Using Classroom Response Systems in a Tenth Grade High School Geometry Classroom in a Suburban School District

by

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Abstract

This project will investigate the ways in which the classroom response system (CRS) affects student learning and attitude during instruction. Comparisons of unit test scores for students who used the CRS and for students who did not use the CRS were compared. Surveys were administered to students in regards to their experiences in using the CRS. Thirty-nine students from two tenth grade geometry classes were participants in this study. It was reported at the end of the study that test scores increased significantly when the CRS was used. The CRS also increased levels of interest and participation. Implications for teaching and further research are discussed.

Chapter 1: Introduction

Background and Rationale

Many teachers and students are under a lot of stress when it comes to taking high stake exams. Teachers struggle to keep the students' attention, covering an entire curriculum, and increasing student learning.

In 2003 the New York State Board of Regents requires all students to pass several standardized tests in order to graduate public high school (Michelle Fine, 2005). Specifically in math, my school requires students to pass at least one regents mathematics exam in order to graduate from high school. Requiring that students pass these high stake exams has caused for a severe decrease in graduation rates. New York State currently ranks 45th among the states in graduation rates (Fine, 2005). Students are failing these high stake exams, which then leads to dropping out of school. This is a huge problem because high school drop-outs are more likely to live in poverty and crime. Due to these high stakes, students are missing out on opportunities after high school.

This study focuses on the New York State Geometry Regents Exam in particular. The regent exam is broken down into two parts: multiple choice and short answer. Due to the generous curve, students could pass the regents exam solely on the multiple choice section alone; assuming the student got all of the questions correct. The multiple-choice section plays a very important part in passing the exam. Students who typically do well on the multiple-choice section pass the exam.

Many students struggle to pass the exams not due to their lack of knowledge, but their lack of test taking strategies. Barriers that I have seen in my students include failing to read a question thoroughly or working too slowly. Students may also face anxiety when preparing to take a high stake exam, other students may be unsure as of how to approach a multiple choice question (i.e. eliminating choices, an awareness of distracters). Identifying multiple choice strategies and increasing the use of multiple-choice formatted assessments may help increase multiple-choice performance. When increasing the amount of multiple-choice questions given it is important to engage students and keep them interested. It is also important that students learn how to work through the answers instead of guessing. In order to hopefully increase engagement and accountability a classroom response system will be used for this study.

A classroom response system, sometimes referred to as CRS or clickers, are handheld electronic devices. Each student has his or her own CRS. The receiving device is hooked into the teacher's computer. A teacher would then project a question on the board for students to do either individually or in groups. Teachers typically ask students multiple-choice and true/false formatted questions (Conoley et al., 2006). Once the students decide on an answer, they then use their CRS to send an electronic signal to the receiver and the teacher is able to see how the class responded as a whole. Later on after class the teacher can also look in the database to look over individual student responses. Individual responses are recorded because students are able to log into their CRS.

The purpose of this study is to find if the classroom response system enhances student engagement and improves multiple-choice performance. Current research discusses the many benefits of using the classroom response system particularly at the college level. Due to the lack of research at the K-12 level, this study strictly focuses on a 10^{th} grade regents geometry course. The need for this study is to investigate how the CRS may positively affect my students; especially in improving the passing rate for the New York State Geometry Regents Exam.

Research Question

A theoretical look at this study will include how the CRS affects student motivation and attitudes. According to past research the clickers have successfully engaged students and increased learning outcomes. I hypothesize that the CRS may increase students' confidence in the subject matter and hopefully make them feel accountable for the material that is being covered. I want my students to feel confident with the material while at the same time making them aware of testing strategies that they can use. Most students have a hard time reading a problem and knowing where to start. Reading strategies, drawing pictures, and eliminating choices are all strategies that can help students improve their test scores. The CRS paired with multiple-choice formatted questions will provide students with experiences in using these strategies.

For this study I plan on answering the following research questions:

Does the classroom response system improve multiple-choice performance in a tenth grade high school geometry classroom in a suburban school district?

Does the classroom response system increase student engagement?

Definitions

For this particular study the following parameters will be investigated: test scores, students' views and comments, student attitude and teacher observations. Based on previous research on CRS, test scores, student interviews and teacher observations are common methods used to collect data. Typically the test scores of the control group and the experimental group are compared in order to determine any significant differences. The control group practices multiple-choice questions using traditional teaching methods, while the experimental group uses the classroom response system during class to answer multiple-choice questions. The traditional teaching method is when the teacher posts the problem on the board and students work on the problem in their notebooks individually. After students find their solution the teacher will call on a student or ask for a volunteer to share their answer. Using traditional teaching methods allows for one to two students to participate. The difference between the experimental group and the control group is that the experimental group will allow all the students to share their solution at the same time while the control group only allows for a few individuals to share their answer.

Past research also looks at students' attitudes when investigating the effects of using the classroom response system in the classroom. The Lickert scale and student interviews are often ways of measuring students' views on using the clickers.

Chapter 2: Literature Review

In this review the use of classroom response systems used in the classroom are discussed. There are many ways in which teachers can use and misuse the CRS in their classrooms. These methodologies and tips for using CRS properly will be discussed. When CRS's are used properly in the classroom there are many benefits for both the teacher and student.

One benefit to using the CRS is the increase in informal testing. Frequent testing can improve student learning (Bangert-Drowns, J. Kulik, C. Kulik, 1991). This review will describe other key studies in order to support the methods used for this study.

Uses for the Classroom Response System

A challenge that most teachers face is trying to determine whether students understand the lesson, while trying to engage them in the lesson. Clickers are becoming increasingly popular in college lecture courses (Douglas Duncan, 2007).

Students can register or (log on) their clicker using their name and ID. When a multiple-choice question is posted on the board, students can then submit their answer using the CRS. During class the teacher can then tally the students' responses. A histogram will appear, indicating the number of students who selected a particular answer (Duncan, 2007). According to Peggy Bertrand, it is more effective to show the histogram first and give the students an opportunity to discuss the reasoning for their choice before displaying the correct answer (Bertrand, 2009).

