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# How well do clicker scores correlate with course performance? A case study in two MIS courses

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## Abstract

Using real time student response systems (clickers) in Management Information Systems classes (as well as in other disciplines) has previously been shown to lead to better student engagement and better student performance. This paper considers how the students' overall performance in the class correlates with the students' performance on various assessment tools used in the class. For medium sized classes (20-30 students) as taught by the author of this paper, the correlation coefficient varies across the various assessment tools, and it also varies for any given assessment tool from section to section of the same class. The main result in this paper is that the correlation coefficient for the clicker score is one of the highest among the various assessment tools, for both graduate and undergraduate classes. This correlation coefficient is also more stable from section to section than the correlation coefficient for most other assessment tools. A possible explanation for this higher stability of the correlation coefficient for clicker scores is that clickers are particularly good at averaging student performance over the entire semester, more accurately than most other assessment methods. Finally, the correlation coefficient does not appear to depend on whether the clicker use is mandated or left optional (for extra credit points). A possible explanation is that clickers engage students in a healthy competition with the rest of the class as well as with themselves. The positive outcomes arising from the use of clickers make them a highly effective classroom tool.

**Keywords:** Clickers, Classroom response systems.

## 1. INTRODUCTION

A variety of classroom response technologies have been used to allow students to participate in real time polling and assessment in the classroom. Although these technologies are discussed under a variety of terms, one of the most frequently used terms is "clickers," the term we choose to use in the remainder of this paper. Introduced several decades ago, clicker systems have continued to evolve and to become increasingly user friendly. For the past several years, a number of researchers have documented the effects of clicker technologies in the classroom. Many papers report on comparison studies, considering test results and student perceptions for sections using clickers and sections not using clickers. An apparent omission in these studies is an analysis of the

correlation between student performance and clicker usage within a class.

The results in this paper were obtained over the course of an academic year (two semesters) in two types of classes offered in the College of Business and Public Policy at a public university in the Pacific Northwest. One of the classes was an upper division General Education Requirements Capstone (GERC) class intended for juniors and seniors, and the other a core course in the Master of Business Administration program.

## 2. LITERATURE REVIEW

Classroom interaction systems have most likely been used since the first days of organized teaching. Even today, it is possible to interact with a class without the use of electronic technology, for example by asking students to

raise hands for a yes/no answer, to hold up one, two or three fingers for a three way choice, or to hold up colored pieces of paper to indicate how well they are following the material (red, yellow, or green, for increasing levels of comfort). Electronic technologies extend the capabilities of these more primitive tools, and allow accurate, real time collection of student input, as well as recording of the data for future use.

One of the earliest uses of electronic classroom interaction systems was in 1985, in a system connecting standard graphing calculators via a proprietary and custom installed wiring network (ceiling mounted) (Beatty, 2004). The system, Classtalk CCS, was rather cumbersome by today's standards, because of the proprietary wiring, but was relatively widely used because of the ability to allow teachers in a variety of disciplines to get instant feedback from their students. A list of older papers based on the Classtalk system can be found at <http://www.bedu.com/classtalk.html>.

More recently, wireless clickers have become the preferred technology, and they allow instructors to set up a system in only a few minutes. The set-up includes a wireless base connected to the instructor's computer and a set of handheld devices for students to input their votes. The student devices can be required as part of the class supplies, or can be loaned out by the instructor as needed. Clickers are used in accounting (Premuroso, Tong, & Beed, 2011), business statistics (Koppel & Berenson, 2009), experimental psychology (Anderson, Healy, Kole, & Bourne, 2013), human development (Beckert, Fauth, & Olsen, 2009), management (Keough, 2012), management information systems (Nelson & Hauck, 2008), marketing (Sprague & Dahl, 2009), and operations management (Yourstone, Krave, & Albaum, 2008).

Studies have uncovered a range of outcomes from the use of clickers. At the negative end of the spectrum, some authors did not find any differences between a traditional lecture class, an online class and a face to face class using clickers (Matus, Summa, & Kuschke, 2011). The authors mention cautionary factors that might invalidate this result (small class sizes of approximately twenty students, short duration of the study, of only five weeks, and possibly limited sensitivity in the assessment tools). At the same time, these are factors present in a large number of classrooms, where these

negative findings may potentially be true. At the positive end of the spectrum, a large number of authors claim both improved student performance and improved student satisfaction in classes that use clickers (Premuroso, Tong, & Beed, 2011), improvements in attention span, attendance and class participation (Keough, 2012), and a better correlation between student performance and self-reported learning outcomes (Sprague & Dahl, 2009). Additionally, real time feedback from students can allow instructors to use class time more efficiently, for example by skipping material that appears to be well understood, and spending more time on material that students have a difficult time understanding (Anderson, Healy, Kole, & Bourne, 2013). The use of clickers is a particularly good way to help students who face cultural barriers (Sprague & Dahl, 2009).

