Using Student Response Systems to Increase Student Participation

And Engagement in High School Mathematics Classes

By

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Abstract

This action research project examined the use of student response systems (SRS) in the high school mathematics classroom. Three different SRS were used during the course of this study – eInstruction clickers, and two online tools – Pear Deck and Poll Everywhere. A student survey was used to gather both quantitative and qualitative data in an attempt to determine the effect of using SRS on student participation and engagement. The SRS were used in a variety of ways and the survey data were used to determine which of the uses were the most helpful to the students in learning and understanding mathematics. The survey data were also used to compare the three SRS and learn from the students what they felt were the advantages and disadvantages of each.

The results of this study showed that the students liked the idea of being able to submit answers anonymously. The students enjoyed using SRS during mathematics lessons and felt that they were more actively engaged in those lessons. Many of the students felt that they learned more during the lessons when SRS were used. The information compiled from the student surveys can be used to help with future lesson planning decisions regarding which types of activities might be most helpful and which kinds of activities needed improvement. The students in this study preferred using Pear Deck, but were split evenly between Pear Deck and the eInstruction clickers for the SRS that kept them most actively engaged.

Table of Contents

Introduction

In the summer of 2009, I was taking a graduate mathematics course at UW-River Falls and when I went to get the textbook for the course, I saw that we were also asked to get a "clicker". My first thought was, "Why would we be using these clickers in a graduate mathematics course?" I remember thinking that the device seemed like kind of a novelty or gimmick that might possibly be useful in an introductory course, but I couldn't imagine how we would be using them in this advanced course.

A couple days into the course, the instructor began to give us a few "clicker questions" each day. The way in which he used these clicker questions to generate discussion – sometimes in pairs or small groups and sometimes whole group discussion – left a big impression on me that the clickers were more than just a novelty or gimmick. For a particular question, we would be asked to submit an answer individually, and then the instructor would display the bar graph showing the distribution of the answers submitted (but not indicating the correct answer). We were then asked to consult with a partner and resubmit an answer. The distribution of the resubmitted answers was then displayed and this was often followed by some great whole class discussion. This seemed like a great way to get all of the students actively engaged in the work of the class.

I also remember that about half-way through the course there was a malfunction of the equipment and we weren't able to use the clickers for the remaining two weeks. I remember a feeling of disappointment among the students in the class, as we had enjoyed the clicker experience thus far and were looking forward to using them more in the remaining days of the course.

Initially, I was very excited about the idea of using clickers in my classroom, but then I did some checking on the cost and it did not appear that it would fit into the budget anytime soon. In recent years, however, the school at which I teach (Turtle Lake High School in Turtle Lake, WI) made some technology purchases, and I was able to get a set of eInstruction clickers to use in my classroom. We are also two years into our one-to-one laptop program in the high school. I have recently attended teacher training workshops in which I had the opportunity to experience the use of two other student response systems – Pear Deck and Poll Everywhere. When using Pear Deck, students can respond to questions from their laptops. When using Poll Everywhere, students can respond by sending a text message from their cell phone.

I was intrigued by each of these student response systems and wanted to start using them in my classroom. Since we are in the early stages of using some of these new technology tools, I am hoping to become one of the leaders on our staff in learning how to use these tools effectively and then to help others to get started using them, too.

Literature Review

Historically, mathematics has often been taught using the traditional lecture format with students passively taking notes. This direct instruction approach has also been a common practice in many other academic disciplines. Lectures are sometimes delivered with little interaction or feedback from the students. When teachers do ask questions, they are answered (if at all) by the best students, while the timid, average, or less articulate students just sit there even though they may not have understood. There is frequently a group of students that attempt to answer every question and these students dominate class discussions, leaving little chance for the less assertive students to respond (Mula and Kavanagh, 2009). Some of these students are just quiet by nature and prefer to listen. Others are truly struggling to understand the material and, thus, don't have an answer. Then there are those who might have a correct answer or at least some useful information to contribute, but are afraid of giving an incorrect answer in front of their peers.

Through the 1980s and 1990s there have been attempts, with reasonable levels of success, at changing the way that mathematics is taught using such innovative pedagogical practices as cooperative learning and brain-based learning. In recent years, technology has come a long way in providing additional tools for teachers to use to make the mathematical experience more interactive. Graphing calculators and computer software that allows teachers to create animations or discovery activities for the students to work through have led to a more hands-on environment. More recently, there has been an increased use of interactive whiteboards and student response systems (SRS).

Using these SRS, instructors can ask questions of the whole class, and every student has the opportunity to provide a response. Strasser (2010) suggests several benefits of using clickers. Students can respond anonymously so that they are not embarrassed by their answers. This allows the instructor to know whether or not most of the students are actually comprehending and how to adjust instruction accordingly. She observed that since students have to respond, they appear more alert, which should result in better comprehension. Strasser also stated that students learn from their mistakes since they get instant feedback on what the correct answers are.

Mula and Kavanagh (2009) suggest that clickers can be used to make lectures more engaging, provide immediate feedback to the lecturer about student understanding of concepts, provide immediate feedback to students about their own understanding, assist students to reinforce key concepts, draw connections to new material, and build on previous knowledge. Sevian and Robinson (2011) add that clickers can be used to determine if students are prepared, to find out if students have misconceptions that need to be addressed, to facilitate peer instruction and discussion, to poll opinions to fuel a debate, and to collect predictions of an experimental outcome. They also stated that the most valuable aspect of using clickers was how their use facilitated more equitable participation by students. Morgan (2008) suggested that clickers could be used to foster discussions of important concepts and to energize and activate student thinking.

The results of studies using SRS have been somewhat mixed. Wolter, Lundeberg, Kong, and Herreid (2011), in their research involving introductory biology courses, indicated that students felt generally positive toward the use of clickers, especially women, non-science majors, and freshmen. Mula and Kavanagh (2009), in their research involving first-year accounting students, found that students felt that the use of clickers was a positive experience, improved their understanding of course materials presented, and increased levels of student participation;

however, they did not find statistically significant differences in student performance on assessments between the clicker and non-clicker groups. Strasser (2010), in her research with college calculus students, also found no significant difference in test scores between the clicker and non-clicker classes. However, the failure rate was lower in the clicker classes.

