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Zachary D. Baumann^a, Kathleen Marchetti^b & Benjamin Soltoff^a

^a Pennsylvania State University

^b Dickinson College

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What's the Payoff?: Assessing the Efficacy of Student Response Systems

ZACHARY D. BAUMANN

Pennsylvania State University

KATHLEEN MARCHETTI

Dickinson College

BENJAMIN SOLTOFF

Pennsylvania State University

Student response systems, or “clickers,” have been presented as a way of solving student engagement problems, particularly in large-enrollment classes. These devices provide real-time feedback to instructors, allowing them to understand what students are thinking and how well they comprehend material. As clickers become more common, it is important to assess their impact on student learning and engagement. Utilizing individual-level data from introductory courses in political science, we demonstrate that students both approve of clicker usage and that they are positively associated with class performance. Using clickers to test students’ understanding of class concepts has positive effects on exam and essay scores even after controlling for previous levels of academic achievement, students’ evaluation of the technology, and other socioeconomic traits.

Keywords active learning, large classes, peer learning, student response systems, technology

Recent innovations in technology have substantially changed our concept of the classroom and effective pedagogy. Less than a decade ago, most college courses were taught according to the standard model of the professorial lecture and a relatively passive student audience. Today, faculty members have a wealth of technologically driven pedagogical approaches at their disposal with Student Response Systems (SRS), or “clickers,” being one of them. These handheld devices allow students to register answers to questions posed by the instructor throughout a lecture. Thus, clickers can measure student comprehension of course concepts, can take attendance or can facilitate discussion. Although many instructors have incorporated clickers into their courses, findings about their effectiveness are generally inconclusive.

In this study, we consider how clickers affect student grade performance in two sections of a large-enrollment introductory political science course. Where other research examines differences in aggregate class performance by comparing the

Address correspondence to Zachary D. Baumann, Lecturer, Department of Political Science, Pennsylvania State University, Pond Lab, University Park, PA 16802. E-mail: zbaumann@psu.edu

average grades of students in classes using technology to those in classes that do not (Caldwell 2007; Damron and Mott 2006; Evans 2012; Stowell and Nelson 2007), we relax the assumption that students are similar from semester to semester by directly observing their sociodemographic characteristics, attitudes, and individual academic predispositions. Our analysis builds on this earlier work to compare the grades of high versus low clicker users, controlling for other factors likely to influence class performance. We find evidence that clickers are positively related to student performance as measured by their scores on papers and exams. Consistently using clickers and providing opportunities for peer feedback helps students who answer questions correctly to earn higher grades, even after controlling for previous academic achievement, their evaluation of this technology, and other socioeconomic traits. Prior to discussing these findings, we consider previous work on clickers in the classroom and describe our data and methods.

Reviewing the Evidence for Clickers

There is a wealth of information regarding the benefits of using clickers to improve pedagogy and student learning. Some of the earliest studies on clicker usage and peer instruction developed out of the physical sciences (e.g., Duncan 2005; Mazur 1997; Zhang et al. 2005) but clickers have been used in classes as diverse as nursing (Halloran 1995), engineering (van Dijk, van den Ber, and van Keulen 2001; d’Inverno, Davis, and White 2003; Sticklen and Urban-Lurain 2006), philosophy (Draper and Brown 2002), economics (Simpson and Oliver 2006), and psychology (Draper 2002; Draper and Brown 2002). Applicable in a variety of class settings, studies of clicker use have been completed across different course types, ranging from large-enrollment courses to small classes of 15 or fewer students (Cue 1998; Draper and Brown 2002; Wit 2003).

Though appropriate for either class type, instructors of large-enrollment courses were often the first to incorporate clickers into their pedagogy. Given the structure of a large-enrollment course, many instructors lecture for long periods of time and there is less of a focus on student engagement or peer learning than one typically finds in a smaller classroom setting. As Trees and Jackson (2007) point out, large enrollment courses typically offer students few opportunities to discuss or critically evaluate the topics being taught, and the lecture alone may not be effective enough for students to truly learn the material (Duncan 2005). It is often difficult to keep students engaged in large-enrollment courses and encouraging critical thinking or grappling with difficult course concepts is virtually impossible (Cooper and Robinson 2000; Hoekstra 2008). In addition, students may feel disconnected from course content, their peers, and their instructor in a large, lecture-based course (Gleason 1986). Others have argued that this form of pedagogy encourages students to assume a passive, noncritically thinking role in the learning process (Boud 1981; McKeachie and Hofer 2002).

