STUDENT RESPONSE SYSTEMS AND BEHAVIORAL ENGAGEMENT IN MIDDLE SCHOOL MATHEMATICS STUDENTS

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STUDENT RESPONSE SYSTEMS AND BEHAVIORAL

ENGAGEMENT IN MIDDLE SCHOOL

MATHEMATICS STUDENTS

A Thesis

by

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Spring 2011

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ABSTRACT

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Student engagement, often defined to include students' attention, interest, participation, and effort in schoolwork, is a concern for educators because of its correlation to achievement. Since engagement encompasses behavioral aspects, researchers have suggested using instructional strategies that could manipulate or influence students' behavioral engagement in the classroom. A student response system (SRS) is a technological tool that may influence engagement.

A SRS consists of wireless handheld response pads and a centralized receiver. A teacher poses multiple-choice-type questions and students respond via the response pads. Responses from the entire class are then instantly displayed in the form of a bar graph for all to view, while individual responses are kept anonymous.

The objective of this study was to answer the question: According to student self-perception, how influential is a SRS on behavioral engagement in a middle-school mathematics class?

Data from a before- and after-use questionnaire, an open-ended questionnaire, and select interviews were used to determine what effect, if any, the SRS had. Statistical results indicated that the SRS did not affect students' behavioral engagement. Instead, students reported that the SRS did provide more opportunities for doing math, participation, collaboration between peers, and immediate feedback.

CHAPTER I

INTRODUCTION

Background

There is great urgency to improve students' mathematical achievement. Some even argue that achievement in middle school mathematics is particularly critical because it is in the middle years that students' performance and attitudes towards math affect subsequent mathematical opportunities, which may further influence occupational opportunities (Singh, Granville, & Dika, 2002). In addition, Lubienski (2001) argues, "not only can mathematics achievement serve as a ladder of economic mobility, but it is also essential for making informed consumer and voter choices" (p. 3).

As a teacher of middle-school mathematics, I frequently ask myself, how can I improve my students' mathematical achievement? At times I have found this question difficult to answer because there are so many factors that likely affect achievement, including socioeconomic status (Lubienski, 2001; Sirin, 2005), students' commitment of academic time, attendance, attitudes towards math, motivation (Singh, Granville, & Dika, 2002), and student engagement (Brewster & Fager, 2000; Finn, 1989; Finn & Voelkl, 1993; Newmann, 1992; Singh, Granville, & Dika, 2002). With so many contributing factors it is difficult to decide where to focus attention. However, educators must remember that they do not have control over all the above-mentioned factors.

As nice as it would be, teachers do not have the power to change a student's socioeconomic status, and while we can monitor academic time during the school day once they leave campus, students and their families are left with the responsibility of scheduling time for academics and making sure that attendance is a priority. This leaves attitudes towards math, motivation, and engagement, all of which we can still not necessarily control but we could influence. Attitudes towards math and motivation tend to be developed and molded from an early age and can be challenging for one teacher to change. However, student engagement is an immediate behavior that may be more easily manipulated by a teacher. Several researchers stress the importance of further investigation into student engagement (Brewster & Fager, 2000; Finn, 1993; Finn & Voelkl, 1993; Singh, Granville, & Dika, 2002).

Student engagement can be defined in a number of ways. According to Helme and Clarke (2001), "cognitive engagement involves the thinking that students do while engaged in academic learning tasks" (p.135). However, Newmann (1992) states, "we define student engagement in academic work as the students' psychological investment in an effort directed toward learning, understanding, or mastering the knowledge, skills, or crafts that academic work is intended to promote" (p. 12). Definitions by Marks (2000) and Finn (1993) include references to attention, interest, participation, and effort. For purposes of this study, the term "engagement" will hereafter refer specifically to a students' behavioral engagement as opposed to cognitive engagement. This definition will be used because it is thought that behavioral engagement can be influenced and enticed through the use of new curriculum or instructional strategies.

Engagement in the middle years is particularly important because researchers report that, as students get older, their engagement in schoolwork decreases, and by the time they are in middle school, lack of schoolwork engagement is an increasing problem (Anderman & Midgley, 1998; Brewster & Fager, 2000; Simmons & Blyth, as cited in Eccles, Lord, & Midgley, 1991). Consequently, what can middle-school mathematics educators do?

As suggested by Guthrie and Carlin (2004) and Abrahamson (1999), one approach for increasing engagement is through the use of a student response system (SRS). A SRS consists of wireless hand-held response pads, similar to television remotes, and a centralized receiver. The system allows a teacher to pose a multiple-choice-type question to his or her students and, in turn, the students can respond via the response pads. This information can then be displayed in the form of a bar graph for the entire class to view. Even though students can see that everyone responded, individual responses are kept anonymous.

Statement of the Problem

The objective of this study was to answer the question: According to student self-perception, how influential is a SRS on behavioral engagement in a middle-school mathematics class?

This study targeted the following specific components of behavioral engagement: attention, interest, participation, and effort in the classroom. Attention in the classroom included actions such as listening and tracking the teacher during lectures. Interest was demonstrated if the student liked mathematics. Participation included asking and answering questions, and discussing problems with peers. Finally, effort included taking notes during class, completing assigned tasks, completing tasks for extra practice (not assigned), and time on task.

Purpose

While research has already shown a SRS to be a positive instructional tool, (Abrahamson, 1999; Guthrie & Carlin, 2004), most studies investigating a SRS have focused on its use in higher education. Because of the correlation between engagement and achievement, in particular that engagement begins to drop in the middle years, studies of the effectiveness of using a SRS with this population are necessary.

Limitations

The small sample size and the limited course content (only algebra 1 students participated) limited the generalization of this study. In addition, even though a self-reporting questionnaire was deemed most useful for this study, varying factors can affect how a middle school student may respond on any given day.

CHAPTER II

REVIEW OF LITERATURE

Engagement and Achievement

"The most immediate and persisting issue for students and teachers is not low achievement, but student disengagement" (Newmann, 1992, p. 2). This statement may be misleading because, obviously, achievement is, and has been, of great concern. Educators and policy makers seem to focus constantly on poor academic achievement in the United States, especially in mathematics education. This is with good reason. The National Assessment of Educational Progress's (NAEP) (2007) report card tried to be positive and highlighted a three-point gain for eighth grade students since 2005, but the data showed more than two-thirds scoring in the basic range (Lee, Grigg, & Dion, 2007). Again, in 2009, the average score remained in the basic range (National Center for Education Statistics, 2009). Furthermore, in response to the 2006 California Standardized Testing and Reporting results, The Education Trust–West, a non-profit educational organization, states, "Today's data show that too few students overall are reaching proficient levels in math and literacy despite higher average achievement – and in too many cases, the number of students testing below the basic level has risen" (Education Trust–West, 2006). Newmann's (1992) statement about disengagement may be misleading, but what he is trying to point out is that achievement should not be expected from students unless they invest in their own learning. He further explains that students need to be "enticed" into academic engagement, and it is the job of the teacher to learn how to entice this engagement. If not engaged, students, in extreme cases, may withdraw from school completely and eventually drop out (Finn, 1989).

It seems natural that if students participated more, they may become more interested, and eventually exert more effort into learning. Finn and Cox (1992) found engagement behaviors contributed to achievement among fourth graders. A sample of 1,388 fourth-grade students was used in the study. The students' teachers were first given questionnaires regarding participation behaviors. A team of ten elementary teachers then were asked to classify the students as active, passive, or non-participants (Finn & Cox). Finn and Cox used achievement data from the Stanford Achievement Test and the Basic Skills First (BSF) tests, the latter a curriculum-referenced test developed by the state of Tennessee, for grades 1 through 3. The data consistently showed lower scores for passive participants and non-participants, which they found remained consistent even within different races. In addition, the data showed that differences between the mean scores grew significantly from first to second grade.

Singh, Granville, and Dika (2002) also found a relationship between engagement and achievement. Using a sample of 24,599 eighth-grade students from across the nation, the authors found that student engagement had an indirect effect on mathematics achievement. They found students' engagement affected math attitudes and the time that they spent on mathematics, and both subsequently affected achievement. On the other hand, other researchers suggest that educators do not have to differentiate between engagement and achievement. Kazemi and Stipek (2002) found that many of the mathematical reform strategies suggested to increase achievement also helped support motivation goals and engagement.

