Benefits of Electronic Audience Response Systems on Student Participation, Learning, and Emotion

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We compared an electronic audience response system (clickers) to standard lecture, hand-raising, and response card methods of student feedback in simulated introductory psychology classes. After hearing the same 30-min psychology lecture, participants in the clicker group had the highest classroom participation, followed by the response card group, both of which were significantly higher than the hand-raising group. Participants in the clicker group also reported greater positive emotion during the lecture and were more likely to respond honestly to in-class review questions.

Increasing student participation is one of many strategies that might lead to improved student learning. To increase student participation, instructors can use "active student responding" methods (Heward, 1994). One method is the use of paper response cards, with possible answer choices such as True/False or A/B/C/D that students can hold up when the instructor poses a question. Response card usage has resulted in increased student participation and improved academic performance (Gardner, Heward, & Grossi, 1994).

More recent active student responding methods incorporate technology that allows students to send their responses electronically from hand-held keypads (clickers) to a receiver attached to a computer. The computer instantly tallies and graphically displays student responses on the computer screen.

Our study examined the impact of clickers on student participation and academic performance. Additionally, we investigated the effect of clickers on academic emotions "directly linked to academic learning, classroom instruction, and achievement" (Pekrun, Goetz, Titz, & Perry, 2002, p. 92). Academic emotions are related to important processes associated with academic performance including metacognition, strategy usage, and working memory functioning (Pekrun, Elliot, & Maier, 2006). Therefore, it is important to know not only how instructional techniques impact knowledge acquisition but also academic emotion (Nelson & Manset-Williamson, 2006).

As noted by others, one of the main differences between clickers and other student responding methods is the former's allowance of anonymous responding. Students privately press a button on their clicker, whereas other forms of active student responding (e.g., hand-raising, response cards) require conspicuous behaviors. Although a direct relation between such anonymity and academic performance is unknown, its potential impact on student participation and academic emotions is more apparent. For example, students who have tendencies toward introversion might be more willing to participate and might experience less negative academic emotions (e.g., anxiety, shame) when using an anonymous responding method.

Other major differences between electronic keypads and other student responding methods include more immediate feedback to instructors and the graphic display of polling results. Whether these differences result in improved academic performance and more adaptive academic emotions is unknown. The purpose of our study was to examine whether the use of clickers in an undergraduate setting would result in greater learning, participation, honesty of student feedback, and more positive academic emotions than other methods of student responding.

Method

Participants

One hundred forty undergraduate students enrolled in introductory psychology classes at a public regional institution in the Midwest participated. Of those, 70% were women and 77% were in their first year of college.

We recruited students from an introductory psychology research pool and awarded 1 hr of research participation credit toward their 4-hr requirement. As motivation to put forth effort on the learning assessment measures, we awarded entries into a drawing for a $25 gift certificate to a local store, based on their postlecture quiz performance.

Materials

Surveys. The Academic Emotions Questionnaire (AEQ; Pekrun et al., 2002) measures emotions over time in academic settings such as a lecture or examination. Twenty-three items measure enjoyment, hope, anger, anxiety, and hopelessness experienced before the event (AEQ-Before). Forty-two items measure enjoyment, hope, pride, anger, anxiety, shame, hopelessness, and boredom experienced during the event (AEQ-During), and 15 items assess enjoyment, pride, anger, shame, and hopelessness experienced after the event (AEQ-After). Participants rated individual items on a Likert scale ranging from 1 (*strongly disagree*) to 5 (*strongly agree*). We asked participants specifically about their emotions concerning the classroom lecture.

Response cards. We made response cards by laminating sheets of white paper, with the choices of 1 and 2 printed in 80-point Arial font at the top and bottom, respectively. A second response card had the choices 3 and 4 printed on it. After the instructor posed a multiple-choice question and said, "Answers please," students simultaneously raised their selected response card to show the instructor their answers.

Clickers. The clickers were approximately the size of a credit card and sent an infrared signal to a receiver attached to a computer. The polling software (TurningPoint, 2006) was seamlessly integrated into Microsoft PowerPoint and graphically displayed the percentage of individuals responding to each answer choice.

