



The Impact of Clickers on Your Classroom and Your Career

Dr. Ted Eschenbach, University of Alaska Anchorage

Dr. Ted Eschenbach, P.E. is the principal of TGE Consulting, an emeritus professor of engineering management at the University of Alaska Anchorage, and the founding editor emeritus of the Engineering Management Journal. He is the author or coauthor of nearly 250 publications and presentations, including 15 books. With his coauthors he has won best paper awards at ASEE, ASEM, ASCE, & IIE conferences, and the 2009 Grant award for the best article in The Engineering Economist. He earned his B.S. from Purdue in 1971, his doctorate in industrial engineering from Stanford University in 1975, and his masters in civil engineering from UAA in 1999.

Dr. Neal Lewis, University of Bridgeport

Dr. Neal Lewis received his Ph.D. in engineering management in 2004 and B.S. in chemical engineering in 1974 from the University of Missouri – Rolla (now the Missouri University of Science and Technology), and his MBA in 2000 from the University of New Haven. He is an associate professor in the School of Engineering at the University of Bridgeport. He has over 25 years of industrial experience, having worked at Procter & Gamble and Bayer. Prior to UB, he has taught at UMR, UNH, and Marshall University.

Dr. Gillian M. Nicholls, University of Alabama in Huntsville

Dr. Gillian M. Nicholls is an Assistant Professor of Industrial and Systems Engineering and Engineering Management, and a 2009-2010 Gray Faculty Fellow at the University of Alabama in Huntsville. Her research interests are in applying statistical analysis and optimization to supply chain management, transportation management, and engineering education. She holds the B.S. in Industrial Engineering (Lehigh University), Masters in Business Administration (Penn State University), M.S. in Industrial Engineering (University of Pittsburgh.), and Ph.D. in Industrial Engineering (University of Pittsburgh).

Dr. Jani M Pallis, University of Bridgeport

Dr. Jani Macari Pallis received her Ph.D. concentrating in Mechanical and Aeronautical Engineering from the University of California, Davis. She has a master's from the University of California, Berkeley in Mechanical Engineering and a master's and bachelor degree in Health Systems from the Georgia Institute of Technology. She is an associate professor in the School of Engineering at the University of Bridgeport. She has over 30 years of industry experience working at United Airlines and as the CEO of Cislunar Aerospace, Inc, a small engineering firm she founded while a graduate student.

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Abstract

Student response units or clickers enhance student learning by providing immediate feedback to both students and the instructor. This feedback *can* be an extremely valuable resource for teaching. In addition clickers increase student engagement with all the material within a class. Not surprisingly, every year there is more quantitative evidence of the value of clickers and richer descriptions of how clickers can be used.

This presentation adds to that evidence and those descriptions, but the paper's focus is a broader perspective. First, the paper discusses how and why clickers can qualitatively change the classroom. Second, how the change can positively impact an academic's career including the promotion and tenure process. These points are supported with anecdotal evidence gathered by professors with a range of clicker experience from first usage in a course to 25 years of use in a variety of classes.

Much of our past work has been in the context of quantitative courses. Clicker use was recently expanded to qualitative courses with very similar results. While some of the details are somewhat different between the two types of courses, student support remained very strong.

Finally, we suggest that one of the best reasons to use clickers is that they can make teaching a lot more fun. Instead of focusing on covering a chapter's worth of material, it is possible to focus on maximizing what students learn in the classroom and the course.

Introduction

Clickers can change the lecture hall from the typical monologue with questions to a dialogue focused on students understanding and learning. For example, many students are culturally accustomed to rote-based instruction, shy, and/or lack confidence in their knowledge and thus reluctant to engage in class discussions. Clickers can efficiently overcome this reluctance. Consider which instructor provides more value: the professor who presents another example like the one in the text or the professor who can respond quickly to a common misunderstanding held by numerous students with a targeted example problem that follows-up on a previous example.

