we found several CRS studies that did not report the total class enrolment, but only the number of people interviewed or surveyed. Whenever this information was available, the class enrolments exceeded 70 students.

In general, we used the CRS to ask multiple-choice and/or true-false questions during the last 10 to 15 minutes of class. In all cases, we used the CRS in the anonymous mode. In a few sessions, we used the CRS to ask questions at the beginning of the lecture, in an effort to stimulate interest and generate discussion about the new topic, and to assess students' prior knowledge of the material. Our questions took various forms and were designed to do the following: (a) check for understanding of concepts (e.g., "Metacognition refers to which of the following…"); (b) to reveal points of confusion and misconceptions (e.g., "True-False: A teacher is employing anchored instruction any time a video is used"); (c) to engage students in reflective thought (e.g., "Which of the following teaching strategies reflects the idea of constructivism?"); or (d) to stimulate discussion around topics and ideas (e.g., "As an instructor, I believe that promoting competition between students is an effective motivational strategy").

Typically, we began by displaying the question along with all the possible answers. Students had 1 to 2 minutes to consider their response and to vote individually for a particular answer. Once all students had answered, a histogram was displayed and the correct answer was presented, if applicable to the question type. Based on the results for a given question, we initiated class-wide discussions in an effort to clarify misunderstandings. Class-wide discussions are thought to be effective because they challenge students to defend their choice in the context of a dialogue with their peers and the teacher (Dufresne et al., 1996). In most cases, we initiated discussions by simply asking for volunteers to state the reasoning underlying their selection, or by having students explain why they disagreed with a particular response. The most interesting discussions seemed to occur whenever the responses were normally (or almost normally) distributed, or whenever the majority of the students selected the incorrect answer. For instance, for the question "A teacher is employing anchored instruction any time a video is used," over

70% of the students chose "true" as the correct answer. In the discussion that followed, we aimed to help students more fully understand the idea of anchored instruction.[3] In a few cases, the discussions continued after class in an asynchronous, online environment using WebCT. On the other hand, whenever the vast majority of students provided the correct response to a question, we did not normally engage in extended discussions.

During the 10th week of classes, a short (10-minute) anonymous questionnaire was administered to investigate student attitudes towards the use of the technology (*CRS attitudinal questionnaire*). Although, on the whole, we were satisfied with the effectiveness of the CRS as a learning tool, we wanted to ensure that our students shared our opinion before we continued using it.

During the 14th week of classes we administered an in-class, summative group assessment using the CRS. Students worked collaboratively, in groups of two or three. Students were not given the option of working along, but they did choose their working groups. The exam was composed of 32 multiple-choice questions. Each group was assigned one clicker (in named mode). During the exam, there was a time limit of 90 seconds for voting; during this time students had the opportunity to discuss the question with their group and could change their answers as many times as necessary. The amount of time remaining to answer each question was provided on the visual display. When the voting time was over, results from the voting for that particular question were shown on the screen, thereby providing groups (and instructors) with immediate feedback regarding how well the groups were performing on the exam. A record of

[3] In anchored instruction the emphasis is in creating an *anchor* or focus that generates interest and enables students to identify and define problems. In the Adventures of Jasper Woodbury, the video materials serve as the anchors. Bransford, et al. (1990) claimed that there are advantages in providing video-based anchors, due to the richness if the medium. However, anchored instruction can also be achieved with printed media or stories presented verbally.

the responses received from each clicker/group was kept by the system to be retrieved by the instructors after the exam.

It is important to note here that students took a regular in-class exam on the same material a week before they took the CRS exam. Because our syllabus had promised a regular exam, and because we knew little (if anything) about the efficacy of the CRS for group test-taking purposes, we elected to administer both exams. The two exams, although they assess the same content, were composed of different test questions. In general, exam questions were designed to check for understanding of concepts and their application (e.g., "Which of the following scenarios demonstrate an example of vicarious reinforcement? Of the following, which is the most effective way to increase your self-efficacy in mathematics?). Only few questions were concerned with recall of factual knowledge (e.g., This is the "cognitive structure" where schemas are stored…; From a motivational perspective, "free and reduced lunch" programs are designed to address which theory of motivation?). Although, the exams were designed to have a similar difficulty level, the CRS exam included a few items that we felt required a deeper understanding of the course content or were controversial enough to warrant negotiation within a group (e.g., Of the following teaching strategies, which is most likely to foster a sense of self-determination? Which one of the following scenarios of learning an applied skill is most consistent with a constructivist approach?) The CRS exam served as an opportunity for our students to improve their grade (i.e., if their CRS group score was higher than their regular exam score), whilst it allowed us to examine the efficacy of this innovative, group assessment method.

