

The Use of Clickers in Summer Undergraduate Civil Engineering Courses

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Abstract – During the summer of 2009, interactive student response pads, commonly known as “clickers”, were integrated into two junior level civil engineering courses at The Citadel. Summer courses at The Citadel are taught at an accelerated rate when compared to courses in the fall and spring semesters. For example, a three-credit-hour course conducted during three weekly one-hour classes in a traditional 14-week semester is compressed into 14 three-hour classes over seven weeks.

At the end of the two summer courses, a student survey was conducted to evaluate the effectiveness of clicker use in these courses. The responses showed that the majority of students in both summer courses (84%) found clickers to be helpful in keeping students actively engaged in class. In addition, the summer course survey comparison indicated that clicker effectiveness may be linked to integration of these tools into the course materials, as the course that incorporated clickers into a new learning technique was rated higher in keeping students focused in classroom (4.3/5 to 3.1/5) and helping them retain material (4.1/5 to 3.1/5) than the course which did not link clickers to a new learning technique.

Comparison of the summer course surveys to student responses collected from a civil engineering course taught during a traditional 14-week semester did not allow for an evaluation if course length and classroom time affect student receptiveness to the use of clickers. However, the comparison showed that regardless of whether the course was offered in a traditional or accelerated semester, 90% or greater of students would like to see future clicker use in classrooms.

Keywords: civil engineering, clickers.

INTRODUCTION

Summer classes may be a necessary part of an engineering program, but they can certainly present a challenge to both professor and student. For schools on a semester system, summer classes are typically taken during a compressed time frame. Consequently, class sessions are long. There is less time for students to master course material, less time for both students and professors to assess learning, and less time for students to make adjustments when they realize that learning has been inadequate. During an accelerated summer term, more information must be digested in a single class than during the other terms. The number of days between tests is significantly less.

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For evening students who work during the day and attend school at night, the shorter time period between tests can be problematic if they depend on catching up on weekends. Fewer weekends are available for study during an accelerated summer term. Of course, students typically take proportionately less course work during a summer term, and on the surface one would expect this to offset the rapid pace. Nevertheless, in reality the balance is never quite achieved and summer school is often perceived to be much more intensive than during the rest of the year.

Teaching techniques designed to engage students in class and to help students better assimilate course material during class time should be valuable in helping students overcome obstacles associated with summer sessions. Based on successful experience with clickers in the previous year [1], it was decided to incorporate clickers into two summer classes. Clickers are handheld devices from which responses to questions posed by the instructor can be submitted. Feedback to the responses can be given immediately. The purpose of the paper is to describe the use of clickers in the summer classes and to compare student response to summer use of clickers with student response to use of clickers during a traditional 14-week semester.

BACKGROUND

Since clickers emerged in recent years as a more commercially available educational tool, they have been used in a variety of ways to add dimensions to the classroom. Examples of benefits and uses of clickers are shown in Table 1. None of the references listed in Table 1 involved data taken during a summer session.

Table 1. Use or Benefits of Clickers.	
Use or Benefit	Reference
Add to learning experience	[2], [3], [4], [5]
Add to classroom experience	[2]
Instantaneous feedback for students and teachers	[6], [7], [8]
Anonymity	[7], [8]
Administering and/or grading pop quizzes or scheduled quizzes	[9], [10]
Collect assessment data for accreditation	[10], [11]
Enhance attitude during lectures	[12]
Evaluate student portfolios	[9]
Testing student recall of required reading	[12]
Testing student synthesis abilities	[12]
Evaluate student mastery of topics through participation in group projects	[9]
Review questions during lecture	[10]
Higher attendance	[6]
Effectiveness in teaching physics to non-science majors	[13]

When clickers were donated by the student chapter of ASCE to the Citadel Civil and Environmental Engineering Department during the summer of 2008, it made available an opportunity to explore the use of clickers to enhance

classes. One of the initial projects undertaken was to assess the value of clickers in teaching concepts associated with looping and subscripted variables in a programming/computer applications class using MathCAD [1]. This class is denoted as CIVL209 Computer Applications in Civil Engineering. To accomplish this, clickers were integrated into a five-week module of three sections of the computer applications course. A different professor taught each section, but class instruction among the three sections was well coordinated, including questions used with the clickers. During the five-week module, a total of 22 questions were asked, primarily to review material discussed earlier in the class. Questions included 13 multiple-choice, eight numerical, and one true/false question and all were delivered with a LCD projector using the MathCAD environment.

