AC 2011-1492: CLICKER CLICKS IT

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Clicker Clicks It!

Abstract

Manufacturing requires collective knowledge of material, metrology, and processes. Synchronizing hands-on laboratory with lecture helps students to learn, appreciate, and be motivated for further study. Learning effectiveness in a large class, however, is reduced due to limited interaction, delaying feedback until after an exam, and tediousness of many repeating laboratory sessions. Classroom Performance System (Clicker) has been an educational tool to gauge student comprehension, collect opinions, receive instant feedback, and automate administrative tasks. This paper presents the results of implementing Clickers in two manufacturing classes and laboratories at Texas A&M University. Both class size and class level are considered in the study. Despite teething problems when implementing a new technology, very positive student feedback, less tedious work for laboratory assistants, and better exam outcome prove the success of Clicker implementation.

I. Introduction

Many pedagogical techniques such as "one-minute paper quiz" or "scavenger hunt" when students have to work out a problem and find others with same answers [1] would work well in a small class with homogeneous student population, but are not practical to implement in a large class with diverse student background. An instructor would need a paperless, automatic, inexpensive, and easy-to-implement technology to know if students understand key concepts, to have more student participation, to keep attendance records, and to receive regular feedback from students during a semester. From student perspective, they would like to have instant feedback to know what are missed, to reinforce what is learned, to know their own ranking in class while remaining anonymous, and most importantly to achieve the desired final grades. Classroom performance system (CPS) – also referred to as electronic voting system, audience response system, personal response device, Classtalk, or simply Clicker – is the electronic device that send answers or votes from a large audience to a computer-driven receiver for quick analysis and immediately displaying results using standard equipments in a multimedia classroom. In an early version, a Clicker with only alphabetical selection is popular in social science or business classes where multiple choice questions are common. Penetration of Clicker in science and engineering fields is observed since the latter version of Clicker allows students to respond with either numerical answers for a work-out problems or alphabetical selections for multiple choice questions.

The role of Clicker as teaching and learning enhancement tool has been discussed in the academic community since 1980s. There are few published papers on using Clicker on engineering subjects and no report on how Clickers can be used effectively in laboratory. We implemented Clicker in manufacturing classes with the following objectives:

i) Creating a more dynamic learning environment,
ii) Enhancing study outcome, and
iii) Reducing tedious paperwork and workload in many repeating laboratory sessions.

II. Literature Review

Clickers started during 1960s in Hollywood to collect opinions on unreleased movies or television shows before spreading into academic areas [2]. The first academic Clicker was introduced at Stanford University, California, in 1966. This prototype system was later improved and implemented at Christopher Newport University, Virginia, in 1985. Significant use of Clickers, however, only picked up in 1999 when wireless infra-red systems were introduced [3]. The latest Clickers utilized radio frequency wave to communicate between large numbers of hand-held Clickers with a central receiver and eliminated inherent limitations of slower infra-red Clickers that required precise aiming for data transmission. One Physics professor at University of Colorado in Boulder pioneered the Clicker in 2001, since then the usage of Clicker has exploded to 70 faculties teaching 10,011 graduate and undergraduate students in 2007 [4]. It was reported that over 6 millions clickers were used worldwide in 2009, a market of US$340 millions and is expanding at 36% annually [5].

The latest Clickers with multiple-choice and numerical input options are now popular in many disciplines including psychology and sociology [4], operation management [6], engineering dynamics [7], physics, astronomy [4,8], astrophysics [4], chemistry [9,10], chemical engineering [4], mathematics [11], engineering mechanics [12], and thermodynamics [13]. Published literature shows both qualitative and quantitative assessment of how Clickers help students and instructors to achieve their academic objectives. Studies were based on data collected from a small class, to large classes over 100 students, to campus wide large classes, and even to a collective study from seven universities and involved more than 1500 undergraduate students [8].

