# The Effects of Formative Assessment via Student Responders in High School Math Classes

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A Thesis

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In Partial Fulfillment

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Master of Arts for Teachers,

Mathematics

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by

Aaron Robert Brien

July 2013

CENTRAL WASHINGTON UNIVERSITY

Graduate Studies

We hereby approve the thesis of

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ABSTRACT

THE EFFECTS OF FORMATIVE ASSESSMENT

VIA STUDENT RESPONDERS

IN HIGH SCHOOL MATH CLASSES

By

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July 2013

This action research project studied the effects of using student responders (or clickers) in high school math classes. A second portion of this study was to gauge student perception of the effectiveness of the responders in helping them learn. This study was conducted in three high school math courses during the spring semester of 2013. Findings included: i) in two of the three courses (Geometry 202 and Algebra 2 302) students in the treatment group (those with whom student responders were implemented) did significantly better than students in the control group (those with whom responders were not implemented); ii) at the end of the semester 88% of students surveyed believed that using student responders helped them learn; iii) the three main reasons why students perceived the responders helped them learn were: the timely feedback they received as to whether they were correct or incorrect, the responders encouraged them to be active participants in their learning, and the responders allowed their answers to be anonymous and thus avoiding fears associated with other means of in-class formative assessment.

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# Chapter 1

## Introduction

### Purpose of the Study

The purpose of the study is to examine the effectiveness of incorporating routine formative assessment into daily instruction through the use of student responders. The researcher will design and implement brief formative assessments that could be used throughout a given lesson in order to gather information to inform subsequent instruction. The technology of student responders will be used to gather the results from these formative assessments in each class being taught. Student-learning progress from the spring of the 2011-2012 school year (without an emphasis on formative assessment) will be compared with the spring of the 2012-2013 school year (treatment year). The courses involved in the study are Geometry 202 (second half of course), Algebra 2 302 (second half of course), and Geometry 201 (first half of course). It is worth mentioning that both Geometry 201 courses had a majority of students taking the class for a second time. Lastly, students' perceptions of the effectiveness of student responders will be analyzed.

### Problem Statement and Brief Introduction of the Problem

At the end of the 2011-2012 year the researcher noticed in the Algebra and Geometry courses the students did not perform up to the standard (70% final grade) at his school. The researcher's mathematics department has made the commitment to acquire student responders as a means of encouraging the practice of implementing formative assessments on a more consistent basis. It is conjectured that the constructive use of student responders, as a means to formatively assess students, will increase student performance in his class.

**Background of the problem**

The issue of the researcher's students not achieving to standard is the primary motivation of this study. Nearly half (49%) of the 45 Algebra 2 students in the spring of the 2011-2012 school year earned final grade scores less than 70%. Exactly half of the 28 Geometry 202 students in the spring of the 2011-2012 school year earned final grade scores less than 70%. Also, 8 out of the researcher's 12 Geometry 201 students (66.7%) in the spring of the 2011-2012 school year earned final grade scores less than 70%. Overall, the researcher's school had an increase in the number of students on the D/F final grade list during that same period.

**Research Questions**

- Does the use of formative assessments via student responders and informed re-teaching improve student achievement in Geometry 201, Geometry 202, and Algebra 2 302?
- Do students perceive that getting formative feedback about their performance, coupled with re-teaching for clarification, helps them learn?

**Significance of the Study**

This study is important for several reasons. First, results could lead to better student achievement in the researcher's classes. Second, results could lead to better teaching practice via formative assessments and student responders. Third, the study may produce results that add to the knowledge about student responders and, more generally, to formative assessment.

# Chapter 2

## Review of Literature

### Introduction

The review of literature that follows will take a look at formative assessment and its relationship to student learning gains. One technology that exists to help educators with formative assessment is student response systems. This review takes a deep look into student response systems, the best practice of using them, their benefits, their drawbacks, as well as a review of what existing research suggests about their effectiveness and student perceptions of their effectiveness. It is worth noting that though the focus of this project is on the use of student response systems in high school math classrooms, the vast majority of all research on student response systems is directed toward their use in post-secondary education.

### Formative Assessment

The term formative assessment has been around for years. It is widely believed that Michael Scriven first used it in the form of “formative evaluation,” however Benjamin Bloom is given the credit for being the first to use it in its currently defined form (Black & Wiliam, 2003, p. 623). Though similar, each researcher seems to have his or her own definition of formative assessment.

Sadler (1989) defines formative assessment as “concerned with how judgements about the quality of student responses (performances, pieces or works) can be used to shape and improve the student’s competence by short-circuiting the randomness and inefficiency of trial-and-error learning” (p. 120). Black and Wiliam (1998), touted by most researchers as having the most exhaustive review on formative assessment state:

> we use the general term assessment to refer to all those activities undertaken by teacher – and by their student in assessing themselves – that provide information to be used as feedback to modify teaching and learning activities. Such assessment becomes formative when the evidence is actually used to adapt the teaching to meet student needs (p. 2).

While there may be many different definitions, most will agree that formative assessment involves an assessment that is intended to gather information. This information is then used to inform (via feedback) students as to where they are at in the learning process. Teachers should use formative assessments to inform and guide further instruction.

As alluded to above, Black and Wiliam (1998) is the standard for their extensive review of literature on formative assessment. After sifting through 250 articles, and choosing more than 20 studies, they have found that:

> these studies show that innovations that include strengthening the practice of formative assessment produce significant and often substantial learning gains. These studies range over age groups from 5 year olds to university undergraduates, across several school subjects, and over several countries (p. 3).

As research points to increased student learning outcomes from formative assessment, the focus then must shift to ways of implementing this practice in the classroom. One of many ways to formatively assess in the classroom is through the use of student response systems. Student response systems allow an instructor the best of what formative assessment has to offer. By using these systems, students can be assessed in multiple formats, feedback can be given immediately through the correct answer (as well as through in-class discussion), and another question can be asked to check for student understanding.

**Overview of Student Response Systems**

Student response systems (SRS) are a class set of hand-held electronic devices (commonly called clickers) that communicate with a receiver at the front of the classroom. SRS may be used by a teacher or instructor to poll the student population with a question. This technology (in various forms) has been around since the 1960's (Judson & Sawada, 2002; Hall & Collier & Thomas & Hilgers, 2005). The "early systems were hard-wired with a series of knobs or buttons on students' desks and instructor stations provided a series of gauges that indicated the percent of students responding to each multiple choice option" (Hall et al., 2005, p. 2). Today's SRS are wireless versions of these previous systems that use infrared or radio-frequency technology. Some institutions today are also using Web-based systems where the hand-held device is a cellphone, PDA, tablet, or personal computer (Lowry, 2005, p. 5).

Just as there is variety in the forms of this technology, unfortunately there is also a multitude of names for this system that appear in literature. Some of the names for this technology are: clickers (Martyn, 2007), electronic voting systems (EVS) (King & Robinson, 2009), classroom communication systems (CCS) (Beatty, 2004), classroom response systems (CRS) (Fies & Marshall, 2006), electronic response systems (ERS) (O'Donoghue & O'Steen, 2007), and student response systems (SRS) (Mula & Kavanagh, 2009; Dangel & Wang, 2008; Hall et al., 2005; Lowery, 2005; Stowell &

Oldham & Bennett, 2010). Due to simple majority, and in hopes of creating uniformity in the field, this paper will refer to the technology as SRS.

How this technology works, is quite simple. The teacher begins by posing a question. This question can be stated orally or projected electronically to the whole class. Depending on the SRS system, a variety of question types may be used. With the most simplistic versions, it is common to only have true/false, and multiple choice as options for questioning. With the more advanced versions (as was the case for the researcher) additional options may be: yes/no, multiple answer, numeric response, and text. Once the students anonymously enter in their answer, the computer software instantly aggregates and displays to the class a histogram of the students' responses (Lowry, 2005, pp. 2-3; Stowell et al., 2010, p. 135; Beatty, 2004, p. 2; Mula & Kavanagh, 2009, p. 3).

