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Using Clickers to Enhance Student Learning in Mathematics

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Abstract

The purpose of this study was to determine how to integrate technology into mathematics classes using clickers in the high school setting. The ability to integrate technology into instruction is a current requirement for mathematics teachers in the United States; however, students have been traditionally taught to solve equations using pencils and paper. In addition to leveraging an understanding of the impact that using interactive Student Response System (SRS) have in helping students learn mathematics, this study also aimed to examine its effect on Special Education and English Language Learner (ELL) student learning outcome. 47 high school students who were enrolled in Geometry class were selected to participate in this study. Pre-tests and post-tests were conducted with both the trial and contrast groups of the study. The trial group contained all of the students in one period of Geometry class in which clickers were integrated into the classroom instruction. The contrast group contained all of the students in the same subject as the trial group but did not use clickers. The key elements of the study included having the technology available to the trial group throughout the entire learning process, having consistent participant groups, and having equal access to the materials presented to both groups. Based on the summative and informal assessment test scores, completion rates of class work and the teacher's observations, the research team concluded that for the students in the trial group, the use of clickers did improve the student learning outcome and class participation in mathematics compared to the contrast group. The test scores of Special Education and ELL students in both groups were also assessed for the clickers' impact on these students' learning. The results showed that the use of clickers had a positive impact as these students gained better test scores. These results align with the current research regarding technology integration in mathematics. Factors affecting the effective integration of technology such as teachers' use of clickers, types of questions teachers should ask and depth of technology integration will be discussed.

Keywords: interactive technology, clicker, mathematics, student response system (SRS), summative assessment, English Language Learners (ELL), special education

1. Significance of Problem

The main goal of a high school mathematics teacher is to motivate students to learn mathematics and help them to apply mathematics in their daily lives. In the article Waking The Dead: Using Interactive Technology To Engage Passive Listeners In The Classroom (Carlin & Guthrie, 2006), the authors conducted research on the use of clickers in adult education classroom settings, and determined it was worth the cost to invest in clickers for the classroom. Carlin and Guthrie's research showed that students were generally positive about clickers' use, and preferred courses that used the technology over those that did not. Their data revealed that student participation approached 100% in class sessions where clickers were used due in part to its anonymity, ease of use, and the ability for students to see how many others answered in the same way. Carlin and Guthrie's research focused on adult education. This study aimed to explore whether clickers produce the same result in a high school classroom setting. Public school districts spend huge amounts of money on technology in order to improve their school performance; however, mathematics and science are still the weakest subjects for most students. This study intended to investigate whether technology can help students' learning in mathematics, and how to integrate technology into mathematics class using clickers.

2. Research Questions/Anticipated Outcomes

To obtain a better understanding of the use of clickers in mathematics education, the following four research questions were developed.

(a) How should teachers use clickers in mathematics class?

(b) In what ways did clickers increase students' participation and motivation in the class?

(c) How did the instant feedback on every test help students increase their mathematics learning outcome?

(d) How did clickers help the Special Education and ELL students?

3. Intervention and Study Design

Students from two out of three periods of Geometry classes at one high school in California were selected to participate in this study. The reason two periods of Geometry classes were selected was because Geometry was one of the mandatory classes for graduation. Geometry requires a lot of visualization, memorization, and life application. The teacher, who was also part of the research team in this study, found based on daily observations of student behavior, that Geometry was difficult for most students. Pre-tests and post-tests with both the trial and contrast groups were conducted. The trial group contained all of the students in one Geometry class in which clickers were integrated into the instruction. The contrast group contained all of the students in the same subject as the trial group but did not use clickers. The students in both groups were given the same pre-tests and post-tests over a period of weeks and months.

Post-tests were given to both groups after every learning objective. The test format was included in the daily warm ups, homework quizzes, objective tests, and STAR Benchmark test. The experimental treatment for clickers was applied throughout the entire study period. The goal of this study was to find the significant differences with the dependent variable. If a significant difference was found where the trial group demonstrated higher test scores and higher learning motivation and participation based on the teacher's observations, and if possible errors could be satisfactorily accounted for, then the integration of the technology could be said to have caused the difference. It could then be said with some confidence that integrating technology through clickers had improved the student learning in the subject of mathematics.

4. Literature Review

The literature review for this research provides some information in the key areas regarding the development of technology in education, its impact as related to teaching mathematics, and the availability of interactive educational technologies such as online asynchronous discussion (AD) forums and Student Response System (SRS).

4.1 Technology in Education

The role of technology in a traditional school setting was to facilitate the education knowledge and skills through increased efficiency and effectiveness as opposed to focusing on the promotion of student learning (Courville, 2011). As time passed however, a technological paradigm shift started to occur and now technology has permeated our learning institutions, homes, businesses, and daily lives. This shift has dramatically altered the way in which information is shared and has led to an entirely new way of teaching where technology now plays a key role in student learning in the classroom. In the new trend of using technology, technology holds the promise of better, faster, and more equal access to educational materials for the learners. Technology has also helped to mitigate the physical barriers to learning and assisted in the transition of education's focus from the retention of knowledge to utilization.

There have been many innovative technologies utilized in classrooms for years. Research has demonstrated that the effective integration of technology into classroom instruction, especially mathematics classes, could positively impact student motivation, engagement and interest in learning mathematics. Technology has also aided in the assessment of student learning as technologies allow representations of domains, systems, models, data, and their manipulation in ways that were not previously possible (Pellegrino & Quellmalz, 2011).