Both negative and positive assessments of Clicker have been published. Bugeja[2] concerned of the implementing cost of Clickers from both students and school administrative views. Others identified top benefits of Clickers as instant feedback for both students and instructors, and strong correlation of Clicker participation and final grade outcome. Fang[7] and King et al [9] found statistically significant correlations between clicker performance and exam performance. King and Joshi [9] studied how gender responded to Clickers in a chemistry class. Female students were more active participant than male. They found 62% of female students were active compared to 48% of male in one semester; the figures changed to 64% and 54% respectively in another semester. Both genders who actively participated in Clicker sessions received higher final grades than the rest of the class. Debourgh [14] concluded that the most powerful impact of Clickers on student achievement was the opportunity for instant feedback. Formative feedback allowed students to correct their misunderstanding, gain clarity, and to indentify gaps and flaws. The timely feedback also allowed instructors to adjust and find a more effective teaching method. Lantz [15] highlighted the benefit of Clickers when students have to generate an answer without being judged by peers, therefore, promoting memory though "generation effect." Keller et al [4] survey more than 10,000 students in 94 lecture sessions. They suggested the maximum Clicker benefit could be achieved if 3-4 questions were given per quiz in practically every lecture (90-100%). Both students and instructors agreed that it would be best to let students discuss during a quiz to foster interaction and improve learning. Kay and LeSage [3] summarized benefits and challenges of using Clickers in Table 1 in which numerous advantages of how Clickers change a passive classroom into a livelier learning environment are highlighted. Both students and instructors benefit when receiving instant feedback for improvement. Table 2 tabulates Clicker

issues including teething problems of newly developed Clicker technology, and adjustment of instructors and students to a new learning environment.

Table 1: Benefits of Clickers [3]

Classroom	Attendance	Students go to class more
	Attention	Students are more focused
	Anonymity	All students participate anonymously
	Participation	Students participate with peers more to solve problems
	Engagement	Students are more engaged
Learning	Interaction	Students interact more with peers to discuss ideas
	Discussion	Students actively discuss misconceptions to build knowledge
	Contingent teaching	Instruction can be modified from student feedback
	Learning performance	Learning performance increases
	Quality of learning	Qualitative difference when learning with Clickers (e.g., better explanations, thinking about important concepts, resolving misconceptions)
Assessment	Feedback	Students and teacher like getting regular feedback on understanding
	Formative	Assessment is done that improves student understanding and quality of teaching
	Compare	Students compare their Clickers responses to class responses

Table 2: Challenges for implementing Clickers [3]

Technology	Bringing Clickers	Students forgot or lost Clickers and could not participate in class
	Clickers did not work	Remote devices did not function properly
Teacher	Responding to student feedback	Less experienced teachers cannot adjust to student feedback
	Coverage	Cover less course content if Clickers is used
	Developing questions	Time consuming to create Clickers questions
Student	New method	Students find it difficult to shift to a new way of learning
	Discussion	Discussion leads to confusion or wasting time
	Effort	Too much effort is required by students when using Clickers
	Summative assessment	Using Clickers for tests may not be popular with students
	Attendance for grades	Students do not like Clickers used for monitoring attendance
	Identifying students	Students want to remain anonymous
	Negative feedback	Students feel bad when receiving negative feedback

III. Methodology

Two manufacturing classes were selected to gauge the impact of Clickers. Both courses offered weekly laboratory sessions to smaller groups of students. Class size and class level are carefully considered when selecting these courses:

a) An introductory course M181 with more than 200 undergraduate students in Fall and Spring semesters.
b) The same course M181 with about 35 students in Summer term.
c) An advanced course M489 with an average of 20 seniors and graduate students each semester.

Each student was required to purchase a clicker ($25 for a new device and approximately half price for a used one), and then registered it online ($13 per semester, or one time for $39) by the 2nd week of class. When registered, each clicker was assigned a unique pad number for a specific course. An instructor was alerted by email when a clicker was successfully registered so that the roster can be updated and clickers can be activated during a quiz. Clicker quizzes with 6-10 questions were given at the beginning of each lab session, while Clicker class quizzes with 6 questions were given at a convenient time during lecture. Several homework assignments were substituted with 10-question Clicker quizzes in the M489 class. Students would have one minute to select answer to a multiple choice question or send numerical answer to a simple work-out problem. Instructor could adjust the allowing time depending on the level of difficulty of each question. Data of each student response were recorded with time and date tagged on to individual answer. The instructor analyzed Clicker data, changed grading scheme if needed, and then uploaded Clicker grades to eLearning website for students to view cumulative results.