Following the completion of the module, the results of a survey showed that students had a high degree of satisfaction with clickers, and found them to be more valuable than several other teaching techniques proven to be successful in the past. A high percentage of the students felt that the clickers were helpful in understanding the material, and students rated them highly in maintaining their attention and interest and in retaining the course material. Finally, most students expressed an interest in using clickers in future classes and did not oppose expanding clicker use to more classes.

USE OF CLICKERS IN SUMMER CLASSES

The initial use of clickers as described above was in a day class attended by students from The Citadel's Corps of Cadets during the fall semester of 2008. Based on the enthusiastic response from these students, it was decided to extend the application of clickers to summer classes with evening students and to broaden the variety of ways in which clickers were used to enhance classes.

The traditional use of clickers is to pose a question to students that may be answered as true/false, multiple choice, or numerical answer. These activities may be accomplished by the raising of hands; however, clickers allow student responses to be anonymous and the results may be shown immediately. If beneficial to the class, the professor may address problems immediately, providing a distinct advantage over tests and quizzes that must be graded later. True/false, multiple choice, and numerical (whole number) answers were all used in the Fall 2008 computer applications class to test student understanding of concepts previously covered. These concepts may have been covered 15 minutes earlier, covered in a previous class, or concepts that were missed by a number of students on the last weekly test.

Clicker questions used in the Fall 2008 computer applications class were designed to be presented to the class from the MathCAD environment using a LCD projector. This worked best in creating questions that looked like work to which the students had been exposed during the course. Other packages such as PowerPoint may also be used or the professor can write the questions on the board or use traditional paper handouts.

During the summer of 2009, clickers were used in two classes. One class was entitled "Engineering Administration," a course that teaches students the fundamentals of engineering economy, and the other class was a dynamics class. Clicker use in the Engineering Administration course differed in two respects from clicker use in the Fall 2008 computer applications class. First, questions in Engineering Administration were presented on a sheet of paper and distributed to each individual instead of by projector to the entire class as was done in the computer applications course. Secondly, the questions in the Engineering Administration course represented a daily quiz instead of an informal concept review. The dynamics course primarily used PowerPoint slides and a projector to present the questions to the students, although clicker questions were also presented on classroom dry erase boards when the Instructor wanted to evaluate student comprehension beyond the prepared questions. Results from the two classes are presented in the subsections below.

It should be noted that clickers used in this study are part of the Classroom Performance System (CPS) manufactured by the eInstruction Corporation [14]. Clicker exercises for the two summer classes were conducted in the same classroom. All clicker exercises were run from a computer at the instructor's station and projected with an LCD projector onto a large screen in front of the class. A 24-inch iMac using OS X 10.5 was used to run CPS 1.5 for Mac.

Clicker Use in Engineering Administration

Engineering Administration, Citadel course CIVL314, was taught during the first summer term of 2009 (Summer I). This course is a two credit-hour course. During a regular semester, the course would typically have 28 days of

instruction, with two class periods per week lasting 50 minutes each. In the summer of 2009, there were 10 days of instruction, with class periods lasting 140 minutes, not including breaks. In each case, the final examination requires an additional class period to administer.

Past offerings of this course during the summer have involved a traditional mix of responding to questions on homework assignments and instruction of new material. With the goal of helping students assimilate more material during class time, it was decided to add a quiz to the instructional format. Quizzes composed 5% of the course grade, and could be administered on any non-test day. During the summer session, quizzes were given on six of the seven non-test days and were based on the material covered earlier during the class period. Quizzes contained two to five problems and were printed on a single sheet of paper.

When the quiz was over, instead of having students hand in the quiz right away, students were asked to submit the answers to each problem one at a time using clickers. Following the submittal of each answer, results from the entire class were displayed on the screen, and any problems noted were discussed. To reduce any tension associated with taking a quiz on material that had not been studied outside of class, students were given an opportunity to provide an explanation of why the answer to a given problem was not correct. If the explanation was included, full credit was provided when the quiz was graded. An explanation had to be detailed enough to demonstrate that the student understood why the answer was not correct; otherwise credit was not given.