Depending on the time participants elected to participate (3:30 p.m. on a Tuesday or Thursday of 2 consecutive weeks), we assigned them to one of the following groups:

1. Standard lecture ($n = 34$). Throughout the lecture, the instructor spontaneously posed open-ended informal questions to students about the lecture material, calling on students who raised their hands.
2. Review questions: Handraising ($n = 35$). In addition to the informal questions, participants in this group received the closed-ended formal review questions (posed in a multiple-choice format) during the lecture. Students gave their answers to the review questions by raising their hands when asked how many thought each option was correct.
3. Review questions: Response cards ($n = 36$). Students in this group used response cards to indicate their answer to the formal review questions.
4. Review questions: Clickers ($n = 35$). Students used clickers to indicate their answers to the formal review questions.

Procedure

After providing informed consent, participants completed the AEQ-Before survey. Once they returned the survey, we told them they would be listening to a lecture on a topic in psychology and asked them to act as if they were in their regular psychology class by taking notes, asking questions, and making comments. The first author gave a 30-min introductory-level lecture on the organization of the nervous system, parts of the neuron, and how neurons work.

On different days, each group viewed the PowerPoint lecture in the same 50-seat classroom equipped with a computer and presentation software. An LCD projector displayed the computer monitor image on a white screen at the front of the classroom. From a front corner of the room, a camera videotaped the class.

Except for the standard lecture condition, we formally presented seven multiple-choice review questions, distributed throughout the lecture. After showing a formal review question on the screen, the instructor read aloud the question and four possible answers. After giving students a chance to indicate their answers in one of the ways described previously, the instructor stated the correct answer and continued with the lecture. The first author and an independent rater coded student participation and correctness of responses to the formal review questions from the videotapes. Tallies of participation and correctness by each rater were in high agreement, as indicated by an intraclass correlation coefficient of agreement of .98. In cases where there was a discrepancy, we used the mean values of the two raters for data analyses.

We counted the number of students who visibly provided an answer, the number of those who gave correct answers, and the number of visible nonresponders. We calculated formal participation rates as the number of responders divided by the total number of students.

We measured informal participation by counting the number of open-ended questions posed spontaneously by the instructor such as, "What branch of the nervous system is responsible for the fight or flight response?" We counted the total number of responses by the students to these questions and divided this by the number of informal questions asked to estimate an informal rate of participation.

After each lecture condition, participants completed the AEQ-During and the AEQ-After

Table 1. Participation Rates and Learning Performance by Assessment Technique

Group	Informal Participation Ratio*	% Formal Participation	% Correct, Formal Review Questions	% Correct, Postlecture Quiz
Standard lecture	1.00	–	–	57_a
Hand-raising	1.20	76_a	98_a	60_a
Response cards	1.21	97_b	$92_{a,b}$	52_a
Clickers	1.11	100_b	82_b	60_a

Note. Means with different subscripts are significantly different from each other at $p < .05$ in a Tukey post-hoc comparison.
*Ratio of number of responses received to the number of informal questions asked.

surveys. Next, they completed a 10-item quiz based on the lecture. Finally, participants completed a survey about demographic information, preexisting knowledge of the lecture topic, and a five-item evaluation of the classroom feedback technique using Likert-scale ratings ranging from 1 (*strongly disagree*) to 5 (*strongly agree*). The direction of the rating scale for the evaluation items was opposite that of the rating scale for the emotions items, which many participants did not notice. Thus, some participants rated the techniques poorly although providing comments that they were excellent. Consequently, we asked the five evaluation items one more time at the conclusion of the study by e-mailing participants and asking them to complete the questions again on a Web-based survey. Most of the participants (71%) responded to our request, and we report the evaluation data using only these participants.

Results

A series of analyses did not find significant differences between groups regarding their age, sex, race, enrollment in a particular section of introductory psychology, or grade point average (ps $> .05$). There were also no preexisting group differences on self-reported knowledge of the lecture topic. One participant in the standard lecture condition entered late and thus did not provide data about emotions experienced before the lecture.