In Linda Collins' (2007) research study, she suggests using the CRS for peer tutoring. When using the clickers for peer tutoring, students first answer the question individually. The teacher then displays the results and has students get into groups to discuss the responses. Once the group decides on the final answer, each group submits a follow-up vote. The responses are then again shown to the class and the correct solution is then discussed. Other popular uses for the clickers include cooperative learning activities through team competition like Jeopardy (Bertrand, 2009).

Other uses for the CRS may include taking attendance and polling students for their opinion on a specific topic. Clickers are also used as an assessment tool. Teachers can give students a quick quiz and then later on review the database to see individual student scores.

Tips for Using the Classroom Response System

Teachers should at least have basic training in how to use the CRS and practice using the technology before using it in front of the class. In deciding when to use CRS in a lesson, teachers should decide first if the technology fits the pedagogy of the lesson. Teachers must first decide if the technology meets the objectives and concepts of the lesson (Duncan, 2007). Research shows that using technology alone cannot bring improvements to achievement and student participation in class (Penuel, Boscardin, Masyn, & Crawford, 2006).

Premkumar and Coupal (2008) suggest using the CRS every 20 minutes during a 60-minute lecture to ask 3-4 questions that will help reinforce learning. For my study, students will be at the high school level; therefore I will decrease the interval of time in asking questions to every 15 minutes due to shorter attention spans.

The questions asked using the CRS must be *good* questions. Good questions usually provoke a diversity of answers (Kelly Cline, 2006). This gives students an opportunity to support the logic in their answer. Kelly Cline suggests that multiple-choice and true/false formatted questions work best. Most effective questions are designed to elicit common errors and misconceptions (Cline, 2005).

Advantages of Using the Classroom Response System

One of the biggest incentives for teachers to use CRS in their classrooms is to gauge whether the students understand the information being presented. Many times, looking into the faces of our students can be misleading. The CRS gives teachers a chance to provide instant feedback from the students.

The CRS is commonly used as a diagnostic tool to assess students and find any possible misconceptions (Penuel et al., 2006). Teachers may also use the clickers during pre-assessment to find out what the students already know about a topic. Posing these questions before the lesson can help shape instruction. During the lesson the teacher can then stop and ask 3-4 questions to see if the students are ready to move on. Having students submit their answers electronically to retrieve immediate results helps to save instruction time (Penuel et al., 2006). If teachers

identify students' misconceptions too late, instruction time could be lost later on because the teacher may need to go back and reteach the topic. With CRS, the teacher can immediately address any misconceptions or gaps in knowledge.

Increase Discussion & Peer Instruction

Research shows that the classroom response system increases student engagement. The CRS provides student with an active learning method. Active learning methods are more effective than traditional methods (Cline, 2005). While lectures encourage students to be passive learners, the CRS breaks students from the passive learner mode.

Clickers can provide a springboard for discussion in most classrooms. The most effective questions asked are designed to pinpoint common errors and provoke a diversity of answers (Cline, 2005). CRS allows for students to participate without being put on the spot. When students use the CRS, they are able to focus more on their ideas rather than worrying about being wrong or losing points. Naturally most students will want to speak out and support the logic for the answer they chose. This prevents class discussions from being dominated by a few students (Cline, 2005).

The classroom response system has been also known to create a higher level of peer tutoring (Linda Collins, 2007). Peer instruction was pioneered by Eric Mazur, a Professor of Physics at Harvard University (Collins, 2007). He stated that we should teach by questioning. Students should be expected to investigate and review concepts in order to construct their own logic. To start, the teacher would pose a

question and students would use their clicker to submit the answer electronically. The students would then break up into small groups to discuss the responses while considering the alternatives. After the peer discussions, students would then resubmit their answers as a group. An earlier study mentioned by Linda Collins investigated the combination of peer instruction. It was found the CRS produced significant results on a standardized test in physics. The research showed that the CRS improved learning outcomes (Collins, 2009). The study stresses that the gains are due to switching from passive to active learning, not due to the specific type of technology that was used.

CRS Improves Student Achievement & Engagement

Research shows that when students are actively engaged in the content that they are learning, the following are improved: critical thinking skills, motivation, retention and transfer of new information (Duncan, 2007). A study by Blood and Neel (2008) investigates whether the use of CRS improves student engagement and achievement within the lesson. In a lecture-based instruction a CRS was use on a class of 35 freshmen in an intro to education course. The class met for three hours once a week for ten weeks. The lectures were paired into five pairs; with weeks one and two being the first pair, weeks three and four the second pair and so on. Each pair of weeks alternated using the CRS and having a traditional lecture. The CRS was used to ask questions throughout the lecture to immediately test student's understanding; while no immediate type of testing was used during the traditional

lecture. The following methods were used to measure achievement and engagement: a weekly content quiz, a weekly engagement self-assessment Likert scale, and an overall course evaluation questionnaire at the end of the semester (Blood & Neel, 2008). For the student questionnaire, students were asked if the CRS helped them stay engaged in the class and whether or not it improved their learning.

The study found that the achievement scores on the weekly content quizzes of the CRS sessions were significantly higher than those of the traditional lecture only sessions. The weekly self-assessment scores of the CRS sessions were also significantly higher. Students commented that they liked using the system and they believed that it aided in their learning (Blood & Neel, 2008).

A research study by Conoley, Moore, Croom and Flowers (2006) also supports the idea that CRS improves student learning and engagement. Participants for this study included three high school classes with a total of 61 students. Three different teachers taught the same agriscience applications course. Each teacher taught one instructional unit using the audience-response system and one unit without the audience-response system. During the first unit, two classes used the clickers and one class did not. The two classes served as a treatment group while the other class served as a comparison group. All three teachers received six hours training on how to use the audience-response system. The students were not aware that they were part of a study until the very end.

Three types of data were collected for this study: two achievement tests and student interviews. At the end of each unit all three classes took an achievement test.

The items on the test were based from the instructional objectives and competencies from the statewide test bank. The test items were carefully examined and deemed both reliable and valid.

The treatment groups (clicker units) were found to have a higher mean average than the control group (received verbal feedback only). Out of 100 points, the treatment group scored a mean score of 89.98 and the control group scored a mean of 84.41. An independent t-test was performed and found the difference in the mean scores to be significant. Therefore, there is a valuable difference between the treatment and control groups (Conoley et al., 2006).