The quiz questions were set up as either multiple choice or numerical format. Since the clickers could handle only whole numbers, numerical answers had to be designed to permit a student to supply an answer as a whole number. For example, on a given question a student might be instructed to round answers to the nearest dollar or to the nearest \$100. On the six quizzes given, a total of 23 questions were given. Of these, two quizzes contained nine multiple choice questions and the other four quizzes contained 14 questions that required numerical answers.

At the close of the course, a survey was completed by the students to help assess the contribution that the clickers and quizzes had on the student's learning experiences. Table 2 presents the survey questions and summary of student responses. Questions 1, 2, 3, and 7 focused on the quizzes and the remainder of the questions related primarily to the use of clickers, although it should be noted that it is difficult to completely separate the effects of clickers and quizzes since clickers were used with the quizzes. For most of the survey questions, students were asked to mark a number 1, 2, 3, 4, or 5, depending on their level of agreement with the question. The least agreement with a question was designated by a "1" and the most agreement with a question was designated by a "5." No specific labeling was provided on the survey form for "2," "3," or "4." Table 2 provides a numerical average of the student responses for each question. A higher numerical average was interpreted to indicate greater agreement with a survey question than a lower average.

Based on the average ranking on Question 1, students felt that the class quizzes contributed almost as much to their understanding as problems worked during class and homework assignments. Example problems in the text were not viewed to contribute as much to their understanding as the other three. The results from Questions 2 and 3 indicated that students believed that the class quizzes were highly effective in helping students to maintain their focus in the class and retain the course material. Moreover, class quizzes were viewed to be just as effective as problems worked in class for maintaining focus and retaining material. From the results of Question 7, it may be seen that the simple technique of explaining why they missed a problem played a very significant role in contributing to the student's understanding. The average ranking of 4.8/5 was almost at the highest possible level. It should be noted that the use of clickers must have been valuable in helping students to identify their mistakes. As may be seen from the average ranking for Question 6, the students felt that seeing the correct answers displayed immediately after taking the quiz contributed greatly to their understanding of the course material.

Students gave a high ranking to the use of clickers in helping them to maintain focus and retain course material. As may be seen in Question 4, the average rankings associated with the contribution to clickers in maintaining focus in class and in retaining course material was 4.3/5 and 4.1/5. Approximately 84% of the students believed that the use of clickers helped them to be more actively engaged. Most of the students greatly appreciated the anonymity offered by the clicker system. An average ranking of 4.1/5 (of which over 60% of the responses was 5/5) indicates the degree of importance of anonymity to the students. Finally, 95% of the students said that they would like to see clickers used in future Civil Engineering classes.

Almost 90% of the students in the Engineering Administration class were enrolled in the evening program administered by the Citadel Graduate College. Most of these students are part of a "2+2" agreement between The

Citadel and Trident Technical College in North Charleston, SC. These students complete their first two years at Trident Technical College and begin their junior year at The Citadel in the summer. Engineering Administration is one of the first courses taken by these students at the Citadel. Characteristics of the 2+2 students are quite different from those of the Corps of Cadets. Nevertheless, in both the Fall 2008 study in the computer applications class and in the Summer 2009 study in the Engineering Administration class, both groups of students were highly complimentary of the use of clickers in their first encounter with them.

Table 2. Summary of Survey Questions and Student Responses for Engineering Administration.

1	How much did each of the following contribute to your understanding of the course material?	Average Ranking n = 19
	• Problems worked in class	4.6
	• Homework assignments	4.7
	• Example problems in the text	2.8
	• Class Quizzes	4.2
2	How effective were the following in helping you to keep your focus on class?	
	• Problems worked in class	4.4
	• Class quizzes	4.5
3	How effective were the following in helping you to retain the course material?	
	• Problems worked in class	4.4
	• Class quizzes	4.4
4	How much did use of clicker technology contribute to	
	• Keeping your focus in class	4.3
	• Helping you to retain the course material	4.1
5	Do you feel that the use of clickers helps you to be more actively engaged during class?	Yes = 84% No = 16%
6	How valuable to your understanding of the course material was seeing the correct answers displayed immediately after taking the quiz?	4.6
7	To receive credit for a missed problem, you were required to explain why you missed the problem. How much did this contribute to your understanding of the material?	4.8
8	How important was it for you to be able to respond anonymously using the clicker system as compared to methods such as raising your hand?	4.1
9	Would you like to see clickers used in your future Civil Engineering classes?	Yes = 95% No = 5%