Anonymous paper surveys were conducted for each class after a midterm test, and at the end of a semester. Effects of class size and class level were gauged by comparing raw test scores and their statistics before and after Clickers were implemented.

IV. Result and Discussion

IV. Clicker assessment

A Clicker quiz with 6 questions was integrated in a PowerPoint lecture, or used as a standalone PowerPoint file with 5-10 questions in each laboratory quiz. The questions could be True/False type (Fig. 1), multiple-choice type (Fig. 2), polling type (Fig. 3), or calculating type (Fig. 4). In a calculating problem, the range of acceptable answers was set by specifying the allowable tolerance (± value). Animation, sound, and movie can be embedded into a question to help clarifying or answering the question.

Figure 5 shows a typical screen during an actual quiz with information for instructor to know the remaining time and number of answers received so that manual time adjustment can be made. The key pad numbers would roll in groups to display all numbers in a large class. After students submitting their answers from their hand-held Clickers, the corresponding key pad numbers on the screen would be highlighted and confirmed by a message "Received" on their own Clickers.

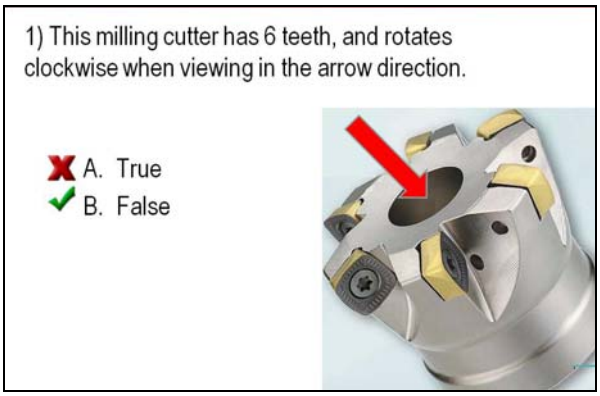


Fig. 1: True/False question.

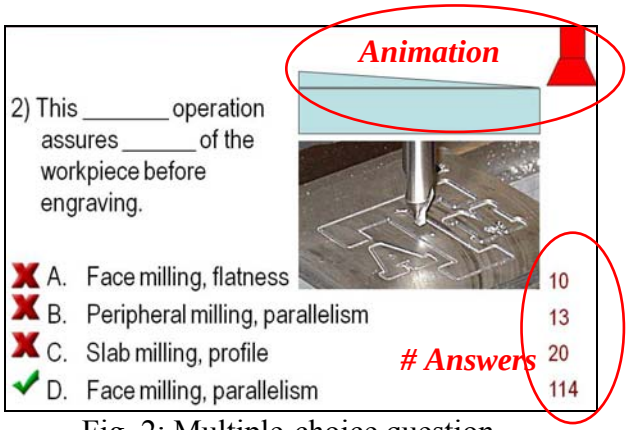


Fig. 2: Multiple-choice question.

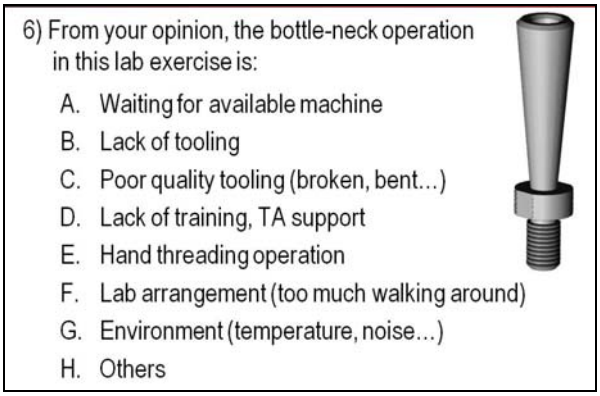


Fig. 3: Polling question.