Suggested Instructional Strategies

Upon developing the California mathematics framework and mathematics content standards, the California State Board of Education contracted with the National Center to Improve the Tools of Educators in Oregon to investigate high-quality research about mathematics achievement (California, 2006). The results of the research showed that studies found “clear and positive gains in achievement” (p. 205), specifically in regard to the difference between what they define as “conventional” instruction and other types of instructional strategies. Conventional mathematics follows what is considered a two-phase model of instruction, whereas more effective instruction follows a three-phase model.

A two-phase model of instruction is simply that, two phases. During the first phase, the instructor presents a new concept while the students listen, and during the second phase, students are expected to work independently. However, a three-phase model provides additional time and support for students to gradually work independently. Similar to the two-phase model, the first phase again includes the instructor presenting a new concept. However, during this time, the instructor and student actively interact with each other, with the students asking questions and the instructor checking for understanding. The second phase includes students practicing the new concept, again similar to a two-phase model, but, in this case, they are provided feedback and correction from the instructor and/or peers. After this period of practice, students are finally individually assessed either formally or informally (California, 2006).

Not necessarily included in the findings from the National Center to Improve the Tools of Educators, additional research noted below expands on specific aspects of the three-phase model that should be highlighted during instruction.

The National Council of Teachers of Mathematics (1991) suggest instruction should include “posing questions . . . that elicit, engage, and challenge each student’s thinking” (p. 35). Effective use of questioning allows a number of events to occur; it “arouses curiosity, stimulates interest, and motivates students to seek new information” (Caram & Davis, 2005, p. 20). In addition, good questioning allows a teacher to clarify concepts and formatively assess students’ understanding. During her study on the types of instructional activities that engage students, Steele (1993) found “high levels of engagement are demonstrated when students answer questions and discuss issues. . .” (p. 19). Aside from questioning, general communication in the classroom is also beneficial: “Yakel et al. say that when children are given opportunities to talk about mathematical understandings, occasions for mathematics learning are natural” (as cited in Steele, 1993, p. 3). Fogarty (2002) explains that when students are working in a cooperative group, they usually need to restate their thoughts to others in a way that makes sense. For this to occur, the student must first deepen his or her own understanding to effectively relate these ideas. She goes on to remind us that those who are doing the talking are usually the ones doing the learning.

In addition to following the three-phase model of instruction and other suggested strategies above, effective instruction requires educators to first grab the attention of students and then subsequently keep it. As previously mentioned, Newmann (1992) says teachers need to "entice" attention, and when considering how the brain works, information can only be learned and retained if it is first noticed. Once it is noticed, information can then begin the pathway from short-term memory to working memory and finally long-term memory (Fogarty, 2002). It is because of this memory process that attention becomes a key component of instruction. Moving beyond the initial notice or attention phase, effective instructional strategies become important by allowing students' brains to process and make connections so that the incoming information moves throughout the memory process rather than getting thrown out.

One final component of instruction and learning that we should not forget is the importance of a student's need to feel safe within the environment of the classroom. Roeser, Eccles, and Sameroff (2000) explain that teachers need to allow students " to be motivated to learn rather than motivated to protect themselves from situations they perceive as threatening to their self, meaningless, or somehow threatening to their social image" (p. 454). Engagement and communication among students will most likely not occur unless they know that they can comfortably discuss mathematics and take risks without fearing put-downs from classmates or embarrassment from inadequate solutions.

Student Response Systems

Incorporating suggested instructional practices, grabbing students' attention, and ensuring a safe environment could be a daunting task. However, there exists a technological tool that may foster all three. SRSs, also sometimes known as a classroom performance system (CPS), have been around since the 1960s. Judson and Sawada (2002) explain that while the systems' architecture has changed over the years, many aspects have remained the same. The system allows students to immediately respond to a multiple-choice question posed by an instructor. The information is then gathered and displayed in a variety of formats ranging from paper tape, in the 1960s, to being displayed as a computer projected bar graph in the present.

In the 1980s, a team of three developed an updated version of a SRS and called it "Classtalk," a classroom communication system (CCS). George Webb (as cited in Abrahamson, 1999), the professor to pilot the system, used Classtalk in his introduction to physics course by incorporating questioning into his lecture. During his lecture, he would occasionally stop and ask students to have a short discussion in small groups and then together respond via a handheld keypad. He was excited about the positive responses using the system. Webb found his students enjoyed classes more, attended class more regularly, paid more attention, and even felt they understood the material better (Abrahamson, 1999). Approximately 10 years later a team of professors, including the original inventors, developed an updated version of Classtalk. This team was intrigued by the new discipline of cognitive science and wanted to incorporate active learning in their courses so that students could construct their own knowledge. In 1993, Eric Mazur (as cited in Abrahamson, 1999), a physics professor at Harvard, used the system. Comparing his traditional lecture courses to those that used the system in conjunction with interactive engagement techniques (having students discuss questions in small groups prior to answering), Mazur found that students in the courses he taught using the system actually scored higher and made greater gains on a diagnostic test used in his courses (Abrahamson, 1999).

While the results of this study were positive, Mazur, along with other members of the Classtalk research team, believed "CCS is simply a tool to facilitate and catalyse interactive engagement" (Abrahamson). They realized that it was not the system itself that increased the students' knowledge, but rather the difference in pedagogy. Subsequent research supported this claim (Abrahamson).

Additional research also found positive outcomes when using the SRS. A study by Cue (1998) found students attended classes more regularly and claimed to do more thinking in classes that used a SRS. Guthrie and Carlin (2004) found heightened levels of participation and student perceptions of increased learning. In addition, they found that, of the 129 students in the sample, "42% of the students felt that anonymity of their responses encouraged their participation" (p. 5). Furthermore, students with language difficulties particularly liked the response system because it allowed them to easily check their own understanding without having to be singled out. While Guthrie and Carlin's sample was small, these findings have been supported by previous research (Abrahamson).

Response systems began appearing in K-12 classrooms as well; however, research at that level is very limited. One study surveyed why teachers were using the systems, and in which subjects they were being used (Penuel, Crawford, DeBarger, Boscardin, Masyn, & Urdan, 2005). Penuel et al. found there were two main goals for using the system: first, to improve learning and instruction, and, second, to improve assessment and feedback. Out of 585 teachers, 209 were elementary, 175 middle school, and 201 high school teachers. The survey also found the system was used across subjects in elementary schools, primarily in mathematics for middle schools, and primarily in science courses in high school. Penuel et al. point out that while research on the use of SRS at the college level tends to focus on science, research at the K-12 level should focus on mathematics and language arts because of the widespread use.

Research has shown there is no clear single answer for how to increase engagement or achievement; however, there are numerous suggested instructional practices that may support both. In an attempt to effectively incorporate these practices, teachers may benefit from the use of a SRS to help facilitate instruction that is engaging and encourages achievement.

CHAPTER III

METHODOLOGY

Sample

The sample for the first phase of the study initially consisted of 77 seventh and eighth grade students in Mountain View, California. The students selected for the study were limited to those being enrolled in one of three of the researcher's algebra 1 classes during the 2007-2008 school year. The demographics of the students included approximately 43% White, 28% Latino, 23% Asian/Pacific Islander, and the remaining 6% African-American. Of the 77 students originally surveyed, 65 actually agreed to have their data included in the study.

From the 65 students, 12 were asked to participate in a one-on-one interview. These students were selected because they showed an overall positive or negative change of 15 points or more from the pre- to post-questionnaire (the point system is discussed in more detail later). Of the initial 12, 11 students agreed to participate. The final student to participate in an interview was selected based on responses from the open-ended questionnaire. Eight students showed an increase of scores, while four decreased. Eight students were female and four were male, with seven students in the eighth grade and five in the seventh grade.

Treatment

Data collection for the study occurred in two phases. The first phase included the collection of quantitative data through the use of a self-reporting questionnaire (Appendix A), while the second phase involved the collection of qualitative data with open-ended questions and a one-on-one interview (see Appendix B for open-ended questions and the complete interview protocol).