While fostering discussion and critical thinking may not be the initial goal of every course, it undoubtedly helps students to understand class material on a deeper level while engaging them in active learning. Active, or inquiry-guided, learning has become a popular pedagogical approach in the social sciences and allows students to take an active, participatory role in class (Atkinson and Hunt 2008; Stowell and Nelson 2007). This approach overcomes the limitations presented by lecture-based

models of instruction but is often best facilitated in smaller classrooms; it can be difficult for an instructor to incorporate discussion and deeper analysis into a class of several hundred students. As a result, many students in large-enrollment courses lack opportunities to collaborate with their peers when working through course material.

However, studies have shown that incorporating clickers into large-enrollment courses ultimately increases student interaction and involvement with course content (Kaplan 2011; Mollborn and Hoekstra 2010). As students see and hear more actively than they would during a traditional lecture, clickers help them pay attention and engage with classroom material; some even suggest that clickers enhance students' cognitive processing of course content (Gauci et al. 2009; Hoekstra 2008; Smith et al. 2009; Stowell and Nelson 2007). Instructors are also better able to adapt their teaching to meet students' needs as they receive instantaneous feedback regarding student comprehension of class topics via clicker responses (Caldwell 2007; Draper et al. 2002; Roschelle, Penuel, and Abrahamson 2004). Thus, clickers provide instructors with a more accurate depiction of student understanding than they previously had while simultaneously improving students' involvement with the class.

While feeling more involved with a course and having the opportunity to discuss class concepts are beneficial in terms of student interest, the effects of clicker use on student grade outcomes are less certain. Though students and instructors alike tend to think of clicker technology in a positive way (Beatty et al. 2006; Bunce, Van de Plas, and Havanki 2006; Evans 2012; McDermott and Redish 1999), it is generally unclear whether clickers' effects on student engagement are ultimately mirrored in higher grade outcomes. Clickers have a significantly positive effect on student attendance, which could matter in large-enrollment courses where it is difficult for many instructors to routinely keep track of students' attendance (Cue 1998; Hake 1998; Trees and Jackson 2007). Similarly, increased attendance is likely to correspond with better understanding of course content and higher grade outcomes. Those studies that attempted to parse out the separate effects of clicker usage on grade outcomes found that they have either a positive or insignificant effect on grade performance overall (Caldwell 2007; Knight and Wood 2005). However, several studies point out that there is insufficient evidence to draw permanent conclusions regarding the direct effects of clicker use on student grades (Roschelle, Penuel, and Abrahamson 2004; Simpson and Oliver 2006).

Ultimately, the literature on clicker usage suggests that their incorporation into large-enrollment courses will have positive effects on students' engagement and may increase performance in the class. At the very least, clickers will more strongly motivate students to attend, whether due to higher levels of interest in class content or because instructors now have the ability to easily monitor attendance. While the potential positive effects of clickers are obvious, much of the literature has been conducted on student learning in the physical sciences, with comparatively less work done in the social sciences and/or humanities. Research conducted in political science classrooms suggest these devices have efficacy (Evans 2012) by creating a more interactive environment where students are prompted to consider critical questions and to examine their level of understanding (Damron and Mott 2006). Furthermore, clickers may play a particularly important role to those students who are hesitant to participate or who do not feel comfortable discussing difficult topics (Holland, Schwartz-Shea, and Yim 2013; Ulbig and Notman 2012). This article contributes to this burgeoning literature via evidence from additional classes and through alternative methodological techniques in evaluations of the technology's effectiveness.

Using Clickers in an Introductory Political Science Classroom

Over the past several years, we have used clickers in an introductory, high-enrollment, political science course at a large, land-grant university. The university selected i>clicker as its preferred vendor, equipping its classrooms with the manufacturers' base stations (i.e., receivers) and requiring all faculty to adopt these devices if student response systems are used. The model of clickers selected by the university allows students to respond to questions with one of five response options: A, B, C, D, or E.¹ While more modern versions allow students to enter text or even use their phones as response devices, our study is conducted using these more rudimentary units.