**Best Practice**

Multiple sources hypothesize that the technology alone will not improve student learning, but rather the shift in pedagogical approach will (Martyn, 2007, p. 72; O'Donoghue & O'Steen, 2007, p. 772; Fies & Marshall, 2006, p. 106). The literature suggests that the use of SRS and the shift from lecture-driven to student engagement and active learning that occurs as a result can be attributed to improved student learning. Beatty (2004) states:

> This engagement results in more learning than the traditional lecture format offers and in learning of a different kind: students develop a more solid, integrated, useful understanding of concepts….Merely asking rhetorical questions and pausing for students to think is insufficient; once students have

> committed to and externalized an answer, even if only guessing, they are emotionally invested in the problem and pay far more attention to subsequent discussion and resolution (p. 5).

For this reason, it is suggested that the role of the SRS is much larger than just a diagnostic to inform the student and instructor of whether the student answered correctly or not.

Beatty (2004) and Cline (2006) offer a suggestion as to what this pedagogical shift might look like with the SRS. They advise that the best practice should begin with the instructor presenting the problem, followed by time for the students to discuss within groups. After a couple minutes, and once a consensus has been agreed upon, students then key in their responses. The instructor at that point displays the histogram of the class responses. Next, still without revealing the answer, the instructor facilitates a class-wide discussion, asking for volunteers to support the various answers. Only then, if necessary, the instructor should conclude with a short lecture addressing the question at hand. Judson and Sawada (2002) state that the discussion that results from the SRS use is what "…advances understanding of concepts and unveils misconceptions…" (p. 177).

The effectiveness of SRS can be largely related to the levels of questions being asked. Though there is definitely a place for recall and simple checking for understanding questions, the best SRS questions are those that have well thought out distractors or that will elicit common misconceptions (Cline, 2006, p. 102). Beatty (2004) also suggests some additional goals to keep in mind when creating SRS questions:

> drawing out students' background knowledge and beliefs about a topic, distinguishing two related concepts, realizing parallels or connections between different ideas, elaborating the understanding of a concept, and exploring the implications of an idea in a new or extended context. (p. 10)

It is through these questions where much of the discussion mentioned above, and consequently learning, will arise.

Further research indicates other best practices for implementing SRS in classrooms. In a study on faculty members who used SRS in their classrooms, they recommended that student response questions be paced throughout a lecture (King & Robinson, 2009, p. 28). In addition, Martyn (2007) suggests keeping the number of answer options to five when using multiple choice questions. Martyn also recommends not having the questions be too complex, allowing enough time for students to answer the questions, allowing and encouraging time for active discussion between questions, and not asking too many questions (Martyn, 2007, p. 73).

**Benefits**

In reviewing literature on SRS use in classroom environments, most articles included a list of their benefits. One of the common benefits addressed was that when using SRS in the classroom, students are able to anonymously enter their answers (Martyn, 2007, p. 72; Stowell et al., 2010, p. 136). Howard, Short, and Clark (1996), in their study on student participation, found that "…females more often than males cited factors related to a lack of self-confidence for their nonparticipation, [and] males more often cited reasons related to fears of a negative perception in the eyes of other students and the instructor" (p. 16). The anonymity of the SRS provides an avenue for students to respond that otherwise would not due to the aforementioned fear associated with volunteering an answer audibly in class. Likewise, Stowell et al. (2010) found that students who were shy would prefer using keypads than raising their hands to answer questions (p. 139).

"The anonymity of responding with a clicker guarantees near or total participation" (Martyn, 2007, p. 72). The increase in participation and thereby student engagement is another benefit of SRS. The use of SRS does not allow students to sit passively, but rather requires that all students submit a response to a given question. This not only engages each individual student, but it also prevents the more confident, vocal students from dominating the classroom discourse (Beatty, 2004, p. 5; Burnstein & Lederman, 2001, p. 10; Cline, 2006, p. 101; King & Robinson, 2009, p. 25; Lowery, 2005, p. 9). Cline (2006) adds in his article on classroom voting, that "[using SRS] breaks students out of the passive receptive mode and requires them to participate, creating a more effective learning environment" (p. 100).

According to Judson and Sawada (2002), the greatest potential benefit of SRS is the opportunity presented for further discussion after a question is posed to the class. Judson and Sawada, from their research, believe that the only way student learning outcomes will increase (when implementing SRS), is when students actively communicate with one another (p. 178). SRS are structured to allow for this discussion. After all students respond and results are revealed to them, students are less fearful in discussing their thought process, as they often see they are not alone in their answer (Cline, 2006, p. 101). Beatty (2004) adds that discussion helps students "sharpen their vocabulary, clarify their thinking, discover gaps and contradictions in their understanding, and identify flaws in their logic" (p. 5).

Another benefit of SRS referenced throughout literature, is the feedback that SRS provides to the student (Dangel & Wang, 2008, p. 100; King & Robinson, 2009, p. 25; Martyn, 2007, p. 72; Mula & Kavanagh, 2009, p. 6). This feedback is immediate, and as Cline (2006) contrasts with a traditional lecture setting, students have the opportunity to learn from their mistakes instantly, instead of finding out (if at all) on their homework assignment when returned days later (p. 101). Beatty (2004) also suggests that this student feedback help students "take charge of their own learning, seeking out information and experiences they need to progress. Used consistently, it can impact their approach to learning beyond class, helping them transform into more motivated, empowered, aggressive learners" (p. 5)

Just as SRS provides feedback to the student, equally as important, it also provides feedback to the teacher. The SRS software, once students have entered their answers, will aggregate all entries and display the results on a histogram. This information can inform the teacher of the class' understanding of concepts, and assists the teacher in determining whether and how to re-teach (King & Robinson, 2009, p. 25; Lowery, 2005, p. 3; Martyn, 2007, p. 72; Mula & Kavanagh, 2009, p. 6). Ultimately, this feedback, informs the teacher as to whether the class, as a whole (as opposed to certain vocal students), understands the concepts being taught and whether or not to move forward (Cline, 2006, p. 101). The teacher feedback, ties directly back in with the importance of asking good questions. If the teacher has asked a good question (with good distractors – if it is of a multiple choice format), he/she may then use this information to resolve common misconceptions (Beatty, 2004, p. 5).

SRS systems have novelty to them that makes them very fun for students to interact with. In this generation, students are very adept to technology, so when they get the opportunity to use technology, most are excited by it. According to Cline (2006), several of his students have commented that "the class 'goes faster' than regular classes, and they complain if we skip the voting for a day" (p. 101). While reviewing literature, several articles referenced this "game-based" fun (Cline, 2006, p. 101; Martyn 2007, p. 72; Mula & Kavanagh, 2009, p. 2; Popelka, 2010, p. 295).

**Drawbacks/Challenges**

Though research seems to suggest the benefits outnumber the drawbacks, it is important to include the drawbacks associated with SRS. One of those is the cost. Cline (2006) was the only author to mention the cost of purchasing a SRS. The reason for this can be associated to the fact that there is not much research related to secondary education. He stated that his "department paid approximately $1,450 for each package containing a receiver, the software, and thirty-two clickers, where needed in addition to a laptop and a projector" (p. 103).

A second practical challenge with SRS deals with usage. There can be a steep learning curve to implementing SRS. In a survey of instructors who used SRS in the course, the only two responses of high importance for disadvantages/barriers were "setting up and closing down takes too much time" and "technical (i.e. operation) difficulties" (King & Robinson, 2009, p. 31). Dangel and Wang (2008) allude to the extra time up front necessary for an instructor to design questions and restructure their courses in order to make them SRS friendly (pp. 101-102).