Previous research has shown questionnaires (Fredricks, Blumenfield, & Paris, 2004; Marks, 2000; Singh, Granville, & Dika, 2002), observation (Helme & Clark, 2001; McIntyre, Copenhaver, Byrd, & Norris, 1983), or a combination of questionnaires and observations (Finn, 1993; Finn & Voelkl, 1993; Fredricks et al., 2004; Steele, 1993; Voelkl, 1997) have been used to measure students' behavioral engagement. Questionnaires have been administered directly to the students or to the student's teacher, while an outside observer usually collects observational data. For purposes of this study, the use of an outside observer was not economically feasible so the use of a questionnaire was deemed a more accessible tool. The teacher did not complete a questionnaire regarding student behaviors in this study since the teacher and researcher were the same. Therefore, a student self-report questionnaire was used. Upon a review of current literature about student engagement behaviors, no previous questionnaire was found to suit this particular study. Instead, the researcher developed and used a questionnaire consisting of 15 questions focusing on the specific targeted engagement behaviors. As mentioned before, the targeted behaviors included those relating to attention, interest, participation, and effort in a mathematics classroom. The questions asked students to rate the frequency of their behaviors on a scale from 1 to 4 (1= never and 4= always). To provide content validity, a review of literature about engagement revealed agreed examples of engaged behaviors.

Helme and Clarke (2001) studied levels of cognitive engagement during different classroom situations: students working together in pairs, in groups, and in whole class situations. During their investigation, they referred to concentration (resisting distraction), exchanging ideas, and asking and answering questions, as some of the indicators of engagement. Marks (2000) included questions regarding students' attention and assignment completion in her questionnaire on engagement patterns across grade levels. Finn (1989) identified attending to the teacher, interest, responding to questions, and completing assignments (assigned or not) as some of the behaviors associated with participation. Finally, McIntyre, Copenhaver, Byrd, and Norris (1983) examined student engaged and non-engaged behaviors in relation to the types of activities occurring in a mathematics classroom. They identified engaged behaviors to include "1) attending (pays attention or listens to instruction); 2) writing; 3) reading; 4) raises hand; 5) answers questions; 6) asks questions; 7) talks to peer (regarding subject matter)" (p. 56). Included in the list of non-engaged behaviors were talking to others about topics not related to the subject matter and not paying attention to instruction (McIntyre et al., 1983). The questionnaire created for the current study included questions identifying the frequency of behaviors very similar to those identified above.

The questions in the survey were also phrased in a manner that would attempt to address the validity issue of positive versus negative phrasing as it pertains to adolescents. Benson and Hocevar (1985) suggest that when developing question items for children, a few negatively phrased questions may help avoid response bias, but warn that using negatively phrased questions could affect the validity. They claim that it may be difficult for the participants to disagree with a negatively phrased question in order to actually show their agreement. The questionnaire instrument that the researcher created for this study included only two items considered negatively phrased or unfavorable (questions 3 and 4), and only one used the term “not.”

Question items were also grouped and explicitly labeled into the categories attention/interest (these items were combined because of how closely related they are), participation, and effort. Bradlow and Fitzsimons (2001) studied the effects of labeling, clustering, and grouping question items on surveys. They found that items presented in this manner showed higher levels of reliability. They claim that clustering, grouping, or labeling items more clearly directs the participant to what is being asked.

In order to allow time for students to experience instruction without the SRS, the questionnaire was completed approximately five weeks after the start of the school year. The questionnaires were collected during the same class period in which they were given. Student questionnaires were identified by student ID numbers for later use.

Following the initial time without the SRS, classes used the system at least two out of the five times their mathematics class met in a week. The system was used both during class lectures, to include the students in instruction, and after lectures, in order to check for understanding. During the course of a typical 90-minute block, lectures lasted approximately 20-30 minutes with student responses interspersed, collaborative work that included checking for understanding lasted approximately 30-40 minutes, and the remaining time was spent on review exercises, independent work, and classroom logistics.

When used in conjunction with lectures, the researcher would incorporate multiple-choice questions for students to respond to during the same time in which they were also taking notes on a new concept. The notes were displayed on an overhead projector, while the questions were displayed with the use of a LCD projector (see Appendix C for sample notes and accompanying questions). Students were encouraged to speak with classmates at their own table before responding. This method aimed at following the three-phase model of instruction and is similar to the ways in which George Webb and Eric Mazur conducted their lectures while using Classtalk (Abrahamson, 1999). Depending on the complexity of the question, students were given varying amounts of time to respond. Because questions presented during a lecture were new to students, the teacher would usually wait until all students had responded before "ending" a question session and discussing the solution. During these sessions, students usually spent no more than five minutes on any one question. The number of questions the students responded to during lectures varied from five to ten questions. Seating charts were created at the beginning of each month by randomly placing student name cards into a small pocket chart. There were eight tables with four to five students at each table.

When used after lectures, the system was used as a means of providing practice and checking for understanding. Again students responded to five to ten questions related to recent topics covered in class and were encouraged to confer with classmates. There was usually a set time limit for responding to review questions rather than waiting for all to respond. The time was varied, depending on the difficulty of the question. Once students responded, they were occasionally asked to defend a solution orally or through writing before the researcher indicated the correct response. If written, student volunteers would complete a solution on the overhead projector for the entire class to view. After the system had been used for approximately 15 weeks of instruction, students who completed the original questionnaire completed the same questionnaire.

The pre- and post-questionnaire did not specifically ask students to relate their behavioral engagement in relation to the use of the response system. In order to provide students with a more explicit opportunity to express this relationship, three additional open-ended questions were provided to students so that the researcher could gain more information for the interview selection process, as a well as additional data related to the remote systems influence.

Students that had an overall positive or negative change of 15 points or more were selected for one-on-one interviews. The interviews took place at the researcher's school site and they were tape recorded and transcribed by the researcher. The researcher also took notes during the interview. Students attended interviews during their regular mathematics class time. Initially, they were asked to explain why they believed there was a change in the frequency of the engaged behaviors according to their responses on the questionnaire. Subsequent questions were used to identify more clearly what specific experiences could be associated with the change. Students were also asked to elaborate on their responses to the open-ended questions specifically related to the system.

Data Analysis

As previously mentioned, the questionnaire was grouped into three categories, attention/interest, participation, and effort. Each category contained five questions. All student responses were recorded in an Excel spreadsheet. Individual question, categorical, and total responses were tabulated. A raw score for the first category, attention/interest, was calculated by adding the scores of three positively phrased questions and subtracting the scores of two negatively phrased questions. Raw scores for the last two categories were calculated by adding the scores for each positively phrased response; there were no negatively phrased questions in either of these sections.

In order to properly compare scores between categories, a normalized score[1] was created in which the highest score for each section was 100, with the lowest possible score being 0. Each student was also assigned a total score, an average of the three categories. The same formula was applied to the data collected during the post-SRS questionnaire, and a difference for each question, category, and total was calculated. To investigate the statistical significance of any apparent change, a paired difference *t* test of individual questions, categories, and the data as a whole was also performed.

Twelve students who had the greatest change, positive or negative by 15 or more points, from pre- to post-questionnaire, were asked to participate in a one-on-one interview. The responses to the open-ended questionnaires for these students were also considered to provide useful information as to the remote systems influence.

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[1] Since two of the five attention questions were negatively phrased, those scores were subtracted from the section total rather than added. This caused the attention section to initially have a highest possible total different from participation and effort. In order to create a more comparable scale between sections, five points were added to the total raw score for questions 1-5, the sum was then divided by 15, and finally multiplied by 100. For the last two sections (questions 6-10 and questions 11-15), five points were subtracted from each of the raw scores; the differences were then divided by 15, and finally multiplied by 100.

Upon completion of the interview, an analysis of interview notes, as well as the tape recording, occurred to identify what influence, if any, the SRS specifically had upon students' behavioral engagement.

CHAPTER IV

RESULTS

In order to determine the influence a SRS had on the behavioral engagement of middle school students, 65 Algebra I students completed both a pre-response and post-response system questionnaire. Of those 65 students, 12 were selected to participate in a one-on-one interview.