Our course, Introduction to American National Government, typically attracts over 300 students from across the university and meets twice a week with no smaller recitation sessions. Only one section of this course is taught per semester, presenting us with a wide variety of students holding different levels of preexisting knowledge and interest in the subject material. Integrated throughout each lecture are several (about four to six) questions that ask students to demonstrate how well they understand the content covered, how concepts relate to current political events, or how they think and feel with regard to the political world. These questions assess levels of understanding while prompting students to think more carefully about the content they are consuming.

The questions asked during class tend to fall into one of three categories: opinion, application, and discussion. Opinion questions ask students to register their attitudes about a variety of ideas, policies, or scenarios and are useful in building interest in the subject matter. For example, asking an opinion question at the beginning of a lecture or new section can prompt students to think about course material via connections between course content and broader public debates outside the classroom. Unlike opinion questions, application questions require students to use course material to generate a response that can be assessed as correct or incorrect. These questions have a number of benefits, including gauging levels of student understanding, applying course materials to "real-world" political events, and helping students distinguish between similar or related ideas. Finally, discussion questions are meant to spark interest and debate. While similar to opinion questions, the goal of a discussion question is to introduce students to the public policy controversies they are likely to encounter outside the classroom and to cause them to discuss the insights that can be gleaned from the literature. These questions directly integrate peer learning into the class by encouraging students to think about a contentious issue area that they can discuss with their classmates. Discussion questions help reinforce topics and provide another opportunity to relate content to the practice of politics.²

Beyond students' need to either think about their position on an issue or to reflect on the course material they have learned on their own, clickers can also foster peer learning. In smaller classrooms, it is possible to survey everyone in the room by asking students to explain their answers and to elaborate on their ideas. Unfortunately, in a large lecture hall, these practices are often eschewed in the interest of time. Discussions, however, help students by requiring them to verbalize their thought process and to discover shortcomings they may have with the material. To accomplish this goal, clickers initially require students to answer questions individually. Next, students are instructed to turn to a neighbor and to discuss their

response. Finally, using new information gleaned from these brief discussions, students use their clickers to respond again to the same question. To help guide students' discussions with one another, we frequently asked them to convince their neighbor of their position on a given question. This process encourages students to fully engage with class concepts and to exercise a deeper understanding of course material by arguing for (or against) their particular position. While we often think of clickers as connecting students to professors, they can also be used to foster classroom discussion and debate, allowing students to learn from the experiences and knowledge of others in the room.

The grading of clickers is another important consideration in their use. In our class, assessment schemes for clickers were typically divided into two camps: "high-stakes" and "low-stakes." High-stakes grading examines students' responses to application questions and assigns them points based on the number of items answered correctly, while low-stakes grading assigns scores based on students' willingness to participate in class (i.e., grades are assigned by completion, not accuracy). One benefit of high-stakes grading is that it encourages students to consume required information before attending class and to be attentive to the questions posed. When questions are graded for correctness, there is an increase in attention paid to these items and students exhibit a strong desire to answer correctly even if individual questions are worth a small amount. However, these potential benefits are not without cost. Due to the desire to perform well, these questions often cause higher levels of anxiety among students who feel their grades are at stake every time a clicker question is asked. Additionally, this grading method leaves little room for opinion or discussion questions, which are also helpful in explaining how lecture material relates to practical politics but do not have right or wrong answers.

In both courses, we utilize low-stakes grading and evaluate only how often students participate during each class period, awarding them two points for answering all of the questions asked in the lecture, one point for responding to some, and zero for responding to none. We expect that even though students are not rewarded for every correct answer, the act of participating will create an environment where they stay engaged with the material. This strategy should reduce the stress induced by the high-stakes scheme while still encouraging thoughtful responses.³ Ten percent of students' final grade in the course is determined by their overall clicker participation.⁴

Data and Methods

Using data collected over two semesters, we evaluate both how students feel about the use of this technology and what influence, if any, it has on their grades. Clickers could potentially impact performance in a number of ways. As noted in the literature, student response systems could simply encourage attendance and, thus, the acquisition of knowledge otherwise missed by staying home. Second, once students have decided to attend class, the knowledge questions that will be asked throughout the period may cause them to pay closer attention to what is being taught. Third, the questions posed during class sessions could cause students to think more deeply about the connection between what is being discussed and their everyday lives, prompting a richer understanding of the material. Fourth, clickers could force students to make a decision about the correct answer, an impetus that may better solidify concepts and theories in their minds. Fifth, the desire to do well and to

respond correctly could prompt some to read course materials more closely before coming to class. While we cannot assess which of these causal processes may influence learning, our data allow us to measure whether higher clicker usage corresponds to better grades and attitudes toward the course and technology.