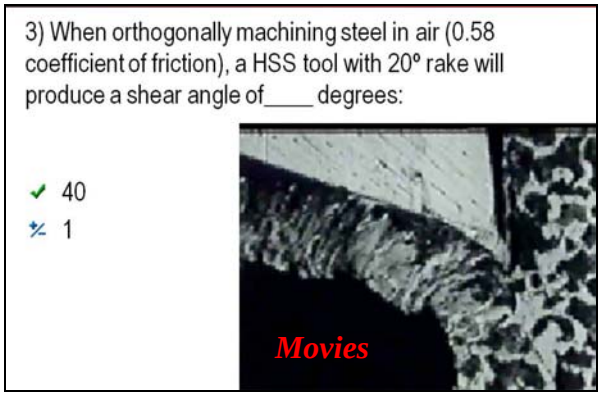


Fig. 4: Calculating question.

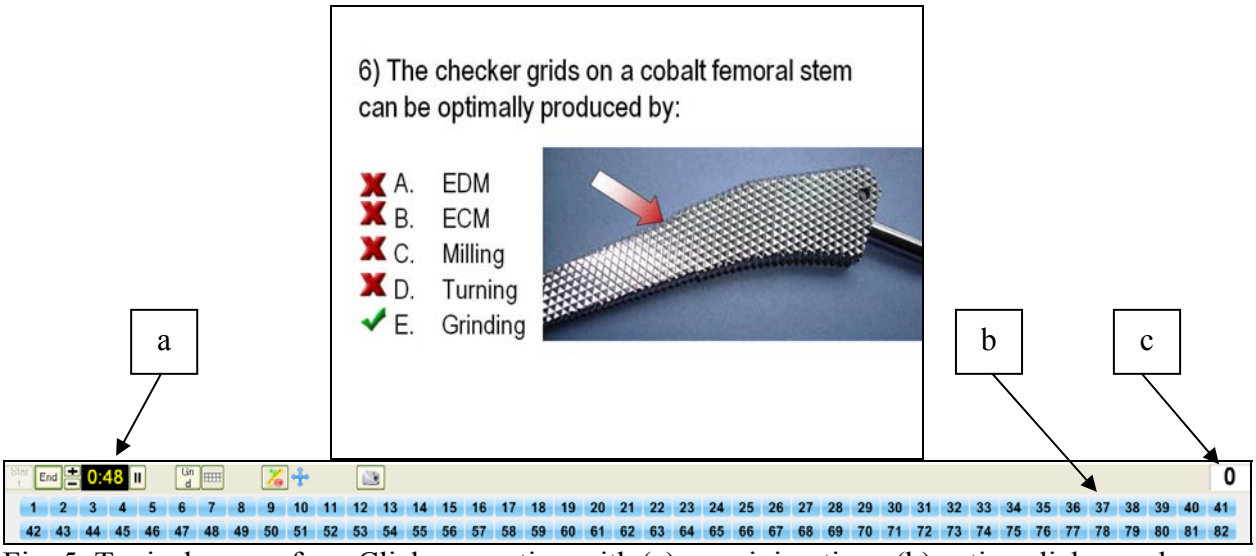
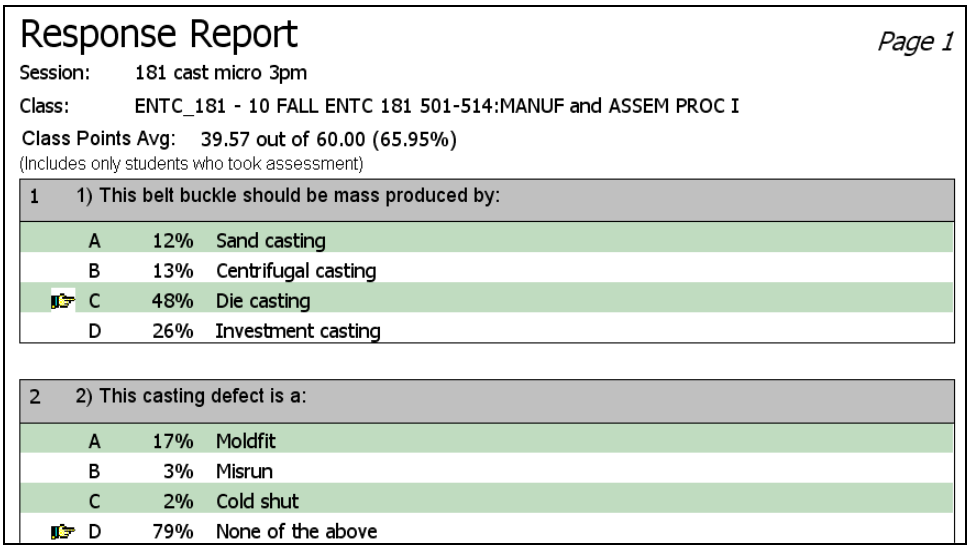


