THE EFFECTIVENESS OF STUDENT RESPONSE SYSTEMS IN SECONDARY SCIENCE EDUCATION

by

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A Master's Paper

Submitted to the Graduate Faculty

in partial fulfillment of the requirements for the Degree of

Master of Science in Education - Physics

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May 14th, 2013

University of Wisconsin - River Falls

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Abstract

This paper reports the findings of the effectiveness of Student Response Systems (SRS) in two ninth grade Physical Science classes. SRS are handheld devices given to each student so that they may respond to questions posed by the teacher during class. The teacher then uses the data from the responses to immediately guide their instruction. For this research, SRS were used for formative assessment for a two week unit of study in the test class but was not used in a control class studying the same material. Each class was given a pretest at the start of the unit and the same posttest at the end of the unit. After the units were finished, the test and control classes were swapped for another two week unit of study and pre and posttests were administered. No significant increases in posttest scores were found in the class using SRS compared to the class not using SRS for either unit. There was a noticeable increase in student engagement in class and students overwhelmingly preferred using SRS.

Introduction

Teaching is a profession that requires frequent re-education of the instructor to keep up with the changing needs of students. Keeping students engaged is more difficult than ever with the advent of the internet that gives access to endless information in a matter of seconds. Students are also constantly and instantly getting feedback from various places in their lives; a video game scores them throughout the duration of the game, their post on Facebook is "liked" or commented on multiple times, and a text message sent to a friend gets a reciprocal message within seconds. Most of these exchanges happen in the palm of their hand from a gaming system, laptop computer, or phone. None of those technologies were allowed in the school in which I was teaching, and I often wondered how I could keep students engaged and interested in class as when they were playing a game, on the internet, or texting on their phones. The first time I heard about an instructor genuinely trying to engage his students by allowing them to communicate in a familiar medium was a college lecture that allowed cell phones. The professor gave out his cell phone number to which students could text message with questions or comments. During the lecture, the professor consulted the phone and responded to the most common questions posed. It allowed students to communicate in a familiar context, gave the professor instant feedback on a large group of students, and provided an opportunity to clarify and correct misconceptions.

Since cell phones are not typically allowed in high school classrooms and not all student have cell phones, I decided to use an official student response system (SRS as it will be referred to for the remainder of this paper) that my school had recently purchased. SRS are hand-held devices given to each student that allows them to

respond in real time to questions posed during class. Individual students use their own "clicker" to answer multiple-choice, true/false, short-answer questions, or even ask questions of their own, much like the college professor mentioned earlier. A student's individual result is reported back to them as well as to the teacher's computer. The combined results from the class are immediately available to the teacher for viewing and analysis, giving them the ability to check understanding of the class within seconds of the questions being asked. SRS were becoming more common and I wanted to see if this technology was an effective way to engage students using communication already familiar to them: that of instant feedback in the palm of their hand.

Literature Review

The iGeneration, as defined by psychologist Larry Rosen (as cited in Jayson, 2010) can be identified by their "adeptness at multi-tasking, desire for immediacy, and the ability to use technology to create content." It is the job of educators to meet students' instructional needs by giving them more opportunity to use these skills they have acquired from being brought up in a world of technology. One of the ways to utilize the skills of the iGeneration is to give immediate feedback using a Student Response System for formative assessment.

Formative assessment is important for effective instruction. According to William Ferriter (2009) SRS gives teachers quick and meaningful data if used properly. Teachers feel they are more apt to easily monitor student understanding and learning.

A quasi-experimental study by Wong, *et al.* (2009) from Singapore compared two similar secondary five Physics classes taught by the same instructor. Secondary five is an additional year beyond the typical four years of secondary school in Singapore.

Each class consisted of 35 students. One class used a SRS and one did not. The class that used the SRS performed "significantly better than their counterparts who did not use the system" on a posttest. The pretest scores were not significantly different and methods for teaching were the same with the exception of using the SRS, which suggests that the study is reliable. The study proposed that the overwhelming success of the use of SRS might be attributed to the fact that the study took place in an Asian classroom where students are less likely to speak up. It also suggested that the effectiveness of SRS should be studied over a longer period of time for more accurate results.

In a similar study by Gauci*, et al.* (2009) at Melbourne University in a second semester Physiology lecture, SRS were found to increase attendance and test scores. The study tracked the participation of 175 students using SRS for 12 weeks. The more the students participated during lectures with the SRS, the greater their scores. The greatest gains were made by students categorized as “low achievers” from previous performance.

Not all studies claim that SRS increase student scores, however, other benefits were found. The National Research Council (2000) reported on a study of a specific SRS, Classtalk, found that “Communication technologies, such as Classtalk, can promote more active learning in large lecture classes and, if used appropriately, highlight the reasoning processes that students use to solve problems” (p. 219). A review by Caldwell (2007) of multiple studies on clickers found that although scores may not necessarily increase significantly, attendance was typically higher in classes where

SRS were used, there was greater student engagement because students liked using the clickers, and instructors noticed that students were more actively involved in class.