To understand the efficacy of these devices in class it is important to understand what students think about their use. With approval from The Pennsylvania State Institutional Review Board (IRB), we distributed surveys to our students in the Fall 2011 and 2012 sections of Introduction to American National Government.⁵ The survey instrument evaluated students' attitudes toward the use of clickers in the classroom, their evaluation of the course, and their sociodemographic characteristics, among other items. Additionally, with informed consent and names removed

Table 1. A profile of the survey respondents

	Fall 2011	Fall 2012	Overall
White/Nonwhite			
White	79.07	74.13	76.46
Nonwhite	20.93	25.87	23.53
Race			
African American	4.48	4.35	4.58
Asian	10.48	7.97	9.16
Hispanic	–	6.52	3.44*
White	82.26	76.81	79.39
Other	–	4.35	3.44*
Gender			
Female	51.59	51.82	51.71
Male	48.41	48.18	48.29
Born Outside the U.S.			
Yes	11.11	13.87	12.55
No	88.89	86.13	87.45
Year in School			
Freshman	23.62	18.98	21.21
Sophomore	44.09	44.53	44.32
Junior	23.62	25.55	24.62
Senior	8.66	10.95	9.85
High School Civics/Government Course			
Yes	78.74	76.64	77.65
No	21.26	23.36	22.35
Level of Interest in Politics			
Very interested	42.52	34.31	38.26
Somewhat interested	42.52	37.96	40.15
Neutral	11.02	16.79	14.02
Somewhat disinterested	1.57	7.30	4.55
Very disinterested	2.36	3.65	3.03

Note. $N = 272$.

*The Hispanic and "Other" race categories were omitted from the Fall 2011 survey.

**Note that not all categories sum to 100%. This represents either answers of "other" or nonanswers.

to protect individuals' identities, these data were matched to students' clicker usage and grades on papers and exams.

Table 1 reports the heterogeneity in our survey respondents. About 52% are female (48% male), they are predominately white (about 76%) while the major subgroups in the nonwhite population include Asian (9%) and African American (5%) identifiers. Because this is a general education course, most students are not political science majors, but they do report high levels of interest in the subject matter (about 78% are either "very" or "somewhat" interested in politics). Additionally, a substantial number of our students have previous experience with government and civics in high school (about 78%).

Our data allow us to answer two questions: First, how do students evaluate the use of clickers in the classroom, and, second, do those who frequently use clickers earn higher grades on exams and essays? The first question seeks to understand students' attitudes toward these devices and their perception of their efficacy. The second attempts to understand more objectively the impact responding to questions can have on grades. If clickers are used in the classroom, do students perform well on other assessments of the course material? While our analysis does not permit us to examine the precise causal process through which clickers could impact student learning, it does allow us to track how frequently individuals use these devices and how this corresponds to their performance in the course.

Gathering survey data also allows us to build an individual-level model of grade performance that accounts for students' characteristics and attitudes. Much of the evidence examining the efficacy of clickers relies on comparing sections of a class, looking for differences in average scores between sections where clickers were, or were not, used. These studies make a *ceteris paribus* assumption that students in each class are substantively similar and that differences in teaching style, student composition, time of day, interest in the subject matter due to world events, instruction, and other factors are held constant. We know, however, that performance in class can be a function of students' previous exposure to the material, their predisposition to perform well academically, interest in the subject matter, and participation in assignments and projects designed to encourage content mastery. Therefore, we chose to directly assess the characteristics of individual students, relaxing the assumption that the distribution of relevant characteristics among participants is similar. Relaxing this assumption allows us to account for the ways in which these individual-level variables directly affect individual student performance. We conduct our analysis over two semesters to maximize the number of cases and to capture more variation on quantities of interest, allowing us to draw more reliable conclusions. These data also add to the growing literature on clickers in the classroom by providing another methodological angle from which their usefulness is assessed.