4.2 Interactive Technologies

There are many interactive educational technologies that have been incorporated into mathematics teaching. Asynchronous discussion (AD) forums and SRS (clickers) are the good examples. Mathematics requires students to know and apply complex vocabulary and concepts. With AD forums students are forced to communicate in writing using the specific vocabulary, theorems and concepts they learn in class. The student blogging provides them the opportunity to reflect on their own use of text in their writing during time intervals and triggers meaningful dialogue with their peers leading to new writing cycles. Students with access to the Internet could read blog entries and leave comments on what they had read. Clickers are the other kind of the interactive educational technologies.

4.3 Clickers in Education

Using clickers is one of the technologies that teachers can use in the classroom to assess student learning immediately. Students use clickers as a tool to respond to questions anonymously and teachers can provide students feedback instantly, but students cannot give each other feedback in writing. With clickers, teachers fulfill the educational technology requirement for teaching in the 21st century.

4.4 What is the Clicker?

Clickers are the handheld devices used in a SRS, commonly called "clickers" or "key-pads" in the United States and "handsets" or "zappers" in the United Kingdom (d'Inverno, 2003; Simpson & Oliver, 2006). Clickers are small transmitters about the size of a television remote control. Students use their clickers to transmit their answers by pressing the clicker buttons. Clickers use either infrared or radio frequency technology to transmit and record student responses to questions. The technology allows for the active participation by all students and provides immediate feedback to the teachers and the students regarding any confusion or misunderstandings of the material being presented.

4.5 Who Uses Clickers?

Earlier research and development of clickers shows that the SRS technology was used by physics instructors; however, a creative or willing instructor can apply the technology to virtually any subject if they integrate it correctly. Because of the many benefits of clickers, the SRS technology has been incorporated into courses in nursing, communication, engineering computer science, mathematics, chemistry, philosophy, biology, and dental education (Draper & Brown, 2002; d'Inverno, 2003; Roschelle et al., 2004). Clickers have been successfully used in varied course formats, ranging from optional tutorials to formal standard lectures and cooperative learning through peer instruction (Nicol and Boyle, 2003). With a skilled instructor, the clickers can be a useful instructional tool for students of all ages and levels of preparation, from freshmen in large, introductory courses for non-majors to juniors and seniors in required, high-level major courses. The clicker system has also been used in elementary and K-12 settings (Roschelle et al., 2004).

4.6 Benefits of Using Clickers

In recent decades university educators have experimented with various alternatives to the traditional instructional paradigm of lecturing, and adopted modes of learning that more actively engage students during class. Clickers have been used to motivate student learning especially in mathematics classes (Liu & Stengel, 2011). The major attractions of clickers are that students can participate and respond to questions anonymously, teachers can collect learning results instantly and educators follow the principles of game-based learning in the 21st century.

First, anonymous responses to questions add more value to learning than traditional techniques such as calling on individual students or even asking students to designate a response by a show of hands. In mathematics classes, many students are hesitant to respond to an answer until they know how others will respond. With clickers, the fear of embarrassment that the student's answer may be wrong is mitigated as the answer is submitted anonymously. Students can freely express their views in complete anonymity and the cumulative view of the class appears on a public screen. Clickers allow students to respond to questions in a safe manner thereby encouraging them to take additional risks with their potential responses. As a result, teachers receive greater student engagement, increased student interest and heightened discussion and interactivity in mathematics classrooms.

Second, clicker technology not only facilitates active learning but enables immediate feedback which is effective in promoting learning. Teachers can quickly glance at what answers students have selected, and instantly gauge their level of comprehension. In contrast, in the traditional classroom environment, the teacher would need to instruct the students to "put your right hand for A, left hand for B, both hands for C, and stand up for D" to simulate what the clickers achieves anonymously and instantly. Additionally the clicker results can be downloaded and stored digitally for recordkeeping and or future analysis and trending. The technology also allows teachers to review individual scores and re-teach mathematics concepts where students are struggling. These abilities give teachers a tool by which they can tailor their daily lesson planning for more effective teaching in mathematics content.

Third, integrating clickers in the classroom also helps fulfill the requirements for 21st century learning. Students growing up in the 21st century have grown up using computer games for learning and entertainment. As a result, many of these students are more likely to respond to questions using clickers rather than traditional classroom methods such as raising a hand (Martyn, 2007). Students can develop critical thinking skills by discussing both the correct and incorrect responses after looking at the results graph. This is a great strategy to help students develop higher orders of thinking which is required in the 21st century.

When clickers were used, students tended to view the teachers as more aware of their needs and the teaching style as more warm, friendly, close, and caring (Jackson & Trees, 2003). Students particularly like clickers' anonymity feature, its potential to reinforce learning, and the possibility of comparing one's answers with the rest of the class because "they like the reassurance that they're not alone even when they're wrong" (Beatty, 2004). When allowed to work in groups, students feel that talking with a classmate helped increase their learning (Beatty, 2004). Francis and Schreiber (2008) and Yourstone, Kraye, and Albaum (2008) found evidence of improved student attitude and performance in operations management courses. The authors Liu and Stengel (2011) concluded, based on their study results, that clickers are an effective tool in improving student attention and performance in basic quantitative analysis and statistics courses. In addition to the comparison of completion rates and test scores, the mathematics teacher had a clear impression that students in the sections with clickers seemed to be more engaged in class.

4.7 Integrate Clickers Correctly

To take full advantage of clickers, proper instruction is required for all teachers on how to retool lessons and develop new skills necessary for supporting the technology. Proper implementation is not merely adding clicker exercises to traditional lectures. The need to rethink the instructional delivery for effective use is consistent with similar realizations about the pedagogical use of other information and communication technologies (Webb & Cox, 2004). More important than the technology, is the need to ask the right questions. Poorly structured questions or ones that do not focus on key concepts or reveal misunderstandings can undermine the value of clickers. Identifying misconceptions and providing frequent feedback to the students are important. Clickers can also facilitate discipline-specific discussions, small group-work cooperation and student-student interactions. Clickers in conjunction with well-designed questions can provide an easy to implement mechanism. Clicker technology enables a more effective, more efficient and more engaging education.