At the end of the group exam, students were asked to complete a short (10-minute), anonymous questionnaire designed to assess their attitudes toward the group exam (*CRS group assessment questionnaire*).

Instrumentation

CRS attitudinal questionnaire. The questionnaire was modified from Siau et al. (2006; see Appendix A) and was designed to assess the following four constructs on a 7-point, Likert-type response scale ranging from 1 (*completely disagree*) to 7 (*completely agree*):

(a) level of student interactivity from an *individual* perspective (e.g., "I interact with the instructor in class");

(b) level of overall class interactivity (e.g., "Students are involved in learning during class");

(c) ease-of-use of the CRS (e.g., "I find it easy to get the clickers to work as intended");

(d) usefulness of the CRS (e.g., "I find the clickers useful in enhancing my interaction in the class").

Due to the small sample size, factor analysis could not be used to validate the unidimensionality of the subscales (Pett, Lackey, & Sullivan, 2003). However, based on previous research (Siau et al., 2006), the individual Likert-type items were expected to form four reliable subscales.

Two additional Likert-type items with a 7-point agreement response scale were also included in the *CRS attitudinal questionnaire*: (a) "When the clickers were used in class, my learning experience was enhanced?" and (b) "When the clickers were used in class, I understood the material better." Finally, participants responded to two open-ended questions: (a) "What are the advantages of using the clickers in the classroom?" and (b) What are the disadvantages of using the clickers in the classroom?"

CRS group assessment questionnaire. This questionnaire was initially developed by the us and underwent content-validation by a senior educational psychologist with extensive experience using a CRS in the classroom (see Appendix B).

The first part of the instrument queried students about the administration of the CRS exam (e.g., Approximately how many times - of the 32 items on the exam today - did your response to a question deviate from your partners?). A block of nine items were designed to assess students' attitudes towards the CRS group exam on a 7-point, Likert-type response scale ranging from 1 (*completely disagree*) to 7 (*completely agree*). Sample items included: "As far as learning is concerned, working in groups for this exam was beneficial" and "Had I worked alone on this exam, I would have done better." Due to the small sample size, factor analysis could not be used to examine whether these items formed one or more unidimensional subscales (Pett et al., 2003); thus we analyzed these item individually. In addition, the instrument included three open-ended questions concerning students' study practices for the CRS exam and test-taking experiences (items 5-9; e.g., Did you study differently for this CRS exam than you did for your regular exam. If so, how?).

Results

Attitudes Toward CRS Use

Descriptive statistics. Of the 33 undergraduates, 27 students completed the *CRS attitudinal questionnaire* (response rate = 82%). An internal reliability analysis was conducted on each subscale. The resulting Cronbach's alphas for the four subscale scores, presented in Table 1, were deemed acceptable (see guidelines in Gable & Wolfe, 1993).

Table 1

*Descriptive Statistics for the Four Subscales (*N = *27)*

Subscale	Items	Cronbach's Alpha	*M*	*SD*	Skewness			Kurtosis		
					Statistic	*SE*	Critical Ratio	Statistic	*SE*	Critical Ratio
Individual Interactivity	10	.91	4.9	1.0	-0.02	.45	-0.04	0.30	.87	0.34
Overall Class Interactivity	10	.94	5.9	0.7	-1.16	.45	-2.58 [a]	3.58	.87	4.11 [a]
Ease-of-Use	3	.81	6.8	0.4	-1.69	.45	-3.76 [a]	1.60	.87	1.84
Usefulness	2	.81	6.3	0.9	-1.11	.45	-2.47 [a]	0.35	.87	0.40

Note. The response scale ranged from 1 (*completely disagree*) to 7 (*completely agree*). Critical ratio = statistic / standard error.
[a] Values were outside the recommended acceptable range of ± 2.0 (Tabachnick & Fidell, 2007).