Bartsch and Murphy (2011) conducted a laboratory experiment to isolate the use of SRS and student engagement as the only factor in student achievement. The method was a lecture outside of the normal classroom with no grades assigned, a scripted lecture with no instructor feedback, and no group learning. Students volunteered to be a part of the study. A test class used SRS for answering questions during a brief lecture and the control class raised their hands. The questions did not check for knowledge or understanding, but were biographical or opinion questions. There was no difference in perceived knowledge between the classes. The test class scored significantly higher on a quiz given after the lecture, suggesting that the use of SRS increased student engagement.

Gray and Steer (2012) suggest that the use of SRS does not lead to learning gains. In their study, students in introductory undergraduate Earth Science courses used peer instruction lecture tutorials. The control class sample size was 48 students, while the test class sample size was 78. The control class consisted of a brief lecture where students individually answered formative questions. After the lecture, students always worked in small groups to answer specific questions and solve problems. The test class used SRS during the lecture and would only work in small groups if 25% or more of students answered in-class formative questions incorrectly. Pretests showed no different in perceived knowledge between the control and test classes. Summative quiz and test scores between the control and test classes did not significantly differ. The researchers pointed to the methods of instruction as being the reason for success

of both classes; the use of SRS in the absence of student-centered lecture tutorials will not make a difference. The study was done throughout an entire semester and therefore eliminated the novelty of using SRS as a variable.

Formative assessment is becoming increasingly important to teachers of all disciplines and grade levels. The timeliness of feedback is also important but difficult for large classes of students. Using SRS, teachers can give instant feedback and respond to the needs of the class. Although my study is aimed specifically at science education, it is reasonable to suggest that the findings may be externally valid for all teachers.

Purpose of the Project

This study was designed to investigate the following research questions:

1. What is the impact of Student Response Systems used for formative assessment on student learning?
2. Does the use of Student Response Systems increase student engagement?
3. How does the use of Student Response Systems affect the attitudes of students regarding participation?

The largest gap in the Literature Review was that most of the studies were done with higher level courses in secondary schools or undergraduate courses. Using a younger student group with lower science skills and less general exposure to science classes would address the gap making the results valid for a broader range of classrooms.

The hypothesis of the research was with the use of SRS, posttest scores would increase as a result of increased student engagement. It was assumed that students

would quickly and easily adjust to using SRS technology. The novelty of using SRS should not affect the outcome of the investigation.

Method

The school in which the study took place was an urban high school, grades 9-12 with approximately 2,000 students. The demographics of the school were 11% Asian, 35.37% Black, 8.71% Hispanic, 1.54% Native American, and 43.80% White. The school day is broken up into 8 periods, with each period lasting 46 minutes. The first step taken was to choose two classes of similar makeup; a control and a test class, both ninth grade Physical Science classes. The classes were representative of the overall demographic. Guardian consent forms were given to all participants and sent home in the mail as well as given to students in class. Many guardian consent forms were never returned, giving a small but comparable sample size; ten out of 27 students in Period 2 and 14 out of 25 students in Period 4. Data was used only from students whose guardian permission slips were signed and returned. From those students, Period 2 had three students with Individualized Education Plans (IEP), while Period 4 only had one student with an IEP.

Pretests were then given to both the test and control classes for the first unit on the Periodic Table (see Figure 1 in the appendix). All questions on the pretests were multiple choice and were checks for knowledge or comprehension. SRS were not used during pre or posttests for either class. Throughout instruction of a two week unit on the Periodic Table, the same formative approaches were used with the exception that the test class used the SRS to respond to the questions (see Figure 2 in appendix) and the control class was limited to one student answering at a time. Often, questions would

build on one another and become more difficult. In the test class, if the data from the response showed that more than half of the class answered a question incorrectly, more time was spent reviewing the specifics of that question. Peer discussion regarding the questions often happened without my direction, especially if the questions posed were more difficult. Most of the SRS questions were checks for knowledge and understanding and were lower on Bloom's Taxonomy (Bloom's Taxonomy). For the specific SRS used, only multiple choice and numerical response questions were possible (open-ended questions were possible to ask but not possible to assess using the SRS). The control class was asked the same questions but only one student could respond. If that answer was incorrect, I would ask another student for the answer. If the second student answered incorrectly, more time was spent reviewing the question. There was some discussion between students regarding the questions but not as much as the class using the SRS.

At the end of the unit, a posttest was given to both test and control classes. The posttest was the same as the pretest. Anonymous attitude surveys were administered to all students and five randomly chosen students were asked to participate in a short interview. Finally, the test and control classes were swapped and the process repeated throughout another two week unit of study on Bonding and Reactions. Although similar in difficulty as the first unit, the Bonding and Reactions Unit built on knowledge learned in the Periodic Table Unit.

Pretest and posttest scores were recorded for every student in each class for both units of study. A pretest was necessary to confirm that the classes were similar at the beginning of the units in their level of understanding of the material. Swapping the

test and control classes for a second unit attempted to isolate the use of SRS as the only variable that affects the student scores. However it is impossible to completely isolate the use of SRS as the only variable because each class is made up of very different individuals, the sample size is very small, and the material for each unit is different.