To assess student attitudes, we ask two questions: "Overall, how satisfied are you with the use of clickers in this class?" and "Overall, would you recommend using clickers in future versions of this course?" To measure student performance, we isolate their scores earned on exams and essays. Both of these assignments ask students to demonstrate their knowledge of the material and mastery of course content.⁶ Clicker usage is operationalized in two ways to examine their efficacy: the frequency with which students participated using these devices and the percentage of questions answered correctly. Frequent use may not be a sufficient condition to encourage better performance as our low-stakes approach to grading means students can make any choice and still receive credit. While our data do not indicate this to be the case

(i.e., that students simply responded randomly rather than with what they hoped to be the correct answer), responses to questions where there is a clear right or wrong answer may help students prepare for exams and papers more directly. Feedback on the question can be offered in these cases and, as mentioned earlier, opportunities for peer learning emerge for questions with a clear right (or wrong) answer. It is expected that the number of correct clicker responses influence grades on later exams and papers more than simply using the device.⁷

A number of other factors may impact students' grades including past academic performance, their backgrounds, and their attitudes toward the course and classroom technology. It may be expected that, in addition to using clickers, how students feel about them may influence their grade outcomes with those who like the technology performing better than those who dislike their use. Accounting for this possibility, we include measures of student satisfaction with clickers and how they are used in the classroom. To control for the attitudes students have about the subject material and their previous experiences with the discipline, we include measures of interest in politics, previous high school government or civics courses, and previous college-level classes in political science. We also ask survey questions about students' race, gender, country of birth, year in school, educational attainment of parents, involvement in community and university groups, and grade point average.

How Do Students Evaluate Clickers in the Classroom?

To measure student satisfaction with clickers, we asked students to report their overall satisfaction with using these devices on a 5-point scale bounded by "very dissatisfied" and "very satisfied." Figure 1 shows only 10% of students were either "somewhat" or "very dissatisfied" by clickers whereas 78% reported being "somewhat" or "very satisfied." The modal response category was "very satisfied" with 45% of all respondents reporting that they felt this level of positivity toward clickers. These same positive feelings are mirrored when students are asked to recommend their use in the future. Figure 2 indicates 82% of students either "strongly" or

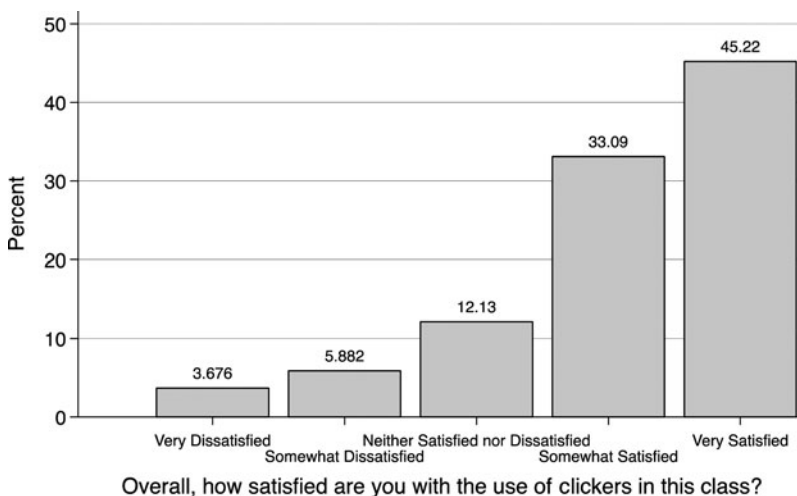


Figure 1. Satisfaction with clickers.