Fig. 5: Typical screen for a Clicker question with (a) remaining time, (b) active clicker pad numbers, and (c) number of received answers.

Daily Clicker quiz is given during an intensive 4-week summer course, but random during a regular semester. A quiz is given at a convenient time during lecture, but at the beginning of a laboratory session. This not only encourages students to attend but also paying attention in class since a question could be about what was explained earlier. At the end of each question, the system provides the answer distribution and shows the correct answer on screen (Fig. 2). Students then have a brief moment to discuss results among themselves then the instructor would explain why an answer is incorrect. Stimulated students would modify the question and ask if the answer is still valid. Peer interaction and student-instructor interaction are greatly enhanced after each thought-provoking question. When analyzing a quiz, there are options to find the answer distribution in table form (Fig. 6) or graphic form (Fig. 7), or find list of top score students, or find the demographic data of student for each answer.



Response Report

Page 1

Session: 181 cast micro 3pm

Class: ENTC_181 - 10 FALL ENTC 181 501-514:MANUF and ASSEM PROC I

Class Points Avg: 39.57 out of 60.00 (65.95%)

(Includes only students who took assessment)

1	1) This belt buckle should be mass produced by:		
	A	12%	Sand casting
	B	13%	Centrifugal casting
☞	C	48%	Die casting
	D	26%	Investment casting

2	2) This casting defect is a:		
	A	17%	Moldfit
	B	3%	Misrun
	C	2%	Cold shut
☞	D	79%	None of the above

Fig. 6: Analysis of Clicker quiz results.