Shieh and Chang (2013), in their study involving high school physics students, found from student interviews that many of the students mentioned that the use of clickers was interesting and exciting and that they were eager to know whether they had outperformed their peers. They also noted that some of the students stated that the use of clickers helped them grasp the key concepts of the lecture content, with one student stating that teaching group members the concepts embedded in the clicker questions increased his sense of accomplishment. Morgan (2008) suggests that students appear to favor electronic response systems over traditional lecture formats, but in her study involving college students in introductory courses in several subject areas, she did not find significant differences in student learning based on course grades. She also indicated that several students reported that they disliked the clickers because they interfered with the type of interaction they were accustomed to with their professors. Since her study involved smaller classes averaging around 30 students, she suggested that clickers might be best used in large introductory lecture sections where faculty interaction with the students is limited. Sevian and Robinson (2011), however, warn that in traditional classroom settings, instructors could be fooling themselves by thinking that in small classes they can easily tell if students understand the material just because they are operating in a more intimate learning environment.

Sevian and Robinson (2011) found that clickers are most effective when their use is transparently integrated with the content. Clicker use should not disrupt the lesson. They also found that students responded best when the instructors did not have predictable times or patterns

of clicker use, preferring instead when they "mixed it up" from class to class. Morgan (2008) stressed the importance of sufficient training for faculty members in order for them to use the clicker system smoothly. It is also important that instructors receive training in designing good questions (Morgan, 2008; Sevian and Robinson, 2011). Shieh and Chang (2013) define high quality questions as those that are able to help students engage in deeper thinking and which eventually lead to comprehensive understanding of the learned concepts. Han and Finkelstein (2013), in their study involving university students in a variety of disciplines, found that professors' participation in pedagogical development activities had positive impact on student perception of clicker assessment and feedback. They also found that the use of clickers in their study for formative assessment was more influential on student engagement and learning than its use for summative assessment.

In the studies cited above, students seemed to generally like using clickers and they felt it helped them to understand the material they were learning. These studies did not show significant changes in achievement through the use of clickers. Most of these studies involved college students with the lone exception being the research by Shieh and Chang (2008) that involved high school physics students. The plan for my research was to study the use of student response systems with high school students in my mathematics courses. I have been trying to find ways to get all students actively involved in classroom discussions and activities. I also like to use technology when I feel that it can help students in their learning of mathematics. Based on the favorable experience that I had a few years back as a student using a student response system, I felt that there was great potential in using these tools with my students.

It was my belief that when used properly SRS could keep students paying attention better and participating more frequently in class. I was hoping that the quieter and less confident

students would feel more free to give answers since they could respond without the other students knowing what answer they had submitted. I was planning to use the SRS in a variety of ways – sometimes to stimulate discussion, and other times for formative assessment to check for understanding to get immediate feedback when students are struggling. I wanted to use SRS to review prior material needed when introducing a new topic, to review important homework problems, as part of a closure activity at the end of a lesson, and to prepare for the ACT. I believed that the students would enjoy using the SRS since it was so much like their world of cell phones, instant messaging, texting, etc.

While the studies cited above focused exclusively on handheld clickers, my plan was to explore the use of three different student response systems with my classes – eInstruction clickers, Pear Deck, and Poll Everywhere. The eInstruction clicker is a handheld device with a keypad that allows students to submit answers when I have a question activated using the companion software on my laptop. The questions appear on my interactive whiteboard for the students to see. As students submit their answers, their clicker number changes color on the display, but only indicates that they have answered, not what their answer was. Once I close the question, we can look at a whole-class display of the answers submitted. However, no names are attached to the displayed answers. We can then have some discussion before moving on to the next question. The eInstruction clicker software offers a variety of question types, including multiple choice, numeric, ascending sequence, short answer, and essay. In my classes, we used multiple choice, numeric, and short answer.

Pear Deck is a web-based system that integrates with the Google Apps suite of applications. When using Pear Deck, the students see a slideshow both on the board and on their laptop. A variety of question types can be created on the slides, including multiple choice,

numeric, written text, drawing, and draggable dot questions. Students can submit answers from their laptop. Pear Deck gives the option of displaying the answers as they come in or toggling them on after all of the students have had a chance to submit their answers. As with the clickers, the students can submit answers anonymously, without other students knowing who submitted a particular answer. Another feature available in Pear Deck is that it allows for non-interactive, informational slides between and around the question slides. As an alternative to using their laptop, students can access a Pear Deck presentation from a tablet or smartphone.

Poll Everywhere is also a web-based application, but students can submit their responses by texting on their cell phone. The available question types include multiple choice and open ended. The open ended questions allow for both numerical and text answers. A student who doesn't have a cell phone can answer the questions using their web browser on their laptop or tablet. As with Pear Deck, the submitted answers can be displayed as they come in or later after all of the students have had a chance to submit an answer. Both Pear Deck and Poll Everywhere display on the screen the number of students who have answered.

All three of these student response systems have advanced features that allowed me as the teacher to save individual students responses to later look back at. I did not use these features since I was focusing on using SRS for formative rather than summative purposes. I let the students know that I would not be using those features yet during this study as I wanted them to feel more comfortable with the anonymous submission of answers.

I want to use the results of my research to guide my future lesson planning decisions about the use of SRS in my classes. I want to get a feel for whether the students enjoy using SRS in class and if they like being able to submit anonymous responses. I want to see if they felt that they are more actively engaged in the lessons in which we used SRS and if they feel that they

learned more. For my planning purposes, I wanted to determine which kinds of activities the students felt were most helpful to them in learning mathematics. I also wanted to gain some insight into which of the three student response systems the students enjoyed using most and which one(s) kept them the most actively engaged in the activities of the class.