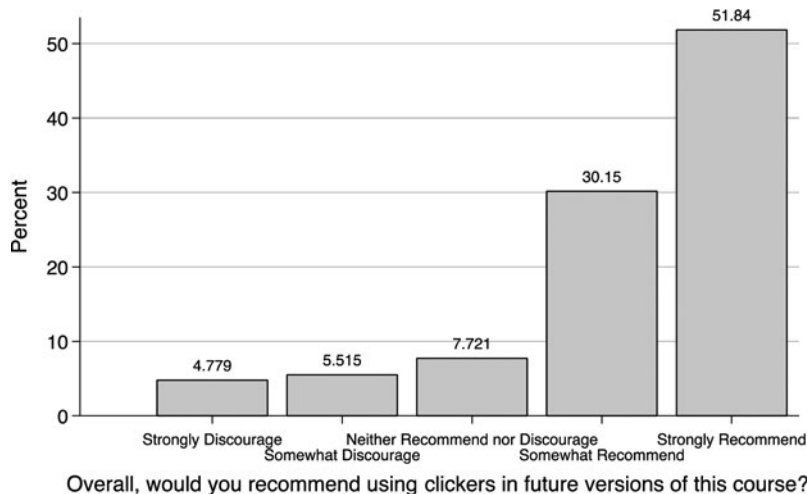


Figure 2. Recommend clickers in the future.

“somewhat” (strongly) recommend continuing the use of clickers while only 10% discourage their use in the future. Again, the largest group of students (52%) “strongly” supports the use of clickers in the future.

Given that majorities of students approve of clicker usage, what types of questions motivate these responses? A majority of students approved of each type of prompt with concept-based questions receiving the most support, followed by those asking their opinions, and finally those that prompt further discussion.⁸ Perhaps the knowledge that concept questions are more similar to those they will see on an exam causes students to prefer them relative to alternatives, but no question type is disapproved of by more than 8% of respondents. These results comport with the extant literature showing support for this technology as long as it is not being used exclusively as a measure of class attendance.

Does Clicker Usage Influence Grade Performance?

While students approve of the use of clickers in the classroom, do they have any effect on grade performance? If we are to see a significant effect of clickers on student performance, more dramatic improvements would probably occur in large-enrollment courses as compared to smaller class types given that discussion, student interaction, and detailed analysis of course topics are less likely to occur in large-enrollment courses. Thus, the introduction of clicker technology is more of a substantial change to typical pedagogy (e.g., lecturing) in a large-enrollment course as compared to a smaller class that may more routinely incorporate active learning. We realize that attributing improvements in grades to clickers alone, even while controlling for mediating factors, may be overly simplistic or too dramatic an effect to expect from clicker use. Thus, we simultaneously control for the ways in which students’ attitudes towards the class overall and political events specifically might affect their overall performance in the course. Given the previous findings that students and faculty alike have positive feelings towards clickers, measuring grade outcomes while controlling for attitudes provides a well- rounded picture of the potential benefits of clickers in class.

We estimate a model of grade performance using ordinary least squares (OLS) regression. The dependent variable is students' grades on papers and essays (measured between 0 and 100) while independent variables include the participation rates of students using clickers, the percentage of questions answered correctly, the satisfaction students have toward these devices, and a number of other control variables obtained from our questionnaire.⁹ Though the majority of students completed the survey in its entirety, there were some who skipped particular items, possibly due to uncertainty or unwillingness to answer.¹⁰ To prevent nonresponse-based listwise deletion in our statistical analysis, we correct for missing data through multiple imputation by chained equation.¹¹ Finally, we estimate robust standard errors to correct for heteroskedasticity in the error variances of the model.

The percentage of clicker questions answered correctly is positively related to student grades, as seen in Table 2. However, these results also indicate that the frequency with which clickers are used is not associated with grade outcomes in a statistically significant manner. In sum, clickers are positively related to grade outcomes, but they require students to do more than simply press buttons; they must engage in the class and answer correctly to see benefits to their overall course score. Answering questions correctly, however, has a substantively small relationship with students' overall grades: a one unit change in the percentage of clicker questions correctly answered by students produces a corresponding increase in students' final grades of 0.09, or a ninth of a percent. A more effective way of understanding this is to say that a 10-point increase in the percentage of questions students answered