Motivating and assessing student learning in mathematics are the most challenging tasks for many mathematics teachers. The clicker is one type of technology that teachers can use in the classroom to enhance student learning and assess their academic progress more effectively. The clicker provides a safe learning environment because students can respond to questions anonymously. Lastly, the clicker allows teachers to provide instant feedback which is effective in promoting learning.

5. Methodology

This study explored whether using clickers in the Geometry class was able to improve student learning in mathematics through the instant feedback that the teacher was able to provide. Data was collected to determine the effectiveness of clickers on student learning outcomes. The learning outcomes included student participation, motivation, and performance on assessments.

5.1 Setting

This research study was conducted at a high school in California. This high school has approximately 3,270 students. Approximately 50% of the students at this school are English Language Learners (ELL) with Spanish being the primary language. The school is comprised of the following ethnic groups: Hispanic or Latino (91.2%), White (2.5%), Filipino (1.4%), and Other (4.9%). 92.2% of the students participate in the federal Government's Free and Reduced Lunch Program.

5.2 Participants

The pool of participants in this study consisted of 47 students. The participants were students who were enrolled in Geometry class. Out of 47 students, 17 students were males and 30 students were females. The students were randomly assigned into two classes. There were 28 students enrolled in the third period Geometry class (contrast group) and all of them were sophomores (10th graders). There were 19 students enrolled in the eighth period Geometry class (trial group), and 2 of them were seniors (12th graders), 16 of them were juniors (11th graders) and 1 of them was an 8th grader. 25% of students in the contrast group were ELL students and 7% were Special Education students; 32% of the students in the trial group were ELL students and 11% were Special Education students.

All students in the contrast group were first time Geometry students. 5 students in the trial group were second time Geometry students and 14 students were first time Geometry students, but all of them had failed Algebra I twice.

There were four pre-tests given to the students in both the trial and contrast groups. The four pre-tests included two chapter tests (Test 1 and 2) and two STAR review tests (Test 3 and 4). The test results show that the average scores of the four pre-tests were very similar in both the contrast and trial groups.

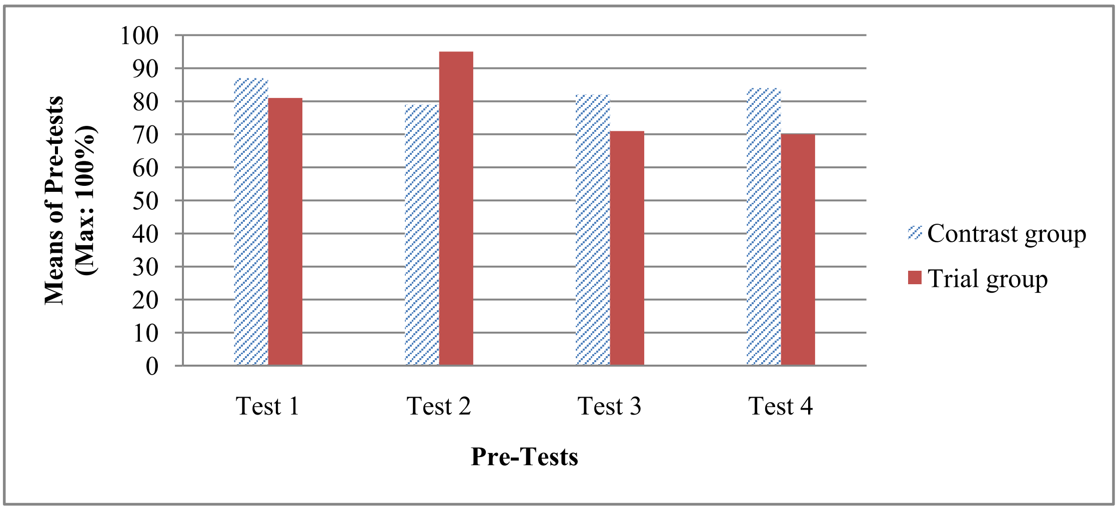

Figure 1. Means of pre-tests

5.3 The Strategy of Integrating Clickers

The clickers were applied to the daily lessons and sometimes they were used as a quick assessment tool. The students were asked to respond to the questions for homework quizzes and warm ups. Most teachers have difficulty settling down students during the first five minutes of class. Using clickers to answer the questions on warm ups or homework quizzes helped the teacher to manage the classroom better because students did not have any excuse, for example, not having a pencil or paper. It also saved time by eliminating the need to collect papers after the students were done with quizzes or warm ups.

The clickers were also used as a tool to review the tests in this study. The strategy to review the tests applied in this study was very similar to how some teachers use small white boards to do quick assessments in the classroom; however, the teacher in this study did not need to spend time passing out whiteboards, erasers, or markers. Each student was assigned a number which corresponded to his or her clicker's number. Students usually picked up clickers as soon as they entered the classroom. So, all students were ready to use clickers whenever it was needed during the lesson.

5.4 Student Participation

Students were more willing to try and participate in doing the warm ups and taking the homework quizzes. The reason for this was that the teacher and everyone in the class knew immediately if everyone did the work just by looking at the result on the screen. Most of the students did not want to be the only one who did not participate. However, this study could not avoid some students who just guessed on the answers instead of really trying to solve all of the questions. The teacher did not have a control on this factor.

5.5 Improve Student Learning

The main purpose of this research study was to assess if clickers could improve student learning by way of the test scores and class work completion rate. The clickers were used for reviewing the tests with the trial group and traditional white boards were used for the contrast group. The review materials and the amount of test time were exactly the same for both groups. The instant feedback was given to the trial group every time students submitted answers. Most of the students felt insecure when they were trying mathematics problems; however, they were more encouraged to continue to try when they knew they did problems right.