Methodology

I carried out this study with the students in my mathematics courses during the fourth quarter of the 2014-15 school year. I had been using a set of eInstruction clickers, Pear Deck, and Poll Everywhere on and off during the first three quarters of the school year. I began more intensive use of these student response systems during the fourth quarter as my Professional Practice Goal – one of the components of the new Wisconsin Educator Effectiveness model for teacher evaluation. I used an SRS at least once per week, on average, in each of these classes during the fourth quarter, during this time and I used each of the three SRS approximately equal numbers of times within a given class. I collected my data using a survey that I had created using Google Forms. The 35 students who chose to participate in this study and take the survey were students in my Algebra 2, Pre-Calculus, and Calculus classes. They included 10 sophomores, 17 juniors, and 8 seniors – with 22 male participants and 13 female participants.

My survey consisted of four parts. In the first part, I asked the students to reflect on their attitude, participation, and engagement during traditional lessons in which we did not use SRS. In the second part, I asked students about their attitude, participation, and engagement during the lessons in which we did use SRS. In the third part, I asked the students about the value they found in the different kinds of activities we did using SRS in class. In the fourth part, I asked the students to compare the three different SRS that we used and to reflect on the positives and negatives of each.

Many of the survey questions were answered using a Likert scale. However, I also had some open-ended, free response questions on the survey in order to gather some qualitative data from those students who were willing to write a little more about the experience. The data from

the Likert scale questions were summarized in bar graphs, tables, and pie charts in the Results section. The qualitative data that I collected from the student comments on the surveys helped to add descriptive detail to some of the quantitative results.

In this study, I did not attempt to assess the effect of SRS on student performance other than student perception of whether or not they learned more using SRS. While student performance is of interest to me, I did not think that I could obtain meaningful results from the groups of students that I had. The only course that I taught during two different class periods was Algebra 2. Since the students were not randomly assigned to those two class periods, I had to assume that they were nonequivalent groups. In fact, the way in which they were assigned almost guaranteed nonequivalence. One group consisted of the advanced sophomores who were in there because they had been high achievers in mathematics in past courses. The other group consisted of juniors who had not been in the advanced group as sophomores. I also thought about comparing student achievement for a particular class from one chapter to another, but then the difference in topics might make it difficult to know whether differences in achievement could be attributed to the use of SRS.

Results

Attitude, Participation, and Engagement During Non-SRS Lessons

In Part 1 of my survey, I asked questions that would give me some insight as to how the students felt about their participation and engagement in class activities on days when we did not use student response systems. I wanted to get a feel for their attitudes toward both the situation of volunteering answers during class and for being selected by the teacher (perhaps involuntarily) to answer questions. I first asked them to rate their feelings about voluntarily responding to questions from the teacher. This survey item and the results are shown in Figure 1.

2. **Thinking about the days when we DID NOT use the student response systems in math class, please rate your feelings about responding to questions from the teacher.**
Mark only one oval.

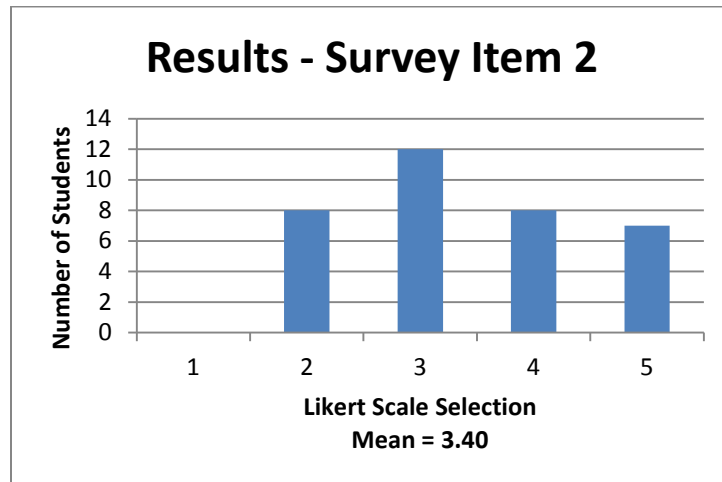|	1	2	3	4	5	
I usually hope that others will answer so that I don't have to.	⬭	⬭	⬭	⬭	⬭	I enjoy answering questions in class.

Figure 1

The data shows that 23% of the students prefer to let others volunteer answers during class discussion with 8 of the 35 students answering this item with a 2 and no students answering with a 1. On the other end of the scale, 15 of the 35 students (43%) answered with a 4 or 5, indicating that they enjoy volunteering answers.

I then asked them to rate their feelings about being called on to answer questions in class. This survey item and the results are shown in Figure 2.

3. **Thinking about the days when we DID NOT use the student response systems in math class, please rate you feelings about being called on in class.**
   Mark only one oval.

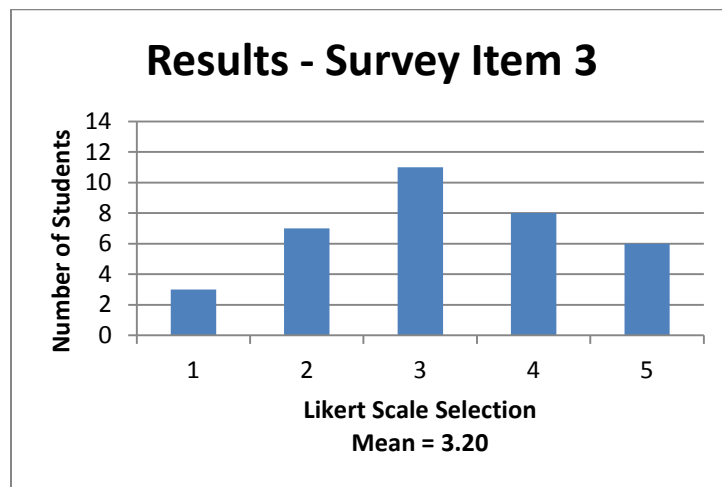|	1	2	3	4	5	
I always hope NOT to get called on.	◯	◯	◯	◯	◯	I enjoy being called on during class discussions.