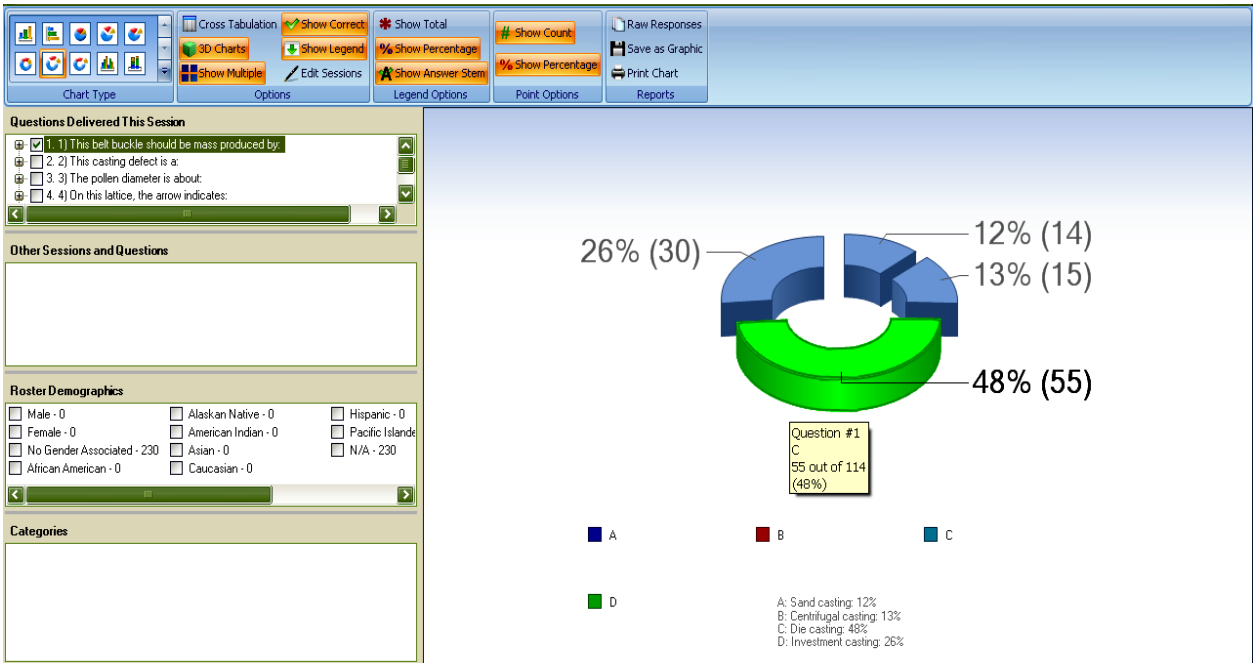


Fig. 7: Analysis of Clicker quiz results with optional demographic data (left column).

The method of "Just-in-Time Teaching" is implemented in the laboratory. By having a Clicker quiz at the beginning of a laboratory session, students will come on time and be prepared. The learning is enhanced after student reading the laboratory instruction and objective ahead of time, taking a quiz, and hearing explanation of any wrong answer. The students would remember and apply what they learn immediately after a quiz with relevant hands-on tasks. This way, students would make fewer mistakes and cause less damage to laboratory equipment and machines since some Clicker questions stress what should be avoided in the exercise.

By replacing a paper quiz with Clicker quiz, the test scores are electronically collected, transferred, and uploaded to eLearning website as feedback to students. This also serves as proof of attendance and participation in class or laboratory. How Clicker grade associated with final grade changes student attitude. A Clicker grade percentage larger than 15% promotes not only student attendance, attention, and preparation but also opportunity for cheating in a large class [4]. A very small percentage, on the other hand, defeats the objective of implementing Clicker especially when students have to pay for. The grade distribution for both classes in this study is: Laboratory 10%, Homework 10%, Clicker 10%, Midterm #1 20%, Midterm #2 20%, and Final 30%.

Figures 8 and 9 plot the sorted raw test scores, ranging from the lowest to highest, for all students in each class. Some outstanding students obtained more than 100 points on their tests since they correctly solved optional problems for extra points. Significant impact on learning outcome is observed for both the small senior class M489 and the large introductory class M181. Implementing Clickers boosts the average test score from 80.3 to 95.7 in the M489 class (Fig. 8). Improvement for the M181 class is 74.6 to 81.7 during a regular semester, but only marginally from 74.1 to 75.4 in the summer term (Fig. 9) when Clicker was first implemented.

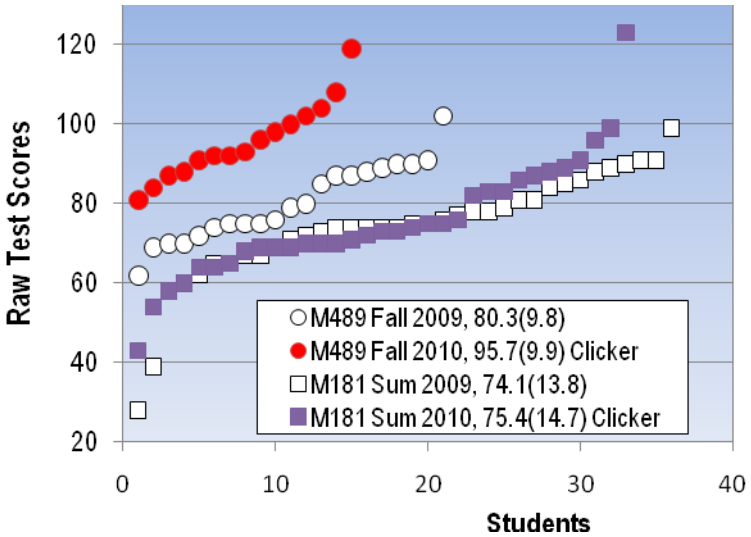


Fig. 8: Impact of Clicker: raw test score comparison for the small M181 (summer) and M489 classes. The average and standard deviation (in bracket) of test scores are listed at the legend end.