The dialogue changes how both students and faculty approach the material, learn from the material, and absorb it within the classroom. Passively presenting or watching the lecture is not the best method for students to deeply learn the material or for instructors to gauge students' learning. Dialogue that enhances both student and instructor learning positions both parties for better success in future courses and careers.

At most institutions faculty members want to be recognized as a good, excellent, or outstanding teacher, albeit not to the extent that excellent teaching is negatively viewed as a lack of focus on research proposals and publications. We have observed that department chairs and deans are positively influenced by students' reported perceptions of enjoying and learning more in classes

with Professor X. Such positive impressions can aid promotion and tenure as well as increasing such faculty members' influence on decisions of which classes they teach.

This paper reviews the literature about student response units' use and discusses prior research into their benefits. While this will touch on some best practices for using clickers, the focus is not upon convincing instructors how to adopt or improve clicker usage. Much of the authors' prior experience with clickers has been in courses with a large quantitative component. This paper discusses the authors' findings from their first application of clickers in a mainly qualitative course. The results are consistent with previous results indicating that clickers are also valuable tools for qualitative courses. The paper will also discuss how using clickers in the classroom can positively affect a career in academia.

Literature Review

Clickers have a long history in education. They were developed in the 1960s as a way of increasing student engagement and aiding the transmission of challenging material¹. Through the years they've been referred to using multiple names including student/classroom/audience response or performance units/systems. The utility of these systems has been the subject of numerous research studies. Among the earliest work were studies that analyzed their success in improving learning in large quantitative classes^{2 3 4} in the mathematics and sciences. The findings suggested that the clickers had positively affected the students' engagement in the classroom and learning process. Additional studies have been done through the present time that examine the use of clickers in educating engineering students^{5 6 7 8 9 10 11 12 13 14 15 16 17 18} and those in other academic disciplines. The general consensus is that clickers are a useful technology to aid learning. Clickers can empower students by making them aware of a gap in their understanding of the material in a timely fashion, and to take ownership in correcting it. The most common conclusion of the literature concerns the potential for clickers to increase student engagement and create a more active and participatory learning process. The analysis of clickers' effect on student engagement and active learning has been explored by numerous studies^{19 20}.

Using clickers to engage students and assess their learning builds on research into student learning without technology aids. Posing thoughtful questions that prompt reflection of recently introduced concepts, along with interaction with the instructor is a way of sparking generative learning. This has been demonstrated by research showing that combining "adjunct" questions with a reading assignment produces more effective learning than assigning the reading in isolation.^{21 22 23 24 25 26 27 28} The timing of the questions is also significant. Some studies^{29 30} found that students did better on exams when they were presented with the questions after the reading as opposed to beforehand. Mayer³¹ and Sagerman & Mayer³² reported that questions which concerned conceptual knowledge as opposed to simple facts also produced better exam performance. Ozungor & Guthrie³³ and Dornisch & Sperling³⁴ studied the results with adjunct questions that probed students' understanding of the material at a deeper conceptual level and found that this aided students in answering final exam questions that required more than simply regurgitating facts. A testing effect was found when students were instructed to take a practice exam to prepare for an exam as opposed to merely re-reading the material^{35 36}.

Mayer et al.³⁷ extended this research by attempting to create an environment of generative learning by using clickers to efficiently ask adjunct questions when lecturing to large classes of a psychology course. Three classes were compared: one was taught without clickers; one was taught with clickers and adjunct questions; and the remaining control class was taught with paper forms to ask the adjunct questions and collected the responses. The three groups were compared by prior performance on the SAT exam and the class without clickers had a significantly higher mean SAT score. Despite this, the class taught with the clickers had a significantly higher performance level in the course. The interaction between the instructor and the students using clickers to respond to thoughtful questions appeared to have resulted in a greater atmosphere of generative learning. Dawson, Meadows & Haffie³⁸ also found that clicker question performance was positively associated with course grade. Students who participated more and were more often correct did better in the course.