Figure 2

When asked to rate their feelings about being called on, 10 of the 35 students surveyed (29%) answered this question with a 1 or 2, including 3 students who answered with a 1, indicating that they strongly dislike being called on to answer questions in class. There were 14 out of 35 (40%) who selected a 4 or 5 for this item, indicating that they enjoy being called on by the teacher to answer questions.

These two items yielded similar results and, not surprisingly, showed a slight preference toward volunteering answers compared to being called on. It is interesting to note that these 10 who selected a 1 or 2 on Item 3 were not just the struggling students. In fact, four of the them were students whose fourth quarter grade was a B+ or higher. On the free response survey item regarding participation in traditional (non-SRS) discussions in math class, one student commented, "Math is one of my favorite classes, but sometimes I don't want to give a wrong answer." One student did seem to support traditional discussions, indicating that he feels good when he can answer a tough question in class.

Attitude, Participation and Engagement During SRS Lessons

In Part 2 of my survey, I asked the students questions about the lessons in which we used the student response systems (SRS). I wanted to get a feel for whether they enjoyed using SRS or if they would prefer to just have traditional classroom discussions. I began this section of the survey with the following question:

7. **Please rate your thoughts on the lessons in which we DID use the student response systems in math class.**
   Mark only one oval.

	1	2	3	4	5	
I really do not like using the student response systems.	◯	◯	◯	◯	◯	I look forward to those lessons.

Results - Survey Item 7

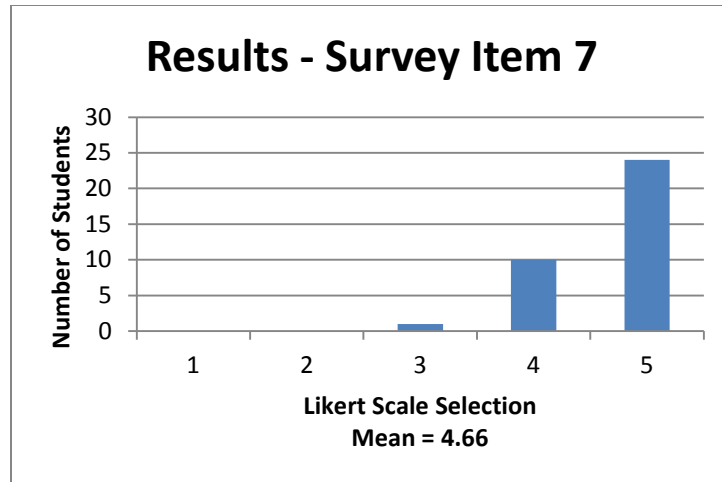*Number of Students* vs *Likert Scale Selection*
Mean = 4.66

Figure 3

The results in Figure 3 indicate that they seemed to have overwhelmingly enjoyed using SRS, with 34 of 35 (97%) answering with a 4 or 5, including 24 of them (69%) responding with a 5. For the free response question regarding the use of SRS, several of the students indicated that they liked the lessons better when we used SRS. Two of these students went on to explain that SRS provided a nice change from the usual routine. Some students did provide some negative, but helpful, feedback about SRS. One student explained that she enjoyed these lessons except when students would "mess around", making reference to times when students would submit silly answers to try to be funny. Two other students commented that they felt that it was more time consuming using SRS compared to traditional class discussions. These are good reminders to me as the instructor to try to improve these two situations.

I then used the item in Figure 4 to gauge the extent to which the students liked being able to answer questions anonymously.

8. **Rate the extent to which you agree or disagree with the following statement.**
   When using student response systems, I like the fact that I can submit my answer without the other students knowing what answer I submitted.
   Mark only one oval.

   | | 1 | 2 | 3 | 4 | 5 | |
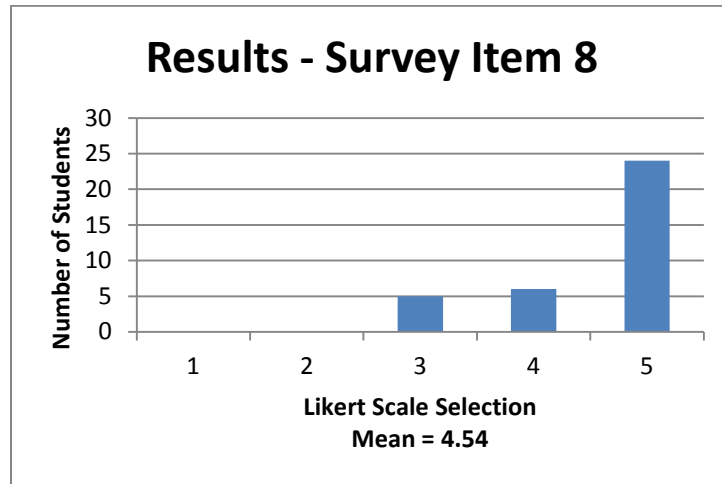   Disagree ◯ ◯ ◯ ◯ ◯ Agree

Figure 4

Here again we see a large percentage of the students (30 out of 35 or 86%) answering with a 4 or 5, including 24 of them (69%) selecting a rating of 5. These students clearly seem to appreciate being able to submit answers anonymously. Five students wrote comments stressing that they enjoyed the anonymous nature of submitting answers using SRS. Their feelings can be summed up by two of the responses. One student wrote, "I like using the SRS because then I don't have to feel obligated to answer questions in front of the class." Another student stated, "I think they make class more fun and if you mess up, no one knows it's you." One student did comment that while the answers were submitted anonymously, some of his classmates would get preoccupied trying to figure out amongst themselves who submitted a particular answer. This was more of an issue in a small class.

Earlier in the survey I asked the students to rate their level of engagement in the days when we did not use SRS, and subsequently I had them rate their level of engagement when we used SRS. These two items and their results are shown in Figures 5 and 6.

4. **Thinking about the days when we DID NOT use the student response systems in math class, please rate the extent to which you were typically actively engaged in the lesson of the day.**
   Mark only one oval.