Clickers are also most useful in large sections, where it would be otherwise impractical to seek input from students via a show of hands. In particular, Lincoln (2008) makes several good suggestions for how to use clickers well in such large sections.

In addition to the challenges encountered in typical classes, Management Information Systems (MIS) courses also suffer from low student interest and reluctance to participate, especially when classes include both MIS majors and less technically savvy non-majors. Only one paper has reported on the use of clickers in an MIS class, and the authors found an increase in the students' self-reported performance, improved attendance and a strong link between student outcomes and class attendance (Nelson & Hauck, 2008). In a treatment with three different levels of clicker use (including no use at all, medium and heavy use), the positive outcomes from the use of clickers increased with the level of usage.

This paper reports on another aspect of clicker use. First, we investigate the correlation between clicker scores and students performance in the class. Second, we consider the relative impact of requiring clickers with that of making clicker participation optional (for extra credit points). While many authors report on the student perceptions of their learning, we show that clicker performance is well correlated with the student performance as assessed by the instructor.

### 3. THE INSTITUTION

#### College overview

The College of Business and Public Policy is part of a public university in the Pacific Northwest. The university has 20,000 students and offers undergraduate and graduate degrees in a variety of fields. Many of the students are working full time and prefer to study part time, taking mainly evening and weekend classes. Enrollment in daytime classes tends to be heaviest for those sections offered around lunchtime, when students can take time off from work. There are 1600 students in the College of Business and Public Policy, ten percent of these students pursuing graduate degrees.

The members of the faculty in the CBPP have considerable freedom to explore emerging technologies in their teaching work. This makes it difficult to enforce standards at the technology level across sections of the same class. Nonetheless, in Fall 2011, a committee in charge of technology usage recommended a common clicker technology to be used in all the classes in the College. The main driver was a desire to reduce the number of clicker devices students had to purchase, by adopting a single technology that would be used across all courses in the College. A campus visit by a representative of the vendor, iClicker, and several presentations by the few early adopter faculty members who had tested several competing clicker technologies ultimately led to adoption of the recommended standard clicker technology by a larger initial group of instructors. The adoption was further aided by the fact that the instructor platform (receiver base, instructor clicker, and data collection software) were free and provided by the vendor in the campus visit.

The clicker technology adopted is based on radio frequency devices, which are more robust and reliable, and which are better able to handle interference and obstructions from various objects in the classroom environment. An older technology, based on infrared waves is less reliable, as it requires a line of sight between the student device and the receiver. With the iClicker technology, the student input can be submitted via a hardware device (available for purchase from the university bookstore) or via an online interface (accessible on a computer with internet connectivity, or via a smartphone). The hardware device is a one-time cost (\$46), and students can either register the same device

for various courses (a separate registration is required for each semester they are using the clicker) or they can email the instructor the clicker ID to have it added to the course roster. The alternative to the hardware device, the online interface, is a much lower cost option (\$10), but is only valid for a single semester at a time, and subsequent renewals cost as much as the first purchase (multiple semester options are also available, up to a 4 year subscription for \$32). The vendor also offers a free two-week trial of the online interface, allowing students to test drive the product before making a purchase.

#### Course #1: General Education Capstone (undergraduate, required)

The first class in which the clickers were used was Management Information Systems, an upper division General Education Requirements Capstone (GERC) class. GERC classes must be taken once a student has completed all his or her General Education Requirements (GER) courses, and are intended to test four different skill sets that students should have acquired in their GER classes: critical thinking, information literacy, quantitative analysis, and communication skills. The students in the class are juniors and seniors from all the majors in the College. Typical class size is in the range of 20-35 students, with lunch time and evening classes having larger enrollments.

The author taught one section of this class in each of the Fall 2012 and Spring 2013 semesters. The use of clickers in the class was a last minute decision in Fall 2012. Because of the last minute nature of the adoption, the syllabus did not include a mention of the clickers and points associated with them. The instructor announced in the first day of class that clickers would be used as extra credit and real time feedback mechanism, with points accounting for an unspecified amount, but no more than 5% of the final grade. Students were not required to use clickers, and no specifics were given as to the number of questions or the frequency of use. For Spring 2013, the same approach was taken, this time deliberately: the clicker usage was not mentioned in the syllabus, but was only discussed in the first class, and students were encouraged, but not required to use clickers.