Pre- and Post-system Questionnaire

Pre-response system questionnaires showed an average total score of 60.0 out of a possible 100, with student scores ranging from 22.2 to 91.1. The category attention/ interest indicated the highest levels of engaged behavior (68.0), with effort (57.0) second and participation (55.1) last. Question 11 ("I try my hardest on assignments") indicated the most frequency for specific behaviors, with questions 4 ("I talk to other students about topics not related to math during instruction") and 15 ("I seek help for math during non-class time") showing the least frequency.

Post-response system questionnaires showed an average total score of 60.1, a gain of only .1 from the pre-questionnaire, with individual student scores ranging from 37.7 to 82.2. Even though scores for attention/interest dropped by 2.3, it still remained the highest frequency category, while participation showed the greatest gain in frequency (2.1). Question 11 ("I try my hardest on assignments") remained the highest frequency behavior, while question 14 (“I do extra practice problems on my own”) became the least frequent behavior. Although not the highest frequency, question 9 (“I check my solutions with other students in class”) showed the greatest increase in frequency (+.3).

A paired *t* test was performed for individual questions, categories, and overall total scores (Tables 1-2). The only test to show a statistical significance was question 9 (p>.02). All other tests indicated no statistical significance at the 0.05 level.

Students selected for interviews showed an increase or decrease of 15 points or more, with the exception of student 9. One of the original students selected for an interview decided not to participate further, so student 9 was included, based on the open-ended responses. Table 3 shows the students overall pre- and post-scores. While the interviewed students overall scores showed greater gains/losses than the group as a whole, their category scores were quite similar to the entire group (Table 4).

During the interviews, students expressed numerous reasons why their behaviors may have changed over the course of the year (see Appendix D for general responses). However, three main themes emerged.

In response to questions from the attention/interest and participation categories, students frequently commented on the familiarity and/or comfort level with the teacher and other students in the class. Student 7 commented that she would ask the teacher more questions (question 6) because,

> . . . at the beginning of the year I was kind of nervous to say stuff in front of the rest of the class. Because I mean some of them I didn’t know at all, and then I got used to being around them and stuff and I could ask questions easier.

Table 1

Raw Scores of Individual Questions

	Mean					
Question	Pre	Post	Difference	*SD*	*t* value	*p value*
1	3.12307692	3.10769231	-0.01538461	0.69579783	0.178262544	
2	3.26153846	3.21538462	-0.04615384	0.71656231	0.519285764	
3	2.10769231	2.2	0.09230769	0.55122242	1.350105442	0.2
4	1.98461538	2.16923077	0.18461539	0.80801276	1.842070982	0.1
5	2.89230769	2.90769231	0.01538462	0.87486263	0.141776283	
6	2.70769231	2.69230769	0.-01538462	0.76018722	0.163163453	
7	2.12307692	2.2	0.07692308	0.71387351	0.868744517	0.4
8	3.15384615	3.16923077	0.01538462	0.83838214	0.147945389	
9	2.75384615	3.04615385	0.2923077	0.93077718	2.531927157	0.02
10	2.6	2.47692308	-0.12307692	0.83866882	1.183158153	0.4
11	3.55384615	3.53846154	-0.01538461	0.76018722	0.163163347	
12	3.35384615	3.4	0.04615385	1.00670827	0.369624693	
13	2.49230769	2.43076923	-0.06153846	1.08795857	0.456027407	
14	2.16923077	2.06153846	-0.10769231	0.88605652	0.979895911	0.4
15	1.98461538	2.2	0.21538462	0.99203559	1.750427443	0.1

Note: N=65

Student 1 explained, “Before I didn’t used to check my answers with other students because I didn’t really know them but like now I started meeting other people and working at different tables.” However, there were some students who explained that by knowing more people, they were more distracted (question 3) or talked more about topics not related to math (question 4).

Questions from all three categories elicited responses about the increasing difficulty of the course. Student 8 explained that he found math class less interesting (question 5) because, “it got a little bit harder and I started liking science a little bit better.

Table 2

Normalized Scores of Categories

	Mean					
Question	Pre	Post	Difference	*SD*	*t* value	*p value*
1-5	68	65.7435897	-2.2564103	13.5029278	1.347245701	0.2
6-10	55.0769231	57.1282051	2.051282	15.4974495	1.067141028	0.4
11-15	57.025641	57.5384615	0.5128205	15.9994658	0.258414318	
Total						
1-15	60.034188	60.1367521	0.1025641	11.2999971	0.073176852	

Note: N=65

Yeah, it's just that it did get a little bit harder." Student 7 began checking solutions with other students (question 9) because,

> I thought I would never need to check my answers with someone else because I thought I knew this as well and I possibly can and I don't think anyone else did better than I do. At least that's how I felt at the beginning of the year, and then I started getting confused. . . .

Table 3

Interviewed Students' Normalized Total Pre- and Post-Scores and Differences

	Student											
	1	2	3	4	5	6	7	8	9[a]	10	11	12
Pre	57.7	22.2	55.5	77.7	82.2	42.2	48.8	64.4	55.5	44.4	55.5	82.2
Post	75.5	42.2	77.7	42.2	60.0	62.2	71.1	48.8	62.2	60.0	71.1	62.2
Diff	17.8	20.0	22.2	-35.5	-22.2	20.0	22.3	-15.6	6.7	15.6	15.6	-20.0

[a] Selected based on responses to open-ended questions.

Finally, grades were mentioned in response to questions from all three categories as well. Student 6 paid more attention (question 3) in order to get better

Table 4

Interviewed Students' Normalized Scores for Category and Total Averages

Mean	Pre	*SD* (Pre)	Post	*SD* (Post)
Q1-5	63.2916667	19.155415	62.75	8.74523247
Q6-10	53.3	22.9245799	64.9666667	19.3061617
Q11-15	53.8583333	19.795521	56.0833333	20.2078668
Q1-15[a]	57.3583333	17.620002	61.2666667	11.8871461

[a] See Appendix D for a detailed look at scores for individual questions.

grades. Student 3 also paid more attention to get better grades. Student 3 further explains that he sought help outside the classroom: ." . . I was talking to my parents and they got me a tutor. So I decided to, when my grades started to go down, I decided to make an effort to bring it back up."

In no instance did any student mention the response system as a factor contributing to a behavioral change.

Open-ended Questions

Even though students did not discuss the remotes in relation to the pre- and post-system questionnaire, when asked specifically about the system most had very positive comments. Of the original 65 students to participate in the study, 54 completed and returned responses to the three open-ended questions. Eighty percent believed that the system made a difference to them as a learner, 76% felt more involved in the class because of the system, and 61% were more willing to participate. Even students who showed a decrease in pre- and post-system scores from the questionnaire, expressed positive feelings towards the system in response to the open-ended questions. Of the 12 students interviewed, only two indicated that the remote system was not beneficial. Student 5 mentioned that while she liked using the remote, they did not help her learn better. She felt that she could do problems from a textbook just as easily as from the remotes. Student 4 did not provide reasons why, but still indicated that the SRS did not affect her in any way.

CHAPTER V

DISCUSSION

Effect of the SRS

The purpose of this study was to determine how influential a SRS was on behavioral engagement in middle-school mathematics students. A review of the questionnaire data revealed the SRS did not have an effect on student behavioral engagement. Rather than sharing about how influential the system was, students instead discussed comfort and familiarity, course difficulty, and grades as factors contributing to the frequency of the engagement behaviors listed on the questionnaire. While not at a statistically significant level, overall participation had a minimal increase, specifically in relation to checking solutions with other students. However, responses to the open-ended survey specifically in reference to the SRS described positive attitudes towards the SRS and the comments made all point to a positive learning experience. In order to gain a better understanding of what effect the SRS did have, an in-depth review of all open-ended questionnaires (n=54), not just of interviewed students, was performed (Appendix E).

The results of that analysis showed the SRS, in conjunction with the suggested instructional practices, appeared to have affected the students in four main areas: the SRS provided the students with more opportunities for doing math, participation, collaboration between peers, and immediate feedback.