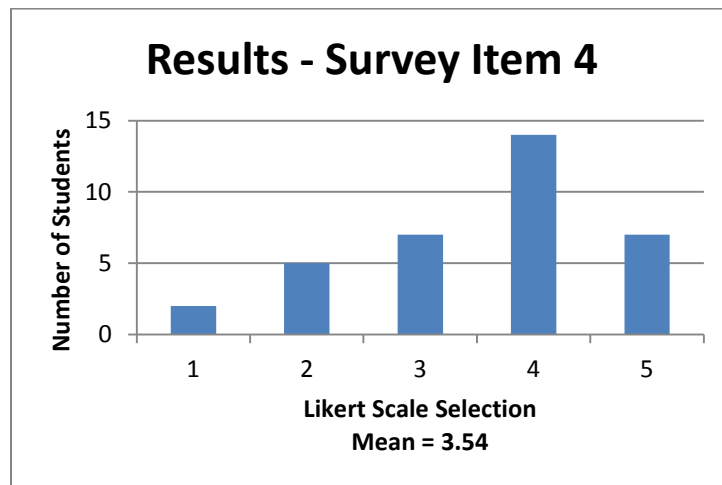|	1	2	3	4	5	
I often found myself NOT paying attention to the lesson.	◯	◯	◯	◯	◯	I was paying attention and actively engaged throughout the lesson.

Figure 5

9. **Thinking about the days when we DID use the student response systems, please rate the extent to which you were typically actively engaged in the lesson of the day.**
Mark only one oval.

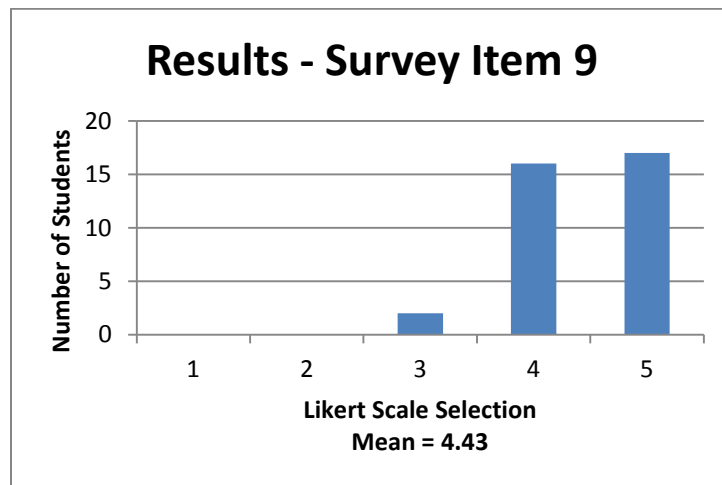|	1	2	3	4	5	
I often found myself NOT paying attention to the lesson.	◯	◯	◯	◯	◯	I was paying attention and actively engaged throughout the lesson.

Results - Survey Item 9

Figure 6

Comparing these two sets of data seems to suggest that the students felt more actively engaged during the lessons in which we used SRS. The mean response for the lessons using SRS was 4.43 compared to a mean of 3.54 for the lessons not using SRS. 7 of the students (20%) responded with a 1 or 2 regarding their level of engagement during the lessons without SRS, whereas there were not any students who responded with a 1or 2 for the SRS lessons. 21of the 35 students (60%) responded with a 4 or 5 for the non-SRS lessons compared to 33 of 35 (94%) for the lessons in which we used SRS. These two items seem to provide convincing evidence that the students felt more actively engaged during lessons in which we used SRS. One student, speaking about his own level of interest, commented, "When we use SRS, I feel a lot more interested than just regular discussion." Two students made observations about the class as a

whole with one of them stating, "I feel that they [SRS] were helpful and had everyone

participating." The other said, "I think they are a good way to get more people involved and

more people answering questions."

I concluded this part of the survey by asking the students if they felt that they learned

more during lessons in which we used SRS. This item and the results are shown in Figure 7.

10. **Rate the extent to which you agree or disagree with the following statement.**
I feel that I learn more when we use the student response systems.
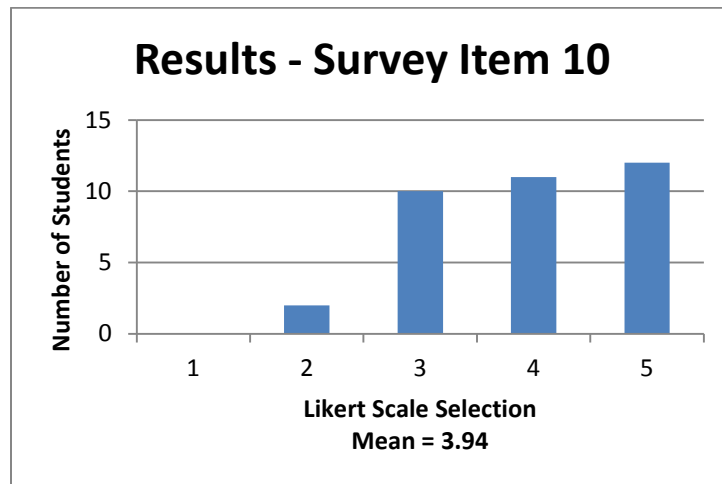*Mark only one oval.*

Figure 7

These results here look promising, though not quite as convincing as the results from

items 7 and 8, and the comparison between items 4 and 9. For this item, 23 out of 35 students

(66%) responded with a 4 or 5 indicating that they felt that they learned more when we used

SRSs. The only responses below 3 (neutral) were 2 students who responded with a rating of 2.

Almost two thirds of the students felt that they did learn more with SRS. This is consistent with

the idea that if students enjoy using SRS and they feel they stay more actively engaged during

these SRS lessons, then they will learn more when we use SRS. The free responses pertaining to this survey item were interesting. One student stated, "I learn, I am actively engaged, and it's fun." Another student wrote, "I don't necessarily learn more, but I pay attention better." A third student had the helpful observation that he felt that he and his classmates learned more, but that time was wasted getting everything set up. He was most likely referring to the time it takes to get logged in for Pear Deck and Poll Everywhere and the time spent getting the eInstruction clickers distributed to the students. I also note that on a couple of occasions, a software issue required me to close down the clicker software and start it back up. This is also a good reminder to me as the instructor to make sure to have my laptop and my interactive whiteboard all set up and ready to go ahead of time – that way, the students will not have to wait while the application goes through the start-up process.