Seven students were interviewed from each of the three classes. The researchers gathered self-reported data from the students by using an audio-tape. After the interview, the researchers transcribed and analyzed the students' comments. These comments were broken down into emic contructs that tallied the most frequent descriptive words that the students used when describing their experiences using the audience-response system. The words most commonly used in order from greatest to least were: helped, easy, participate, fun, learn, pay attention, and understand. Other student comments included: "I enjoyed the responder system because it allowed me to interact directly with the instructor while not feeling singled out," "This is great form of a no-pressure atmosphere," "…gives instant and graphical feedback" (Conoley et al., 2006).

Overall the students who used the audience-response system scored higher on the achievement test. Therefore, the clickers helped to increase student learning. The

students also found the clickers enjoyable because it made class more interesting (Conoley et al., 2006).

Improving Multiple-Choice Performance

Peggy Bertrand (2009) conducted a study that specifically examines how CRS improves multiple-choice performance in AP Physics. Participants for this study consisted of Bertrand's AP Physics classes. Students started class everyday with a few multiple-choice review questions (that included distracter questions). Before students were given the correct answer, the histogram of student responses was displayed. Students were encouraged to discuss the choices by peer-facilitated learning.

Besides giving students review questions, Bertrand uses the CRS for review games like Jeopardy and also sets up independent student practice. The independent student practice allowed for students to work at their own pace. The CRS was used on a daily basis for the entire academic year.

Student performance was measured by comparing the mean scores of the students to the national mean scores for the multiple-choice components of the AP Physics exam (Bertrand, 2009). This difference in means was also compared to the difference of means from the previous year; when CRS was not used as frequently in the classroom.

The results showed a significant increase to students' multiple-choice test scores. Also, based on informal observation of student behavior, the CRS seems to have increased student engagement (Bertrand, 2009).

Frequent Testing Improves Student Learning

Research shows that frequent testing may improve learning outcomes (Bangert-Drowns et al., 1991). Bangert-Drowns et al. (1991) suggests that frequent testing can help students learn and encourages mastery testing. Mastery testing is testing at frequent intervals during instruction to evaluate student progress. Classroom response systems can be an effective tool to quickly and efficiently assess students more frequently.

Bangert-Drowns et al. claims that mastery testing when used as a diagnostic tool, followed by remedial help can improve classroom learning. Increasing the number of "test-like events" will help prepare students better for a written test, improving their overall achievement. Students typically favor classes that test more frequently versus less frequently tested classes (Bangert-Drowns et al., 1991).

After reviewing the literature, many common methods are used for data collection. These methods include: comparing test scores, student questionnaires and student interviews. Improving student engagement and achievement is very important for schools. In order to do this, CRS can be used to aid this process. However, simply using CRS will not improve test scores. CRS needs to be incorporated into the pedagogy very carefully.

For this research study, it is hopeful that frequent use of the CRS coupled with multiple choice questions will increase students' multiple-choice performance and engagement. It is important to increase student achievement so that we can help our students become successful high school graduates.

Chapter 3: Methodology

Research Question

The current study presents an analysis on the effects of using a classroom response system in a tenth grade setting. Through the use of student surveys and unit assessments, I hope to answer the following research questions:

> Does the classroom response system improve multiple-choice performance in a tenth grade high school geometry classroom in a suburban school district?
>
> Does the classroom response system increase student engagement?

Participants and Procedures

During the fall of 2010, I conducted a research study in an averaged-sized suburban public high school in Western New York. The socioeconomic status of the school district consists of middle to lower class residents.

The participants for this study included thirty-nine (39) tenth grade students from two geometry classes. Of the thirty-nine participants, nineteen (19) of the subjects were male and twenty (20) were female.

There is a wide range of student ability in each of the two geometry classes. For purposes of this study each geometry class will be referred to as block two and block three. Block two students appear to be unmotivated, while the block three class is very motivated and works very hard. Block two has eight males and four females consisting of 50% White, 33% Black and 17% mixed race (White/Asian and White/Black). There is one student in block two who has a 504 plan and two students whose second language is English. Block three has eleven males and sixteen females

consisting of 44% White, 41% Black, 7% Hispanic, 4% Asian, and 4% mixed race (Black/White). There are six students with IEP plans in block three.

The school uses block scheduling in which the students attend six 56 minute classes. The researcher will be teaching both geometry classes in this study in order to maintain consistent teaching practices. The geometry course curriculum follows the NYS Integrated Geometry Curriculum. The classroom is typically arranged into rows. Sometimes students are allowed to sit in groups during group activities. Students sit in rows during all assessments.

A typical class starts with students walking in and grabbing their assigned calculator. Many students are visual learners and will also choose to grab a piece of graph paper. Once students are seated, they begin their warm-up on the board. The teacher will first answer any questions from the previous night's homework and will then collect the homework. After going over the warm-up, the teacher provides the students with an anticipatory set for the lesson. Since many students have problems with word processing and writing skills, guided notes are provided for all students every day. During the lesson the teacher provides several opportunities for students to try examples. At the end of class the teacher will put 3-5 multiple-choice questions on the SMARTboard for students to work on. The problems are presented one at a time and quickly reviewed after the completion of each question so that students may confirm their knowledge of the subject. After closing the lesson, students begin their homework. Sometimes if the students are working in groups on a specific activity the teacher will prompted the students at the end of class to share their findings.

Instruments/ Data Collection Methods

The study took place during two units over the course of twenty-one days. The first unit referred to as unit 3 was ten days long and covered topics such as: midpoint, distance, bisectors, incenter, etc. The second unit was unit 4, which lasted eleven days and included topics such as: equations of lines, equations of circles, and geometric constructions. Both qualitative and quantitative data are collected for this study. These instruments include: unit 3 test, unit 4 test, and a student survey.

The unit 3 test (Appendix A) and unit 4 test (Appendix B) were given out after each of the corresponding units. The format for each of the unit tests consist of ten multiple-choice questions and five short answer questions. The multiple-choice questions were selected from old NYS Regents Exams. The difficulty level for the multiple-choice questions selected for both unit tests were consistent and examined for both validity and reliability. The short answer questions were designed to create more thought provoking questions that require students to use two or more steps to complete. Each student was looked at individually for each assessment. The percentage of correct multiple-choice questions was then recorded for each student for both exams. These results were then averaged for both the control group and experimental group to see if using the clickers improved multiple-choice performance.