Clicker Use in Dynamics

Dynamics, Citadel course CIVL301, is a three credit hour course that was taught during the second summer term of 2009 (Summer II). During a regular semester, the course would typically have 42 days of instruction, with three class periods per week lasting 50 minutes each. In the summer of 2009, there were 14 days of instruction, with class periods lasting 150 minutes, not including breaks. In each case, the final examination requires an additional class period to administer.

As with Engineering Administration, past offerings of this course during the summer have involved a traditional mix of responding to questions on homework assignments and instruction of new material. However, clicker use in the Dynamics course differed significantly from the Engineering Administration course in that clicker questions were not used in quizzes but during primarily in-class problems, although in-class quizzes were given. These in-class

problems used were taken directly from the course textbook (reference) and used during the presentation of new material or during review of homework assignments. Also, instead of being able to “retake” quizzes in class, students were given the chance to resubmit homework assignments to improve their course grade. As with the Engineering Administration course, students had to provide an explanation of why their previous answer to a given assignment problem was not correct; otherwise credit was not given. This process was designed to help students assimilate more course material during the compressed timeframe of the course.

At the close of the course, a survey was completed by the students to help assess the contribution that the clickers and assignment had on the student’s learning experiences. Table 3 presents the survey questions and summary of student responses. Questions 1, 2, 3, and 7 focused primarily on the use of quizzes, in-class problems and homework assignments and the remainder of the questions related primarily on the use of clickers. It should be noted that this course focused more on assignments than quizzes when compared to Engineering Administration and that clickers, while used with in-class problems, were not associated with assignments. For the numerical responses, students were asked to mark a number 1, 2, 3, 4, or 5, depending on their level of agreement with the question. The least agreement with a question was designated by a “1” and the most agreement with a question was designated by a “5.” No specific labeling was provided on the survey form for “2,” “3,” or “4.” Table 3 provides a numerical average of the student responses for each question. A higher numerical average was interpreted to indicate greater agreement with a survey question than a lower average.

Table 3. Summary of Student Responses for Dynamics.

1	How much did each of the following contribute to your understanding of the course material?	Average Ranking n = 30
	• Problems worked in class	3.9
	• Homework assignments	4.4
	• Example problems in the text	4.0
	• Class Quizzes	3.8
2	How effective were the following in helping you to keep your focus on class?	
	• Problems worked in class	4.1
	• Class quizzes	4.2
3	How effective were the following in helping you to retain the course material?	
	• Problems worked in class	4.0
	• Class quizzes	3.9
4	How much did use of clicker technology contribute to	
	• Keeping your focus in class	3.5
	• Helping you to retain the course material	3.1
5	Do you feel that the use of clickers helps you to be more actively engaged during class?	Yes = 83% No = 17%
6	How valuable to your understanding of the course material was re-submitting an incorrect assignment problem?	4.7
7	To receive credit for a missed problem, you were required to resubmit the problem done correctly. How much did this contribute to your understanding of the material?	4.6
8	How important was it for you to be able to respond anonymously using the clicker system as compared to methods such as raising your hand?	3.9
9	Would you like to see clickers used in your future Civil Engineering classes?	Yes = 90% No = 10%

Based on the average ranking on Question 1, students felt that the homework assignments contributed more to their understanding than problems worked during class, text example problems, or class quizzes. However, the results from Questions 2 and 3 indicated that students believed that the problems worked in class and class quizzes were approximately equally effective in helping them to maintain their focus in the class and in retaining the course material. From the results of Question 7, it may be seen that the simple technique of explaining why they missed an assignment problem and resubmitting it correctly played a very significant role in contributing to the student's understanding. The average ranking of 4.6/5 is close to the highest possible level of agreement with the question and approximately matches the importance students associated with explaining quiz questions that were missed in the surveyed Engineering Administration class (Question 7, Table 2). As may be seen from the responses to Question 6, the students felt that resubmitting assignments also contributed greatly to their understanding of the course material.