Student Participation and Review Question Performance

Using a one-way ANOVA and a Tukey post-hoc comparison, we found a significant effect of group on formal participation rates, $F(2, 18) = 16.84$, $p < .001$ (see Table 2). Although informal participation rates were comparable between groups, formal participation was highest in the clicker group, followed by the response card group, both of which were significantly higher than the hand-raising group. In contrast, the hand-raising group performed the best on the formal review questions (M = 98% correct, range = 88–100% across the seven review questions), whereas the clicker group did the poorest (M = 82% correct, range = 66–97%). The greatest differences between these two groups on the percentage correct occurred on questions that were apparently more difficult, with greater difficulty defined as a lower percentage of all students who got the question correct. On the most difficult question, there was a 22% difference in the percentage correct between these two groups (88% – 66%), whereas there was only a 3% difference on the easiest question (100% – 97%). These differences might relate to the honesty of feedback, which we discuss later.

Postlecture Quiz

Planned contrasts among the three review question groups (M = 57%, *SD* = 16%) and the standard lecture group (M = 57%, *SD* = 21%) found no significant differences on postlecture quiz scores (ps $> .18$). However, the clicker group's performance on the formal review questions was closer to their performance on the postlecture quiz than the other groups (see Table 2), suggesting their answers to the review questions were a more honest (accurate) reflection of their actual learning.

Academic Emotions

Comparisons among groups on academic emotions experienced over time appear in Table 3. Entering group as a between-subject factor and time of measurement (before, during, after) as a within-subjects factor in an ANOVA did not result in any significant interactions. However, across time, enjoyment was lowest in the standard lecture condition, resulting in a

Table 2. Mean Emotion Ratings by Feedback Technique

Emotion/Group	Before	During	After
Anger			
Standard	1.85_a	1.74_a	1.40_a
Hand-raising	1.77_a	1.51_a	1.46_a
Response cards	2.00_a	1.51_a	1.37_a
Clickers	2.09_a	1.72_a	1.47_a
Anxiety			
Standard	1.99_a	1.77_a	
Hand-raising	1.73_a	1.63_a	
Response cards	1.73_a	1.76_a	
Clickers	1.75_a	1.75_a	
Boredom			
Standard		3.17_a	
Hand-raising		2.39_b	
Response cards		2.03_b	
Clickers		2.22_b	
Enjoyment			
Standard	2.51_a	2.35_a	2.86_a
Hand-raising	2.92_a	2.60_a	3.21_a
Response cards	2.94_a	2.80_a	3.17_a
Clickers	2.82_a	2.89_a	3.09_a
Hope			
Standard	3.21_a	3.21_a	
Hand-raising	$3.65_{a,b}$	3.71_a	
Response cards	$3.54_{a,b}$	3.58_a	
Clickers	3.52_b	3.54_a	
Hopeless			
Standard	1.72_a	1.49_a	1.59_a
Hand-raising	1.59_a	1.22_a	1.40_a
Response cards	1.46_a	1.32_a	1.46_a
Clickers	1.45_a	1.32_a	1.41_a
Pride			
Standard		2.62_a	2.88_a
Hand-raising		3.14_b	3.31_a
Response cards		3.20_b	3.23_a
Clickers		3.15_b	3.29_a
Shame			
Standard		1.65_a	1.65_a
Hand-raising		1.48_a	1.67_a
Response cards		1.52_a	1.76_a
Clickers		1.54_a	1.61_a

Note. Means with different subscripts are significantly different from each other at $p < .05$ in a Tukey post-hoc comparison. Scale anchors are from 1 (*strongly disagree*) to 5 (*strongly agree*).

significant main effect of group, $F(3, 135) = 3.02$, $p = .03$, $\eta_p^2 = .06$. Although comparable to each other, the three groups with review questions reported significantly less boredom and more pride than the standard lecture condition, resulting in main effects of group in each case, $F(3, 136) > 3.81$, $p < .01$. However, the sizes of these effects were small, $\eta_p^2 = .08$ and .13, respectively.

Evaluation of Assessment Techniques

As shown in Table 1, the three groups that used active student responding methods had higher overall ratings of their respective classroom feedback technique than the standard lecture condition, $F(3, 95) = 3.44$, $p = .02$. However, in a Tukey post-hoc comparison, the only groups that significantly differed from one another on the overall subjective evaluation of the feedback technique were the standard lecture and hand-raising conditions ($p < .05$).