Immediately following the experimental unit, students filled out a student survey (Appendix C). The survey questions asked for students to describe their experiences in detail about using the classroom response system in the classroom.

The purpose of this survey is to determine from a student's point of view, if they thought the clickers provided a positive experience for them in math class. Such experiences would include their likes and dislikes of using the clickers, how it has affected their participation in math class, confirming their knowledge of the objectives learned that day or if it has improved their attitude and/or confidence towards math.

Both block two and block three were part of the experimental and control groups for this study. In order to avoid differences in ability, block two acted as the control group for unit 3 and the experimental group for unit 4. Block three acted as the experimental group for unit 3 and the control group for unit 4. The experimental design for this study is visually represented in Table 1. This method in choosing the control and experimental groups is similar to the research study done by Conoley, Moore, Croom and Flowers (2006).

Table 1: Experimental Design

Geometry Class	**Unit 3: Midpoint, Distance, & Bisectors**	**Unit 4: Equations of Lines & Equations of Circles**
Block Two	Control Group	Experimental Group
Block Three	Experimental Group	Control Group

Before the unit tests were administered at the end of each unit, students were exposed to multiple-choice questions on a daily basis. During the end of each lesson for both units students were presented with 3-5 multiple choice questions. These

questions were designed to sum up the objectives for each lesson. Students were presented with one question at a time. After students were given enough time to answer one question the teacher would then immediately tell the students what the answer was along with an explanation if necessary. The students in the control group answered their questions to themselves and wrote their answer down on paper. The teacher would then call on a volunteer to share their response. The experimental group responded by using the classroom response system. The teacher would then share the overall student responses by displaying a bar graph showing the percentage of student responses for each answer choice. Whether the students were part of the control group or experimental group the teacher would always go over the problem. The multiple-choice format was used to increase students' ability in answering multiple-choice questions especially for the NYS Geometry Regents Exam. The multiple-choice questions were a mixture of teacher designed problems and old NYS Regents Exam problems.

Data Analysis

There were three measures used during this study: unit 3 assessment, unit 4 assessment, and a student survey. In order to measure if using clickers improved multiple-choice performance, the percent of correct multiple-choice answers were compared. Each test had ten multiple-choice questions. The percent of correct multiple-choice answers were found for each student and for each test. The percentages for block two's unit 3 test (control group) and block three's unit 4 test

(control group) were averaged together for the control group. Likewise, the percentages for block two's unit 4 test (experimental group) and block three's unit 3 test (experimental group) were also averaged together for the experimental group. By having both blocks being a part of the control and experimental groups the differences in student ability between each class is eliminated. The average of correct multiple-choice answers for each control group and experimental group will then be compared to measure the effect that the classroom response system had on multiple-choice performance.

These two independent samples will be compared with one another to determine the relative effectiveness of using the clickers and not using the clickers. In order to determine whether there is a significant difference in the performance of the two groups, a *t*-test of independent samples will be used with a .05 significance level.

The third measuring tool that will be used in this study is the student survey along with teacher observations. At the end of the experimental unit, students will be asked to fill out the survey. A coding system will be used to analyze the data into a bar graph. Each of the four survey questions will be coded under three categories: yes, no, and unsure. The teacher will read through each of the surveys and tally up the number of yes, no, and unsure responses for each question. A bar graph will then be used to show the percentage of students who thought the classroom response system had a positive, negative or no effect on them. The teacher will also identify any major themes or commonly used phrases used throughout the surveys. These

comments will then be discussed later with the results along with the teacher's observations.

Chapter 4: Results

Reliability

Multiple-choice questions for each unit test were graded correct or incorrect; no partial credit was given. The multiple-choice section of the unit tests were graded twice by the teacher to eliminate any grading errors. The reliability was 100%.

Analysis

The analysis of the test scores to determine if multiple-choice performance had improved is shown in Table 1. The mean was found by taking the percentage of correct multiple-choice answers for each student, then averaging the percents for the entire group. It was found that the experimental group had more multiple-choice questions correct than the control group by 12.1%. A *t*-test for independent samples was used to derive a *t* value of -3.38. A 0.05 significance level was used for this study. As seen in Table 1, $p = .00057$, therefore the 12.1% increase from the control group to the experimental group is a significant difference.

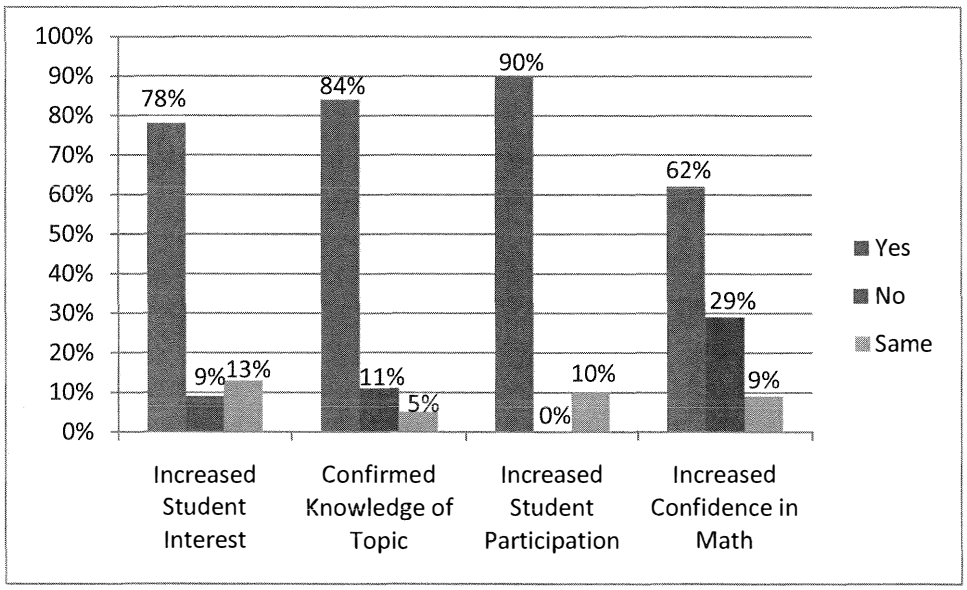
Table 1
Comparison of Control Group and Experimental Group Unit Test Scores

Group	*N*	Mean	Standard Deviation	*T*-Value	Significance
Control	39	63.95%	.1462	-3.38	.00057
Experimental	39	76.05%	.1653		

The analysis of increased student participation was determined by reading each of the student surveys. Each survey had four questions (Appendix C). Students

were asked if it had increased their interest in math, did it help them confirm their knowledge, did participation improve, and if their confidence in math increased. The teacher read through each survey and determined whether the student was affected positively, negatively, or not affected at all for each question. The teacher then tallied the number of positive, negative and no effect comments for each student for each question and took the percentage for each category. Table 2 illustrates the percentage of students affected by each category.