Students as Learners

Doing Math

The most frequently mentioned reason for how the SRS made a difference to students as learners was that it provided more opportunities for practice. Instead of the teacher talking at students and doing math by showing example after example, the SRS helped draw students into the discussion by asking them to also do the work. On any given day when the SRS was used, every student was asked to complete up to ten or more problems before leaving. This is important to note because, according to Thalheimer (as cited in Guthrie & Carlin, 2004): ." . . unless a student cognitively processes a question and participates in answering it (even if mentally), that learning does not take place" (p. 2). Marzano (2001) also explains, "It's not until students have practiced upwards of about 24 times that they reach 80-percent competency" (p. 67). When using the remotes, students are getting a fair amount of practice and, since it is during class, they can ask the teacher questions rather than leaving the practice for homework. Student 8 felt more involved in this class because of the practice. He explains, "In other classes only once in a while they would ask you to do something and say responses and here you could go up to the overhead and help the teacher do the problems and things like that."

Many students also mentioned the fact that the system obliged everyone to answer. Below is an excerpt of an interview conducted with student 6, who was responding why he felt more involved in the class (S=student; T=teacher).

S: You have to answer every question. You answer every question instead of like one person just answering the question. You don't raise your hand or anything so everyone has to answer.
T: Do you think you answer more questions in my class than in other classes?
S: Yeah, probably.

T: Is it because you have to or because you just feel like answering more?
S: Uh, like you mean because of the remotes? Mostly because in other classes when they are asking questions you don't (pause) you can't talk or ask for help from your friends or like other people. The responses have to be quick. You don't get that much time to think about anything.
T: So the remotes give you a little more time to think about it?
S: Yeah.

Not only did this student feel more involved because he had to answer the question, but by waiting for each response to be entered, there was additional think time built in that allowed this student to feel he could answer the question.

A drawback of using multiple-choice questions could be that even though everyone was required to answer, theoretically, a student could simply enter any choice without first working through a problem. This would obviously negate the benefits of doing the work and participating. However, most students commented that they did do the work before responding. The teacher observed this as well. Student 5 explained, "Everyone had to answer and you were part of the outcome where in other classes you could just sit back and let other people answer for you." The outcome that this student is referencing is the class average that gets displayed when the teachers ends the question session. Other students also commented on the group score. Student 14 responded, "You have to put an answer then you look at the class average and it's a class average not just one or two." Student 20 stated, "Everybody punches in an answer and everyone's answer effects the class average." Student 15 further explained, "I think I felt more involved because with remotes you want to have a good class score, so it's important that you get your answers right." One student even mentioned that he wanted to do well because he felt he had to beat other classes. The remotes propelled answering questions into a competition. This seemed to help motivate students to not only participate but to want to do well.

Participation

With so many chances to do math, many students commented that the SRS increased their willingness to actually participate and answer questions. Because individual choices are kept anonymous, the system helped provide the safety and comfort students needed to be able to participate. Student 5 explained, “I used to never answer because I was afraid of getting it wrong, but with the remotes no one knows who you are. . . .” The SRS also made a difference to student 7: “It’s not as nerve racking as answering a question in front of the class cause if I get it wrong the only two people that know are me and Mrs. Ruiz.” The system not only takes the pressure off the students but also releases teachers from feeling like they are calling on the same students repeatedly or embarrassing a child that rarely responds by finally calling on them.

Collaboration

Often before students were asked to respond to a question (and at times after the correct response was revealed), they were given time to speak with others at their table: “It made a difference to me as a learner because it allowed me to do my work and after doing my work [consult] someone else and compare and share our answers, which has taught me new things and has made me understand things I did not get before” (Student 9). She further explained, “. . . in other classes all we get are notes to copy down and we never really have a chance to compare things and work together when we don’t get something.” Student 24 shared,

> I would help other students [by sharing] how I got my answer and why I chose it. Also they would explain how I got a problem wrong or what I was doing that wasn't right. I could also actually ask many questions since I normally don't when we are [taught] a new unit in front of the class.

There are two important details imbedded in this student's response. First, she brings up the point that helping was not one-sided. Each student shared his or her strengths and would help when they could. As previously cited, Fogarty (2002) noted that being able to explain your process to others is a great way to check your own understanding when trying to learn. The remotes provided many opportunities for working and learning in small groups. Second, by working in a small group, she actually asked questions. Without the opportunity to work in small groups, this student may have had many questions unanswered that could have prevented her from learning.

Checking solutions with other students was, in fact, the only question from the original survey that showed any type of statistical significance. While not a directly required component of the SRS, the data and student responses show that combining the SRS with collaboration may be better than using the system alone.

Immediate Feedback

The final aspect of the SRS that students mentioned was the immediate feedback it provided. Research has also suggested that using classroom-networking devices, such as a wireless remote system, can improve student learning because of the teacher's ability to provide immediate feedback (Abrahamson, 2004). He cites Guskey's (2003) article about effective assessments. Guskey explains that assessment can help improve student learning in three ways.

1) "*Make assessment useful"*(p. 7). Don't try to trick students by including information not previously discussed, just assess what has been taught. When used during lectures, the SRS assessed directly what had been taught just moments before. Student 23 explained, "It [SRS] was a way to check that I thoroughly understood the concept while in class. I didn't have to wait until homework to test my knowledge on different examples."

2) "*Follow assessment with corrective instruction"* (p. 9). Both teacher and students play the role of instructor when going over solutions after students have used the SRS. "I get to see the right problem almost immediately after if I get it wrong, and most of the time it gets explained so I know how to avoid the problem next time" (Student 19). "If you don't get it you could try to see what you did wrong as to getting a paper back and just looking at your score. Also you work with people at your table so you get help" (Student 11).

3) "*Give second chances to demonstrate success*" (p. 10). If the SRS is used regularly in the classroom, along with other forms of assessment as well, students are provided numerous opportunities to demonstrate learning and improvement.

Opposition

Student Indifference

Even with all the praise for the SRS, there were some students for whom the system did not make a difference in their learning. Student 21 seemed to have an opposite view compared to many of his peers, explaining he did not feel more involved: "You can push a button and nobody knows who pushed what. People don't know what you're doing. But in other classes we have to raise our hands and speak." One student (Student 5) indicated that while she liked the system and thought it was fun, she didn't feel the system made a big difference for her. She explained, "I can do them [problems] on the whiteboard, I can do them from the textbook, or overhead and it's all the same." Student 5 also explained that she already participated in most of her classes, so the SRS had no effect. Student 4, who had the greatest decrease in overall points, indicated that her drop-in scores might have been because she did not pay very close attention to the questions on the questionnaire. She also said that the SRS had no effect because she likes to be quiet and will only participate when no one else in the class knows the solution.

Lack of Supporting Quantitative Data

If the majority of the students did like the system and they felt that it enhanced their learning experience, why did it not show up in the quantitative data? The survey questions could be the reason. The intended use of the SRS was as a tool for enticing engaged behaviors, so questions were aligned to engaged behaviors. However, as previously noted, the students' opinion about the main purpose of the SRS was opportunities to do more math. It seems that it did not occur to the students to make an association between the SRS and what was being asked on the questionnaire because they had different ideas about the purpose of the SRS. The closest association made was in relation to participation, which may be why this was the only area to show any real growth.

In addition to the questions, another reason for the lack of supporting quantitative data could be that the results were not as reliable as they could have been. The first questionnaire was given early in the school year when students may have been more receptive to participating in the survey. However, the second questionnaire was not administered until after the two-week December break. During this time, students may not have provided their full attention. As mentioned earlier, Student 4 claimed to not have paid very close attention to the questions. It is not known how many other students may not have either, thus skewing the results.

Technology versus Pedagogy

While the SRS may not have *directly* affected engaged behaviors, the way in which it was used addressed many student needs and allowed a better environment for learning. As noted before, this was also the belief of the team that used Classtalk in the 1990s. Understanding the impact of technology vs. pedagogy on learning can been seen as the difference between *what* is being used as opposed to *how* it is being used. This has been the case with other technology used in the classroom.

Ellington (2003) explains that while in the 1970s calculator use in the classroom was controversial, the 1980s showed a shift in the overall attitude about using calculators in the classroom. In the early 1980s, many researchers didn’t feel there was a positive or negative effect, but by the late 1980s, Ellington claims that the attitudes changed. Because calculators were being more widely used, there was an influx of research at this time. Her own meta-analysis sought to “determine the effects of calculators on students’ acquisition of operational and problem-solving skills as well as student attitudes towards mathematics” (p. 455). The findings showed that calculators did help average students increase their operation skills, but noted that the most significant gains were when calculators were used not just as a tool for practice and checking work, but rather when their role was pedagogical. Ellington also points out that attitudes towards mathematics showed the most improvement in most studies.