One pedagogical challenge that comes along with using SRS is the need for giving up some level of control that is comforting in a lecture driven teaching style (Cline, 2006, p. 102). A lecture can be well planned out, and even rehearsed. SRS-based teaching, however, has the entire classroom or students in small groups, often in discussion over their responses. The teacher needs to be able to facilitate this discussion and guide the students towards understanding. SRS-based instruction cannot be rehearsed, and if true-formative assessment is going to happen as a result of student responses, the instructor must be prepared and willing to re-teach (Beatty, 2004, p. 6). The focus in teaching shifts from the teacher to the student.

Another added challenge, and mentioned briefly above, is the time necessary to create good questions. Dangel and Wang (2008) refer to need for these questions to be higher order questions. They make the point that it can often be real easy to ask recall questions, but these do not make students think to the level that analysis, synthesis, and evaluation questions would (p. 96-97). Judson and Sawada (2002) suggest that good questions are those that “include common sense wrong answers, thus allowing the formative nature of misconceptions to be revealed” (p. 174).

**Student Learning Outcomes**

Previous research on the effect of SRS-use on student learning outcomes has resulted in mixed outcomes. In general, the results seem to point to either positive, or no gains in student learning when integrating SRS in the classroom (Dangel & Wang, 2008, p. 94). In reviewing literature, those that cite positive learning gains, often refer to a study performed by Poulis, Massen, Robens, and Gilbert (1998) in physics classes at Eindhoven University. Poulis et al.(1998) “found that the pass rate for students in SRS sections was significantly higher than those in the non-SRS sections, with a pass rate of almost 50% higher for the SRS sections” (Hall et al., 2005, p. 2). Additionally, Hall et al. (2005) in their own study in chemistry classes at University of Missouri-Rolla found that grades, following statistical analysis, were “substantially better during the semester when SRS was used” (p. 5).

Conversely, there is still other research that suggests that SRS has no impact on student learning. Mula and Kavanagh (2009) in their study in accounting classes at the University of Southern Queensland found that there were “no statistically significant correlations found between the performance in assessment between student that experience the use of SRS and those that did not” (pp. 11-12). Also, Martyn (2007) in her study in introductory computer information systems classes at Baldwin-Wallace College, found no statistically significant difference between the mean final exam scores when comparing one class that used SRS, and another that used class discussion only (p. 73).

In addition to those that have found SRS to have no impact on student learning, others believe the positive impact that some researchers claim is due to the shift in pedagogy rather than in technological implementation of SRS (Judson & Sawada, 2002, p. 177). In other words, is the increase in student learning due to the shift from lecture driven instruction to the active learning approach which SRS demand (Martyn, 2007, p.72)? Some researchers, like Dangel and Wang (2008), explain that most research on the efficacy of SRS “lacks controls that are necessary to determine whether the technology or the accompanying pedagogical changes are responsible for apparent increases in learning" (p. 94).

**Student Perceptions**

A common component in the existing literature on SRS use is a survey on student perceptions of the impact that SRS has on their learning. Universally the perception by students is that the use of SRS helps them learn. For example, in the same above mentioned Martyn (2007) article, surveyed students (on a scale from 1 to 5, with 1 being strongly disagree and 5 being strongly agree) on average responded with a 4.03, agreeing that the use of SRS improved their understanding of the subject matter (p. 74). Additionally, Mula and Kavanagh (2009) found in their survey that "students perceive that the use of SRS during lectures and tutorials improves their understanding of course materials presented" (p. 11). Greer and Heaney (2004), in their survey of introductory earth science students, found that "between 65% and 81% of students believed that [SRS] helped them learn" (pp. 348-249).

# Chapter 3

## Overview of the Methodology

The purpose of the study was to examine the effectiveness of incorporating routine formative assessment into daily instruction through the use of student responders. This action research study consists of two parts:

1. a causal-comparative study of student achievement in Geometry 201, Geometry 202, and Algebra 2 302 between the spring of 2013 and the previous spring semester in the same courses;
2. an assessment of student perceptions of the effectiveness of student responders.

In the causal-comparative study of student achievement in Geometry 201, Geometry 202, and Algebra 2 302 between the spring of 2013 and the previous spring semester in the same courses, the researcher will compare the end of course grades. The researcher will use daily formative assessments via student responders coupled with re-teaching as the treatment for this study. The researcher will incorporate multiple questions throughout each lesson and elicit a response from his students via student responders. Depending on the results of the responses, the researcher will either re-teach the concept or proceed with the lesson. The researcher will then compare results of end of course student grades from his previous spring's four courses with the treatment year's five courses to determine impact of treatment on student achievement.

In the study on student perceptions of the effectiveness of student responders, the researcher at the end of every lesson will assess whether students perceive the use of student responders helped them learn the material from that lesson. This assessment will consist of one question that they will submit via student responders at the conclusion of each lesson. The question will be: “Did our use of student responders help you learn today,” and the students will be asked to respond with a yes, no, or don’t know. A second part of this study will be at the end of the semester, where students will be asked to answer, “Did using student responders this semester help you learn? Why or why not?” The researcher will use the qualitative results to identify any emerging themes from the student responses.

**Research Hypotheses**

1. Formative assessment using SRS and informed re-teaching improves student achievement in Geometry 201, Geometry 202, and Algebra 2 302.
2. Students perceive that getting formative feedback about their performance, coupled with re-teaching for clarification, helps them learn.

**Statistical Hypothesis**

$H_0$: There is no difference between pass rates for Year 1 and Year 2.

$H_\alpha$: There is a difference in pass rates for Year 1 and Year 2.

**Participants, Populations, Samples, and Subjects**

The participants were 110 Geometry 201, Geometry 202, and Algebra 2 302 students at West Valley High School in the spring of the 2012-2013 academic school year. All of these students were either Sophomores, Juniors, or Seniors.  In each year’s spring semester Geometry 201 classes, greater than 75% of the students had already failed Geometry 201.  West Valley is a diverse, rural suburb of Yakima, Washington. The demographics of the school were as follows: 77.5% White, 16.9% Hispanic, 2.8% Asian/Pacific Islander, 0.8% American Indian/Alaskan Native, 1.0% Black. Out of the entire student body, 53.7% are males and 46.3% females, with 31.4% on free or reduced price meals. (All statistical information based on October 2011 data from Washington OSPI Report Card)

**Population and Sampling Procedures**

The participants were chosen from the population by the school scheduling computer system, so sampling was by convenience. The population of students participating in the study were all students chosen to be in the researchers Geometry 201, Geometry 202, and Algebra 2 302 courses during the spring semester of both the 2011-2012 and 2012-2013 school year.

**Variables, Data, and Measurements**

For the first research hypothesis that formative assessment and informed re-teaching improves student achievement in Geometry 201, Geometry 202, and Algebra 2 302, the independent variable was the academic year which had two factors. The first factor was the 2011-2012 academic year (also referred to as Year 1). The second factor was the 2012-2013 academic year (also referred to as Year 2). The dependent variable was the end our course student percentages. There was also a covariate within the design of the study. The covariate was the participating students GPA's upon entering the course.

Using the end of course student percentages, coupled with the student's entering GPA data, the researcher plans to test for significance via a One-Way Analysis of Covariance (ANCOVA). In order to best compare two separate groups of students, both years were graded according to a 0-100% grading scale where 93-100% is an A, 90-92.99% is a A-, 87-89.99% is a B+, 83-86.99% is a B, 80-82.99% is a B-, 77-79.99% is a C+, 73-76.99% is a C, 70-72.99% is a C-, 67-69.99% is a D+, 63-66.99% is a D, 60-62.99% is a D-, and below 60% is a F. The researcher based grades on weighted averages, where homework accounted for 35%, tests for 30%, quizzes for 20%, notebook for 7.5%, and participation for 7.5% of the final grade. The researcher also made every effort to "copy" his gradebook from Year 1 when teaching Year 2. More specifically, the researcher assigned the same homework assignments, tests, and graded each of these tasks the same between the two years.