The variables used in the descriptive analysis were created by computing mean scores for the items associated with a particular subscale (i.e., the variables were un-weighted composite scores; Gable & Wolfe, 1993). Table 1 presents the means and standard deviations for the four variables. Overall, the variable means were quite high (≥ 4.9), suggesting that students' attitudes towards CRS use were generally positive. Standard deviations for the variables ranged from 0.4 to 1.0, and visual inspection of the associated histograms revealed that all four variables were negatively skewed. Moreover, three variables (overall class interactivity, ease-of-use, and usefulness) had distributions with evidence of severe negative skew (i.e., their skewness critical ratios [skewness statistic / standard error] were greater than 2.0; Tabachnick & Fidell, 2007). These negatively skewed distributions suggest that students' ratings of CRS use tended to fall above the midpoint of the distribution; that is, their ratings were generally quite positive. Finally, all four variable distributions were positively kurtotic (i.e., too peaked), and one variable distribution (overall class interactivity) was severely positively kurtotic (critical ratio > 2.0).

These findings indicate that students' ratings were tightly distributed around the relatively high mean scores for the four variables.

Responses to the two individual Likert-type items were equally positive. Specifically, students scored with a mean of 5.9 (*SD* = 0.8) in response to the item "When the clickers were used in class, my learning experience was enhanced," and with a mean of 5.6 (*SD* = 1.1) in response to the item "When the clickers were used in class, I understood the material better."

Qualitative results. Overall, students' responses to the qualitative questions regarding the advantages of using the CRS in the classroom supported our quantitative findings. Two researchers coded the qualitative data and agreed that five themes seemed to emerge:

1. *Feedback and Comprehension Monitoring*. Receiving immediate feedback and monitoring student understanding was the most highly-cited benefit of the CRS. Students highlighted that the CRS helped them realize what they did and did not understand from the lecture. A few students reported that using the CRS at the end of the lecture was a great way to review the material, which ultimately reinforced their learning.

2. *Interactivity and Engagement*. Not surprisingly, interactivity and engagement were also frequently cited CRS benefits. Students explained that the CRS increased their individual involvement and participation in the class.

3. *Anonymity*. Students stated that the anonymity feature made it easier to participate in the class without feeling embarrassed if their answers were wrong.

4. *Peer Comparisons*. Some students commented that the CRS helped them evaluate how they were doing in relation to their peers. They reported that such information made them feel better about their capabilities.

5. *Increased Learning Enjoyment and Attention*. Many students found that, in general, the CRS helped make the class more enjoyable and also helped direct their attention toward the relevant material.

Finally, students were asked to identify disadvantages of using the CRS. More than half of the students did not respond to this question, or said that they did not see any disadvantages. A few students mentioned that the CRS consumed too much lecture time; two students discussed that learners may have been distracted by the novelty of technology; one student felt that several peers did not take the assessment seriously; and two students reported that the 1 to 2 minute time limit for answering CRS questions was, at times, very stressful. All the advantages and disadvantages reported by our students were consistent with findings from previous research (e.g., Elliott, 2003; Fies & Marshall, 2006; Siau et al., 2006).

Attitudes Toward CRS Group Assessment

All students ($N = 33$) completed the *CRS group assessment questionnaire*. With respect to the administration of the CRS exam, the majority of the students ($n = 22$) reported that their response to a question deviated from their partner(s) answer only one or two times. Approximately half of the students ($n = 15$) reported that 90 seconds was the perfect amount of time for each question, while another 16 students reported that they need a little more time (i.e., like 2 minutes). The majority of the students reported that if they had to take another test in this class, they would you prefer a group CRS exam ($n = 21$), versus a regular exam ($n = 7$), or an individual CRS exam ($n = 1$).

Table 2 presents the means and standard deviations for the nine Likert-type variables concerned with students' attitudes toward the CRS group exam. Overall, the variable means were quite high (≥ 5.1) for the positively-worded items and low (≤ 3.7) for negatively-worded items,

suggesting that students' attitudes towards CRS-enhanced, summative group assessment were generally positive. On average, students felt that as far as learning is concerned, working in groups for this exam was beneficial ($M = 5.7$). Moreover, they reported that they enjoyed this kind of assessment ($M = 5.6$), and they believed that it was as beneficial ($M = 5.5$) and as fair ($M = 5.1$) as a regular exam. Students said they would like to participate in this type of assessment in more classes ($M = 5.4$). Particularly noteworthy were three variables (items 1, 4, and 9) that had distributions with evidence of severe negative skew (i.e., their skewness critical ratios [skewness statistic / standard error] were greater than 2.0; Tabachnick & Fidell, 2007). These negatively skewed distributions suggest that students' ratings of CRS use tended to fall above the midpoint of the distribution; that is, their ratings on these three items were quite positive.