5.6 Improving ELL and Special Education Student Learning

One of the advantages of clickers was that students were able to respond to questions anonymously. ELL and Special Education students usually did not like to draw attention to themselves because of a lack of confidence possibly as a result of their limited language abilities or learning needs. However, their fears of embarrassment from answering incorrectly were reduced through their use of clickers.

5.7 Validity

The research was a Quasi-Experimental design. Quantitative experimental data and qualitative data were collected and analyzed. The data collections included completion rate of class work, informal assessments, participation work, summative assessment and the teacher's observation journal. The teacher briefly explained the purpose of this study and made clear to participants and their parents that participants would not receive bad grades if they did not want to participate. The participants also were informed that their information would be confidential.

5.8 Data Sources

During the data collection, the types of data collected included objective tests, class work, informal assessments, and summative assessments. The teacher in this study kept a journal to record the differences observed in the student behavior while using clickers, transcribed the comments made by the students about using clickers, and noted the differences observed in the motivation of students, especially for ELL and Special Education students.

5.8.1 Objective Test

The student individual conceptual understanding was assessed throughout the entire unit. The objective test allowed the teacher to gauge if the students had learned the content before moving on to the next concept. The objective test scores also showed if clickers helped participant short term memory. The objective tests were usually 15 to 20 multiple choice questions that were built with Exam View software which is compatible with clicker software. Each objective test included three to four concepts, and there were five to six variation questions to each concept.

5.8.2 Class Work

During the data collection, the completion rate of class work was collected and the observation of student behavior from the first day of using clickers was recorded in the teacher's journal. The teacher graded the class work based on the number of students who completed the problems, and not on the number of correct responses. For the participants in the contrast group, the teacher used white boards for doing class work. The purpose of using white boards was to assess student learning and provide instant feedback if the teacher saw that a majority of the students got the wrong answers. The teacher usually did the first five to six questions with the white boards, and then had students work the remaining questions on their own. With the trial group, the participants were required to submit their answers with clickers and work at the teacher's pace for the first five to six questions as guided practice. The teacher provided instant feedback based on their answers that showed on the screen. After five to six guided practice questions, like the contrast group, the students did the remaining questions on their own and submitted each answer through clickers.

5.8.3 Informal Assessments

The teacher gave students informal assessments daily to guide the teaching pace. The informal assessments included warm ups and homework quizzes. The warm ups and homework quizzes were usually two to three questions and those questions were related to the concepts the students had learned the previous day. The participants in the contrast group completed the warm ups and homework quizzes on regular paper with pen or pencil, and the participants in the trial group finished those questions with clickers.

5.8.4 Summative Assessment

The participants were required to take a summative assessment at the end of the unit. There were 40 multiple choice questions in the summative assessment and the questions were built by Exam View which is compatible with clicker software. The questions were designed to assess the participant recall, application and evaluation of the content learned during the course of the study. Level one questions required definitions of the Geometry vocabulary presented in the unit, such as identifying opposite angles, linear pairs, and so on. Level two questions required the processing of Geometry information and equations such as set-up to solve problems. Level three questions required the application abilities necessary for solving word problems, such as having the ability to comprehend the questions, apply the knowledge they had learned, and use Algebra skills to solve the problems and find the results. Out the 40 questions, there were 15 level one questions, 20 level two questions and 5 level three questions. The summative assessment was also used to assess the participant long term memory. The participants in the contrast group used regular scantrons to complete the test, and the participants in the trial group used clickers to complete the test.

6. Procedure

One of the steps taken at the beginning of this study was obtaining consent from both parents and students. The study was approved by the College Internal Human Subject Review Board. The teacher used clickers and Excel software to generate the test data. At the same time, she also recorded the data and wrote weekly journals to keep an accurate record. The journals included the observations of the differences and similarities of the student behavior, student engagement during the classes, and homework return rates between the two groups.

7. Findings and Discussions

This section describes the research findings of this study. Through the analysis of the data, four major themes were identified and include: clicker integration by the teacher, student participation and motivation, student learning in mathematics, and clicker's impact on Special Education and ELL students.

7.1 Finding #1 Clickers' Integration

To take full advantage of clickers' potential, teachers must receive thorough instruction on how to integrate them into the classroom properly. Proper implementation is not merely adding clicker exercises to traditional lectures. The teacher in this study changed the warm up and homework questions to multiple choice questions or simple answers because clickers do not allow students to submit complicated answers. Students were not able to enter answers that contain fractions, rational numbers, and special mathematics symbols such as %, π, and so on. Therefore, designing questions with multiple choices was the best way to solve the limitation of clickers.