The class Powerpoint presentations included two to ten questions in each class period. There were three types of questions. The vast majority were comprehension or application questions about the class material, at the completion of a lecture

segment. A small number of the questions were about opinions and perceptions, including questions about the level of difficulty of the current chapter in the textbook. Finally, a third set of questions were used as pre and post survey of opinions on controversial topics that were used for in-class debates. The questions were posted in advance, along with the class presentation.

Over the course of the semester, the proportion of students using clickers moved steadily up, and by the end of the semester all but one student in each section had participated in at least one clicker session. One student only signed up within the last two weeks of the semester, when he became concerned she might not be able to get a passing grade. In the absence of clicker points, it is highly likely that this student would have failed the course. Because he decided to use a clicker, he was able to get sufficient extra points that he passed the class.

The variation in clicker scores is mostly due to student preparation. For a small number of questions where the majority of the students did not get the correct answer, the scoring was adjusted to give points for any answer, not just for the correct one. Although there were no regular "seat time" points for simply being present, a student who was not present would not be able to accumulate points. Proactive students who elected to purchase a clicker early in the semester ended up with more points than those who waited until later on. At the end of the semester, the clicker score was based on normalizing the points, so that the top score would be equivalent to a five percent extra credit (half a grade point). This way, the clicker points accounted for at most five percent of the final grade in the course.

### **Course #2 MBA core course (graduate, required)**

The other class in which clickers were used is Management Information Systems Seminar, a core (required) course in the MBA program. In a typical semester, there are 20-25 students enrolled, although at times there have been as many as 35 students enrolled. The class requires considerable time for reading, as well as a strong writing component. Students are required to present to the class and to participate in discussions on case studies that supplement the theory discussed.

In Fall 2012, the author of this paper was returning from a sabbatical leave and was scheduled to teach one section of this course. The author of the paper had been interested in using clickers, but had not made a decision to adopt the technology. The instructor who taught the class in Spring 2012 had placed an order with the university bookstore requiring that students use clickers in the class. Book orders are typically due several months in advance, and the author of this paper was not consulted on the order for Fall 2012. Now that students had been required to purchase clickers, the author of this paper was no longer able to postpone the technology adoption, and adopted the required clickers for Fall 2012.

Because students were required to purchase clickers, the syllabus had to be clear on the point value for clickers. Out of the class grade, up to twenty percent was for participation. The participation was only for correct answers, either verbally, during a case discussion, or via clickers, before the case discussions. The clicker questions tended to be higher order, comprehension or evaluation based on the readings assigned outside of class, ahead of time. The clicker questions were intended to allow more students to participate than would have otherwise been practical for only an oral discussion of the readings. No more than ten percent of the class grade could be from clickers, but students could get full participation points by combining points for oral contributions with however many clicker points they obtained. The actual weight of the clicker points in the final grade depended on the activity of the student, hence it varied between five and ten percent. For students who had been very active in the oral discussions, the relative contribution of the clickers to the final grade was lower, and limited up, as the combined (clicker plus oral) participation points could not exceed twenty percent of the final grade.

Instead of instructor lectures, the graduate class includes mainly student presentations and student led class interactions, only loosely directed by the instructor. Students were encouraged to make use of clickers in their class interactions. Many chose to use basic recall questions (and sometimes on rather obscure topics). When most students did not get the right answer because the topic was obscure or the question was poorly phrased, the clicker score was sometimes adjusted to give points for any answer.

#### 4. QUANTITATIVE RESULTS

The papers cited in the literature tend to report on experiments involving control groups and using two sets of metrics. One of the metrics is from surveys of students' perceptions on the use of clickers, as well as on IS in general. The second metric is from student results, as measured by assessment tools in the class: exams or overall performance. In contrast, this paper does not involve a controlled experiment, but rather an investigation of a different metric, within a single class section (repeated in two different semesters and two different courses).

In this paper we report on a related metric, within a given class: the correlation between the clicker points and the students' performance on classroom assessments. We show that clicker points have high correlation with the final score in the class, sometimes the highest correlation among the various assessment tools.

<u>Assessment tool</u>	<u>Weight</u>	<u>Correlation with final class grade</u>	
		<u>Fall 2012</u> <i>N</i> = 21	<u>Spring 2013</u> <i>N</i> = 16
Clicker points	5%	0.7544	0.7789
Midterm exam	20%	0.6054	0.7475
Research paper	13%	0.4363	0.5314
Final exam	20%	0.6011	0.7581
Quizzes	10%	0.8160	0.2993*
Debate points	12%	0.7356	0.6497
Hands-on tests	20%	0.5657	0.3414

Table 1. Correlations between scores on individual assessments and the final score for two sections of the undergraduate MIS class (students were offered the option to purchase and use clickers for extra credit, but were not required to do so). *N* is the number of students in each section. The asterisk indicates the correlation coefficients that are not significantly different from zero.