Students gave moderately high rankings to the use of clickers in helping them to maintain focus and retain course material. As may be seen in Question 4, the average rankings associated with the contribution to clickers in maintaining focus in class and in retaining course material was 3.5/5 and 3.1/5. Although the students only moderately agreed that clickers were helpful in retaining course material, approximately 83% of the students believed that the use of clickers helped them to be more actively engaged, as shown in Question 5. It is possible that the moderate response of the students on retaining course material was related to the way clickers were used in the class, but this could not be determined and will need to be explored in a future study. Most of the students greatly appreciate the anonymity offered by the clicker system. An average ranking of 3.9/5 (of which 40% of the responses was 5/5) indicates the degree of importance of anonymity to the students. Finally, 90% of the students said that they would like to see clickers used in future Civil Engineering classes.

As with the Engineering Administration class, a high percentage of students (81%) were enrolled in the evening program administered by the Citadel Graduate College. Most of these students are part of the "2+2" agreement between The Citadel and Trident Technical College. Dynamics is one of the first four courses offered to these students at the Citadel during their first summer in the program. Nevertheless, in both the Fall 2008 study in the computer applications class and in the Summer 2009 study in the Dynamics course, both groups of students were highly complimentary of the use of clickers in their first encounter with them. As was the case in the Fall 2008 CIVL209 Computer Applications in Civil and Environmental Engineering class and the Summer 2009 Engineering Administration class, students in the Dynamics course verified the use of clickers was effective.

COMPARISON OF COURSE CLICKER SURVEYS

Four questions regarding student clicker use were common to the three course surveys. These questions focused on four areas: evaluating how clickers affected student classroom focus, keeping students actively engaged and retention of course materials as well as evaluating possible future use of clickers within Civil and Environmental Engineering Department courses. Table 4 presents the survey questions for each class in each of these comparison areas. As shown in Table 4, questions within three of the comparison areas are identical or nearly identical between the surveys, with the exception of the question concerning keeping students actively engaged. This question was based on the level of student agreement with the question using a 1 to 5 scale in the full semester course (CIVL209), while it was asked as a Yes/No question for the summer courses (CIVL314, CIVL301). Given that there is no significant difference in the questions from the surveys with this noted exception, it was deemed that a valid comparison between the surveys could be conducted. The survey comparison results between the three courses are presented in Table 5.

In the comparison area of classroom focus, Table 5 shows good agreement between the CIVL209 course (4.1/5) and the CIVL314 course (4.3/5), which indicates that students found the use of clickers effective in maintaining focus in the classroom. However, the results for CIVL301 (3.5/5) show a marked decrease in the effectiveness of clicker use for helping students to maintain their focus as compared to the other classes. This decreasing pattern is also noted in the comparison area of retention of course materials. Table 5 shows good agreement between the CIVL209 course (4.0/5) and the CIVL314 course (4.1/5), while CIVL301 shows a substantial decrease (3.1/5).

Several factors may contribute to these observed differences between the CIVL209/CIVL314 and CIVL301 survey results. As noted in previous sections, the frequency and implementation of clickers within the one fall semester and

two summer courses was significantly different. This difference is more pronounced between the two summer courses, where clickers were integrated into a newly implemented teaching technique (i.e. the re-submittal of quizzes) during the one course (CIVL314) and not within the other (CIVL301, where clickers were not integrated into re-submittal of assignments). Clicker integration with the new teaching techniques may be the major difference, as the surveys showed that both newly implemented teaching techniques were extremely valuable to students (ratings of 4.6/5 and 4.7/5 for CIVL314 and CIVL301, respectively, from Tables 2 and 3). The differences may also be attributed to the previous experiences of the students enrolled in the two classes. For example, some of the students in the Dynamics class had used clickers previously in the Computer Applications in Civil and Environmental Engineering class or in the summer Engineering Administration class which may have impacted their responses. Additional research into this area is needed.