Comparison of SRS Activities

In Part 3 of my survey, I wanted to find out from the students which SRS activities they found most valuable (and least valuable) for learning mathematics. I asked them to give a rating to each of the following seven ways in which we had used SRS in class:

- Reviewing material from a prior unit or course using SRS

- Reviewing homework problems or important topics using SRS

- Using SRS questions to generate discussion

- Using SRS to develop a new topic

- Using SRS to check for understanding during a lesson

- Using SRS as a closure activity at the end of a lesson

- Preparation for the ACT using SRS

I asked the students to rate each of these activities as "Very Valuable", "Valuable", "Some Value", or "Little or No Value". Table 1 reveals the data gleaned from this part of the survey:

	Little or No Value	Some Value	Valuable	Very Valuable
Reviewing material from a prior unit or course using SRS	0%	17%	57%	26%
Reviewing homework problems or important topics using SRS	3%	12%	50%	35%
Using SRS questions to generate discussion	3%	21%	23%	53%
Using SRS to develop a new topic	3%	30%	37%	30%
Using SRS to check for understanding during a lesson	3%	9%	41%	47%
Using SRS as a closure activity at the end of a lesson	0%	26%	41%	33%
Preparation for the ACT using SRS	3%	3%	38%	56%

Table 1

It was interesting (and reassuring) to see that so many of the students found all of these kinds of activities to be either "Valuable" or "Very Valuable", with all seven categories of use having at least 67% of the students selecting one of these two top ratings. When looking at the sum of the percentages for these top two ratings, "Valuable" and "Very Valuble", **preparation for the ACT using SRS** was the leader (94%), followed by **using SRS to check for understanding during a lesson** (88%), **reviewing homework problems or important topics using SRS** (85%), and **reviewing material from a prior unit or course using SRS** (83%).

Another way to rank these seven categories of use would be to assign the numbers 1 – 4 to the four ratings with "Little or No Value" = 1, "Some Value" = 2, "Valuable" = 3, and "Very Valuable" = 4, and then find the mean for each. The results are shown in Table 2.

	Mean Rating	Rank
Reviewing material from a prior unit or course using SRS	3.09	5th
Reviewing homework problems or important topics using SRS	3.18	4th
Using SRS questions to generate discussion	3.26	3rd
Using SRS to develop a new topic	2.94	7th
Using SRS to check for understanding during a lesson	3.32	2nd
Using SRS as a closure activity at the end of a lesson	3.07	6th
Preparation for the ACT using SRS	3.47	1st

Table 2

Looking at it this way, the top two categories of use remained the same – **ACT preparation** and **checking for understanding**. However, **using SRS to generate discussion** slips into the third place, pushing the categories previously in third and fourth place into the fourth and fifth place, respectively. It is validating to note that each of the seven categories of use had a mean rating between 2.94 and 3.47 on this 1 to 4 scale. It will be helpful for my future planning decisions to know that the students found so much value in all of these uses of SRS.

This section of the survey concluded with three free response questions. The first of these three asked the students to add comments regarding SRS activities that they really liked or that

were memorable to them. I followed that up by asking for information regarding SRS activities that they did not like. Consistent with the data shown above, several students mentioned how much they felt the ACT preparation activities helped them. One student specifically mentioned an activity in which we reviewed the properties of exponents as one he really found helpful. Some students answered this in a more general way without referring to a specific activity. In particular, three students mentioned that they felt that the SRS activities helped to ensure that all students were actively involved and understanding the material. Two students mentioned that they enjoyed the fact that SRS activities made the learning more fun. When asked what they didn't like, three students mentioned that it bothered them when students didn't try and just guessed at their answer or submitted a silly answer. One student stated that she didn't think that there were any SRS activities that she didn't like.

This part of the survey concluded with an item asking students for any thoughts or ideas for different ways I would use SRS in the future. The most common response here was a request simply to use SRS more often. Three students suggested that we use them to review for tests and one student suggested that SRS be used for pre-testing at the beginning of the year or the beginning of a new unit.

Comparison of eInstuction clickers, Pear Deck, and Poll Everywhere

In Part 4 of my survey, I wanted to get a feel for the students' preferences among the three student response systems. Their choices here were eInstruction clickers, Pear Deck, Poll Everywhere, and no preference. The first question was simply which one they liked the best. The results are shown in Figure 8.
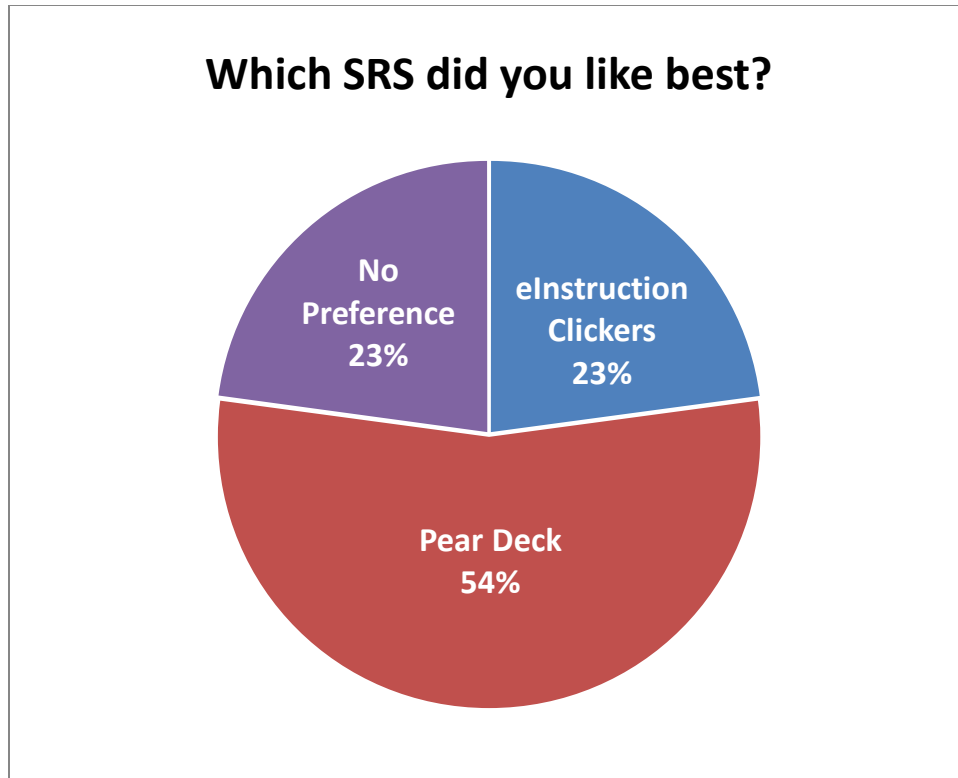
Figure 8