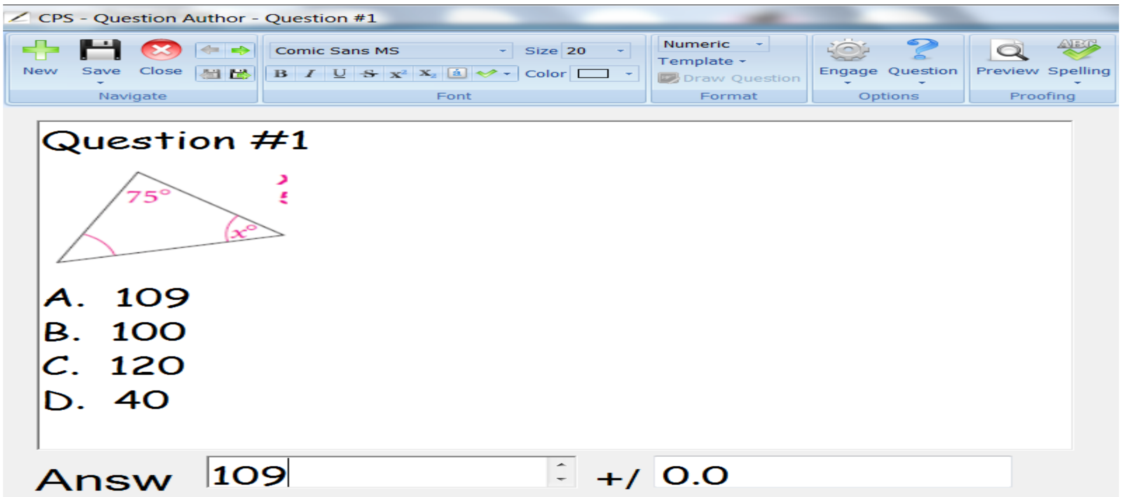

Figure 2. Sample homework quiz question

Figure 2 is one of the quiz questions used in the classroom and visually displays what the questions look like with the clicker software. The students can answer these questions at their own pace because each of them has a handout of the questions.

The teacher started with some simple and primarily factual questions in the warm ups and homework quizzes as a review and to stimulate prior knowledge. During the lesson, the teacher asked more challenging conceptual questions. The questions in the objective and benchmark tests largely embodied the material that the students had learned. The way the teacher designed the lessons and tests followed Webb and Cox's three stages of asking questions with clickers (Webb & Cox, 2004). The following note was found in the teacher's journal: "From period eight students which is the trial group, the students seemed to be able to make connections with their prior knowledge by designing lessons in such a way." Another note in the teacher's journal was, "I get more aha moments than before in period eight (trial group)." Also in the teacher's journal, she quoted one of student comment, "oh, yeah, we learned this formula yesterday. Today, we just change finding circumference to area, right?" With students in the contrast group, the teacher designed the same questions during the lessons and tests, but the teacher did not notice any obvious teachable moments, and the teacher usually had to provide more guidance in order to help the students understand and utilize the concepts.

One of the key findings in this study regarding how to integrate clickers appropriately was the importance of asking the right questions. Therefore, starting with simple and conceptual questions that were related to the key concepts at the beginning of the class, and ending with some application problems could help students master the concepts. Designing questions with multiple choices was the most effective way of using clickers. Some students might become stressed over not being familiar with the decimal key, space key, and other special keys on the key pad. However, with clickers, responding with answers A, B, C, or D was quick and easy for students, and made it easier for teachers to design the questions and integrate clickers properly in the classroom.

7.2 Finding #2 Student Participation and Motivation

The data from the warm ups, homework quizzes and class work was analyzed to explore the student participation and motivation in the class. Many students were unmotivated in mathematics classes because of all kinds of reasons, such as the class was boring, the work did not matter to them, and so on. However, in the teacher's journal for the trial group, the teacher noted, "one of the students said, 'mathematics class is interesting now. I can text the teacher my answers. Finally, I can text in the class!'" The teacher described in the journal that the students were playing with clickers as their cell phones. They were typing the words and pretending they could send the words to other students through the clickers. The whole class was laughing and having fun with clickers in their hands.