Table 2
Survey Results- Student Views on CRS



The majority of students were positively impacted by using the classroom response system during instruction. Almost every student believed that the clickers improved participation.

Limitations

This study was only conducted with two classes. It is possible that the results of this study may be unique to this particular group of students.

In order to eliminate differences in ability, both geometry classes were part of the control and experimental groups. This may cause concern over the multiple-choice test taking skills carrying over from one unit to the next unit and possibly skewing the results of unit 4.

Block three has seven students who came from a two year algebra course (all other students took algebra in one year). These seven students have strong algebra skills due to the two year algebra course and may have a slight advantage when taking the unit 4 test, since unit 4 is mostly algebra based. Since block three is the control group for unit 4, they may score slightly higher on the test due to their strong algebra background. This could then cause an insignificant difference between the unit 3 and unit 4 test scores.

Finally, using the classroom response system is fairly new for most of the students. This may cause students to engage more than they would normally. If this study were conducted over a longer period of time this newness may wear off and overall student participation may be effected.

Chapter 5: Conclusions and Recommendations

Discussions

It was found in this study that students improved on their multiple-choice performance and increased student engagement when using the classroom response system. These findings are also supported through the work of Conoley et al. (2006) who also found a significant difference when students used the classroom response system. The students who used the classroom response had shown an increase in their learning. Findings by Blood and Neel (2008) support that CRS increases engagement in the lectures and students demonstrated higher scores on weekly quizzes when the response system was used.

There are suggested reasons as to why the clickers may have improved test scores and engagement. The classroom response system provides many re-teaching opportunities. The CRS gives immediate feedback on how well the class did on a question as a whole. This enabled the teacher to instantly alter instruction when necessary. The CRS also saved instructional time; if it was evident that all students knew the concepts, then the teacher would move on rather than dwelling too long on a topic.

Students enjoyed using CRS and through the teacher's observation it was evident that students appeared to be more engaged. Students felt ownership of their answer because it was their "vote" that was counted in the overall results. This feeling of ownership motivated the students to challenge the teacher when they felt that their answer was correct. The CRS gave students a chance to support the logic of

their answer. This initiated quality classroom discussions and provided an opportunity to teach students test taking skills, especially multiple-choice formatted questions. The teacher did discuss the same test taking skills during the control unit. However, students appeared to be paying attention more when using the clickers.

The low standard deviation in percentage of correct multiple-choice answers suggests that the clickers affected a majority of the population rather than a few individual students. This means that most students clearly benefited from the use of the CRS.

As seen in Table 2, the CRS had a significant positive influence on the students regarding their interest and participation. Ninety percent of the students believed that the clickers increased the overall class participation. Many students enjoyed seeing other student responses. One student said, "You can see the percentage of people submitting the answer." Students were excited when it was time to use the clickers, "... it's something different and gets us out of the same routine." Students also commented that it gets the whole class involved rather than one person being called on. When the teacher walked around the classroom many students would take out a piece of paper to show their work before they submitted their answer. Taking out a piece of paper was not initially encouraged by the teacher, but was something that students started on their own.

When it was time to use the clickers it was clear that the energy in the room increased. Students appeared to be refreshed and ready to go. "Clickers are more interesting than just doing a worksheet." Some students were even disappointed

when the class was done answering all the questions. Many students wanted to do more problems. Seventy-eight percent of students said that the clickers have increased their interest in math. "It was new and different." "I love using electronics and combining electronics and math is awesome." Other students said that it was a fun way to submit their answers and that it made them feel more active in class.

Some of the students have writing disabilities, so writing and keeping up during instruction can sometimes be challenging. One student said, "I hate writing so the clickers keep my interest, and help me be more focused." This has suggested a new teaching method that can be implemented in the classroom; using clickers as a tool to decrease the amount of writing for students.

Eighty-four percent of students said that the clickers helped confirm their knowledge of the topic. "I can think about my answer before going over it." Many students mentioned how they liked that the teacher would review the question afterwards and re-teach the topic if needed. Students were intrinsically motivated to get the answer right and enjoyed finding out if the other students were getting it or not. "Clickers also help you practice; it's like having a mini quiz so you stay sharp on your math skills."

Overall, the CRS helped increase student confidence in math. One student said, "No one laughs at me when I am wrong." Students liked responding anonymously while still knowing whether they got the question right or wrong. "I don't like to talk out loud, but I can participate and the answer is explained." "It seems that I can answer more questions without being judged or hesitant for making

mistakes." Students felt a sense of security when using the clickers. The clickers eliminated the fear of making a mistake.

Conclusions

The CRS improved student multiple-choice performance. It is clear through the students' test scores that students who used the clickers performed better on the unit test. The CRS increases student participation and has brought practicing questions in class to a whole new level. Students are eager to be involved in the polling process.

According to Premkumar and Coupal (2008), the CRS improves classroom teaching by enhancing interactivity as long as the pedagogy is the focus. Unit 3 and unit 4 were specifically chosen for this study due to the consistency in appearance for these types of questions on the NYS Regents Exam. Specifically with these two units containing topics like: midpoint, slope, distance, equations of lines, and equations of circles; students experience many misconceptions and common errors for these types of problems over the years. Practicing multiple-choice questions during class and pin-pointing these common errors has not only improved test scores, but student attitudes as well. Students felt confident when they got the answer right, and when they chose the wrong answer they were corrected and reassured by the teacher.