The majority of the students ($n = 28$) reported that they studied again for the CRS exam after taking the regular exam, for approximately two hours on average. When students were asked how they studied differently for the CRS exam, 18 students reported that they studied in the same manner. Another 15 students explained that they focused on the material they felt they struggled with during the regular exam. Among them, four students (from two different groups) reported that they studied together with their teammates for the CRS exam.

Students not only reported that they enjoyed this type of assessment, but they also performed quite well. Students scored significantly higher (mean difference = 8.1, $t(32)= 5.0$, $p < .001$) on the CRS group exam ($M = 84.2\%$, $Mdn= 84$, $SD = 6.6$) than on the regular exam ($M = 76.1\%$, $Mdn = 76$, $SD = 8.4$). Not surprisingly, when students were asked if they learned the material better by taking a second exam, 30 students (91%) responded positively. Revisiting the material and learning from their mistakes on the first exam were the most highly-cited reasons

why students felt they learned more. A few students reported that negotiating and getting feedback from their group help them understand the material better.

Table 2

*Descriptive Statistics for the Nine Variables in the CRS group assessment questionnaire (*N = *33)*

Subscale	*M*	*SD*	Skewness			Kurtosis		
			Statistic	*SE*	Critical Ratio	Statistic	*SE*	Critical Ratio
1. Getting feedback right away regarding our groups' responses improved my understanding of the material.	5.1	1.3	-0.98	.41	-2.39 [a]	1.50	.80	1.88
2. Getting feedback right away on our groups' responses stressed me out.	3.5	1.6	0.00	.41	0.00	-1.28	.80	-1.60
3. The 1.5-minute time constraint stressed me out.	3.7	1.7	0.04	.41	0.10	-1.11	.80	-1.39
4. As far as learning is concerned, working in groups for this exam was beneficial.	5.7	1.1	-0.86	.41	-2.10 [a]	0.59	.80	0.74
5. I really enjoyed this kind of assessment.	5.6	1.5	-0.59	.41	-1.44	-0.60	.80	-0.75
6. Had I worked alone on this exam, I would have done better	3.2	1.2	-0.13	.41	-0.32	0.26	.80	0.33
7. I would like to participate in this type of assessment in more classes.	5.4	1.4	-0.64	.41	-1.56	-0.15	.80	-0.19
8. This type of assessment is just as fair as a regular exam.	5.1	1.4	-0.31	.41	-0.76	0.41	.80	0.51
9. As far as learning is concerned, this type of assessment is as beneficial as a regular exam.	5.5	1.4	-0.88	.41	-2.15 [a]	0.80	.80	1.00

Note. The response scale ranged from 1 (*completely disagree*) to 7 (*completely agree*). Critical ratio = statistic / standard error.
[a] Values were outside the recommended acceptable range of ± 2.0 (Tabachnick & Fidell, 2007).

Student feedback on the last open-ended survey question highlighted that the CRS-enhanced group assessment was enjoyable, less stressful, promoted student understanding, and should be adopted for other courses. These views were endorsed when students had the opportunity to speak about their perceptions of the CRS group exam in a class-wide discussion

the week after the exam. Also, a few students mentioned minor concerns such as "the clicker did not change one of our answers" and "bigger font size when presenting a question would help."

Discussion

Current views of learning challenge the effectiveness of traditional pedagogical practices, such as lecturing, by emphasizing the need for learners to become cognitively engaged in their own learning (Anderson, 1987; Glaser, 1990; Jonassen, 1995; King, 1993; Mayer, 2002, 2004). At the same time, the availability of CRSs has expanded dramatically during the last 10 years, with vendors marketing these devices as promising tools to help instructors create a more interactive, learner-centered classroom. CRSs have been predominately used in large enrollment science education classrooms. We successfully used a CRS in a small undergraduate educational psychology course to enhance interactivity and engagement. Consistent with other research (e.g., Duggan et al., 2007; Fies & Marshall, 2006; Siau et al., 2006), we found that students positively endorsed our use of the CRS in the classroom and felt it was an innovative method for (a) checking students' understanding of material covered; (b) enhancing classroom interactivity; (c) maintaining student interest, engagement, and concentration; and, (d) making lectures more enjoyable.