The second research hypothesis is that: students perceive formative feedback about their performance, coupled with re-teaching for clarification, helps them learn. This hypothesis was addressed in two parts. For the first part, the independent variable was the formative assessment and informed re-teaching. The dependent variable was student perception. Students were asked at the conclusion of every lesson where student responders were used to respond to the following question: "Did our use of student responders help you learn today?" This student perception was measured by three factors. The three factors were: yes, no, and don't know. The researcher will use this data to examine the perception of student responders helping students learn over the course of the semester for each course.

The second part of the study on student perception is qualitative in nature. Data will be taken via a written assessment at the conclusion of the semester. The participants will be asked a similar, but more summative question: "Did using student responders this semester help you learn, why or why not? This instrument will measure student perception of the effectiveness of student responders on their own overall learning for the semester, as well as provide the students an opportunity to explain why they helped them learn, or why they didn't. Results of this assessment will be categorized and grouped to identify common themes for reasons students perceive SRS to be effective (or not effective).

### Treatments and Controls

Students in the spring semester of the 2011-2012 academic year served as the control group, while the students in the spring semester of the 2012-2013 academic year were the treatment group. The treatment in this study was implementing the use of formative assessment via student responders.  The treatment group on a daily basis was asked to respond to questions by entering their answers on the student responders.

### Instruments, Validity and Reliability

One of the instruments that were used was a student survey. This survey asked the participants whether or not the use of student responders for any given lesson was helpful to their learning. A second survey asked the participants at the end of the course to describe how the use of student responders helped them learn. For the third part of the action research, the end of course grades from the 2011-2012 and 2012-2013 school year served as the instrument.

### Timeline

1. January 28, 2013 – February 1, 2013 (First week of semester)
    a. Go over study with students, get students set up with student responders, send the parent letter home with the class syllabus.
2. February 4, 2013 – February 8, 2013
    a. Begin using student responders as formative assessment throughout lessons.

   b. Have students assess at the end of the period whether the use of student responders helped them learn today.

3. February 11, 2013 – May 31, 2013
   a. Continue daily using student responders as formative assessment throughout lessons.
   b. Continue having students assess at the end of the period whether the use of student responders helped them learn today.
4. June 3, 2013 – June 11, 2013 (Last days of second semester)
   a. Ask students to answer the final assessment question: “Did using student responders this semester help you learn, why or why not?”
5. End of Semester
   a. The researcher will gather end of course pass rates for each of his classes.

**Analysis of Data, method(s)**

1. The researcher will perform an ANCOVA test on Year 1 and Year 2 end of course grades.
2. 
   a. The researcher will use results from daily assessment on student perception of the use of student responders in the learning process as a way of gathering feedback to determine the effectiveness of their use for a given lesson. The researcher will use these results to examine any trend in the student perceptions over time for each of his three courses.

b. The researcher will use the qualitative results from the end of course open-ended student response to identify emerging themes.

**HSR Compliancy Statement**

The researcher was trained in Human Subjects Review (HSR) requirements. The Central Washington University HSR board has approved this project.

**Conclusion**

This study was conducted as action research in two Geometry 202 classes, two Algebra 2 302 classes, and one Geometry 201 class during the 2012-2013 academic school year. In this study, the researcher examined the impact of formative assessment (through the use of a student response system) on student achievement via a statistical comparison of the previous years end of course grades in the same courses. The researcher also studied student perception on the effectiveness of student responders for their individual learning.

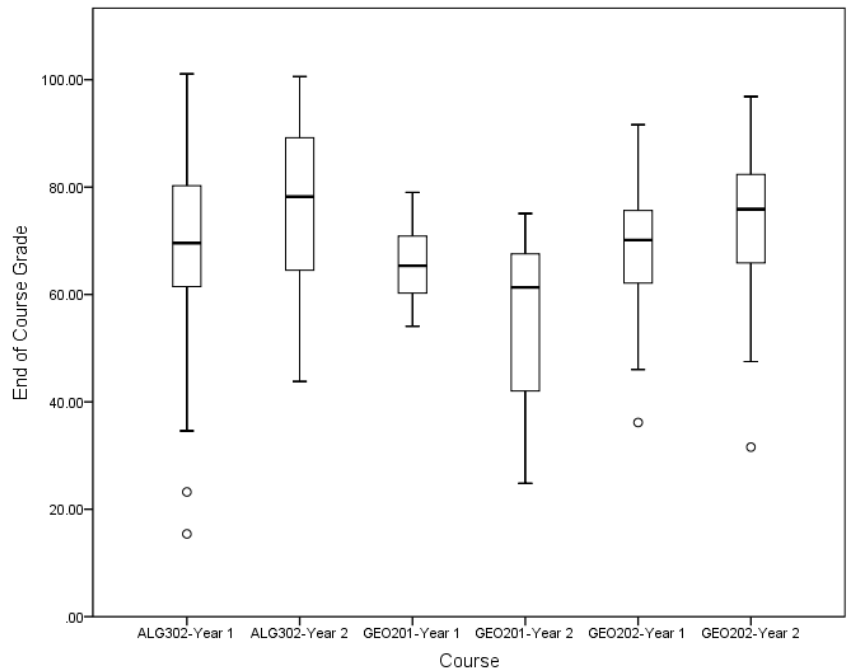
# Chapter 4

## Data and Analysis

### Introduction

This chapter presents the data analysis for the two research questions, which were: (1) Does the use of formative assessments via student responders and informed re-teaching improve student achievement in Geometry 201, Geometry 202, and Algebra 2 302? (2) Do students perceive that getting formative feedback about their performance, coupled with re-teaching for clarification, helps them learn? Necessary data was first collected during the spring semester of the 2012-2013 school year and then later analyzed using the IBM's SPSS statistical software package, edition 21.

The purpose of this analysis is to determine whether the treatment (use of formative assessments via student responders and informed re-teaching) improved student achievement in Geometry 201, Geometry 202, and Algebra 2 302. For purposes of convenience, from here on, the 2011-2012 control year will be referred to as Year 1, and the 2012-2013 treatment year will be referred to as Year 2. Prior to statistically analyzing whether or not significant growth occurred in student achievement for each of three courses, the researcher first took a look at a box and whisker plot of the end of course grades for each course in the study.




*Graph #1: Box and whisker plot of students end of course grades for each course in the action research study.*

The box and whisker plots shown in Graph #1 demonstrate the spread of student end of course grades for each course. In comparing the two plots for each course, there appears to be an increase in Algebra 302 and Geometry 202 treatment years (Year 2), and there appears to be a decrease in the Geometry 201 treatment year. The sections that follow will take a deeper look into whether these increases and decreases were statistically significant.

**Student Achievement (Geometry 201)**

To begin, the researcher first took a look at some of the basic descriptive statistics (i.e. mean, minimum, maximum, and standard deviation) of the end of course grades and student's entering the course GPA for both the control year (Year 1) and the treatment year (Year 2). These results can be seen in Table #1 and Table #2.

| Geometry 201 Year 1 Descriptive Statistics | | | | | |
|---|---|---|---|---|---|
| | N | Minimum | Maximum | Mean | Std. Deviation |
| End of Course Grade | 12 | 54.07 | 79.01 | 66.1800 | 7.754512 |
| GPA | 10 | 1.051 | 2.574 | 1.75480 | 0.490323 |

*Table #1: Geometry 201 Year 1 Descriptive Statistics*

For Year 1 Geometry 201 the two most important statistics are the mean end of course grade (66.18%) and the mean GPA of students entering this course (1.7548). Also worth mentioning, there are two students whom didn't have GPA's on record upon entering the course. This is likely due to these students transferring and the school district not having this data entered electronically.

| Geometry 201 Year 2 Descriptive Statistics | | | | | |
|---|---|---|---|---|---|
| | N | Minimum | Maximum | Mean | Std. Deviation |
| End of Course Grade | 14 | 24.85 | 75.07 | 55.2864 | 15.82106 |
| GPA | 12 | 0.662 | 2.420 | 1.78758 | 0.524359 |

*Table #2: Geometry 201 Year 2 Descriptive Statistics*

For Year 2 Geometry 201, the two are the mean end of course grade (55.29%) and the mean GPA of students entering this course (1.78758). Just as in Year 1, there were once again two students whom didn't have GPA's on record upon entering the course.