Table 2. Effect of student response systems on student grade outcomes

	Coefficient	Robust Standard Error	
<i>Clicker Use and Attitudes</i>			
Frequency of Clicker Use	0.07	0.06	
Percent Correct Responses	0.09	0.05	*
Satisfaction with Clickers	-0.43	0.70	
<i>Previous Experience and Civic Engagement</i>			
Political Interest	2.65	0.75	***
Number of Government Courses	0.00	0.43	
Campus/Off-Campus Groups	0.12	0.33	
<i>Demographic Controls</i>			
Female	1.38	1.17	
Born Outside the U.S.	-2.35	1.55	
Nonwhite	-0.60	1.33	
<i>Educational Performance and Background</i>			
GPA College	2.70	0.85	***
Year in School	-0.59	0.64	
Mother's Education Level	-0.01	0.59	
Father's Education Level	1.36	0.57	**
Fall 2012	-0.07	1.37	
Constant	54.92	5.45	***
No. Observations	272		
R^2	.27		

* $p < .10$. ** $p < .05$. *** $p < .01$.

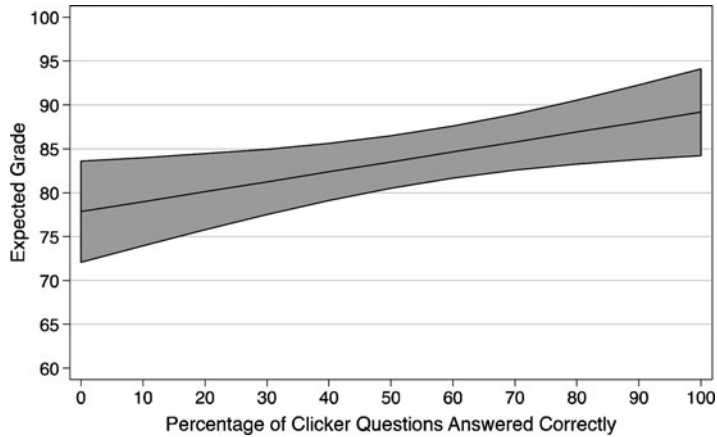


Figure 3. Predicted grade outcomes by levels of correct responses.

correctly corresponds to an increase in students' overall grade of 0.9, or approximately 1%. Figure 3 more clearly illustrates this relationship with students answering all questions correctly scoring approximately 11.3% higher on exams and papers relative to those who did not answer any questions correctly.

Other variables found to play a statistically significant role in grade performance include political interest, college grade point average (GPA), and paternal educational attainment. Each of these factors is positively associated with how individuals performed in the class. A one-unit increase in students' political interest is associated with a 2.7% increase in their grades, while a one unit increase in a student's father's education (e.g., the difference between a two-year and a four-year degree) increases one's grade by 1.4%. Not surprisingly, increases in students' overall GPAs correspond to higher grades in this course; every unit increase in our categorical measure of students' GPA (e.g., moving up from the middle category of 2.5–2.99 to the next highest category of 3.0–3.49 on a 5-point scale) corresponds to a 2.7% increase in their grade on essays/exams in this course. In other words, students who had higher overall GPAs also tended to have higher grades in our course. Interestingly, a number of items that might likely impact grade performance did not achieve traditional levels of statistical significance in these analyses; having completed high school or college civics classes, gender, race, year in school, maternal education, engagement in the campus and community, being born outside the United States, and satisfaction with the clicker system did not play a role in explaining grades. How students performed on exams and papers is the product of a handful of variables: how interested they are in politics, their past academic performance, their father's level of educational attainment, and the percentage of clicker questions answered correctly.

Discussion

Engagement in the classroom can often be difficult for a number of reasons: Students may not sufficiently understand the material to risk talking, may be intimidated by large class sizes, may be uncomfortable expressing minority points of view or may simply refuse to participate. However, the literature consistently demonstrates that

those who apply course content to the world around them and engage in the classroom perform better on exams, papers, and essays are more likely to retain information. Clickers have been offered as a technology that fosters student engagement, making them particularly relevant for large-enrollment classes where it is difficult to have personal connections between the professor and class. These devices allow instructors to gauge how well students understand the ideas presented, while pushing students to consider the practical implications of the subjects being discussed.