Bojinova & Oigara³⁹ and Zapf & Garcia⁴⁰ also concluded that clickers aided students in active learning. They found no significant differences in the mean exam scores of classes taught by clicker vs. without clickers, but the variance of exam scores for the clicker group was smaller. Levesque⁴¹ tested an approach in which students were exposed to new material, asked to solve a problem, voted by clicker, then saw the results, and were asked to solve another problem of the same type. The students who more frequently answered the questions performed better on exams than the students who more frequently answered the clicker questions correctly. Her conclusion was that students who were more engaged to work through their difficulties were apt to do better in problem-solving on exams. Other studies by Martyn⁴² and Anthis⁴³ found that clickers created a more engaged class but did not produce significantly better exam results.

Much of the prior research studying the use of clickers in the classroom has focused on students' perceptions of the clickers' utility and their satisfaction with using the clickers, including Draper & Brown⁴⁴, Fang⁴⁵, Zapf & Garcia⁴⁶, Fike, Fike & Lucio⁴⁷, and Lennox Terrior & Aceti⁴⁸. Students generally responded favorably to clickers although Dallaire⁴⁹ found that the satisfaction and grades declined if clickers were used too frequently. Duncan⁵⁰ and Hoekstra⁵¹ conducted analyses of clicker usage in large classes that indicated less than 30% of the students achieve complete mastery of the material even when taught by outstanding instructors. This number rises to 60-90% of the students when the instruction is supplemented with clicker utilization. However, there is a point of diminishing returns relating to the design of the clicker technology. As the clickers acquire more features and are used to answer more complex questions, the learning results decline as more thought is placed on using the clicker to respond and less on the question response itself.

Overall, clickers have shown potential to keep students engaged in the learning process and provide a means to quickly assess learning success. Students are prompted to connect the new concept(s) to those learned previously and demonstrate their mastery of it. This allows the students and the instructor to rapidly discover whether the introduction of a new concept was successfully scaffolded onto prior knowledge by a critical portion of the class. If the answer is no, the instructor can return to the concept with a clarification or another example. If the answer is yes, the instructor may move on, but the students who privately know they were not correct are now aware and motivated to correct the deficit. This dramatically shortens the cycle time of learning from introduction of a concept to a student knowing whether the concept was

correctly/incorrectly understood. Rather than waiting for the feedback from attempting a homework problem, a quiz, or even an exam, the student now knows where he/she stands in attempting to learn the concept. Martyn⁵² observed that the privacy of electronic voting also encourages greater participation by students reluctant to speak publicly and risk the embarrassment of being wrong while still allowing the instructor to know how each student answered.

The design of clicker questions has also been the subject of academic analysis. Bruff⁵³ created a taxonomy of clicker questions including content questions to test recall and conceptual understanding; critical thinking questions to get at the single best answer; process questions to gather student perspectives and assess their confidence level; and classroom experiment questions which can further foster a many-to-many conversation.

Recent Results from Qualitative and Quantitative Courses

Past surveys of our undergraduate and graduate classes found that over 80% of both sets of students found the clickers beneficial in these quantitatively oriented classes.⁵⁴ Here we use results from three graduate courses (all taught by the same faculty member) at [University 2] as a data point to examine whether results are significantly different between qualitative and quantitative courses. The sample is very small, but it does control for the instructor, the university, and the level of the course.

These results are detailed to also provide a concrete example of student evaluation of clicker use with clear implications as to the impact on course evaluations. One course was qualitative in nature (N=28), a second course was a management course considered 1/3 quantitative and 2/3 qualitative (N=10), and the last course was a quantitative class (N=18). The students in the three courses were surveyed and the results shown in Table 1 were similar between the three classes as well as to past quantitative course results⁵⁴. These results are not surprising, as the literature review included a broad variety of classes; nevertheless, we were still glad to have the value of using clickers confirmed.

As shown in TABLE 1, the majority of graduate students found clickers helpful. In each course and in an average of the three courses, over 75% of the students reported that the clickers were beneficial in learning the course materials. (Note that more undergraduate students typically select response A, than do graduate students.) While there does seem to be a slightly stronger correlation for the courses with more quantitative aspects, the overall results are consistent with our past findings.