After careful inspection of these four means, it is pretty easy to conclude the answer to the first research question for Geometry 201. Due to the large drop in the mean end of course grade in Year 2, coupled with a relatively similar mean GPA, it appears that the treatment did not improve student achievement in Geometry 201. The researcher had designed (by collecting the GPA data) to perform an ANCOVA to test for statistical significance between the control year (Year 1) end of course grades and those of the treatment year (Year 2). However, upon running Levene's test of Equality of Error Variance, it was determined ($p$ = 0.039) that we must reject equal variance and hence assume that the error variance of the end of course grades is not equal. Due to this, an ANCOVA test cannot be conducted. Instead, the researcher conducted an independent-samples $t$ test to evaluate whether there was statistical significance in student achievement between the two years. The test was significant, $t(19.50) = 2.28$, $p = 0.034$, but the results were counter to the alternative hypothesis as mentioned above. In comparing the means, it can be concluded that students in the treatment year ($M$ = 55.29, $SD$ = 15.82) earned significantly lower end of course grades than students in the control year ($M$ = 66.18, $SD$ = 7.75).

The researcher does not believe that this is due to the emphasis of formative assessment via the use of student responders. The researcher noticed another factor that he believes better explains the significant decrease in student performance. As mentioned earlier, this Geometry 201 course consists of a majority of students whom are taking this class for a second time. As a result, in Year 1 the researcher, with the encouragement from administration, decided to have every student and their parent sign a contract that required, among other things, to be present in class (no more than three unexcused absences), and to have no more than three missing assignment for the entire semester. Students were informed that failure to meet this requirement could result in them being dropped from the class. This policy was only put in place during Year 1, because in Year 1 the class was offered during first period. On the other hand, in Year 2, the class was taught during third period and logistically the school chooses to not make a habit of dropping students from classes in the middle of their schedule.

To add numbers to this claim, the researcher found that in Year 1 as a result of the contract, there were in total 74 missing assignments and out of those, 2 of them were tests that were never made up. Conversely, in Year 2 (treatment year) there were in total 168 missing assignments and out of those, 6 were tests, 3 were quizzes, and 1 was a final exam that was never made up. Though the researcher doesn't have the attendance data, he believes it would also show a similar trend between the two years.

**Student Achievement (Geometry 202)**

Once again, in an effort to determine whether the treatment (use of formative assessments via student responders and informed re-teaching) improved student achievement in Geometry 202, the researcher first took a look at some of the basic descriptive statistics (i.e. mean, minimum, maximum, and standard deviation) of the end of course grades and students entering the course GPA for both the control year (Year 1) and the treatment year (Year 2). These results can be seen in Table #3 and Table #4.

| Geometry 202 Year 1 Descriptive Statistics | | | | | |
|---|---|---|---|---|---|
| | N | Minimum | Maximum | Mean | Std. Deviation |
| End of Course Grade | 28 | 36.16 | 91.62 | 69.0739 | 13.03606 |
| GPA | 28 | 1.827 | 3.879 | 2.83725 | 0.555073 |

*Table #3: Geometry 202 Year 1 Descriptive Statistics*

For Year 1 Geometry 202 the most important statistics are the mean end of course grade (69.07%) and the mean GPA of students entering this course (2.83725).

| Geometry 202 Year 2 Descriptive Statistics | | | | | |
|---|---|---|---|---|---|
| | N | Minimum | Maximum | Mean | Std. Deviation |
| End of Course Grade | 49 | 31.57 | 96.87 | 73.9520 | 14.01932 |
| GPA | 49 | 1.096 | 3.968 | 2.74267 | 0.737744 |

*Table #4: Geometry 202 Year 2 Descriptive Statistics*

For Year 2 Geometry 202 the most important statistics are the mean end of course grade (73.95%) and the mean GPA of students entering this course (2.74267). In Table #4, *N* = 49 and in Table #3, *N* = 28. This is due to the fact that in Year 2, the researcher taught two sections of Geometry 202, as compared to just on in Year 1. After initial inspection of the descriptive statistics, note that in Year 2 the mean end of course grade increased, while the mean entering GPA of students in the course decreased.

To test whether this increase was statistically significant an ANCOVA was conducted. First, Levene's test of Equality of Error Variances was run to determine if there was equal variance of the end of course grades across both the treatment and control years. Levene's test for this data was not significant ($p = 0.777$), meaning that we do not reject the null hypothesis of equal variance and may proceed with the ANCOVA test. Second, the researcher tested for homogeneity-of-slopes. Analysis evaluating the homogeneity-of-slopes assumption indicated that the relationship between the covariate (GPA) and the dependent variable (end of course grade) did not differ significantly ($p = 0.653$) as a function of the independent variable (year of instruction).

Having passed both of the above mentioned tests, the researcher performed an ANCOVA and the results are shown below in Table #5.

| Source | *P* | $\eta^2$ |
|---|---|---|
| Corrected Model | 0.000 | 0.430 |
| Intercept | 0.000 | 0.387 |
| Year | 0.017 | 0.074 |
| GPA | 0.000 | 0.413 |

*Table #5: ANCOVA Results for Geometry 202*

The results of the ANCOVA suggest that, after accounting for the covariate (incoming student GPA's), there was a significant ($p$ = 0.017) difference between students end of course grades between the two years. More specifically, by comparing means, we can conclude that students in the treatment year (Year 2) significantly outperformed students in the control year (Year 1). The strength of relationship between the year and the end of course grade was moderately strong, as assessed by a partial $\eta^2$, with the year accounting for 7.4% of the variance of the end of course grades, holding constant the incoming student GPA.

Table #6 below shows the adjusted means for Year 1 and Year 2 when factoring in the covariate (GPA).

| Dependent Variable: end of course grade | | | | |
|---|---|---|---|---|
| Course | Mean | Std. Error | 95% Confidence Interval | |
| | | | Lower Bound | Upper Bound |
| Year 1 | 68.293 | 1.996 | 64.317 | 72.270 |
| Year 2 | 74.398 | 1.508 | 71.394 | 77.402 |

*Table #6: Geometry 202 Adjusted Means*

**Student Achievement (Algebra 2 302)**

Again, the researcher first took a look at some of the basic descriptive statistics (i.e. mean, minimum, maximum, and standard deviation) of the end of course grades and students entering the course GPA for both the control year (Year 1) and the treatment year (Year 2). These results can be seen in Table #7 and Table #8.

| Algebra 2 302 Year 1 Descriptive Statistics | | | | | |
|---|---|---|---|---|---|
| | N | Minimum | Maximum | Mean | Std. Deviation |
| End of Course Grade | 45 | 15.41 | 101.10 | 68.6233 | 18.91331 |
| GPA | 44 | 1.582 | 3.958 | 3.05041 | 0.587128 |

*Table #7: Algebra 2 302 Year 1 Descriptive Statistics*

For Year 1 Algebra 302 the important statistics are the mean end of course grade (68.62%) and the mean GPA of students entering this course (3.05041). Once again, there was one student who didn't have a GPA on record upon entering the course. This is likely due to this student transferring and the school district not having his/her data entered electronically.