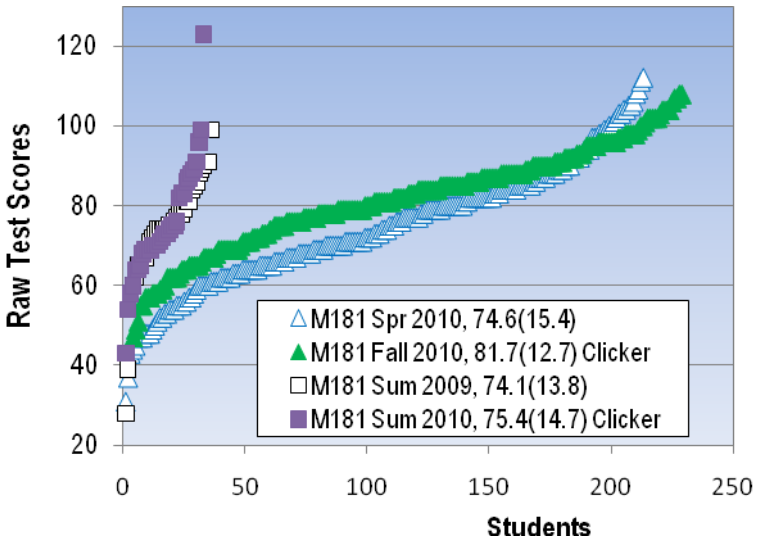


Fig. 9: Impact of Clicker: raw test score comparison for the large M181 classes. The average and standard deviation (in bracket) of test scores are listed at the legend end.

IV.2. Student feedback

Despite some teething problems, majority of 204 students participated in the midterm surveys indicated favorable responses to the Clickers (Fig. 10). When asking if "Clicker helps me to achieve my academic objectives in this class," the large majority 86.7% of students in M489 class strongly agreed (rank #1) or agreed (rank #2) with the statement. The students in freshman level M181 voted for this at 70.8% in Summer term and 60.6% in Fall semester.

In general, the students' comments are in agreement with those from published literature (Tables 1, 2). Samples of positive student feedback on Clicker and class policy in this study are:

- It's an easy, fast way to take a quiz. I like that it's an open book. It gives us insight to what test questions will be like.
- It helps me think faster.
- The Clicker helps me concentrate in class and it helps me remember terms.
- It helps me in knowing if I am studying correctly and if I need to focus more on certain aspects before an exam.
- Interactive, each question is answered right away, more easy to grasp.
- It's fun to see the distribution of answers at the end to see the stupid answers some people put.
- Quizzes are quick to finish.
- Easier than writing a paper and turning it in.
- Save papers.
- It's good to have a quick easy quiz everyday [of summer term] to have the material fresh in our minds.

Samples of negative student feedback on Clicker and class policy in this study are:

- Sometimes technology is a pain in the rear! People are cheaters!
- If your clicker is malfunctioning or not working at all, you are out of luck and cannot participate in the quizzes.
- Can't skip class.
- Force me to study A LOT.
- Costs money.
- Inconvenient if you forget it. It takes so long to get to other questions.
- A little rush sometimes, but it's only because I am not solid with material.
- Had a lot of trouble registering the clicker, and was registered to the same [Clicker] number as another student for some time.