Most striking here is that none of the students chose Poll Everywhere as their favorite. An overwhelming 54% liked Pear Deck best. This preference for Pear Deck was not completely surprising as I remember informally getting positive verbal feedback from several students on the days when they saw that we were going to use Pear Deck. The remaining students were equally divided between the eInstruction clickers and No Preference.

After answering which student response system they liked best, students were given the opportunity to offer comments regarding why they chose a particular SRS as their favorite. Several students who chose Pear Deck mentioned that they liked the variety of question types available. In particular, they like to answer questions using the drawing tools and the draggable dot. One student stated that she had to think more to answer a question with the drawing tools than she did with multiple choice questions. Another student said that he liked the drawing tools, but that students would sometimes mess around with their drawings rather than focusing on the

math. There was an interesting observation from one student who preferred the eInstruction clickers. She felt that the multiple choice questions were better in that students were limited to the selection available and couldn't send in silly answers. Some of the students who indicated no preference simply stated that they liked all of them.

I then asked which SRS kept them most actively engaged with the lessons. The results are shown in Figure 9.

Which SRS kept you more actively engaged in the lessons?

- No Preference 14%
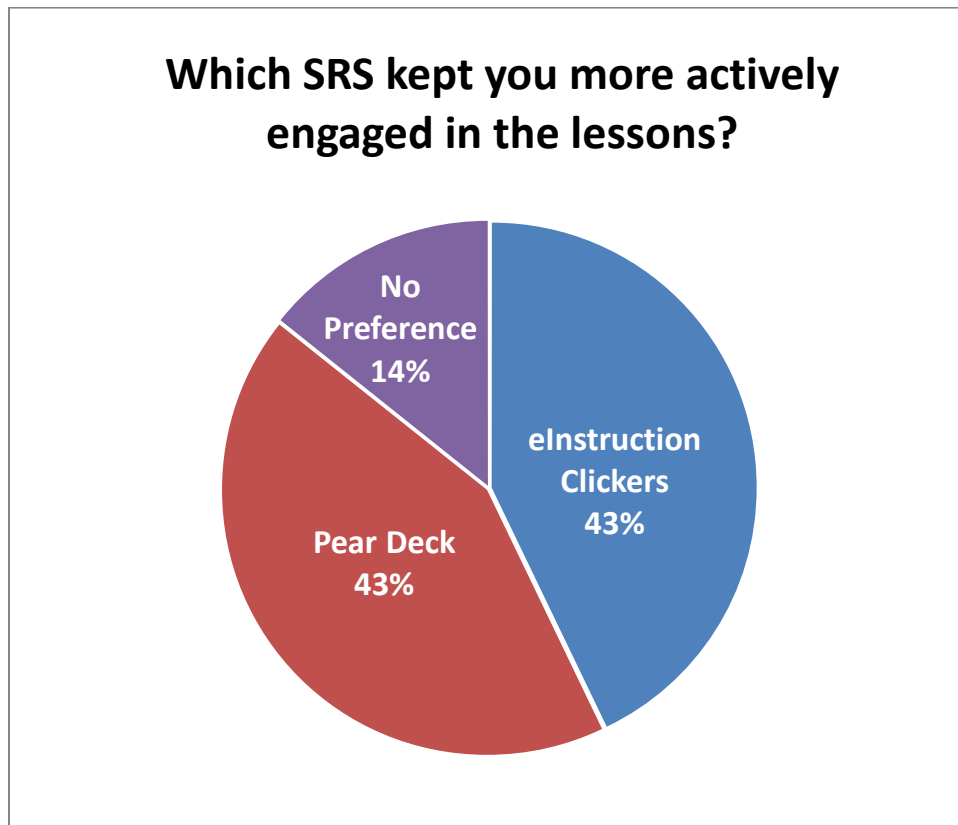- eInstruction Clickers 43%
- Pear Deck 43%

Figure 9

This time the results were equally divided between eInstruction clickers and Pair Deck. Again on this item, no students chose Poll Everywhere. Some students who felt more actively engaged with the eInstruction clickers commented that it helped that each clicker number was displayed on the board and that it changed color once an answer was submitted. They felt that this pressured them in a positive way to participate. Two students commented that when using the

clickers, they stayed more on task since it was a device with only one purpose. There wasn't the temptation to check their email, text a friend, or play a game like there might be when using their laptop for Pear Deck or their phone for Poll Everywhere.

Some of the students choosing Pear Deck as the SRS that kept them more engaged echoed the earlier responses that drawing out their answer was more interesting than just pressing a button. Two students said that they prefer to work from their laptop, with one of them elaborating that it was helpful to him to see the questions appear on his individual screen rather than to just on the board. Another student commented that he enjoyed seeing the anonymous answers pop up as they were submitted.

The last three items on the survey asked the students for any last comments, positive or negative, about each of the three student response systems that we used. Regarding the eInstruction clickers, two students commented that they really liked the bar graph showing the submitted answers that was available after the multiple choice questions. On the negative side, some students felt that it was difficult and time consuming to type a free response answer using the clickers and thus they were only practical for multiple choice. Others indicated that they found multiple choice questions less interesting.