After using the clickers in the classroom, many students are now requesting to use the CRS everyday in class. Students' enthusiasm towards the clickers has caused

much excitement in the classroom. Students are now beginning to offer the teacher new ways to incorporate the clickers in the classroom (i.e. games and warm-ups).

Recommendations

In this study the CRS was used at the end of every class. Students were given multiple-choice questions that were directly related to the objectives for each lesson. Incorporating the clickers into the warm-ups and anticipatory set can also be a great way to measure students' prior knowledge before starting a lesson is to use the CRS. Posing a question before a lesson and having students use the clickers can give the teacher a snap shot of the class' prior knowledge of a topic.

According to Premkumar and Coupal (2008), in a sixty minute lecture consisting of undergraduate students, the CRS should be used every twenty minutes or so for only 3-4 questions. Past research has shown that fewer questions more frequently are better than more questions at one time (Premkumar and Coupal, 2006). Students at the high school level may benefit even more if the clickers were used more frequently during instruction. Lessons could be structured so that each question is posed at the appropriate timing. Using the CRS at more frequent intervals may better evaluate student progress.

The types of multiple-choice questions that were asked during this study were typically factual recall, knowledge and application. These types of questions do not reach the higher levels of Bloom's Taxonomy. The NYS Regents Exam questions are designed for factual recall and application. Typically, the exam does not contain

higher level questions. The purpose of this study was to improve multiple-choice performance so that students could perform well on the NYS Geometry Regents Exam. In the future, looking beyond the exam, it would be to the students' benefit to experience higher level questioning. During this research study when students were given a question that may have taken three or more minutes to solve, it was anticipated that students would slowly lose interest and become off task. In fact the exact opposite happened when using the CRS. Students became very invested in the problem and some of the slower workers even begged the teacher for more time before going over the question. Students did not give up so easily or become bored with the problem, they wanted to finish before the teacher began to review the problem. In the future, clickers could be used to ask higher level questions. The teacher could design higher level questions and reduce the number of questions asked from 3-4 questions to 2-3 questions.

The CRS is a great tool to help students increase their test scores and participation. The clickers are also a great way to motivate and challenge students. Teachers are also challenged by the CRS to refine their teaching practices and designing good questions for their students.

References

Bertrand, Peggy (2009, April). Using a Classroom Response System to Improve Multiple-Choice Performance in AP Physics. *The Physics Teacher*, 47, 216-219.

Conoley, John; Moore, Gary; Croom, Barry; and Flowers, James (2006, Oct). A Toy or a Teaching Tool? The Use of Audience-Response Systems in the Classroom. *Techniques: Connecting Education & Careers*, 81 (7), 46-48.

Premkumar, Kalyani and Coupal, Cyril (2008). Rules of engagement – 12 tips for successful use of "clickers" in the classroom. *Medical Teacher*, 30, 146-149.

Blood, Erika and Neel, Richard (2008). Using Student Response Systems in Lecture-based Instruction: Does it Change Student Engagement and Learning? *Journal of Technology and Teacher Education*, 16 (3), 375-383.

Cline, Kelly S. (2006, Sept). Classroom Voting in Mathematics. *Mathematics Teacher*, 100 (2), 100-104.

Fine, Michelle (2005). High Stakes Testing and Lost Opportunities The New York State Regents Exams. *Encounter: Education for Meaning and Social Justice*, 18 (2), 24-29.

Bangert-Drowns, Robert L., Kulik, James A., Kulik, Chen-Lin C. (1991). Effects of Frequent Classroom Testing. *Journal of Educational Research*, 85 (2), 89-99.

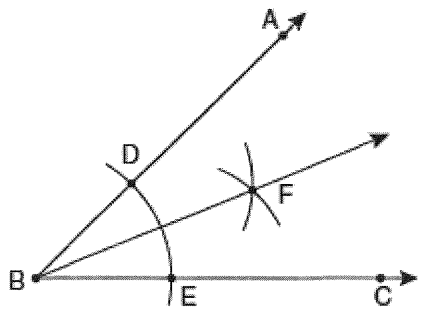
Martyn, Margie (2007). Clickers in the Classroom: An Active Learning Approach. *EDUCAUSE Quarterly Magazine*, 30 (2), 71-74.

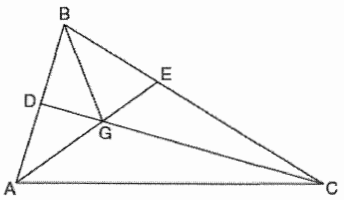
Collins, Linda J. (2007). Livening Up the Classroom: Using Audience Response Systems to Promote Active Learning. *Medical Reference Services Quarterly*, 26 (1), 81-88.

Penuel, William R., Boscardin, Christy K., Masyn, Katherine, Crawford, Valerie M. (2006, Nov). Teaching with student response systems in elementary and secondary education settings: A survey study. *Education Tech Research Dev.*, 55, 315-346.

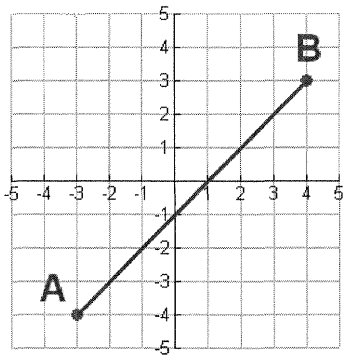
Duncan, Douglas (2007). Clickers: A New Teaching Aid with Exceptional Promise. *Astronomy Education Review*, 5 (1), 70-88.