As shown in TABLE 2, a major impact of clickers is that students learn from their mistakes (total average for the three courses was 56.9%). The anonymity of clicker responses encourages quieter, less confident students to participate, increases student attention in class and helps students stay engaged. Additionally, when a student sees a large percentage of the class reach the same correct or incorrect conclusion on a posed problem the student may recognize that other classmates have gotten or are having difficulty with the same concepts.

TABLE 1. Student Responses to the Question “What was the Value of Using Clickers?”

Question 1	Graduate Course Qualitative (N=28)	Graduate Course 1/3 Quantitative 2/3 Qualitative (N=10)	Graduate Course Quantitative (N=18)	Total Graduate Course Average (N=56)
A: They are the reason I will successfully complete this class	3.6%	10.0%	5.6%	5.4%
B: They were helpful in my learning	75.0%	80.0%	94.4%	82.1%
C: Neutral	21.4%	0%	0%	10.7%
D: Using fewer would have been better	0%	10.0%	0%	1.8%
E: They were a waste of time	0%	0%	0%	0%

Clickers also help the student to stay engaged in class. Students have claimed that they cannot mentally drift off because they never know when a clicker question might come up. Instructor observation suggests that periods of student inattention are much shorter and less frequent—but they do still occur. With greater attention and commitment to providing an answer (right or wrong) students are more involved in the class, which creates a form of dialogue. As would be expected in the qualitative course, students responded 0% to the answer that clickers allowed them to “preview calculations for the homework”. However, in the absence of needing to learn a mathematical procedure, the students in the qualitative course responded that the use of clickers required their greater attention (46.4%) (“It forced me to wake up and respond”) in contrast to the more quantitative courses (30%).

TABLE 2. Student Responses to the Question “What is the Biggest Advantage of the Clickers?”

Question 2	Graduate Course Qualitative (N=28)	Graduate Course 1/3 Quantitative 2/3 Qualitative (N=10)	Graduate Course Quantitative (N=18)*	Total Graduate Course Average (N=58)
A: Previewed calculations for the homework	0%	20.0%	5.0%	5.2%
B: I learned from my mistakes	53.6%	50.0%	65.0%	56.9%
C: It forced me to wake up and respond	46.4%	30.0%	30.0%	37.9%
D: Instructor was quiet for a while	0%	0%	0%	0%
E: There weren't any advantages	0%	0%	0%	0%

*Some students gave multiple answers to multiple questions.

The student responses to the question on “Class Discussion and Clickers” (Table 3) demonstrate the technology’s ability to support class and small group discussion. A small difference exists between the qualitative and quantitative courses and may be expected due to the nature of the quantitative courses. For example, students answer clicker questions individually, but when a significant portion of the class answers incorrectly the instructor may ask the students to discuss the problem before answering again. The quantitative courses may require calculations and

students may spend more time working in small groups in the quantitative course versus a qualitative course. However, the focus in this study has been to determine if students recommend the use of the clickers and if clickers encourage discussion. Clearly, with a total average of 94.7% (Answer A – “Clickers help us discuss things as a class” plus Answer B – “Using clickers helps us discuss in small groups, then vote”), clicker technology encourages student discussion.

TABLE 3. Student Responses to the Question on “Class Discussion and Clickers”

Question 3	Graduate Course Qualitative (N=28)	Graduate Course 1/3 Quantitative 2/3 Qualitative (N=10)	Graduate Course Quantitative (N=18)*	Total Graduate Course Average
A: Clickers help us discuss things as a class	75.0%	60.0%	63.2%	68.4%
B. Using clickers helps us discuss in small groups, then vote	14.3%	40.0%	36.8%	26.3%
C. It is fun, but does not really change anything	10.7%	0%	0%	5.3%
D: Instructor gets quiet for a while	0%	0%	0%	0%
E: There weren't any advantages	0%	0%	0%	0%

*Some students gave multiple answers to multiple questions.