Moreover we used the CRS to administer a summative group assessment. Student data support the view that, at the very least, the CRS-enhanced group assessment was enjoyable, less stressful, and was perceived to be as fair and beneficial as a regular exam. These findings are consistent with resent studies on collaborative assessment (e.g., Bali & Keaney, 2007; Cortright et al., 2003; Zeilik & Morris, 2004; Shindler, 2004).

We believe that such outcomes would not have been observed without the unique affordances the CRS brought to the classroom, such as its anonymity attribute during formative

assessments and its ability to display real-time feedback on a group responses during the summative group assessment (see Kozma, 1994, for a discussion of media attributes and their influence on learning). Clearly, however, more research is needed to provide additional evidence for this assertion. Further, we also endorse the argument by Trees and Jackson (2007) that putting clickers in students' hands does not guarantee student engagement and learning. The potential for CRSs to transform the classroom relies heavily on the instructor's pedagogical practices and on students valuing and understanding the relevance of the CRS activities for their learning.

Instructor Evaluations

Consistent with our students' attitudes, we believe that one of the most valuable benefits of the CRS was that it afforded us the ability to conduct real-time, formative assessments of student understanding. In doing so, we were better able to identify materials that needed to be revisited in subsequent lectures or in online discussions. Although it is possible for instructors to effectively use questioning during traditional lectures (i.e., without the use of a CRS), we generally agree with Siau et al. (2006) that this technique can be problematic. First, it can be easy for an instructor who is deeply devoted to lecturing to unintentionally skip the practice of student questioning. And second, when instructors *do* effectively employ questioning, not all students will choose to participate and, due to time limitations, it is unlikely that all students can be given the opportunity to respond. We believe that incorporating a CRS into classroom instruction not only encourages the instructor to plan for good questions ahead of time, but it also gives *all* students the opportunity to answer and, as such, is a more effective way to keep the instructor informed of student comprehension.

We also believe that the CRS made it easier to engage students in learning, allowing them to become more actively involved in constructing their own understanding of the material. It is interesting to note that we found students to be rather unmotivated when asked to engage in other types of in-class, collaborative activities and group discussions. However, the CRS seemed to make in-class participation much easier; not only did students enjoy the process, they reported being more engaged overall. It is also worth noting that we used the CRS in the anonymous mode (except for the CRS group assessment), and we did not give students class credit for participating in the CRS discussions. Regardless, during all CRS activities, class participation was extremely high.

Not only did the CRS seem to make in-class participation easier and more enjoyable, it also encouraged *more* students to speak out. We observed that some of the quieter students were more inclined to speak out in class once they realized (from reviewing the histogram) that they had selected the correct answer. What is more, even when students had the *wrong* answer, they tended to speak out, possibly due to the fact that, after reviewing the histogram, they knew that many other students had the same misconceptions. We also believe the CRS helped many students maintain their focus during the last 10 to 15 minutes of class, a time when students are often too exhausted to effectively attend to the lecture material.

Finally, CRSs appear to expand the possibilities for instructors to implement innovative assessment methods, such as CRS-enhanced, summative group assessments. Consistent with social constructivist views of learning (e.g., Brown, Collins, & Duguid, 1989; Bruner, 1986; Pea, 1994; Vygotsky, 1978), collaborative test taking might be capable of improving student learning as a means of testing understanding and evaluating alternatives (e.g., Bali & Keaney, 2007; Zeilik & Morris, 2004). As a group test-taking tool, the CRS was well received by students and

served its intended purpose. Students felt that this new type of assessment was beneficial, fair, and enjoyable. From our perspective, this kind of assessment required some extra time, including: assigning CRS receivers to groups, inserting the questions into the system, and actually controlling the system during the exam. However, in the end, it actually reduced the clerical work for the instructors once the exam had been administered, by eliminating the need to grade by hand. Furthermore, most CRS software can easily generate a variety of reports, including group reports and classroom statistics, thereby speeding up the final grading process.