For Pear Deck, several students wrote about liking the variety of types of questions available. Some indicated that they enjoyed the questions for which they had to draw a graph, but one student mentioned how difficult that was using the trackpad on the laptop. There was only one negative comment submitted about Pear Deck. One student stated that she did not like the fact that when she submitted a second answer to a free response question, her first answer would be crossed out.

For Poll Everywhere, three students commented that they always have their phone with them so it was great to use it this way in class. Some of the rest of the responses helped to explain why no one chose Poll Everywhere as their favorite or as keeping them actively engaged. Three students mentioned that a few students don't have a cell phone or have a limited texting plan. Some others said that they have a cell phone, but often forget to bring it to class. One student suggested that a notification message be sent earlier in the day alerting them to bring their phone to class the days we needed them. Two students had a cell phone, but their phone didn't allow these text messages to Poll Everywhere. One student did offer the reminder that students could submit answers from their laptop if they did not have a phone available. Another student commented that the phone keypad was very limited when trying to use math symbols. Three students commented on how easy it was to get distracted by other apps when they had their phone in their hand.

Conclusions

When planning this research project, I wanted to use the results as a guide to help me in future lesson planning decisions. I enjoy using new technology tools, but I wanted to determine if the students felt that the tools that I was using, student response systems (SRS), were really helping them to stay more actively engaged in the lessons and helping them to understand mathematics. I wanted to find out which activities the students found to be most valuable in learning mathematics and I wanted to determine their preferences and the pros and cons among the three SRS that we used.

The data from my study indicates that a typical class will have some students who prefer not to answer questions during traditional class discussions. Sometimes this even includes high-achieving students who do not want to risk giving a wrong answer in front of their peers. My

students indicated overwhelmingly that they looked forward to the lessons in which we used SRS and that they like being able to submit answers anonymously. The data also shows that my students felt more actively engaged in the SRS lessons and suggests that they felt that they learned more in these SRS lessons than in traditional lessons.

When the students were asked to rate the different kinds of SRS activities as to their value in helping them to understand mathematics, they indicated that they found good value in all of them, with **ACT preparation** and **checking for understanding** ranked first and second, respectively. The next three spots were held by **using SRS to generate discussion**, **reviewing homework problems or important topics using SRS**, and **reviewing material from a prior unit or course using SRS**, with the order varying depending on the way I looked at the data. When asked for their preference among the three SRS, the students indicated convincingly that they liked Pear Deck best, followed by the eInstruction clickers. None of the students indicated that they like Poll Everywhere best. When asked which SRS kept them most actively engaged, the students indicated equal preference between Pear Deck and the eInstruction clickers. Here, Poll Everywhere again received no votes.

This information is encouraging and will motivate me to continue using SRS in my classes in an effort to keep all students actively engaged during class. The students seem to really enjoy the change from a traditional discussion. Some of the free response answers on the survey offer good reminders to me as the instructor about classroom management issues. I need to work to minimize the temptation for students to submit silly answers, and I need to make sure that when we are using laptops or cell phones, students are staying on task, not getting distracted by going to a different web site or using other apps.

I plan to continue to use the kinds of activities that the students found to be valuable and I plan to modify and improve some of the others. I will always be looking for new ways that I can use SRS in my classes. I will probably use Pear Deck and the eInstruction clickers most often. The best use for eInstruction clickers seems to be for multiple choice questions, and while Pear Deck also works nicely for multiple choice questions, it will be my tool of choice for free response questions, drawing problems, and draggable dot questions. I will probably use Poll Everywhere only sparingly. Poll Everywhere did seem to be effective when students could submit free response answers to suggest next steps when we worked through a problem. Since Pear Deck and Poll Everywhere are web-based applications, new features become available from time to time without having to update any software. I will need to watch for these improvements so I can try using them with my students.

With any of these three tools it will be important that I get the equipment set up and have the applications open and ready to go ahead of time so that students don't have to wait for the activity to begin. As I gain experience using these applications, I should be able to more smoothly integrate them into the lesson. I want the mathematics to be the focus of the lesson, not the technology. While the students indicated that we should use SRS more often, I don't plan to use them every day. I plan to use SRS only during lessons for which I feel it will be most effective in helping them to learn and understand mathematics. Premkumar and Coupal (2008) stated that use of SRS day after day, in every lecture, may become tiresome to both instructors and students.

The information that I gained from this research project will be useful for me, not just in my own classroom, but in helping my colleagues who are interesting in using SRS with their

students. I plan to share with them the things that worked best in my mathematics classes and they can adapt that information to their needs in their classroom.

Reflection

When I began this MSE–Mathematics program, I was not sure what to expect. Each summer I would enroll in the mathematics courses and I soon discovered that these courses provided some of the best professional development that I have had as a mathematics teacher. It was refreshing to be in those classes with others who were passionate about mathematics and teaching mathematics. These courses provided me with a deeper understanding of mathematics that helped me to teach even the most difficult of topics with greater confidence. I still use many ideas from my notes, assignments, projects, and other materials from those courses to provide creative learning activities for my students.

The Educational Psychology course gave me a chance to consider educational issues that I don't always think about as a mathematics teacher and the Research Methods course gave me a good introduction to the proper way to do educational research. My correspondence in getting approval for this project from the IRB helped me to better understand the precautions that need to be taken to protect the participants in this kind of study. It was in one of the mathematics courses that I first learned about clickers and the mathematics coursework gave me the additional background knowledge that helped me to write better questions in creating the activities using student response systems for this project. In carrying out this study, I have gained an appreciation for gathering and using data to help make educational decisions.

In the future, if I were to do more research beyond this project, there are a number of directions I could go. I will always be looking for more ways to use SRS effectively for formative assessment in my classroom. It would also be interesting to look further into effective questioning in order to develop high level questions for use with SRS. I would like to see

whether the use of SRS improves student achievement. There are some new SRS products that I have recently became aware of that would be worth exploring and there are many new technology tools besides SRS that sound exciting and might be worth studying to see if they are, in fact, effective in helping students to learn mathematics.

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