| Algebra 2 302 Year 2 Descriptive Statistics | | | | | |
|---|---|---|---|---|---|
| | N | Minimum | Maximum | Mean | Std. Deviation |
| End of Course Grade | 47 | 43.81 | 100.59 | 77.0745 | 15.07848 |
| GPA | 47 | 1.672 | 4.000 | 3.20340 | 0.661445 |

*Table #8: Algebra 2 302 Year 2 Descriptive Statistics*

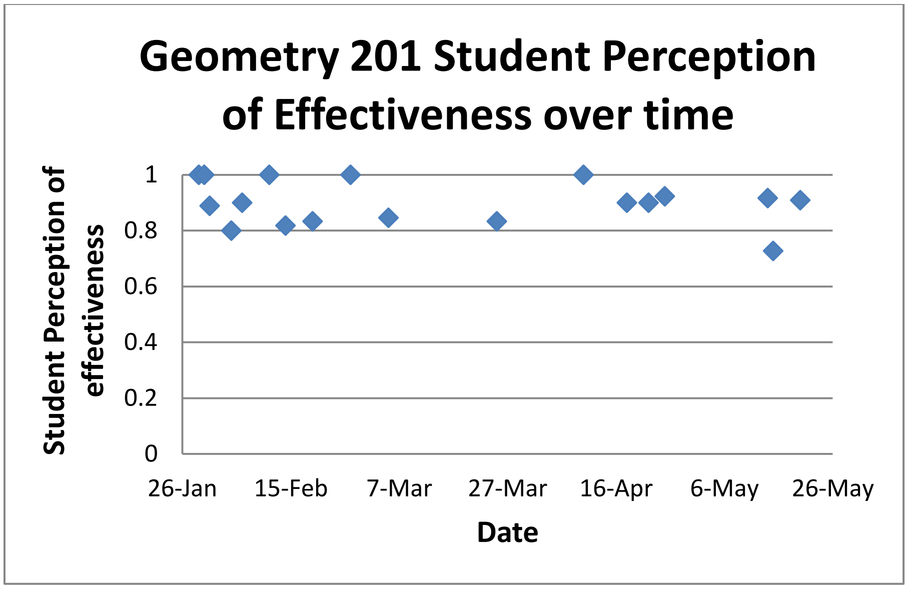
For Year 2 Algebra 302 the important statistics are the mean end of course grade (77.07%) and the mean GPA of students entering this course (3.20340). After a cursory inspection of these descriptive statistics it should be noted that in Year 2 the mean end of course grade increased over 8%, however the entering GPA of students also increased. To test whether or not this increase in student performance in Year 2 was significant, the researcher set out to run another ANCOVA test.

First, Levene's test of Equality of Error Variances was run to determine if there was equal variance of the end of course grades across both the treatment and control years. Levene's test for this data was $p$ = 0.756, meaning that we can accept the null hypothesis of equal variance and proceed with the ANCOVA test. Second, the researcher tested for homogeneity-of-slopes. Analysis evaluating the homogeneity-of-slopes assumption indicated that the relationship between the covariate (GPA) and the dependent variable (end of course grade) differed significantly ($p = 0.02$) as a function of the independent variable (year of instruction). This significant difference means that an ANCOVA test should not be conducted.

As a result, the researcher instead performed an independent samples *t* test. The result of the test were significant, $t(90) = -2.38$, $p = 0.02$. These results support the research hypothesis that students in the treatment year (*M* = 77.07, *SD* = 15.08) earned significantly higher end of course grades than students in the control year (*M* = 68.62, *SD* = 18.91).

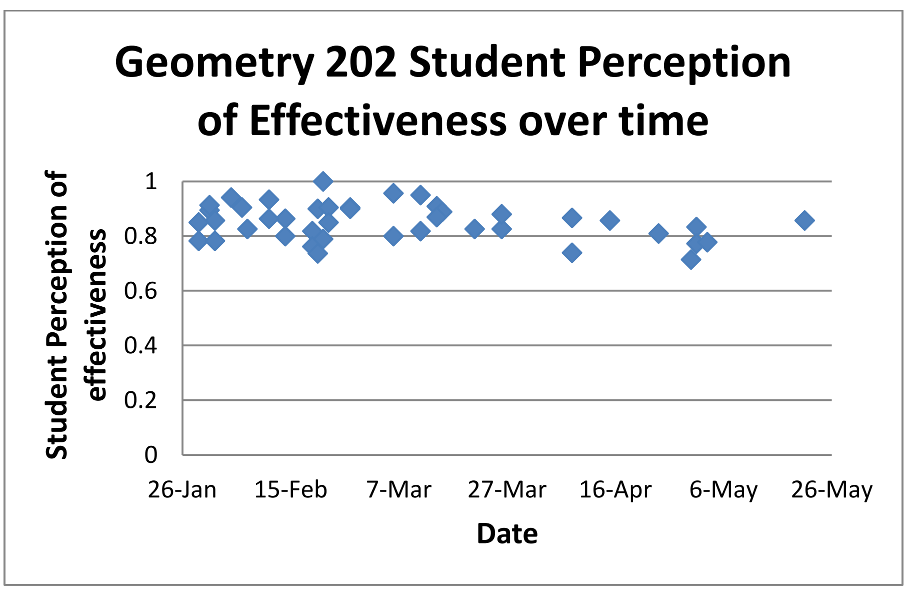
**Student Perception (Part 1)**

For each lesson that the researcher incorporated formative assessment through the use of student responders into his instruction, his students were asked to respond to the following question: Did our use of student responders help you learn today? The students were asked to choose either A = "Yes", B = "No", or C = "Don't Know". This data was collected over the course of the semester for each of the five class periods participating in the study. The researcher then calculated the percentage of students that chose to answer the above mentioned question with "Yes" for each day data was collected. In wanting to see if any trend could be identified between this percentage over time, the researcher decided to graph this data over the course of the semester for each of the three courses. Included below are these three graphs.



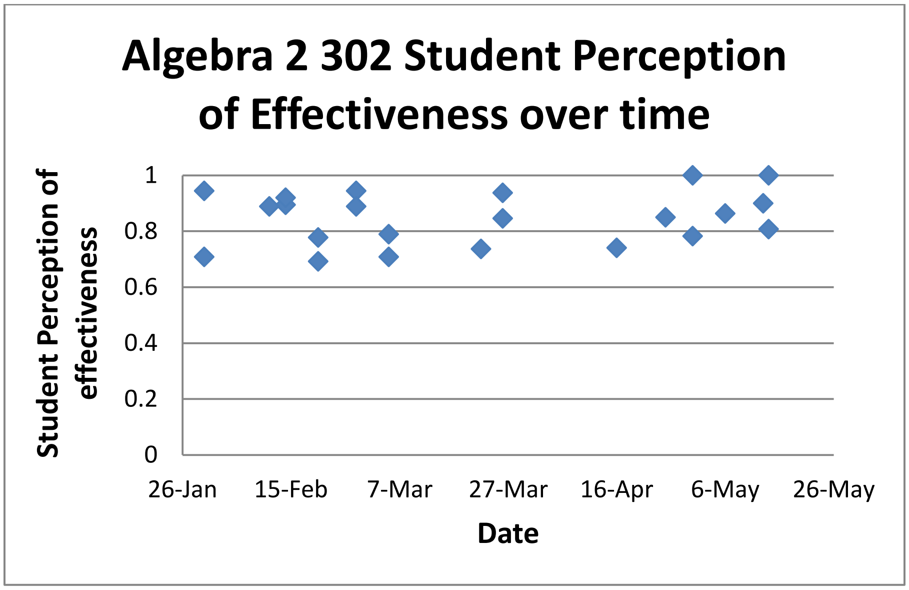

*Graph #2: Percentage of students in Geometry 201 stating that the student responders were helpful to their learning over the course of the semester.*

The researcher also did an average of the daily percentage of students responding that the use of the responders was helpful to their learning. The average for the Geometry 201 course was 90.07%. In other words, on average and on any given day throughout the semester, 90.07% of the researchers Geometry 201 students perceived the use of the student responders to be helpful to their learning.