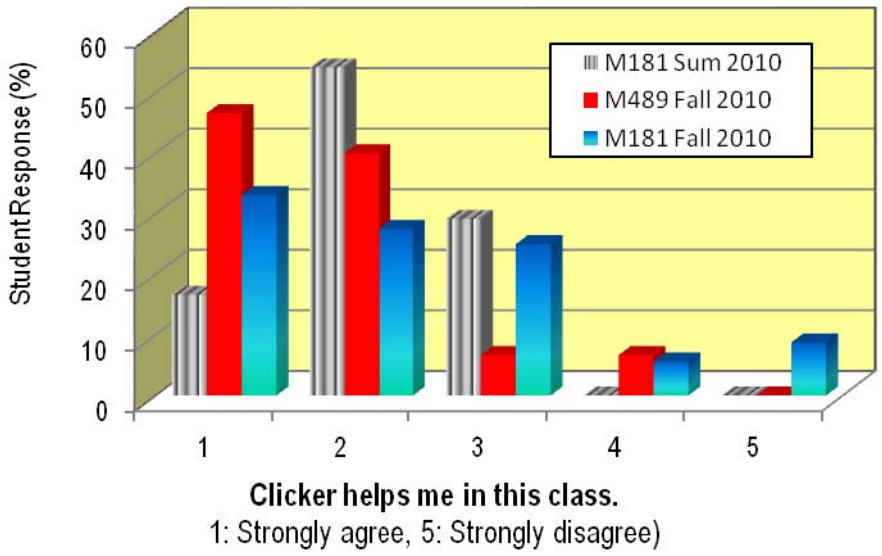


Fig. 10: Students' response to the midterm survey question. Total 204 responses.

IV. Clicker issues

Clicker and any new implementation would have teething problems. It also takes time for an instructor, laboratory assistant, and student to adjust to the new change. We have similar challenges that are detailed in published literature and in Table 2. Some of these can be solved by setting flexible policy not to penalize students for being absent with legitimate reason, or due to truly malfunction of a clicker. About 10-15% of lowest Clicker scores are not counted when computing Clicker grade for both the M181 and M489 courses.

There are unfortunately technological issues that went beyond the control of instructors and students.

- *Technology hiccup*. Even with the latest computer, the CPS system was relatively slow since a receiver had to scan and collected answers from more than 200 students. Some last second answers were not received in time before the cut-off time. The slow system reduced the remaining lecture time and limited number of question for each quiz.

Splitting the activating list into smaller groups for each lab session would help, but this took a considerable amount of time to sort and update all individual group lists.

- *Registration hiccup*. For three consecutive semesters, few students were somehow given "floating" Clicker ID (Pad #) when registered their clickers online. The floating ID changed from time to time and coincided with other pad ID. This caused frustration to those affected students since the receiver seemed to recognize only one from clickers with same ID, and to instructor who had to track the results manually for affected students.
- *Instructor initial training*. Steep learning curve is expected for first time clicker implementation. In addition to learning a new system and solving compatibility issues from different software and hardware, an instructor needed to prepare different versions of Clicker quiz for many laboratory sessions.

Clicker will be continued to use with those classes with some modification.

a) *Cross registration*. Instructor will inform students of the possible technical issues and give a grace period to fix any floating ID issue.
b) *Clicker class quiz*. Due to slow system speed, the quiz frequency will be increased but with reduced number of questions from six to four. Although the time for each question will remain the same at one minute, students will be allowed to use their notes and discuss with neighbors before sending an answer. This will enhance student interaction and foster higher level learning.
c) *Clicker laboratory quiz*. Short Clicker roster for each laboratory group will be created for fast system response. The number of questions will be remained as six. A quiz will be at the beginning of a session and students will keep a log sheet of their Clicker scores to compare with data posted on eLearning. This helps students to be prepared for laboratory while reducing tedious work to laboratory assistants.

V. Summary

Clickers system has been successfully implemented in both manufacturing classes and laboratories. Instructor can quickly view the quiz statistics and know what most students miss so that remedial action can be made. Clicker assessment helps students to know their own progresses and standing in a class. Instant answers and feedbacks help students to reinforce what they learned and remember key points that they missed. The system encourages students to be more organized, utilize their time management skill, attend and pay attention during a laboratory or class.

The Clicker system, however, requires steep efforts in the beginning to effectively administer a quiz and manage data afterward. Crossing of Clicker registration and technical issues sometimes frustrate affected students and instructors. Despite of these hiccups, anonymous student feedbacks show positive attitude from student viewpoints on Clicker, and exam results are very encouraging when comparing data for classes with and without Clicker implementation.

VI. Acknowledgement

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VII. References

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