Lei and Zhao (2005) investigated technology use and how it affected student GPAs at one school in Ohio. They claim that much of the literature about technology use in school had focused on the amount of use and that the lack of use could be detrimental. However, their findings suggest that time alone is not a good indicator of the usefulness of technology. They found that students who averaged the same amount of computer time per day over the course of a year had varying GPA increases and decreases. In order to gain a better understanding about the reasons for the changes, they analyzed the types of technologies used and the purposes for using them. The data showed that the quality of technology use had a greater impact on students' GPA than the actual amount of time spent using technology. While time spent is relevant because not enough time can be detrimental, and too much time can also adversely affect a student, they found that the quality of the technology was the bigger issue.

Both of these studies support that *how* technology is used usually has a greater impact on students than *what* is being used. Just as the wireless remote system may not produce change alone, any incorporation of new technology into the classroom needs specific instruction designed around the use.

Classroom Implications

Since many of the strengths of the SRS have been because of its use in conjunction with the suggested instructional practices, it may seem that the strategies have had a greater impact than that of the system itself. However, it is important to note that the system itself did help to keep the teacher accountable to actually using the strategies. Below are suggested uses of the system (Table 5).

Table 5

Effective and Ineffective Classroom Uses and Strategies

Effective	Ineffective
• Pre-load questions to have them clearly aligned with instruction. • Allow students to discuss questions with others prior to answering. • Provide extension questions to help alleviate off-task behavior for those who finish quicker. • Use the immediate response to help drive instruction (Use the reports available to work with struggling students before they leave class for the day) • Have students show their work prior to indicating what the correct response was. • Ask students to analyze why students may have responded incorrectly.	• Solely using the system for test taking. • Not allowing any discussion to occur with the use of the system • Using the system for just review purposes (this can be just as easily achieved in a textbook) • Using the system everyday (it may become just another routine for the students)

Implications for Further Research

The lack of measureable data has made the effects of the SRS vague. Future studies that included observational data, as well as possibly achievement data, could bring more validity to this and other studies regarding the use of a SRS. In addition, research focusing on comparing the effectiveness of the suggested strategies with and without the system could be very important. While it seems that the SRS helps to guide the strategies and makes them easier to implement, it would be interesting to discover if the investment in a SRS is really worthwhile.

Conclusion

Behavioral engagement was to be the first step in helping students experience greater achievement. I was optimistic that the SRS would be the enticement students needed to become more engaged and do better. While the data indicated that the SRS was not an enticement for the behaviors defined, using the SRS was a positive experience for almost all involved. The majority of the students liked the system and many felt it did help them learn more. Newmann (1992) states, “Lasting learning develops largely through the labor of the student, who must be enticed to participate in a continuous cycle of studying, producing, correcting mistakes, and starting all over again” (p. 3). The SRS may not have enticed the students in the way I thought it would, but it surely persuaded many to participate in a cycle of learning and that can be considered a middle school success.

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APPENDIX A

PRE/POST SYSTEM QUESTIONNAIRE

[This script was read aloud to students prior to administering the questionnaire.]

As many of you know I have been going to school at Chico State University during the summer. As part of my work at Chico I am conducting a research study investigating student engagement behaviors in math class. Engagement behaviors are related to your attention, interest, participation, and effort in math class. Today I am going to ask you to complete a short questionnaire about your engagement behaviors in this class since the beginning of the year (for the post-questionnaire students will be asked to consider their behaviors since the last time they took this questionnaire).

I would like for you to respond as honestly as possible. This questionnaire will not affect your grade in any way, positive or negative. I also want you to know that there are no other risks for you participating. However, you may benefit by becoming more aware of your behaviors in math class.

I am asking that you provide your student ID number because I will be asking some of you to participate in a follow-up audio-recorded interview with me if you and your parents agree to it. Any information that I do use will not have your real name though. I will make up a name so people don't know who you are.

The final thing I want to mention is that even if you signed the previous letter I sent home agreeing to allow me to use your results, you can still change your mind. At the bottom of today's questionnaire is a box that reads, "I do not want my results to be used in the study being conducted by Mrs. Ruiz." If you really don't want me to use your results please check this box. Also, if you don't check this box today and later find that you don't want your results used, you can always tell me then as well. Are there any questions?

Student ID Number ___________________

Please respond to the following questions as honestly as possible.
Your responses below will in no way affect your grade.

Using a scale of 1-4, rate your experiences in mathematics class since the beginning of the year (for post questionnaire since the last time you took this questionnaire).
1 = Never, 2 = Sometimes, 3 = Most of the time, 4 = Always.

Attention / Interest				
1. I watch what the teacher is doing during instruction.	1	2	3	4
2. I listen to what the teacher is saying during instruction.	1	2	3	4
3. I find that I get distracted during instruction.	1	2	3	4
4. I talk to other students about topics not related to math during instruction.	1	2	3	4
5. I think math class is interesting.	1	2	3	4
Participation				
6. I ask the teacher questions when I don’t understand a math problem or need clarification.	1	2	3	4
7. I ask the teacher questions to check my solutions or mathematical understanding.	1	2	3	4
8. I ask other students questions when I don’t understand a math problem or need clarification.	1	2	3	4
9. I check my solutions with other students in the class.	1	2	3	4
10. I respond to math questions that are asked of the whole class.	1	2	3	4
Effort				
11. I try my hardest on assignments.	1	2	3	4
12. I take notes on the math problems that we discuss in class.	1	2	3	4
13. I re-read and review my notes from math class.	1	2	3	4
14. I do extra practice problems on my own.	1	2	3	4
15. I seek help for math during non-class time.	1	2	3	4

o I do not want to have my results used in the study being conducted by Mrs. Ruiz

APPENDIX B

OPEN-ENDED QUESTIONS

Student ID:______________________

Please answer as honestly and completely as possible. These responses will in no way affect your grade positively or negatively.

1) We have been using the remote system since the beginning of the year. For many of you this was the first time you had ever used a system like this in math class. Did it make a difference for you as a learner? If so please explain how. If not, how might it have been used differently so that it could have helped?

2) By using the remote system did you feel that you were more involved in this class than in other classes? If so please explain. If not, explain why not?

3) Do you believe that the remote system made any difference in your willingness to participate in class? If it did, please explain for me how it did. If it didn't, please explain to me why you think that we used the remote system.

Interview Protocol

Script

I've asked you to do this interview with me to find out more about the responses you chose on the engagement questionnaire. The reason I've selected you for an interview is because the choices you selected the second time you answered the questionnaire were different than the choices you made the first time.

While we are talking I will be tape-recording our conversation. The only person other than myself that would possibly listen to this recording is my advisor, who is a teacher at Chico state. I will also be taking notes on some of the things you say. When I write about what you say I will not use your real name. I will use a made up name or number instead. I also want you to remember that just like on the questionnaire, I'd like for you to be completely honest. Nothing you say today will affect you grade at all.

I'm going to show you both of the questionnaires that you filled out. For each of the questions where the number changed I'd like for you to explain to me why you think it changed. You should include specific examples if you can. Do you have any questions? Ok let's start.

For each item on the questionnaire in which the response changed the interviewer began by allowing the student to explain why they believed the response changed. During this time the interviewer took notes and wrote key words used in reference to each question discussed. Subsequent probing questions, based on these notes, were asked to help the student elaborate on what specific experiences may have contributed to the change. The italicized questions listed below each questionnaire question were also asked at times to help students elaborate on responses.

Once the student completed the discussion regarding the questionnaire, they were asked to elaborate on their responses to the three open-ended questions.

Attention/Interest

1. I watch what the teacher is doing during instruction.
What would make you watch/not watch the teacher?

2. I listen to what the teacher is saying during instruction.
During what times would you be more/less likely to listen?

3. I find that I get distracted during instruction.
What are some examples of things that may distract you?
What could happen in the class that would make you want to be doing math?