Limitations and Future Directions

First, the present study was a descriptive account of our experience using a CRS in a small educational psychology course. Our discussion was based on student data and our own recollections at the end of the semester. As such, our findings have limited generalizability beyond the specific students, learning tasks, and situations examined in this study. Furthermore, the descriptive nature of our study does not allow for causal conclusions concerning the efficacy of CRSs in promoting student engagement, classroom interactivity, and, ultimately, student understanding and retention of course material. Therefore, it is important that future work utilize experimental designs to investigate whether CRSs, and the instructional methods associated with their use, have the capability to positively impact these adaptive academic outcomes. Furthermore, in order to better appreciate the positive (and possibly the negative) effects of CRSs on learning, future research should focus on understanding how learners and instructors employ the unique capabilities of this technology inside the classroom (Kozma, 1994).

Another important limitation of this study was the use of self-reports to measure active learning. Like any survey, the one used in this study has reliability and validity limitations. Moreover, several scholars have argued that self-reports often bear little resemblance to students'

actual academic behaviors (e.g., Baumeister, Vohs, & Funder, 2007; Nesbit & Hadwin, 2006). Therefore, to help clarify how CRSs, and the instructional methods associated with their use, ultimately influence students' active learning, future research should include more direct, behavioral indicators of individual and class-wide interactions. Moreover, the CRS attitudinal survey was given only once during the semester (during the 10th week). It would be informative to survey students at different time points during the course. Finally, some of our measures of student perceptions were single-item assessments, especially in the case of the *CRS group assessment questionnaire*. Future work should make use of validated subscales for the constructs of interest.

Last but not least, we recognize that our approach to implementing the CRS–enhanced, summative group assessment involved a number of limitations. As discussed earlier, the CRS exam was given a week after a regular exam and it assessed the same content. It is plausible that the statistically significantly higher CRS exam scores may have been due to a practice effect (i.e., reviewing material again after the exam, practice answering test items even though they assessed different content, etc.) and not the CRS assessment method itself. In fact, survey data confirmed that the majority of the students studied again after the regular and before the CRS exam. Moreover, our framing the CRS exam as an extra credit opportunity (i.e., students were told that they could improve their grade if their CRS score was higher than the regular exam) may have biased results in favor of the CRS. Higher CRS scores might have been due to students being more motivated to achieve in this format in order to improve their grade. Additionally, students' positive comments that the CRS exam was more enjoyable, less stressful, and enhanced their learning may also have been the result of students viewing it as extra credit and not due to the nature of the CRS assessment at all.

One way to circumvent the problems described above would be to counterbalance the administration of the regular and CRS exams (i.e., half the class would get the CRS exam followed by the regular exam, and the other half would get the reverse). To maintain fairness, students could be told that the higher score would prevail for their grade. Another methodologically sound approach to implementing the CRS-enhanced, summative group assessment is the one followed by Bali and Keaney (2007; see literature review section), as their approach also discouraged "free-riding", another limitation of our study. In sum, future attempts to implement CRS-enhanced summative group assessment should be conducted more rigorously to address the limitations described above.

Other Future Directions

The design and development of effective CRS questions appears to be crucial in achieving desirable outcomes. Moreover, creating effective questions requires considerable time and effort on the part of the instructor. Although we did invest significant time and effort in the design and development of our CRS questions, we inevitably found that some questions were less effective than others. In future studies, we intend to dedicate more time to question development and, furthermore, we plan to integrate the CRS into the course curriculum more fully (i.e., to include questions that extend beyond the material found in the textbook).

Understanding the purpose and opportunities and recognizing the potential value of using CRSs in the classroom might help students utilize the technology more effectively (see also discussion by Trees and Jackson, 2007). We observed that it took from two to three weeks (four to six lectures) for students to get accustom to the CRS, see its relevance to their learning, and take full advantage of the CRS activities. As the semester progressed, students became more enthusiastic about the activities and seemed to engage more actively in the discussions. Had

students been introduced to the CRS during the first day of class, this might have accelerated their engagement and enhanced their overall attitudes toward the technology. In future studies, we plan to give students practice with the CRS during the first day of class, as well as provide them with a short overview of the research evidence regarding the positive benefits of using CRSs in the classroom.

During our experience with the CRS, we often used the technology during the last 10 to 15 minutes of class, mainly from fear of falling behind on our schedule of material to be presented. However, this practice introduced an important limitation: if knowledge gaps, misconceptions, and/or interesting ideas for discussion arise during those last few minutes of class, they have to be postponed for the next class or be revisited in online discussions. In future studies, we intend to present CRS questions at several time points during the lecture. We expect that this practice will allow us to respond to students' needs as they arise and to dynamically change the lecture based on what students want/need to know. Related to this, it would be interesting to examine whether presenting CRS questions at regular intervals results in even higher levels of student engagement and classroom interactivity.