*Graph #3: Percentage of students in Geometry 202 stating that the student responders were helpful to their learning over the course of the semester.*

Again, the researcher calculated an overall average percent effectiveness response for the entire semester. The researcher found that, on average throughout the semester, 85.07% of his Geometry 202 students perceived the use of student responders helped them learn.

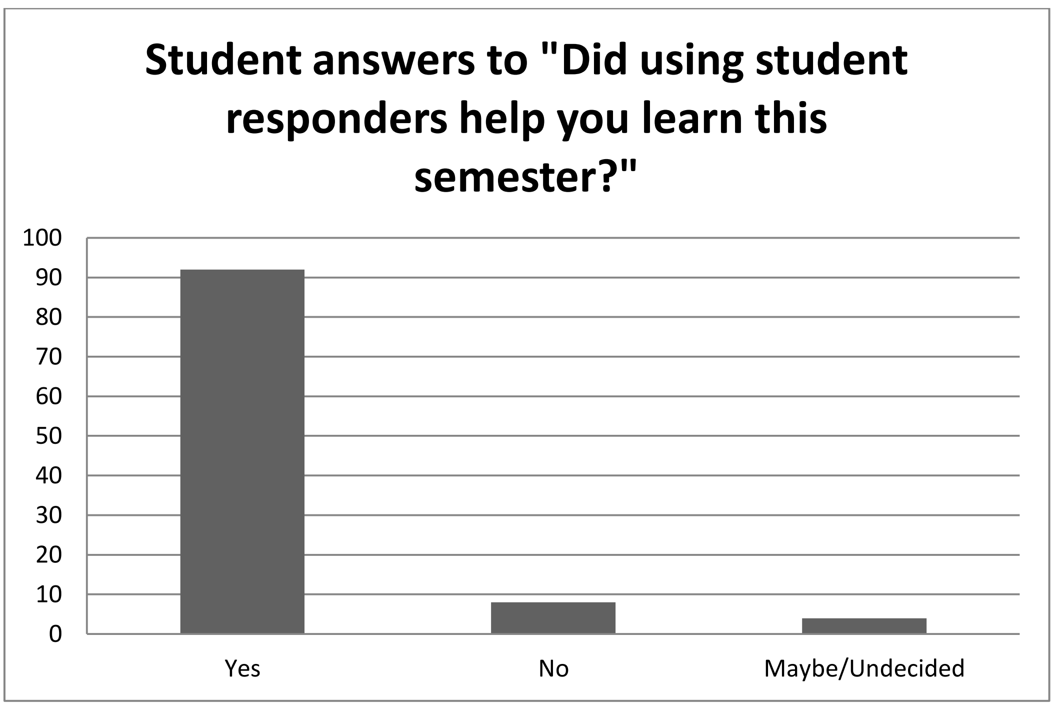



*Graph #4: Percentage of students in Algebra 2 302 stating that the student responders were helpful to their learning over the course of the semester.*

Once again, the researcher calculated an average of the daily percentages of students responding positively to the use of student responders. The researcher found that, on average, 84.75% of his Algebra 2 302 students on a daily basis perceived the use of student responders helped them learn. Out of curiosity, the researcher also calculated an average positive response to the daily question for all of his courses combined. The researcher found that, on average, 86.10% of his students, on any given day, perceived the use of student responders helped them learn. Also noteworthy, the scatterplots shown above do not have a very noticeable positive or negative slope to them. This suggests that, contrary to some reports in literature, students didn't seem to lose any excitement over the technology as the semester wore on.

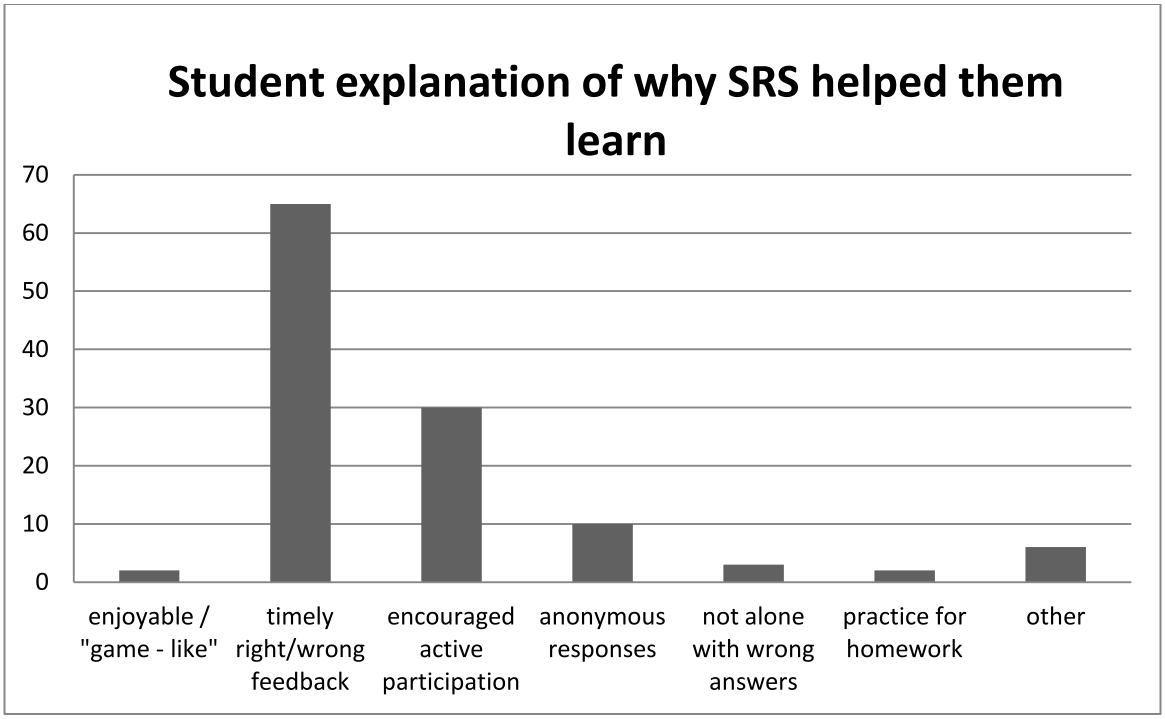
**Student Perception (Part 2)**

At the conclusion of the semester the researcher asked the participants in the study to answer the following question: Did using student responders help you learn this semester, why or why not? Using qualitative analysis the researcher first tallied the number of "yes", "no", and "maybe/undecided" responses. A total of 104 participants responded to this question, with 92 (88.46%) responding with a "yes." There were 8 participants that said "no," and 4 more participants that either said "maybe", or were non-decisive. The following graph depicts these responses.