4. I talk to other students about topics not related to math during instruction.
During what times in class were you talking to others? During instruction, work time, group projects?

5. I think math class is interesting.
Is math class more/less interesting because of specific topics we are covering?

Participation

6. I ask the teacher questions when I don't understand a math problem or need clarification.
Does it bother you if the teacher knows that you are confused?
In the past did you not feel comfortable responding?

7. I ask the teacher questions to check my solutions or mathematical understanding.
Do you just ask if the solution is correct or do you ask if your reasoning / procedure is correct?

8. I ask other students questions when I don't understand a math problem or need clarification.
Do you ask for the answer or do you ask for an explanation?

9. I check my solutions with other students in the class.
Do you check your solutions with anyone outside of class?

10. I respond to math questions that are asked of the whole class.
Do you feel more / less comfortable speaking in front of others now?
Do you feel more / less embarrassed now if you don't get a question correct?

Effort

11. I try my hardest on assignments.
What is included in trying your hardest?

12. I take notes on the math problems that we discuss in class.
Do you write exactly what the teacher writes or do you write your own notes?

13. I re-read my notes from math class.
Do you believe that re-reading your notes helps to clarify what was done in class?

14. I do extra practice problems, ones that were not assigned, on my own.
Do you believe that doing more than what is assigned will help you understand the math better?

15. I seek help for math during non-class time.
Are you embarrassed to ask for help in front of others?

Concluding Script

Thank you. Is it all right to ask you for another meeting if I have further questions?

Interview Notes (Questionnaire)

ID #: ______________________
Date: ______________________
Time: ______________________

Question Number	Original Response	New Response	Key Words	Further Explanation
1				
2				
3 . . .				

Interview Notes (Open-Ended)

ID #: ______________________
Date: ______________________
Time: ______________________

Question	Key Words	Further Explanation
1		
2		
3 . . .		

APPENDIX C

SAMPLE NOTES

Review: How do you find the slope of a line?

- From a graph or 2 points
    - What is the slope formula? (Start responses for question 1)

$$m = \frac{y_2 - y_1}{x_2 - x_1}$$

If only given 1 point and the slope of a line, this formula actually helps us find the equation of a line.

$m = \dfrac{y_2 - y_1}{x_2 - x_1}$ Multiply both sides by $(x_2 - x_1)$

$$(x_2 - x_1)m = \frac{y_2 - y_1}{x_2 - x_1}(x_2 - x_1)$$

$m(x_2 - x_1) = y_2 - y_1$ can also be written as $(y - y_1) = m\,(x - x_1)$

Given that we only know 1 set of coordinates we only substitute in values for x_1 and y_1.

Slope of the line

$$(y - y_1) = m\,(x - x_1)$$

Point on the line

Example: Write the equation of a line with a slope of 2 that passes through the point (9, 3).

Slope

$$(y - 3) = 2\,(x - 9)$$

Point on the line.

(Start responses for questions 2, 3, 4, 5, 6)
What if we are not given the slope, but just two points that are on the line? Can we still write an equation in point-slope form? (Start responses for question 7)

Yes, given that we know two points the line passes through we can still write the equation.

A line passes through the points (2, 5) and (-2, -3). Write the equation of the line in point-slope form. First find the slope:

(2, 5)	(-2, -3)	$m = \frac{-3-5}{-2-2}$	$m = 2$
x_1, y_1	x_2, y_2		

Then write the equation: $(y - 5) = 2(x - 2)$ OR $(y + 3) = 2(x + 2)$

(Start responses for questions 8 and 9)

Sample Questions

1) Which of the following formulas would allow you to determine the slope of a line from two points?

A. $m = y/x$
B. $m = \frac{y_2-y_1}{x_2-x_1}$

C. $m = \frac{x_2-x_1}{y_2-y_1}$

D. None of the above

2) Which of the following equations is written in point-slope form?

A. $(y-4) = 3(x+5)$
B. $y = 2x - 4$
C. $3x + 2y = 12$

3) In the following equation, what does the ½ represent? $(y-2) = ½(x-6)$

A. The x-intercept
B. The y-intercept
C. The slope

4) In the following equation what do the 4 and -3 represent? (y+4) – 5(x-3)

A. The slope and y-intercept
B. The x- and y- coordinate

5) Write in point-slope form the equation of a line that passes through the point (3,4) and has a slope of 3.

A. (y-3) = 3(x-4)
B. y = 3x + 4
C. (4-y) = 3(3-x)
D. (y-4) = 3(x-3)

6) Write in point-slope form the equation of a line that passes though the point (-1,3) and has slope -2.

A. (y-3) = -2(x + 1)
B. (y-3) = -2(x-1)
C. y = 2x -5

7) Can you write in point-slope form an equation of a line given two points?

A. Yes...How?
B. No…Why not?

8) Write in point-slope form the equation of a line that passes through the points (-5, 7) and (2, -7)

A. y = -2x – 3
B. (x+7) = -2(y-2)
C. (y-7) = -2(x+5)

9) Write in point-slope form the equation of a line that passes through the points (-2, 7) and (1, -2)

A. (y-2) = -3(x-1)
B. (y+2) = -1/3(x-1)
C. (y+2) = -3(x-1)

APPENDIX D

DETAILED PRE/POST SCORES FOR INTERVIEWED STUDENTS

AND GENERAL EXPLANATIONS FOR CHANGE

1=Never, 2=Sometimes, 3=Most of the time, 4=Always

Attention / Interest

1. I watch what the teacher is doing during instruction

	S1	S2	S3	S4	S5	S6	S7	S8	S9	S10	S11	S12
Pre	2	2	3	4	4	3	3	3	3	3	3	4
Post	3	4	4	2	3	3	3	3	3	3	3	3

* Watched more because the teacher became more specific in explanations.
* Would / wouldn’t watch the teacher depending on who was at table.

2. I listen to what the teacher is saying during instruction.

	S1	S2	S3	S4	S5	S6	S7	S8	S9	S10	S11	S12
Pre	3	4	3	3	3	3	3	4	3	3	3	3
Post	3	3	4	2	3	3	3	3	3	4	3	3

* Listened more because the course became more difficult.
* Would / wouldn’t talk depending on who was at table.

3. I find that I get distracted during instruction.

	S1	S2	S3	S4	S5	S6	S7	S8	S9	S10	S11	S12
Pre	2	4	4	1	1	3	2	1	2	3	2	1
Post	2	4	3	1	2	2	2	2	2	3	2	2

* I was distracted because other students would talk to me.
* As the year progressed ability to ignore other students increased.
* Was able to focus more because student wanted better grades.
* Distraction grew because class got harder.

4. I talk to other students about topics not related to math during instruction.

	S1	S2	S3	S4	S5	S6	S7	S8	S9	S10	S11	S12
Pre	2	4	3	1	1	3	2	1	2	2	2	1
Post	2	3	2	2	2	2	2	2	2	2	3	2

* Talked less to get better grades.

5. I think math class is interesting.

	S1	S2	S3	S4	S5	S6	S7	S8	S9	S10	S11	S12
Pre	2	2	4	3	3	1	3	4	3	2	2	3
Post	3	2	3	2	2	2	4	2	3	3	3	2

* Specific topics made class more / less interesting.

<u>Participation</u>

6. I ask the teacher questions when I don't understand a problem or need clarification.

	S1	S2	S3	S4	S5	S6	S7	S8	S9	S10	S11	S12
Pre	3	1	2	4	3	2	3	3	3	2	2	2
Post	4	1	4	4	4	3	4	2	3	3	3	2

* Asked more because grades became more important.
* Asked more later because questions were harder.
* Asked more questions later because student was more comfortable with teacher.

7. I ask the teacher questions to check my solutions or mathematical understanding.

	S1	S2	S3	S4	S5	S6	S7	S8	S9	S10	S11	S12
Pre	2	2	3	4	4	2	2	2	2	1	2	2
Post	4	2	3	4	3	2	3	1	2	2	2	1

* Asked for more help later because the math was harder.
* Wouldn’t ask in the beginning because of shyness.