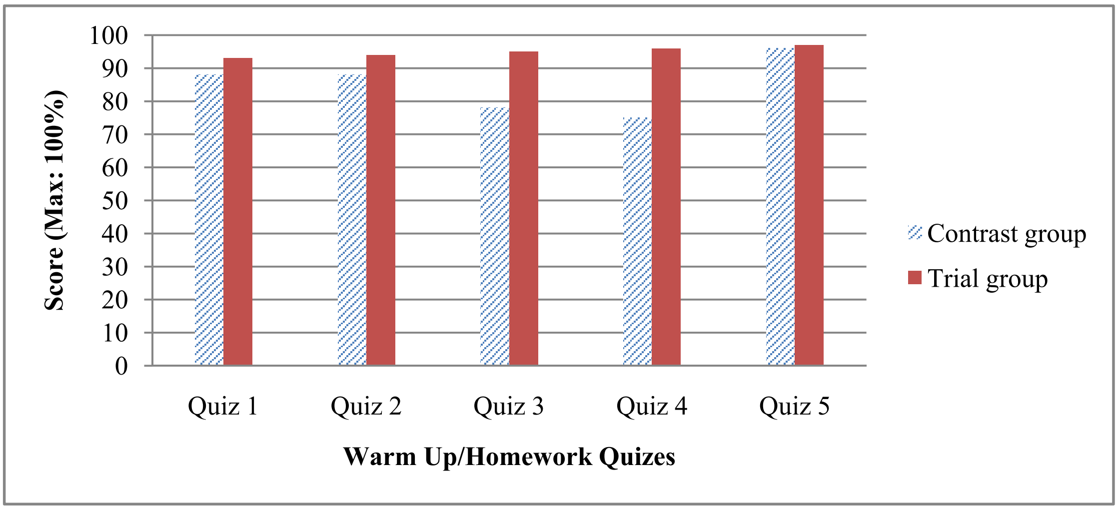

Figure 3. Warm-ups and homework quizzes

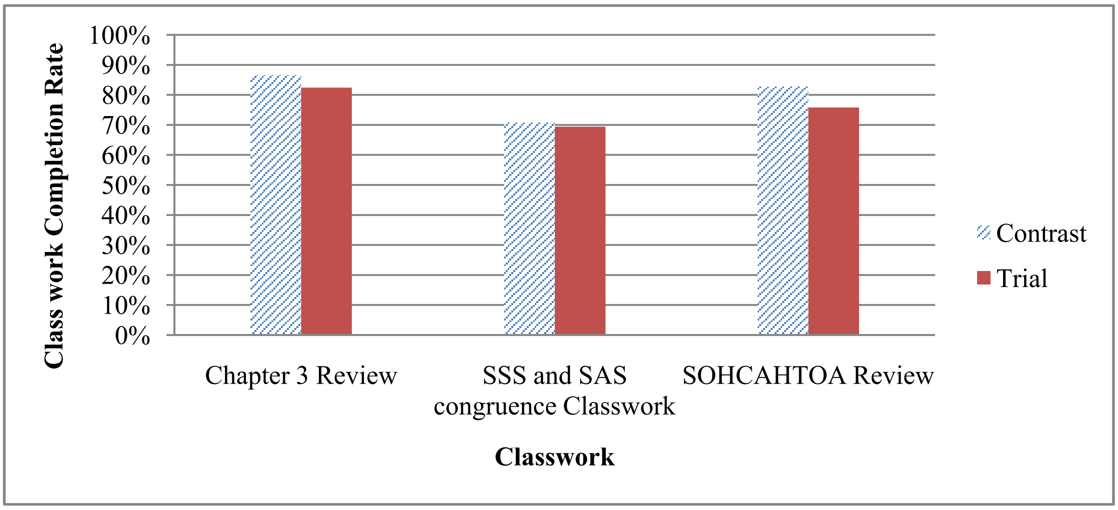

Figure 4. Completion rate of class work

According to Figure 3, the main finding was that most of the warm ups and homework quiz scores in the trial group were higher than for the contrast group. The warm ups and homework quizzes usually contained two to three questions and those questions were related to what the students had learned the previous day. The results show that the use of clickers did improve students' review of the learned content (warm ups and homework quizzes). This finding does align with current research regarding the impact of timely feedback and classroom interaction on student motivation and learning.

Research indicates that student motivation to learn increases when partaking in learning and when immediate feedback is provided because students are able to be certain of their understanding about the content discussed in class (Johnson & Lillis, 2010). According to the teacher's observation journal, students in the trial group were able to make more connections to their prior knowledge. Furthermore, students are motivated to stay focused to learn and participate in order to understand the content by using clickers (Bojinova & Oigara, 2011). Student warm up and homework quiz results revealed that the clicker review questions for learned content encouraged engagement throughout the class period. It is quite possible that student performance in the trial group on these review questions improved as their engagement and content awareness improved, which would in turn increase motivation. Students were also often allowed to interact with peers before responding to the review questions. This is consistent with other studies and scholars argue that both knowledge construction and understanding are heightened when students interact while learning (Brown, Collins, & Duguid, 1989; Driscoll, 2005; Lave & Wenger, 1991; Vygotsky, 1978).

According to Figure 4, the completion rates were consistently slightly higher in the contrast group. The teacher graded the class work based on the number of students who completed the work, and not on the number of correctly answered problems. The results indicate that the use of clickers may not improve student completion rate of class work when learning new content. The research questions posed in this study were designed to explore using clickers to boost student understanding of the materials and raise their motivation by integrating this technology in the mathematics class. The results shown in Figure 3 (warm ups and homework class activities) indicate that clickers had a positive impact on student understanding and participation. A disappointing finding was that the class work completion rates were lower for the trial group using the clickers, when compared to the contrast group. However, it should be noted that there are many factors that influence completion rates (e.g., time, technical issues, and content of class work). Possible explanations for this may be that the content of the class work were newly introduced mathematics concepts and/or the students who used clickers to complete the class work were negatively impacted by using the technology due to the technical problems. Furthermore, the students who used paper and pencil to complete their work did not have to deal with any technical issue and could concentrate more on learning the new content. This suggests that using clickers has a positive impact on student engagement and learning when they are used for reviewing content previously learned. However, using such technology may not positively impact student ability to respond when learning new course content.

According to the teacher's observations, students were able to make more connections to their prior knowledge. Comparing both the trial and contrast groups, the teacher found that clickers had some positive impact on participation and motivation with the trial group since there were differences in the scores for the warm ups and homework quizzes during review and practice class activities. Moreover, the students in the trial group liked having technology in the class as one of the learning tools. It might also be because students had to submit their work; otherwise, the teacher and their classmates could tell immediately who did not do the work. The students usually did not want to embarrass themselves among their peers. Therefore, the clickers did motivate and encourage students to participate in learning in some ways.

7.3 Finding #3 Increase Student Learning

The objective and benchmark test scores were analyzed to find the student learning outcome with clickers. There were 15 to 20 questions in each objective test. The questions in the objective tests tested students on three or four concepts. Question levels were basic memorization, applying the concepts, and real life application scenarios. The benchmark test covered the concepts in all three chapters. There were 40 questions in the benchmark test, and the test required students to comprehend all of the concepts from chapters three, four and seven. Figures 5 and 6 show the data for the objective and benchmark tests.