APPENDIX A: Unit 3 Test

	SHOW YOUR WORK IN THIS COLUMN
1. What is the midpoint of a line segment with endpoints (-3,-8) and (-4,-5)? (a) (-6,-4) (c) (-3.5,-6.5) (b) (-5.5,-4.5) (d) (-3,-5)	
2. If the endpoints of $\overline{AB}$ are $A(-4,5)$ and $B(2,-5)$, what is the length of $\overline{AB}$? (a) $2\sqrt{34}$ (b) 2 (c) $\sqrt{61}$ (d) 8	
3. The diagram below shows the construction of the bisector of $\angle ABC$.  Which statement is ***not*** true? (a) $m\angle EBF = \frac{1}{2} m\angle ABC$ (b) $m\angle DBF = \frac{1}{2} m\angle ABC$ (c) $m\angle EBF = m\angle ABC$ (d) $m\angle DBF = m\angle EBF$	

4. A segment has an endpoint at (-3,-1) and a midpoint at (3,2). What is the coordinate of the other endpoint of the segment? (a) (0,0.5) (c) (6,5) (b) (-2,-1.5) (d) (9,5)	
5. In the diagram below of $\triangle ABC$, $\overline{CD}$ is the bisector of $\angle BCA$, $\overline{AE}$ is the bisector of $\angle CAB$, and $\overline{BG}$ is drawn.  Which statement must be true? (a) $DG = EG$ (b) $AG = BG$ (c) $\angle AEB \cong \angle AEC$ (d) $\angle DBG \cong \angle EBG$	
6. M is the midpoint of AB. The coordinates of A are (-2,3) and the coordinate of M are (1,0). Find the coordinates of B. (a) (-.5,1.5) (c) (-4,3) (b) (4,-3) (d) (-5,6)	
7. Find the midpoint of the segment joining the points (4,-2) and (-8,6). (a) (6,4) (c) (2,2) (b) (-6,-4) (d) (-2,2)	

8. Find the length of AB.



(a) 1 (c) $2\sqrt{7}$

(b) $\sqrt{2}$ (d) $7\sqrt{2}$

9. What is the distance between the points $(-3, 2)$ and $(1, 0)$?

(a) $2\sqrt{2}$
(b) $2\sqrt{3}$
(c) $5\sqrt{2}$
(d) $2\sqrt{5}$

10. If a line segment has endpoints $A(3x+5, 3y)$ and $B(x-1, -y)$, what are the coordinates of the midpoint of $\overline{AB}$?

(a) $(x+3, 2y)$

(b) $(2x+2, y)$

(c) $(2x+3, y)$

(d) $(4x+4, 2y)$

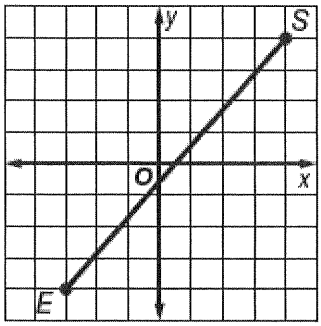
For questions 11-15, be sure to SHOW ALL WORK.

Simplify the following expressions in simplest radical form

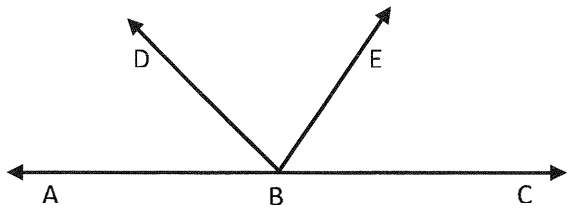
11.) $\sqrt{30} - \sqrt{10}$

12.) $3\sqrt{32} - 6\sqrt{8}$

13.) Express, in ***simplest radical form***, the length of the line segment $\overline{ES}$.

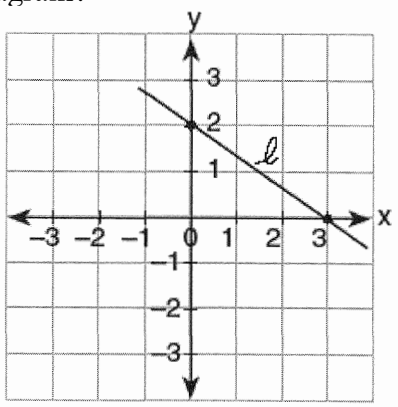


14.) In the accompanying diagram, $\overleftrightarrow{AC}$ is a straight line and $\overrightarrow{BE}$ bisects $\angle DBC$. If $m\angle ABD = 2x$ and $m\angle DBE = 2x + 15$, find x.



15.) Draw a picture and answer the following question: $\overleftrightarrow{XY}$ bisects $\overline{RT}$ at point W. If RW = $6x$ - 20 and RT = 140, find x and WT.

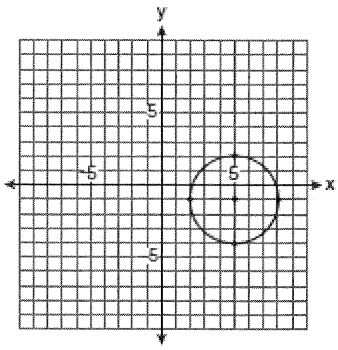
APPENDIX B: Unit 4 Test

	SHOW ALL WORK IN THIS COLUMN
1. What is the slope of line ℓ in the accompanying diagram?  (a) $-\frac{3}{2}$ (c) $\frac{2}{3}$ (b) $-\frac{2}{3}$ (d) $\frac{3}{2}$	
2. Which of the following is perpendicular to the line $=\frac{3}{4}x-1$? (a) $y=-\frac{3}{4}x+1$ (c) $y=-\frac{3}{4}x+5$ (b) $y=\frac{3}{4}x-2$ (d) $y=-\frac{4}{3}x-7$	
3. Find the equation of the line parallel to $y=-2x+3$ that passes through the point (-1,1). (a) $y=-2x-1$ (c) $y=-\frac{1}{2}x+1$ (b) $y=2x+1$ (d) $y=\frac{1}{2}x-1$	
4. Solve the system. $y=x+4$ $y=x^2+4x+4$ (a) (-3,1) and (0,4) (c) (-2,0) (b) (-2,0) and (0,4) (d) There is not solution	

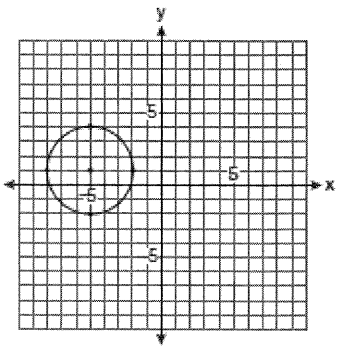
5. Which statement is true about the slope of the line that passes through the points (5,2) and (-1,2)? (a) The slope is undefined (b) The slope is 0. (c) The slope is 3. (d) The slope is $\frac{1}{3}$.	
6. The lines represented by the equations $y+\frac{1}{2}x=4$ and $3x+6y=12$ are (a) the same line (b) parallel (c) perpendicular (d) neither parallel nor perpendicular	
7. Which is an equation of the line that passes through the point $(-2,5)$ and is perpendicular to the line whose equation is $y=\frac{1}{2}x+5$? (a) $y=2x+1$ (b) $y=-2x+1$ (c) $y=2x+9$ (d) $y=-2x-9$	
8. The equation of a circle is $x^2+(y-7)^2=16$. What are the center and radius of the circle? (a) center = $(0,7)$; radius = 4 (b) center = $(0,7)$; radius = 16 (c) center = $(0,-7)$; radius = 4 (d) center = $(0,-7)$; radius = 16	