Results

Table 1 shows the average class scores and standard deviation for pretests and posttests for a class using a SRS compared with the class not using a SRS for the same unit of study. For the second unit of study, the use of SRS switched to the other class. To analyze how much students' learned or gained compared to their previous knowledge, Hake (1999) developed a formula called the Hake gain. The Hake gain is shown as a percentage, which is the possible percent gain (or learned, in this case). Percent gain results are from 0-100%, 0% being the least amount gained or learned, and 100% the most gained or learned. Hake gain was calculated using Equation 1. Unit 1 had a possible score of 18. Unit 2 had a possible score of 13.

(Eq. 1) $$Hake\ Gain = ((posttest - pretest)/(\#\ possible\ score - pretest)) \times 100$$

Table 1.Average Test Scores and Hake Gain in classes with and without the use of Student Response Systems

	Pretest	Posttest	Average % possible gain (Ave Hake Gain)
Periodic Table Unit 1– No SRS Period 2	3.5 +/- 3.0	10.0 +/- 3.8	44.8%
Periodic Table Unit 1 - SRS Period 4	4.5 +/- 2.0	9.6 +/- 3.9	37.7%
Bonding & Reactions Unit 2 – No SRS Period 4	2.2 +/- 1.7	9.4 +/- 1.7	66.6%
Bonding & Reactions Unit 2 - SRS Period 2	4.6 +/- 1.0	8.3 +/- 2.1	44.0%

Analysis

The hypothesis that if a class used SRS, posttest scores would increase as a result of increased student engagement was not supported. The results of the pretests show that for each unit of study, both classes started out with similar knowledge. Table 1 shows the Unit 1 pretest average scores, using the standard deviation, range from 0.5-6.5 for one class and 2.5-6.5 for the other. The posttest average scores show the classes are also similar within the standard deviation. Unit 1's average posttest score range using the standard deviation for Period 2 is 7-13.8 and 5.7-13.5 for Period 4. The results for Unit 2 are consistent with the results of Unit 1; the pre and posttests average scores with the standard deviation range are similar. This suggests that the use of SRS had no significant impact on student learning and the hypothesis of the research was not supported.

Since survey results were anonymous and only a small amount of student permission slips turned in, I was not able to quantitatively use any survey data. Anecdotally, I saw definite positive attitudes among students regarding the SRS. There was noticeable excitement from students when using the SRS. During class, students seemed more engaged and interested in participating compared to other units of study when SRS were not used. After the research was completed, students requested that we continue the use of the SRS for the remainder of the school year.

According to the Hake Gain shown in Table 1, the use of SRS actually had a negative effect on student learning. Period 4 had the greatest Hake Gain overall. However, the Hake Gain was greatest when they were not using the SRS, (37.7% with SRS and 66% without SRS) suggesting that the SRS may have inhibited learning. This

class was made up of more motivated learners so the result of greater Hake Gain compared to the other class is not a surprise. It is possible that the novelty of using the SRS was a distraction for students who already had developed strategies for learning, resulting in a lower Hake Gain.

These results are not consistent with research from Singapore (Wong, *et al.,* 2009) and Australia (Gauci, *et al.*, 2009) that both showed increases in student learning when using SRS. It is more consistent with Caldwell's (2007) findings, which showed no increase in student scores but a significant increase in attendance and engagement.

For continued research, I would implement the SRS for a longer period of time. An entire semester or year would eliminate the variable of novelty for both the students and teacher. It would also give the teacher more time to master when and how the SRS is appropriate to use. I often felt that the SRS should be used as much as possible because the research was during a period of only a few weeks. This may not have been best teaching practices and not the best for student learning. I only used the SRS for multiple choice formative questions during class but the SRS can be used for a variety of instructional techniques. Further research on the use of SRS and its effect on student attendance would be valuable.

Summary

This research was designed to show a relationship between the use of SRS and student learning as shown by pre and posttest scores. The motivation for the research was to see if there is a value to the use of SRS in a high school science class. This data suggest there is no significant relationship between the use of SRS and student learning which is not consistent with the larger body of research. The research data was

collected over too short of time and with too few participants. To improve the research, more classes need to be used over an entire semester. Overwhelmingly, the most important conclusion of this research was my observations of student excitement and engagement while using the SRS, especially those students who were typically neither excited nor engaged.

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Appendix

Moving from left to right across a row of the periodic table, which of the following values increases by exactly one from element to element?

a. isotope number
c. atomic mass unit
b. atomic number
d. mass number

The formation of an ionic bond involves the

a. transfer of electrons
c. transfer of protons
b. transfer of neutrons
d. sharing of electrons

Figure 1. Sample questions from pre and posttests given to all students.

Looking at your periodic table, which element has the greatest number of valence electrons?

a. Lithium

b. Neon

Which of these elements is most reactive?

a. Lithium

b. Neon

Figure 2. Sample questions projected on the SMART Board with SMART Response SRS.