Furthermore, as discussed earlier, we usually revealed the correct answer for a CRS question as part of the histogram presentation. From our vantage point as instructors, this practice seemed to encourage shy students to speak out in class. In future studies, we intend to explore whether students are still willing to defend their responses if the correct answer is not revealed, particularly when there is no clear majority of students voting for a specific answer.

Conclusion

Notwithstanding methodological limitations, results from this study suggest that a CRS can be utilized effectively to enhance interactivity and for summative group assessments in the

context of a small educational psychology course. Overall, students' experiences with our use of the technology were positive. At a minimum, students seemed to feel that the CRS enhanced individual and classroom interactivity, provided immediate feedback and comprehension monitoring, and helped maintain student attention and interest in the learning material. Based on these findings, we intend to conduct follow-on research using this innovative technology in our psychology classrooms. Ultimately, we hope that our ongoing use of the CRS—and the instructional methods that this technology affords—will continue to support students' active learning and construction of meaningful understanding.

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Appendix A

The CRS Attitudinal Questionnaire

This course survey is concerned with your opinions about the interactivity of this course.

The following statements relate to your opinions regarding the interactivity of this course from an individual standpoint (that is, the class interactivity with respect to you as a student).

Using the scale below, select the extent to which you agree with each statement.

completely disagree 1	mostly disagree 2	tend to disagree 3	neutral 4	tend to agree 5	mostly agree 6	completely agree 7

Statement							
1. I interact with the instructor in class.	1	2	3	4	5	6	7
2. I am involved in learning during class.	1	2	3	4	5	6	7
3. I am engaged in class.	1	2	3	4	5	6	7
4. I am attentive in class.	1	2	3	4	5	6	7
5. I participate in class discussion.	1	2	3	4	5	6	7
6. I provide my opinion to questions from the instructor during the class.	1	2	3	4	5	6	7
7. I receive feedback in class on my understanding of the course materials.	1	2	3	4	5	6	7
8. I receive feedback from the instructor during the class.	1	2	3	4	5	6	7
9. I can gauge whether I am following the course materials during class.	1	2	3	4	5	6	7
10. I can assess my understanding of the course materials with respect to other students during the class.	1	2	3	4	5	6	7

The following statements relate to your opinions regarding the overall interactivity of this course (that is, the class interactivity with respect to all of the students in this course).

completely disagree 1	mostly disagree 2	tend to disagree 3	neutral 4	tend to agree 5	mostly agree 6	completely agree 7

Statement							
1. Students interact with the instructor in class.	1	2	3	4	5	6	7

2. Students are involved in learning during class.	1	2	3	4	5	6	7
3. Students are engaged in class.	1	2	3	4	5	6	7
4. Students are attentive in class.	1	2	3	4	5	6	7
5. Students participate in class discussion.	1	2	3	4	5	6	7
6. Students provide their opinions to questions from the instructor during the class.	1	2	3	4	5	6	7
7. Students receive feedback in class on their understanding of the course materials.	1	2	3	4	5	6	7
8. Students receive feedback from the instructor during the class.	1	2	3	4	5	6	7
9. Students can gauge whether they are following the course materials during class.	1	2	3	4	5	6	7
10. Students can assess their understanding of the course materials with respect to other students during the class.	1	2	3	4	5	6	7

The following statements relate to your opinions regarding the ease of use of the classroom response systems (i.e., the clickers).

completely disagree 1	mostly disagree 2	tend to disagree 3	neutral 4	tend to agree 5	mostly agree 6	completely agree 7

Statement							
1. It is easy for me to become skillful at using the clickers.	1	2	3	4	5	6	7
2. I find it easy to get the clickers to work as intended.	1	2	3	4	5	6	7
3. I find the clickers easy to use.	1	2	3	4	5	6	7

The following statements relate to your opinions regarding the usefulness of the classroom response systems (i.e., the clickers).

completely disagree 1	mostly disagree 2	tend to disagree 3	neutral 4	tend to agree 5	mostly agree 6	completely agree 7