Table 1 shows the correlation between the final score (used for determining the grade in the class) and the individual scores for various assessment tools in the undergraduate class. The use of clickers in this class was left optional, as we discussed in Section 3 above. Nonetheless, most students elected to purchase and use clickers, some early on, and some only

towards the end of the semester, when they became concerned they might be a few points short of passing the class. A small number of students (one in each section) who chose not to use clickers were not included in these correlation calculations. Students who did not use clickers tended to be average as is probably expected. When the use of clickers is left optional, top students will typically make every effort to get points, through any means offered, including clickers; top students tend to be the early adopters when allowed the choice of whether to adopt clickers for extra credit points. Low performing students tend to dismiss clickers in the beginning, but will adopt them towards the end of the term, when they become concerned they might fail the class. It is some of the average students that end up not having a strong reason to adopt optional clickers.

<u>Assessment tool</u>	<u>Weight</u>	<u>Correlation with final class grade</u>	
		<u>Fall 2012</u> <i>(N=20)</i>	<u>Spring 2013</u> <i>(N=23)</i>
Clicker points	0-10%	0.7392	0.5459
Presentation	10%	-0.0723*	0.3899
Position paper	5%	0.6594	0.4947
Midterm exam	10%	0.4996	0.5275
Final exam	10%	-0.0225*	0.4207
Oral class participation	0-20%	0.7295	0.8566

Table 2. Correlations between scores on individual assessments and the final score for two sections of the graduate MIS class (students were required to purchase and use clickers). *N* is the number of students in each section. The asterisk indicates the correlation coefficients that are not significantly different from zero.

We show in Table 2 (next page) the correlation of the final score (used for determining the final grade in the course) and the individual scores on key assessment tools in the graduate MIS class. The scores are for two sections, taught in Fall 2012 and in Spring 2013. The individual weight of the various assessment tools is listed in the second column in the table. The weights do not sum up to 100 percent, because we have excluded some of the assignments which are team based (35% of the class grade) or on which most students achieve full score (20%). On assignments where most students get full score, the correlation of the assignments score

with the final grade will be very low. Instead, our objective in this paper is to compare the clicker score with other assignments that have the highest correlation with the overall class performance. By including "easy" assignments that have lower correlation with the class grade, clicker scores would seem to be much better correlated, skewing the comparison. As shown in Table 2, the correlation of the clicker score with the final class grade is among the highest, even though the overall weight of clicker points is only at most 10 percent of the final grade (see Section 3 above for a detailed explanation of the use of the clicker scores in the determination of the final grade).

Although this is not a comprehensive study of the use of clickers, the results presented in Tables 1 and 2 appear to indicate several trends. First, among the assessment tools, clicker scores appear the most highly correlated with the students' performance in the class. Second, the correlation between clicker scores and overall class grade is among the most stable over the two semesters, as compared with other assessment tools.

Indeed, to get a high clicker score students need to be present in class, to constantly pay attention, and to understand the material. Unlike the case of exams, clickers measure the aggregated and distributed attendance and understanding of the students. Some of the really low or negative correlation scores in the tables above are due to special cases. For example, several students who had not done well in the graduate class in Fall 2012 studied very well for the final and got exceptionally high scores, which allowed them to just barely pass the class – hence low correlation between the final scores and overall class score. Similarly, in the undergraduate class, in Spring 2013, students were given the opportunity to do one more attempt on any quizzes where they did not do well. This resulted in higher quiz scores at the end of the semester, but also in a lower correlation with the overall class grade, as this last minute effort was not well correlated with the students' performance over the semester. Students accumulate clicker points over the course of the semester, which makes clicker scores very robust against one-time events (either of preparing exceptionally well or exceptionally poorly).

This paper is the first to show the strong correlation between clicker scores and students

overall performance in MIS classes, although it is likely that the result is not limited to MIS courses. Moreover, the clicker correlation does not appear to be affected by the actual weight, as the two classes used different weights. Finally, requiring clickers or leaving them optional does not appear to affect the correlation (with the exception of a small number of average students).

## 5. QUALITATIVE BENEFITS FROM THE USE OF CLICKERS

In addition to the quantitative results in the previous section, there are also several qualitative observations from the use of clickers. Although the data collected for this paper are not able to prove such qualitative results conclusively, these observations are well aligned with what other authors have already reported.