Discussion

Our findings suggest that certain classroom feedback techniques have moderately large effects on honesty of student feedback and participation rates and small effects on academic emotions. The particular techniques we employed, however, did not appear to have any significant effect on quiz performance after a single lecture. The few empirical studies on the use of clickers to improve student quiz scores have produced mixed results (Ewing, 2006; Kennedy & Cutts, 2005; Lee & Bainum, 2006). The postlecture quiz might also have been too difficult, or students might not have been sufficiently motivated to do well on a quiz that did not affect their course grade.

Compared to the other assessment techniques, the clickers slightly increased student enjoyment during the lecture. Pekrun et al. (2002) found that positive academic emotions are related to adaptive academic-related processes such as flexible strategy usage and sophisticated metacognitive monitoring. Thus, it might not be the experience of enjoyment (or any other emotion) that mediates the benefits of clickers, but rather the enhanced cognitive processing (attention) associated with it. Further research is needed to determine if the relatively small effect sizes related to emotional changes in a single setting have greater cumulative effects over time.

The most apparent advantage of using the clickers was the increased honesty of student feedback. In response to the presumably easy review questions, nearly everyone in each group provided the correct answer. As mentioned earlier, only 66% of the clicker group provided the correct answer to the most difficult question, whereas 88% of the hand-raising group provided the correct answer. Postlecture quiz scores suggested that the clicker group's answers during the lecture more closely reflected how much they were actually

Table 3. Mean and Standard Deviation of Evaluation Items for Feedback Techniques

Evaluation Item	Standard Lecture $n = 21$		Hand-Raising $n = 28$		Response Cards $n = 27$		Clickers $n = 23$	
	M	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*
1. It was easy to learn how to use —.	3.67_a	1.28	$3.86_{a,b}$	1.21	$4.59_{b,c}$	0.89	4.74_c	0.54
2. I feel I would do better on quizzes using —.	3.24_a	1.26	4.14_b	1.21	$3.96_{a,b}$	0.98	$3.35_{a,b}$	1.19
3. I would recommend — be used in future classes.	3.29_a	1.19	4.29_b	1.08	$3.81_{a,b}$	1.18	$3.87_{a,b}$	1.25
4. Other instructors should use —.	3.29_a	1.06	4.29_b	1.08	$3.74_{a,b}$	1.16	$3.96_{a,b}$	1.02
5. I like using —.	3.14_a	1.28	4.29_b	1.01	$3.78_{a,b}$	1.22	4.22_b	1.04
Overall *M*	3.32_a	1.06	4.17_b	1.01	$3.98_{a,b}$	0.94	$4.03_{a,b}$	0.83

Note. Means with different subscripts are significantly different from each other across groups at $p < .05$ in a Tukey post-hoc comparison. Scale anchors are from 1 (*strongly disagree*) to 5 (*strongly agree*).

learning, whereas those in the hand-raising group appeared to be influenced by social conformity. Indeed, this conformity was noticeable in the videotapes when students would hesitate to raise their hands (or response cards) until a sufficient number of other students did. Although hand-raising is a quick and easy way to assess student understanding, it also appears to convey to the instructor the illusion that students are "getting it" when they are not. Use of response cards, which are more anonymous than hand-raising but less anonymous than the clickers, also appears to be susceptible to social influence because of students' hesitation until other students had responded. Over time, the cumulative effects of this illusion might have even more dramatic effects on students' understanding of class material because instructors are unlikely to repeat or elaborate on content they believe students understand.

Another important finding was the difference in participation rates across groups. Although there were no differences for informal participation, only 76% of the hand-raising group responded when asked formal review questions. In contrast, the clickers and response cards increased formal participation to nearly 100%. Thus, another advantage of clickers and response cards is that they create an avenue for interaction with students who might be too shy to speak or even raise their hands.

Although our minilecture was representative of a realistic classroom lecture in terms of content for an introductory psychology class, the lecture was somewhat shorter than a full lecture. In addition, the data are from a single occasion, with the lecture not given by the participants' regular introductory psychology teacher. Despite these limitations, the lecture provided during the study adequately approximated a realistic classroom lecture.

Based on our findings, we offer several recommendations. First, regardless of the classroom feedback technique, in-class review questions will likely increase student participation and reduce boredom. If technologically and financially feasible, a good choice for getting honest feedback, increased participation, and possibly greater student enjoyment is an audience response system with clickers. Although paper response cards are much less expensive and would be an acceptable second choice, they are also somewhat susceptible to the influence of social conformity.

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Notes

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