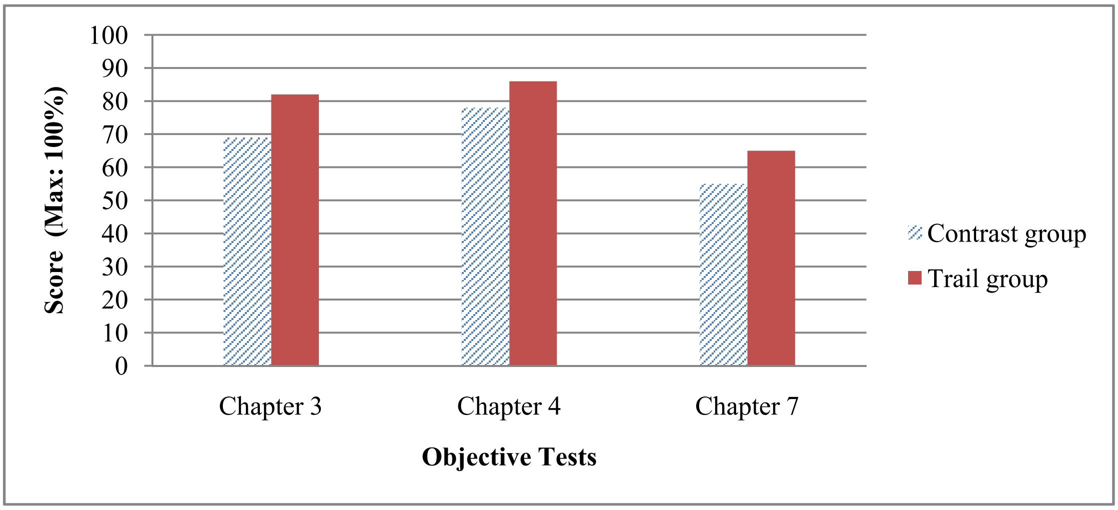

Figure 5. Test scores on objective tests

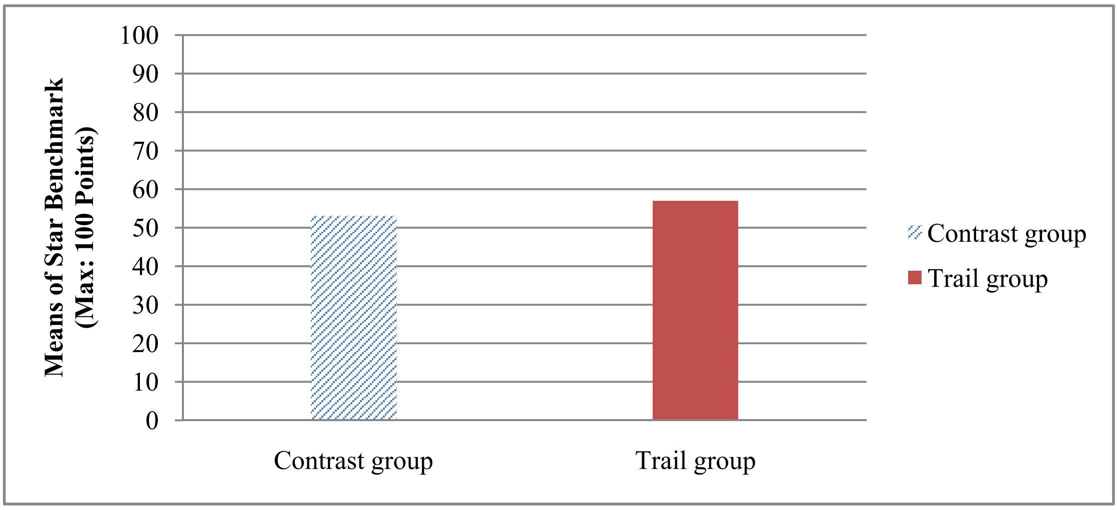

Figure 6. Means of star benchmark

Three objective tests were given to assess the mastery of the concepts from chapters three, four, and seven. Figure 5 clearly illustrates that the average scores of the trial group were consistently higher than the contrast group on all three objective tests. The data demonstrates that clickers did help increase student learning in the trial group. The benchmark test score confirmed that the students in trial group mastered the concepts better than the students in the contrast group**.** It also could be evidence that the students in the trial group performed better on the tests that required either short-term memory or long-term memory. This suggests that the instant feedback, afforded by clickers, played a key factor on student learning.

With every objective test, the teacher posted the test results as soon as the students finished. When the results were released, most students were eager to know why they got the questions wrong. By doing the test correction immediately following the test, the teacher was able to take advantage of the teachable moments that were raised from the test results. However, the teacher could not give the contrast group similar immediate feedback using traditional testing methods. The students in the contrast group usually did not get their test results back until the following day or later. By then, some students could not remember how they solved the problems or what they were thinking during the previous testing time. Therefore, doing the test corrections after one or two days was not as effective as instantly reviewing after the tests.

The clickers allowed the teacher to provide instant feedback in the hope of turning learning into active learning.

As a result, the teacher was able to actively engage students during the entire class period, assess students' level of understanding of the material being presented, and provide prompt feedback to student questions, mistakes, and misconceptions. At the same time, the instant feedback also helped students to develop a more solid, integrated, useful understanding of concepts and their interrelationships and applicability. A concerted focus on understanding rather than recall, and on reasoning rather than answers, bolsters this effect.

7.4 Finding #4 Benefits for Special Education and ELL Students

One of the greatest benefits of using clickers was that students were able to respond to questions anonymously. It added more value to learning than with traditional techniques such as calling student names. It added a huge value for Special Education and ELL students. ELL students were usually afraid to answer questions because of language barriers. Special Education students were afraid to respond to questions because they did not want to embarrass themselves in front of peers. The use of clickers in the classroom created a much safer learning environment because students were able to respond to questions without worrying about having the wrong answers. The following figures show the data from the objective and benchmark tests for Special Education and ELL students.