### **Better student engagement**

For both classes, the use of clickers resulted in increased student engagement. As (Cutts, 2006) pointed out, the clicker questions broke the flow of the class and required that students refocus and reflect. Classes are held in computer labs and students view the class Powerpoint presentation on their own computer, taking notes along the way. The tendency is there to also check the news or social media sites at the same time. It is clear that when a clicker question gets shown, at least some of the student have to shift gears to reconnect with the class. We have not collected data to support this conclusion, but the author's impression is that when showing two clicker questions in a row, the second question always gets faster responses, as students are already engaged by the first question. In contrast, answers to the first question in such a set are considerably slower, because some of the students have to shift their attention from a different task to that of answering the question.

### **Better focus on important concepts**

As students are forced to pay more attention to clicker questions than to other moments in the class time, the instructor has the opportunity to load the clicker question with the most important concepts he or she is trying to communicate. This way, the instructor can receive real time feedback on how well the students have grasped the material (as confirmed by most researchers reporting on the use of clickers). Additionally, students understand that the concepts encountered in the

clicker questions are those they need to focus on for the exams, and they treat the questions almost as a mini study guide for the class.

### **Opportunity to demonstrate information systems concepts**

Discussions about information systems can sometimes be boring (with the exception, of course, of the readers' and the author's classes). Using clickers is an opportunity to demonstrate some of the information systems (IS) concepts in real time. Issues that can be demonstrated include those of IS adoption (how many students choose to use the IS), IS usability (how user friendly the clicker interface is, how well designed are the questions), IS reliability (when the occasional bug appears, for example a student unable to use a clicker that had previously worked just fine) and unintended effects of the IS (unintentional or intentional misuses of the IS, for example by having one student manipulate multiple clickers on behalf of several others who are unable to attend class). Although this author has not tried it in class, a side by side comparison of IS and paper processes is also possible, by using an alternative way to collect students' responses instead of using clickers.

A really ingenious demonstration of IS issues was the brainchild of a graduate student. In a class on security and privacy, he started his presentation by asking several highly private questions of the class, to be answered via clickers. The questions were on ethical uses of IS, including illegal software downloading and plagiarism. After students in class answered the questions and the class had considered the aggregate results displayed, the student presenter then asked the class to ponder the following: their answers were recorded and could be traced back to them by the instructor or by somebody with access to the clicker data. The presenter then continued to discuss other IS privacy issues, using the clicker example as a starting point of familiar IS that we tend to use without considering or defending against possible misuses and privacy traps.

## **6. CONCLUSIONS**

Several other authors have claimed that using clickers can be highly beneficial to the learning environment. Although we do not claim to have demonstrated such effects in this paper, other authors have shown that clickers encourage students to attend more regularly, clickers keep

students more engaged, and they also help students better remember the material taught.

The main result that is central to this work is that the clicker scores are highly correlated with the final scores in the course, even though the clicker scores themselves are a tiny portion (5-10 percent) of the final score. Moreover, these findings are consistent for both graduate and undergraduate courses. Lastly, the results seem to be consistent, regardless of whether the clicker usage is mandated or left optional (and even when the actual clicker points' contribution is not communicated clearly to the students).

This high correlation could mean one of two things. One alternative is that there may be a causal relationship. Using clickers could increase student motivation and involvement. This hypothesis aligns well with what other authors have claimed, that the use of clickers is beneficial not only in appealing to the rational part of the students' brains, but also to the emotional brain, by engaging them in a (serious) game, where students compete against each other and maybe even against themselves. If students can be motivated by a component that is 5-10 percent of their grade, this kind of effect could be further leveraged by giving clickers a higher weight in calculating the final grade. This paper did not use an experimental approach involving a control group, so we cannot claim to show a causal link between using clickers and student performance.

The other alternative is that the clicker score is simply correlated with overall performance, but that there is no causal relationship. In other words, it might be that clickers are able to measure student performance in a manner that is sufficiently robust to randomness that it is a better indicator than most of the other assignments. If this were to be the case, it is still a good argument for giving clickers a higher weight in the final grade, to take advantage of the good qualities of the clicker score as an assessment tool.

This paper is only an observational case study, reporting that clicker scores correlate well with final course grades in two different sections of two different courses, with two different mechanisms for incorporating clicker usage (required or optional). Because of the lack of a control group, it is not possible to determine whether clicker use was a cause or simply a good proxy for improved student performance.

Because their correlation coefficients are higher than those for most other assignments used, clicker scores are at least a good proxy for overall student performance, and could be given a larger weight in determining the final grade.

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