8. I ask other students questions when I don't understand a problem or need clarification.

	S1	S2	S3	S4	S5	S6	S7	S8	S9	S10	S11	S12
Pre	4	3	4	4	4	2	2	3	3	2	4	4
Post	4	3	4	2	4	3	3	2	3	3	4	4

* Asked questions more later because familiarity of students increased.

9. I check my solutions with other students in class.

	S1	S2	S3	S4	S5	S6	S7	S8	S9	S10	S11	S12
Pre	2	1	2	4	3	2	1	1	2	2	2	4
Post	3	3	4	3	3	2	4	3	3	4	4	4

* Checked more later because in the beginning many solutions were incorrect.
* Checked more later just to make sure solutions were correct.

10. I respond to questions that are asked of the whole class.

	S1	S2	S3	S4	S5	S6	S7	S8	S9	S10	S11	S12
Pre	3	1	4	4	3	2	3	3	3	2	2	3
Post	4	2	4	2	2	2	3	2	3	3	3	2

Effort

11. I try my hardest on assignments.

	S1	S2	S3	S4	S5	S6	S7	S8	S9	S10	S11	S12
Pre	4	3	4	4	4	3	3	4	3	4	4	4
Post	4	4	4	2	4	4	4	2	4	4	4	4

* Tried hardest to get good grades.

12. I take notes on the math problems that we discuss in class.

	S1	S2	S3	S4	S5	S6	S7	S8	S9	S10	S11	S12
Pre	3	1	2	4	4	3	4	4	4	4	3	4
Post	4	3	3	1	3	4	4	3	3	4	4	4

* Student took more notes later in year to help with harder topics.

13. I re-read and review my notes from math class.

	S1	S2	S3	S4	S5	S6	S7	S8	S9	S10	S11	S12
Pre	2	1	3	2	3	2	1	2	2	1	2	4
Post	2	1	2	1	1	3	2	3	4	1	4	3

* Topics were easier in the beginning and could remember them without notes.
* Later in the year notes became more important for homework.

14. I do extra practice problems on my own.

	S1	S2	S3	S4	S5	S6	S7	S8	S9	S10	S11	S12
Pre	2	1	1	1	3	3	2	2	2	2	3	3
Post	3	1	1	1	2	2	2	3	2	1	3	3

* Wanted to do better in class later in the year and found that practice would help.

15. I seek help for math during non-class time.

	S1	S2	S3	S4	S5	S6	S7	S8	S9	S10	S11	S12
Pre	3	1	2	1	3	2	1	1	1	2	2	4
Post	2	2	4	1	2	4	2	2	2	2	2	2

* Looked for help later in year because grades were low.
* Realized later in the year that extra help would be good.

APPENDIX E

OPEN-ENDED RESPONSES FROM ALL STUDENTS

Did the remote system make a difference to you as a learner?

Response	Reason	Number of Students*
Yes (43)	Gives me more opportunities for practice	18 (D)
	It's fun	10
	I can see the correct answer immediately and this lets me learn from my mistakes.	10 (F)
	Allows me to work with other students and check my work with them	8 (C)
	Tells me how I am doing in class	6 (F)
	Reminds me to check my work	3
	No pressure	3 (P)
	I pay attention more	2 (P)
	It motivates students to actually get the correct solution	2
	Its not graded	2
	Multiple choice	2
	We can see if the class understood the topic	2
	I remember more	1
	Helped me understand the topics more	1
	I participate more	1
Sometimes (4)	People give away answers / cheat	4
No (7)	I can just ask someone for the answer	1
	The problems are the same as the ones in the book	1
	It's boring	1

Did the remotes make you feel more involved?

Response	Reason	Number of Students*
Yes (41)	Everyone has to answer.	16 (D)
	You got to speak with others at your table and compare solutions.	10 (C)
	We get to go over our mistakes and fix them.	1 (F)
	I didn’t have to raise my hand to feel like I was participating.	2 (P)
	If I didn’t pay attention I would miss the question and not know how to answer.	1 (P)
	Everyone affects the class score.	2
	I participate more.	2 (P)
	It was like a competition and that made you want to answer correctly.	2
No (13)	It’s just another assignment I have to do.	1
	I’m not more involved, it’s just less pressure.	2
	Pushing a button does not mean I’m involved.	1
	No difference to other classes.	1
	It depends on the lesson if I’m more involved or not.	1

*Did the remotes make a difference in your willingness to participate?***

Response	Reason	Number of Students*
Yes (33)	I didn't have to be embarrassed by my answer	4 (P)
	We could learn from our mistakes	3 (F)
	I was having more fun	2
	I want to work with others	1 (C)
	The remotes help me learn more	1
	I had to do more in class	1 (D)
	I didn't have to be called on	1
	I share my thoughts more now	1 (C)
No (18)	It's boring	1
	I already participate	3

Note: N=54
* The responses were classified as follows: (D) Doing Math, (P) Participation,
(C) Collaboration, (F) Immediate Feedback
** Three students had no response to this particular question, and many did not provide reasons for why it did or did not change their willingness to participate.

APPENDIX F

PARENT/STUDENT CONSENT LETTER

Dear Parent / Guardian, September 21, 2007

I am your students' current mathematics teacher. For the past two years I have been working on a master's degree in Mathematics Education at CSU Chico. As part of my work I will be conducting a research study this year. I will be asking your student to complete a questionnaire about the frequency of their engaged behaviors, such as attention, interest, participation, and effort, in mathematics class. I will be asking all students to complete this questionnaire two times this year, first in late September and then again in January. Based on the results of the questionnaires, some students may also be asked to participate in an audio-recorded one-on-one interview with me at school in February. The interview will take place during your students' regular math class.

I would like to make clear that this is not a study of your specific student, but rather an investigation into middle school students in general. There are no risks to your student for participating. However, possible benefits could include your student becoming more self-aware of their behaviors in math class. I would also like to mention that your student's grade will not be affected in any way due to participation or non-participation.

If your student is chosen for an interview you will be notified at least one week prior to the interview. Because I need to be able to identify responses associated with particular students I will be asking students to write their student ID number on both questionnaires. However, any data reported will be done so using a pseudonym. All data, including questionnaires, tape recordings, and interview notes, will be kept securely locked at school or at my residence. This data will only be reviewed by myself and my graduate advisor at CSU Chico.

The information I gain from this study will be used in the master's thesis I present to a board of CSU Chico faculty. In addition, I may present these results to a research audience either in writing or at a conference. Your consent is required so that I may use responses from your student's questionnaires and possible interview as part of my research data. Participation is voluntary and there is no penalty to your student if you chose for your student not to participate in my study. You may also withdrawal your student form the study at any time without penalty.

Thank you for your help and your student's part in my research study. If you have any questions about this process, please contact me at 650-903-6945 ext. 2353 or email me at cruiz@mvwsd.org. I will be happy to address any concerns you or your student may have.

Sincerely,
Callie Ruiz
Mathematics Teacher, Crittenden Middle

Parent Permission

I, ______________________________, give my permission for: (Please check one or both)
Parent / Guardian (please print)

❒ My student's results to be included in the research project described.

❒ My student to participate in a one-on-one interview with Mrs. Ruiz if chosen. I understand that if my student is chosen for an interview I will be notified at least one week prior to the interview and his/her identify will be protected in the study.

_________________________ _________________________ __________
Student's Name Parent / Guardian's Signature Date

Student Permission

I, ______________________________, give my permission for: (please check one or both)

Student (please print)

❒ My results to be included in the research project described.

❒ Me to participate in a one-on-one interview with Mrs. Ruiz if chosen. I understand that if I am chosen for an interview I will be notified at least one week prior to the interview and my identify will be protected in the study.

Please return this sheet to Mrs. Ruiz and keep the first page for your records.

Additional Parent Letter (Prior to Interview)

April 21, 2008

Dear Parent / Guardian,

In the fall you signed a consent form allowing your student to be a part of my research study this year. I wanted to inform you that your student has been selected for a one-on-one interview with me. The interview will occur during your students' regular math class on Thursday May 8, 2008. If you have any questions regarding this interview or would like to withdrawal your consent please contact me at 650-903-6945 ext. 2353 or cruiz@mvwsd.org.

Sincerely,

Callie Ruiz
Mathematics Teacher, Crittenden Middle