Another factor that could explain the differences between CIVL314 and CIVL301 survey results is the workload of the students. As previously noted, the CIVL314 and CIVL301 courses had high percentages of “2+2” transfer students. In addition, the majority of students (74%) enrolled in CIVL314 were also enrolled in CIVL301. These students take an accelerated program of 2 courses within the Summer I and Summer II semesters, with only a short break of approximately 1 week between semesters. This workload, coupled with more advanced nature of the undergraduate engineering courses and accelerated semester pace, could have resulted in students being less receptive to repeated use of a new learning tool such as clickers. The observed decrease (5%) between the two courses in the “future use of clickers in the curriculum” comparison area lends support that this factor was an influence, although this decrease is relatively minor and could also be explained by the increased class size of CIVL301.

Table 4. Survey Clicker Questions.

Comparison Area	CIVL209 Computer Applications in Civil and Environmental Engineering (Fall Semester 2008)	CIVL314 Engineering Administration (Summer I Semester 2008)	CIVL301 Dynamics (Summer II Semester 2008)
<i>Classroom Focus</i>	On a scale of 1 (least) to 5 (most), how effective were clickers in helping you keep your focus on the class?	How much did use of clicker technology contribute to keeping your focus in class? (scale of 1 (least) to 5 (most))	How much did use of clicker technology contribute to keeping your focus in class? (scale of 1 (least) to 5 (most))
<i>Keep Students Actively Engaged</i>	On a scale of 1 (least) to 5 (most), how effective were clickers in helping you keep your interest in the course materials?	Do you feel that use of clickers helps you to be more actively engaged in class? (Yes or No)	Do you feel that use of clickers helps you to be more actively engaged in class? (Yes or No)
<i>Retention of Course Materials</i>	On a scale of 1 (least) to 5 (most), how effective were clickers in helping you to retain the course material?	How much did use of clicker technology contribute to helping you retain the course material? (scale of 1 (least) to 5 (most))	How much did use of clicker technology contribute to helping you retain the course material? (scale of 1 (least) to 5 (most))
<i>Future Use of Clickers in Curriculum</i>	Would you like to see clickers used in your future civil engineering classes? (Yes or No)	Would you like to see clickers used in your future civil engineering classes? (Yes or No)	Would you like to see clickers used in your future civil engineering classes? (Yes or No)

Table 5. Clicker Question Survey Results Comparison.

Comparison Area	CIVL209 Computer Applications in Civil Engineering (Fall Semester 2008) (n = 52)	CIVL314 Engineering Administration (Summer I Semester 2008) (n = 19)	CIVL301 Dynamics (Summer II Semester 2008) (n = 30)
<i>Classroom Focus (1 to 5 scale)</i>	4.1	4.3	3.5
<i>Keep Students Actively Engaged (mixed scale)</i>	4.1	Yes = 84% No = 16%	Yes = 83% No = 17%
<i>Retention of Course Materials (1 to 5 scale)</i>	4.0	4.1	3.1
<i>Future Use of Clickers in Curriculum</i>	Yes = 96% No = 4%	Yes = 95% No = 5%	Yes = 90% No = 10%

The results of all three surveys showed that the use of clickers keeps students actively engaged. The CIVL209 survey results in this comparison area were 4.1/5, which indicates a high level of student agreement that clickers helped to keep them actively engaged. This appears to correspond well with the 84% and 83% yes ratings for the two summer courses. In addition, while a small decrease was observed between the two summer courses in the “future use of clickers in the curriculum” comparison area, in general the results between all three surveys were similar, as 96%, 95%, and 90% of students would like to see future clicker use in classrooms.

CONCLUDING REMARKS

In general, the clicker surveys showed that students found clicker use to be a positive addition to Civil and Environmental Engineering courses regardless of whether the course was taken during a traditional or accelerated semester. Direct comparison of survey results from traditional and accelerated courses revealed that the effectiveness of clicker use varies, although it could not be determined if these variations were due to the pace of the courses. Based on the comparison of the summer course surveys, it appears that clicker effectiveness may be linked to integration of these tools into the course materials, as the course that incorporated clickers into a new learning technique was rated higher in keeping students focused in the classroom and helping them retain material than the course which did not link clickers to a new learning technique.

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