The majority of the students in the three courses responded that they would “strongly recommend” the use of clickers in their respective course in the future (average 75%). The results shown in Table 4 (“Would you recommend using Clickers in this course in the future?”) are similar to our past results for this question.⁵⁴

TABLE 4. Student Responses to the Question “Would you recommend using Clickers in this course in the future?”

Question 4	Graduate Course Qualitative (N=28)	Graduate Course 1/3 Quantitative 2/3 Qualitative (N=10)	Graduate Course Quantitative (N=18)*	Total Graduate Course Average (N=56)
A: Yes, strongly recommend	67.8%	70.0%	88.9%	75.0%
B. Yes, but not strongly	28.6%	30.0%	11.1%	23.2%
C. Neutral	3.6%	0%	0%	1.8%
D: No, but not strongly	0%	0%	0%	0%
E: No, strongly do not recommend	0%	0%	0%	0%

*Some students gave multiple answers to multiple questions.

The students were also asked if they would recommend using clickers in *another course* (Table 5), and the responses were similar to the question on usage in future courses with 64% of the students “strongly recommend” clicker usage in another course.

TABLE 5. Student Responses to the Question “Would you recommend using Clickers in another course?”

Question 5	Graduate Course Qualitative (N=28)	Graduate Course 1/3 Quantitative 2/3 Qualitative (N=10)	Graduate Course Quantitative (N=18)* ¹	Total Graduate Course Average (N=56)
A: Yes, strongly recommend	67.8%	60.0%	61.1%	64.3%
B. Yes, but not strongly	28.6%	40.0%	33.3%	32.1%
C. Neutral	3.6%	0%	5.6%	3.6%
D: No, but not strongly	0%	0%	0%	0%
E: No, strongly do not recommend	0%	0%	0%	0%

Not surprisingly, clicker use is frequently and positively mentioned in our course evaluations. We believe that our numerical ratings are higher than what we would receive if we were not using clickers, and a comparison of before/after use of clickers in courses taught in both ways provides limited data to support that contention.

Impacts Within the Classroom

Professors often focus on what *content* should be covered, but not *how* it should be covered. With a lecture presentation taken for granted the remaining questions are about what chapters to cover, what should be assigned as homework and projects, and how students should be evaluated and tested. The use of clickers should lead to more reflective choices by the professor on *how material should be covered*. While this starts with what clicker questions to use, it can easily expand to how the material is discussed in the classroom and how the material is handled outside of the classroom.

An analogy can be made to a toolbox. The larger the set of tools you employ—the better you can choose the best way to help students learn. Teaching goals should drive choices. Classroom time is precious, and it should be used effectively—which usually means using multiple tools, not just a lecture.

One of the interesting effects of the greater interaction between students and faculty that the clickers promote is that the professor should gain more knowledge of the class. This of course includes what problems the students are having with the material, but it also includes more knowledge about individual students. A specific student experience may become an example that classmates and future classes can easily relate to and learn from.

As professors, we are expert on the content but we are rarely similar to the typical student. Most professors were good, not average, students and then we’ve added degrees and sometimes decades of experience. Not surprisingly, sometimes our main knowledge of students is: “A quarter of the class will make this mistake and half of the class will make that mistake.” Clickers allow us to learn more about what students do and do not understand and *why*. This immediate feedback allows us more opportunities to improve our courses.

As a side note, one of us uses clickers plus photos taken before/after class for the first week to learn all student names (up to a class size of 70). The instructor's experience is that it is harder for students to "blow off" the class if instructor knows them. Another of us has shocked misbehaving students into better behavior simply by using their name; when we know everyone's name, the class experience becomes far more personal.

Impacts Outside the Classroom

Most students prefer classes with properly used clickers. As an example, one of us was teaching one of two sections with clicker use as the main differentiator (same text, "same" syllabus, and similar instructor qualifications). The clicker class had an enrollment of 17 vs. 2 in the other section, until the clicker class was closed to fill the other section.

In our experience, professors with better teaching performance get a few more choices about what they teach (even if they're assistant professors or even adjuncts). Support staff are a bit more supportive; rooms or times may be a bit more flexible. (Note these positive results leading to more flexibility do not seem to follow with students. Better lecturing with clickers, seems to raise expectations for better performance in other areas of teaching. Knowing the professor better can give some students the courage to challenge more of the professor's choices).