Statement							
1. Using the clickers increases my interaction in the class	1	2	3	4	5	6	7

2. Using the clickers makes it easier for me to interact in the class.	1	2	3	4	5	6	7
3. I find the clickers useful in enhancing my interaction in the class.	1	2	3	4	5	6	7

When the clickers were used in class, my learning experience was enhanced?

completely disagree 1	mostly disagree 2	tend to disagree 3	neutral 4	tend to agree 5	mostly agree 6	completely agree 7

When the clickers were used in class, I understood the material better.

completely disagree 1	mostly disagree 2	tend to disagree 3	neutral 4	tend to agree 5	mostly agree 6	completely agree 7

What are the advantages of using the clickers in the classroom?

What are the disadvantages of using the clickers in the classroom?

Are you a (circle one)…

Junior
Senior

Are you male or female?

Male
Female

What is your age in years?

Appendix B

CRS Group Assessment Questionnaire

1. Approximately how many times (of the 32 items on the exam today) did your response to a question deviate from your partner(s)?

A. Almost Never
B. Once or twice (1-2)
C. Three to five times (3-5)
D. Seven to nine times (7-9)
E. Ten or more times (>10)

2. On this exam your group was given 1.5 minutes for each question. In the future, it would be better if groups had…

A. a lot more time (like 3 minutes or more)
B. a little more time (like 2 minutes)
C. the same amount of time (1.5 minutes was perfect)
D. a little less time (1 minute would do)
E. a lot less time (30 to 45 seconds would be enough)

3. If you were to take this CPS test alone, how much time would you like to have to answer each question?

A. 3 minutes or more
B. 2 minutes would be perfect
C. 1.5 minutes would do
D. 1 minute for me please
E. Less than 1 minute

4. If you had to take another test in this class, which of the following test formats would you prefer?

A. Just me and the scantron sheet (i.e., the "bubble sheet")
B. Just me and the CPS clicker
C. Me, my group, and the CPS clicker (like we did today)
D. I don't have a preference

A1. Getting feedback right away regarding our groups' responses improved my understanding of the material.

completely disagree **1**	mostly disagree **2**	tend to disagree **3**	neutral **4**	tend to agree **5**	mostly agree **6**	completely agree **7**

A2. Getting feedback right away on our groups' responses stressed me out.

completely disagree **1**	mostly disagree **2**	tend to disagree **3**	neutral **4**	tend to agree **5**	mostly agree **6**	completely agree **7**

A3. The 1.5-minute time constraint stressed me out.

completely disagree **1**	mostly disagree **2**	tend to disagree **3**	neutral **4**	tend to agree **5**	mostly agree **6**	completely agree **7**

A4. As far as learning is concerned, working in groups for this exam was beneficial.

completely disagree **1**	mostly disagree **2**	tend to disagree **3**	neutral **4**	tend to agree **5**	mostly agree **6**	completely agree **7**

A5. I really enjoyed this kind of assessment.

completely disagree **1**	mostly disagree **2**	tend to disagree **3**	neutral **4**	tend to agree **5**	mostly agree **6**	completely agree **7**

A6. Had I worked alone on this exam, I would have done better.

completely disagree **1**	mostly disagree **2**	tend to disagree **3**	neutral **4**	tend to agree **5**	mostly agree **6**	completely agree **7**

A7. I would like to participate in this type of assessment in more classes.

completely disagree **1**	mostly disagree **2**	tend to disagree **3**	neutral **4**	tend to agree **5**	mostly agree **6**	completely agree **7**

A8. This type of assessment is just as fair as a regular exam.

completely disagree **1**	mostly disagree **2**	tend to disagree **3**	neutral **4**	tend to agree **5**	mostly agree **6**	completely agree **7**

A9. As far as learning is concerned, this type of assessment is as beneficial as a regular exam.

completely disagree **1**	mostly disagree **2**	tend to disagree **3**	neutral **4**	tend to agree **5**	mostly agree **6**	completely agree **7**

5. Did you study again for this CPS exam after taking your regular exam (i.e. after taking exam 2 from last week)?

A. Yes
B. No

6. If yes, for approximately how long did you study for this CPS exam?

_____ hours

7. If yes, did you study differently than you did for exam 2 from last week? If so, how?

8. Did taking a second exam on the same material help you learn the material better? If so, how?

9. Do you have anything else you want to tell us with respect to today's CPS exam?