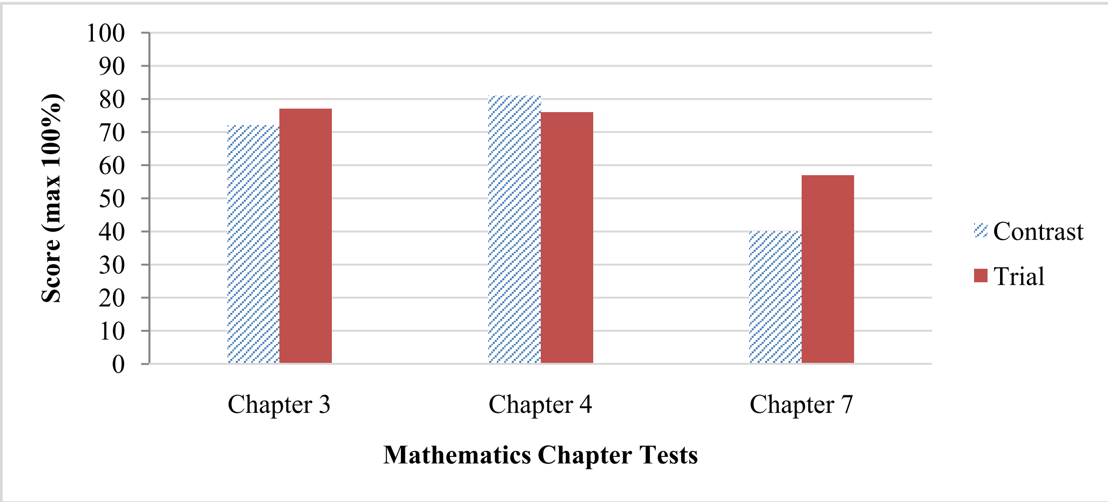

Figure 7. Special education and ELL student objective test scores

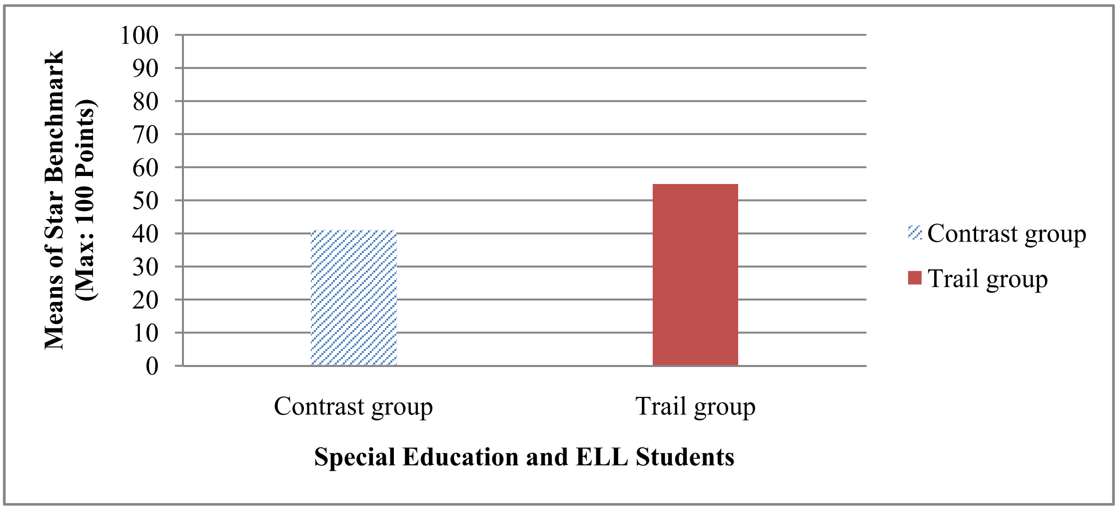

Figure 8. Special education and ELL student means of benchmark test scores

According to Figures 7 and 8, the Special Education and ELL students in the trial group clearly had better scores on these tests. The students in the trial group, because of the integration of clickers and the anonymity that this technology provides, were more motivated to learn and participate in class. Students felt much safer responding to questions which encouraged them to take additional risks because the fear of embarrassment that their answers may be wrong was mitigated as they submitted their answers anonymously. Special Education and ELL students were able to freely express their views in complete anonymity and the cumulative view of the class appeared on a public screen which allowed them to visually see how many others answered in the same way.

8. Conclusion

Student Response System (SRS) provides the instant feedback, allows for anonymous responding, and fulfills the 21st century requirement for education. The clickers motivate students to participate more because they do not need to worry about their answer being wrong in front of the class. In addition, the clickers help teachers to better assess student learning outcomes because it allows teachers to provide students with instant feedback. Clicker technology provides students with a much more engaged learning environment and effective education in the classroom at all levels. Properly integrating technology in the classroom will help students to acquire the skills they need to be successful in the learning context. Technology helps making teaching and learning more meaningful and fun. Integrating technology also changes the way teachers teach, offers educators effective ways to reach different types of learners, and assesses student understanding through multiple means. This understanding also enhances the relationship between teachers and students.

A valuable implication of the results in this study is that the clicker is an effective tool for improving student participation and performance in Geometry classes. In the trial group, students with clickers seemed to be more engaged in class. It is important to mention that the Special Education and ELL students also benefited from using clickers to participate in class activities and gained better test scores. The qualitative data (teacher's journal) shows that the strategy and questioning skills the teacher used highly influenced student engagement and learning outcomes. The quantitative data (test scores) also demonstrates that the learning outcomes of students using clickers did improve more than did the traditional learning approach.

Clickers gave the teacher the ability to fine-tune the instruction based on student responses. Regardless of the class size, the teacher was able to gauge student understanding due to the immediate feedback the technology provided. By using clickers, the teacher was able to create a safer learning environment for all students but especially for the Special Education and ELL students. Clickers allowed students to provide input without the fear of public humiliation and without having to worry about more vocal students dominating the discussion.

The best way to help teachers integrate clickers into their instruction is to provide mentoring and support from other teachers or professionals. The need to rethink the instructional delivery for effective use of clickers is consistent with similar realizations about the pedagogical use of other information and communication technologies. Clickers represent an easy-to-adopt technology that can enhance the learning experience for all students. For teachers, clickers are being used to evaluate student mastery of content and to identify concepts that are difficult for students to grasp. For students, clickers provide a quick way to validate their own learning and help them identify areas that need improvement. Clicker technology enables a more effective, more efficient, and more engaging education. More research is needed to discover the extent to which the SRS technology (clickers) can benefit and enhance traditional learning approaches.

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