Our analysis indicates that clickers are well received by students and that application questions are evaluated more highly than others, but only by a slim margin. Additionally, students who respond correctly to clicker questions are more likely to earn higher course grades after accounting for their previous academic record, attitudes toward the class, and socioeconomic backgrounds. While their substantive effects are not as large as other considerations, like prior academic performance or interest in politics, these devices are still able to explain the grades earned on exams and papers. We find that success in grade outcomes is not simply the product of using clickers but also stems from students' abilities to identify the correct response to questions about course material. In part, these results reflect the findings of others that clickers used throughout the semester and paired with peer learning can positively impact student performance (Smith et al. 2009). Using clickers to promote peer collaboration allows instructors to simultaneously assess current levels of understanding and enables students to use one another as resources to better understand material.

As we consider the use of technology in the classroom, it is important to understand its value added. In large classroom settings, student response systems can improve student performance. Questions that assess levels of understanding and encourage the application of knowledge to the world prompt individuals to think about course content in a novel way. Although the question of how these devices influence grade outcomes will invariably remain open, our analysis suggests that they can influence how students perform on tests and other assignments. These results suggest that, under the right conditions, student response systems can be a useful pedagogical tool for both teaching and learning in large-enrollment courses. However, it is important to keep in mind the fact that clickers' substantive effect appears to be small. Further studies on clicker use in political science may explore their effects in small enrollment classrooms or might consider whether clicker usage affects students' attitudes towards class material or current events alongside their classroom performance. Ultimately, this study provides a first cut at understanding the effect that clickers have in large-enrollment political science classrooms.

Notes

1. More information about the vendor and devices can be found on the i>clicker Web site: <http://www1.iclicker.com/>.

2. To provide context, "Do you believe it is good to have an unelected judiciary in a democratic nation?" is an example of an opinion question. An example of an application question can take on the following form: "Which of the following is an example of fiscal federalism?" Finally, "What alternatives to the electoral college might you propose?" is an example of a discussion question.

3. Alternatively, these two grading schemes can be combined, awarding a portion of the credit based on participation and the balance on correctness.

4. In survey responses, about 20% of students agreed with the statement that participation was worth too much of their grade while approximately 36% agreed that it was worth too little. Seventy-four percent felt the policy for grading participation using clickers was fair while about 14% disagreed.

5. Our response rate is 40% during the Fall 2011 semester and 43% during Fall 2012. In each semester, the same survey is administered about two weeks prior to the end of the term. To account for any semester-specific variation, we include in our statistical models a control variable for the term in which the survey is collected.

6. We do not use the raw final score earned in the class because this also includes the frequency with which students responded to clicker questions. Isolating grades on exams and essays allows us to examine any effect more frequent clicking might have on exogenous assessments of understanding.

7. In creating this measure, we only include questions that contain an objectively correct answer (i.e., application questions). This measure is calculated as the percentage of application questions correctly answered by the respondent.

8. Utilizing a 5-point Likert scale ranging from strong dislike to strongly like, the average score for concept questions are 3.26 and 3.18 and 3.09 for opinion and discussion questions, respectively.

9. Students are allowed to earn their grade in this course by pursuing one of two tracks, one in which they take a series of tests and another where they write essays. Both grading schemes assess the same concepts and theories, but students have a choice in how they wish to demonstrate their mastery of the material. Someone on the essay track does not take exams and, likewise, those on the exam track do not write essays. The dependent variable is the final score earned by the individual on either the essay or exam track and the same essay and exam questions are used across the two semesters.

10. Specifically, items missing student responses include the following: questions about political interest, whether they had taken college-level political science courses or a high school government class, and their year of school (nine missing responses for each); questions about student gender, college GPA, and whether or not the student was born in another country (10 missing responses for each); parents' levels of education (13 missing for father, 15 missing for mother), and students' levels of engagement in on- and off-campus organizations (13 missing).

11. We used the slate of mi commands in Stata 13 to impute data iteratively into five separate datasets. This process utilizes complete information from observations with nonmissing data as well as partial information from observations with partially missing data to estimate missing values. Using the "mi estimate" command in Stata, OLS (version 13) regressions were run on each dataset separately and then pooled into a single table of results with coefficient estimates representing the average effects of each variable across the analyses. It is important to note that imputed information for observations with missing values does not add significance or nonsignificance to an estimate for that variable. In other words, the technique does not skew the results and provides a standardized estimate of a missing value so the nonmissing information provided by a respondent can also be included in the model. More information about the necessity of multiple imputation and its use can be found in King et al. (2001).

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