9. Which graph represents a circle with the equation $(x-5)^2+(y+1)^2=9$?

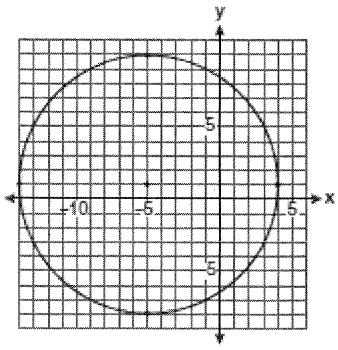
1)



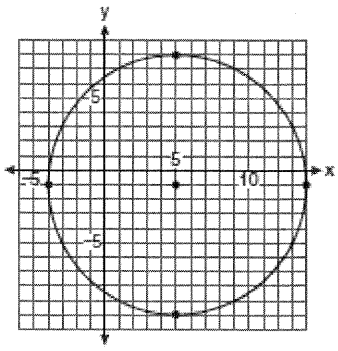
2)



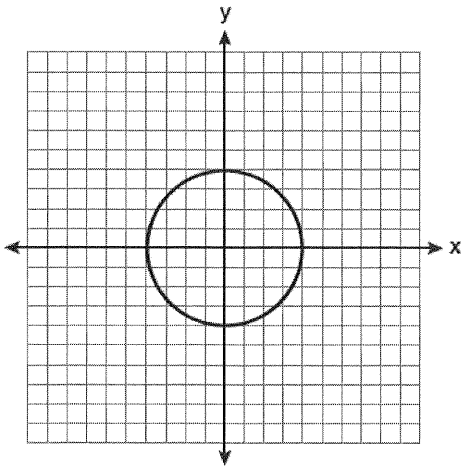
3)



4)



10. What is an equation for the circle shown in the graph below?



(a) $x^2 + y^2 = 2$

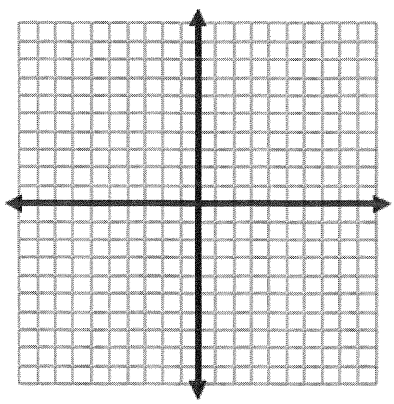
(b) $x^2 + y^2 = 4$

(c) $x^2 + y^2 = 8$

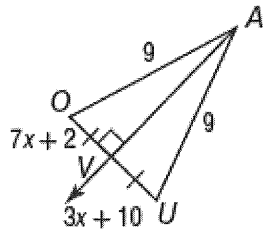
(d) $x^2 + y^2 = 16$

Remember to SHOW ALL OF YOUR WORK for questions 11-15.

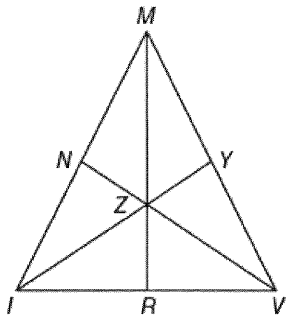
11) GRAPH the circle $(x - 1)^2 + (y + 2)^2 = 9$



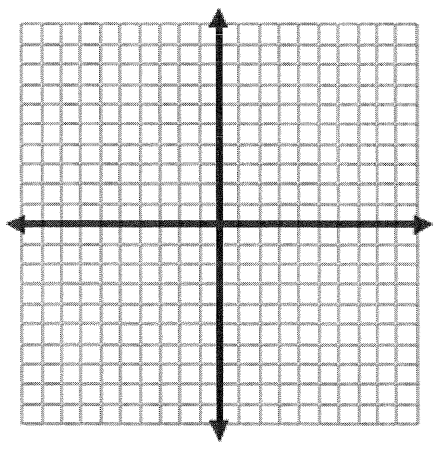
12) If $\overrightarrow{AV}$ is a perpendicular bisector to $\overline{OU}$, find the measure of VU.



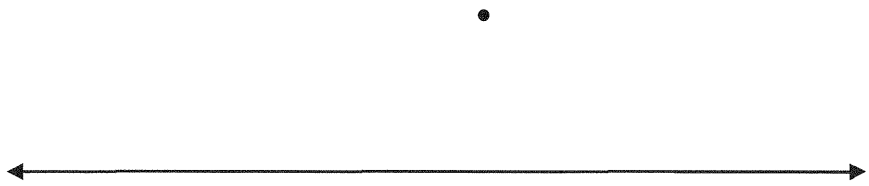
13) In the diagram below, $\overline{MR}$, $\overline{VN}$ and $\overline{IY}$ are perpendicular bisectors. Point Z is the circumcenter, MZ = 5 and YI = 8. Find the measure of MY.



14) Write the equation of the **perpendicular bisector** between the points (-5,-1) and (7, 5). Graph **BOTH** the segment and the bisector on the accompanying graph to check your work.



15) Construct a line that is perpendicular to the line and passes through the point.



STUDENT SURVEY - Please DO NOT put your name anywhere on this sheet of paper.

Please answer the following questions regarding your experiences with the clickers to the best of your knowledge. Thank you in advance for your participation in this study.

1) How has the use of clickers increased your interest in math class or how has the use of clickers decreased your interest in math class?

2) Did the clickers help you confirm whether or not you know the information being taught?

3) How do you think the use of classroom clickers have affected the overall student participation?

4) Do the classroom clickers increase your confidence in the material being taught? If so please explain.