Students who respond as shown in Tables 1 – 5 can be expected to rate a professor's teaching more highly. Since most universities gather little or no direct evidence of teaching performance, responses to qualitative course evaluations (student comments) and having even a few students visit the chair or dean to say good things can make a large difference in promotion and tenure. Even if no comments are received, the simple fact of past clicker use can be used as evidence that teaching is being treated as being important by a faculty member. Furthermore, use over time can demonstrate that teaching innovation and improvement is a continuing effort. One of us has received direct feedback from a P&T committee member ("Your students *love* your clickers.") based on student course evaluations.

Thus, positive impacts on promotion and tenure should result. Our ability to fill a class and teach it effectively is considered in promotion and tenure, including classroom visits by P&T committee members who wanted to see the class after seeing student evaluations. The main anecdotal exceptions we suggest are extrapolated from non-clicker teaching innovations. Senior faculty can be jealous of and out to "get" a high-performing junior colleague. Time taken to teach well can be negatively viewed at institutions with an exclusive focus on funding and publishing.

Summary and Conclusions

As short-term impacts on us as instructors, we've personally:

- Gotten to know our students better as people.
- Gathered knowledge of how they're grasping and using the material
 - Multiple times per day (not just with quizzes, homework, and tests on weekly or longer intervals).
- Been much more sure of what they know and can do.

- Lectures better targeted to increase their learning.
- Better able to write a reference for the A, and the B, and the C level students.
- Had a LOT more fun. Talking with engaged students is *MUCH* better than lecturing to students who are in a near-coma state.
 - Learned more from the students as they presented another situation and presented their perspective or asked what now?
- Had our clicker use positively recognized by administrators and promotion and tenure committees,

Taking a longer time-frame perspective, we suggest the following as why instructors teaching in face to face classrooms need to incorporate clickers as part of their teaching toolbox.

- We suggest that relying on only the classic lecture represents a *failed* model for improving student engagement and learning. Thus repeating that model and expecting a successful result is one definition of insanity.
 - We know that ‘I covered it’ does not ensure that they learned it.
- If we don’t use clickers or other ways to improve the classroom experience, then what is our competitive advantage over on-line delivery of multi-media material by world-class professors with computer mediated examples and problems.
 - Especially since some of these courses are free and available to anyone with an internet connection.
- Clickers are how we can cope with increasing class sizes and add value for face to face classes.
- If professors want to be well paid (or even employed), we have to improve classroom effectiveness and productivity.

We suggest the following value proposition for clicker usage. A cost of \$1 per week for a student to buy a clicker for 1 course and sell it at the end of the semester is inconsequential. The gain in student engagement and learning is easy to justify for them. The question is whether the faculty member feels it is worth the time to slow the pace of the class. Dialogue takes longer than monologue. Less material can be covered in the same amount of time, but the level of learning is greater. The top students may not be *exposed* to quite as much material, but average (and probably top) students *master* more material. Thus, in spite of the slower pace of the class, greater student learning and understanding can be achieved.

In addition, it can be argued that trying for complete coverage of the material in the lecture encourages students to rely on the lecture *more* and their own reading of course material *less*. To the extent that this is true, it is not clear that complete lectures actually cover more than a lecture that is focused on where the instructor can add value *in* the classroom.

In closing, we do want to note that clickers can be and sometimes are used badly. For example, suppose clickers are used just to automate the taking of attendance. Or suppose the clicker response shows few students understand, but the professor ignores this and proceeds as though everyone understands. Within the clicker research community, two questions are what is the *right* number of clickers and what is the right balance between effort/participation/attendance and correct responses.⁵⁵ Thoughtful choices by a professor will almost always be in the range of effective use, but unthinking choices may lead students to bitterly resent the requirement to buy a

clicker. Not meeting expectations that you've created is worse than not creating the expectations in the first place.

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