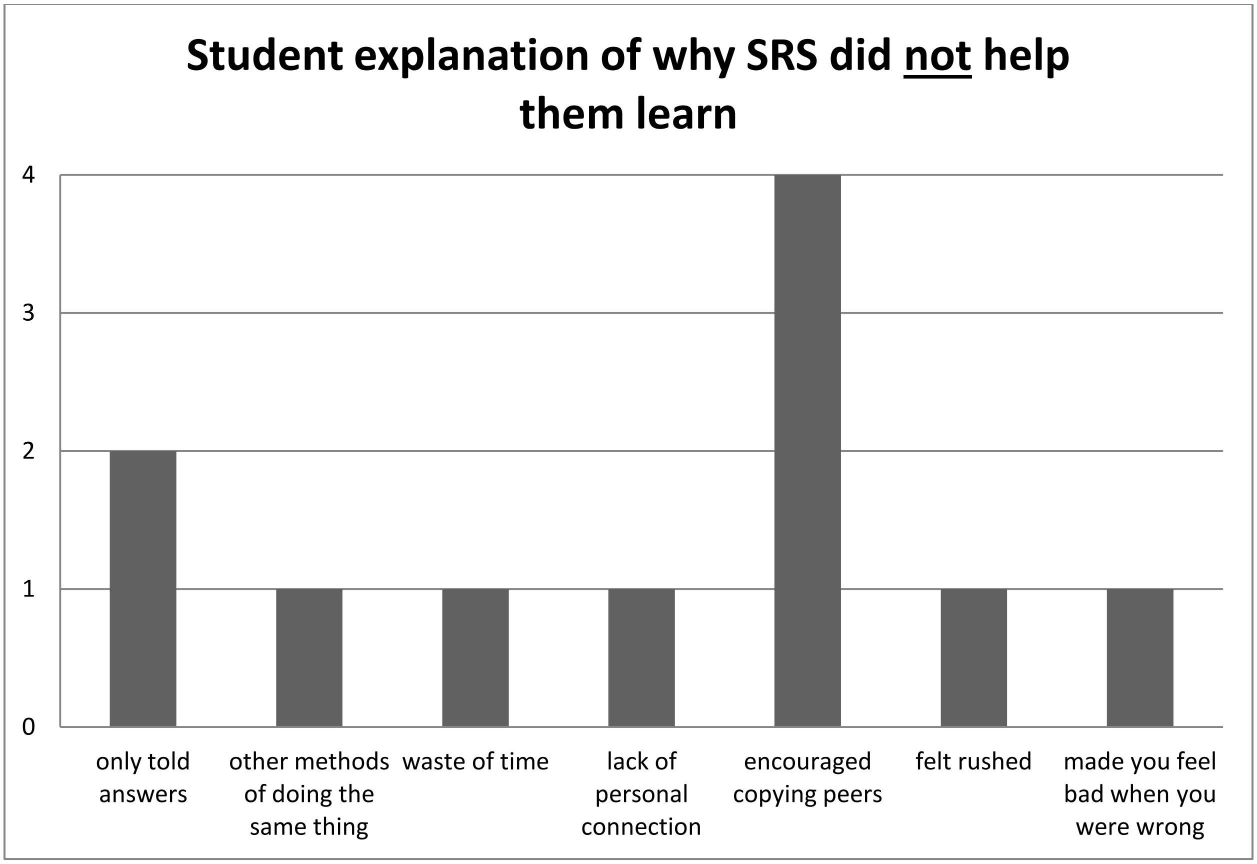

*Graph #5: frequency of student responses to the end of semester question: Did using student responders help you learn this semester?*

In an effort to identify any emerging themes, the researcher then sorted through each of the participants responses to the "why or why not" part of the question. The researcher summarized the responses and then tallied the number of times each explanation occurred in all of the participants responses. For the participants who responded with a “yes”, the reasons listed (followed by the number of times it occurred in parenthesis) were: made class more enjoyable or “game-like” (2), gave me timely right/wrong feedback (65), encouraged active participation (30), responses were anonymous (10), I’m not alone with wrong answers (3), and allowed me to practice for homework (2). There were also some notable responses that were unique and worth mentioning. One student wrote: “Yes, because I got a better grade this semester.” Another participant said: “Yes, because it allowed me to be put in a test-like situation where I was on my own and had to solve a problem without help. This let me know where I needed improvement or help.” In addition to getting timely right/wrong feedback, another student wrote: “along with the in class discussion on said answers, it helped me understand why I got correct or incorrect answers.” Graph #6 below depicts this information.




*Graph #6: student perceptions of why SRS helped them learn and the number of times they were included in the end of semester questionnaire.*

For the participants who responded with “no”, the reasons listed were: they only told me the answer (2), there are other ways of doing the same thing (1), it was a waste of time (1), there is a lack of personal connection (1), it encourages students to copy the answers of their peers (4), I felt rushed (1), and it made me feel bad when I was wrong (1). The following is one response that touched on a couple of these above mentioned reasons: “No, because they allowed me to simply ask a friend what to type in rather than having you come around and check, then see me struggling and help me.” Again, the graph below illustrates these reasons and their frequencies.




*Graph #7: student perceptions of why SRS did not help them learn and the number of times they were included in the end of semester questionnaire.*

# Chapter 5

## Summary, Conclusion, and Recommendations

### Summary and Conclusion

The researcher used a convenient sample consisting of one Geometry 201 class, two Geometry 202 classes, and two Algebra 2 302 classes to conduct an action research study. As part of the action research, the researcher compared the treatment group (above mentioned five classes) to a control group (same courses taught in the previous spring semester). While teaching the treatment group, the researcher made every effort to conduct these classes in the same way he did the previous spring, with the only difference being the intentional focus to implement formative assessment practices by using the student responders. The purpose of this study was to examine the effectiveness of incorporating routine formative assessment into daily instruction through the use of student responders. This effectiveness was measured quantitatively by comparing end of course grades (students earned percentages) between each course taught in consecutive spring semesters, as well as qualitatively by polling students of their perception of the effectiveness of the student responders.

The first research question was: Does the use of formative assessments via student responders and informed re-teaching improve student achievement in Geometry 201, Geometry 202, and Algebra 2 302? This study has shown that in Geometry 201, due to other factors involved, it is inconclusive as to whether or not the implementation of formative assessment via student responders improved student learning. Due to the lack of consistency in the set-up of the course, it would not be fair to conclude that the use of formative assessment lessened or improved student achievement in this course. This study showed that in Geometry 202, through an ANCOVA test, that the use of student responders significantly improved student achievement. This study also concluded that in Algebra 2 302, through an independent samples *t* test, that the again the use of student responders significantly improved student achievement.

In terms of the second research question: Do students perceive that getting formative feedback about their performance, coupled with re-teaching for clarification, helps them learn? This action research study has concluded that students do perceive that the aforementioned treatment helps them learn. Statistically, the study found as result of the daily questions that on average 86.10% of students, on any given day, perceived the use of student responders helped them learn. Additionally, and in agreement with this statistic, at the end of the semester 88.46% of students of surveyed students perceived the use of student responders helped them learn.

As a result of the end of the semester questionnaire, this study also suggests explanations for why students perceive that the use of student responders helps them learn. The three main responses were: (1) the immediate right/wrong feedback they received, (2) the opportunity to actively engage in their learning, and (3) the lack of fear associated with responding due to the anonymous nature of the SRS.

**Recommendations**

Due to findings of significant improvement in student achievement in both Geometry 202 and Algebra 2 302, the researcher recommends continued use of formative assessment via student responders in all courses. The researcher supports this recommendation with additional personal experiences. The researcher recalls multiple occasions where the data collected via the student responders informed him that either he needed to re-visit content that otherwise would not have been, or informed him that he did not need to re-visit content that otherwise would have been.

Inadvertently, as a result of the research findings related to the Geometry 201 course, the researcher recommends any course with a majority of students repeating require students sign a contract.  It is also recommended that these courses be offered during the first or last period of the day, for the option of short-scheduling students who fail to uphold the expectations of the contract.

As a result of the literature review, the researcher recommends not initially sending feedback of whether student responses were correct or not.  Rather, it is suggested that the instructor display the array of student answers, and encourage students to volunteer to communicate why they answered the way they did. Another related suggestion drawn from the literature review is that for incorrect answers, to ask students: What conditions would make that answer correct?  These added dimensions should only increase student achievement levels further.

Lastly, the researcher understands that this research study had a rather small sample size.  The researcher recommends continued study with the same parameters. Consistent findings, in similar studies over the course of multiple years, will have more impact on the educational community.

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