TARGETED FEEDBACK ON GEOMETRY-BASED FORMATIVE ASSESSMENT AND STUDENT RESPONSE IN THE NINTH GRADE MATHEMATICS CLASSROOM

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ABSTRACT

Purpose of the study: the purpose of my study was to conduct a qualitative inquiry into my own practice concerning formative assessment. I wanted to know how useful my students felt formative assessments were, how valuable they considered my feedback to be, and if specific aspects of my feedback were more valuable than others. In doing so, I hoped to gain a deeper insight into my own practice and how I could refine my formative assessments and feedback to best fit the needs of my students and to maximize their learning.

Procedure: in order to determine if and how my students utilized my feedback from formative assessments, I decided to examine their responses to an interview protocol probing their insights into what aspects of our assessments and my feedback were most beneficial to them as a geometry student. I had an initial assessment of student interest and value placed in mathematics as a way to establish a link between students who value assessment feedback and those who enjoy mathematics, or least view it with a positive disposition.

Findings: what I found was that my students, for the most part, cited the single most important factor from assessments as being the feedback I provide. Allowing them the ability to see what they were able to do correctly, what they knew, what they understood, and where they made mistakes. Due to the specific nature of my feedback, they were able to not only see where they made a mistake, but had an idea of how to correct it.

Conclusions: by conducting this inquiry, I learned much about myself as an educator and about my students as learners. I learned that the more specific feedback I can give, the better, and the more beneficial it is to my students. In addition, I learned that my students utilize feedback very differently and this difference tends to stem from how they view success in the mathematics classroom. Going forward, I intend to use this information to better empower my students to do their best and to feel successful.

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Chapter One

Introduction

The field of mathematics has changed rapidly over the past decade. With the arrival of the Common Core State Standards and the Mathematical Practice Standards, there has been a noticeable shift in the way mathematics is viewed in the classroom. The definition of being proficient in mathematics is changing as reflected in Alan H. Schoenfeld's (2015) description of a proficient mathematical student as one having rich and connected mathematical knowledge. Procedural fluency (skills) is no longer the sole focus under the lens of the Common Core. Knowledge and understanding have seen an increase in importance with the emphasis on problem solving, reasoning, communicating, and modeling with mathematics. The National Research Council (NRC, 2001) shows the representation of mathematical proficiency as intertwining adaptive reasoning, strategic comprehension, conceptual understanding, productive discussion, and procedural fluency. With a shift in what is being assessed, there must also exist a shift in the way that we, as educators, assess student understandings.

Formative assessments are examinations of performance opportunities, the primary purpose of which is to provide students and teachers feedback about the student's current level of proficiency and understanding, while there are still opportunities for student improvement (Schoenfeld 2015). The aim of my study was to examine the shift in my own teaching practice from the use of traditional to formative assessment to provide students with feedback on their learning. In doing so, I aimed to motivate them to become more confident and self-directed learners, drawing upon research that has demonstrated that classrooms in which teachers regularly employ formative assessment strategies, student learning is enhanced (Black & Wiliam, 2010; Ehrenberg et al., 2001, Popham, 2013). Formative assessment is perhaps the best way to assess student learning. Because the assessment is individualized, the results cannot be influenced by elements outside of the student's own knowledge and understandings. Furthermore, formative assessments allow the student an opportunity to learn from his/her mistakes and to focus on ways to develop his/her areas of weakness.

The aim of this research was to create a new type of formative assessment, one that breaks down each question into categories of skills, knowledge, and understanding. This new type of formative assessment was a necessary component of the shift in mathematics because it provided the student with a more detailed understanding of what they knew and do not yet know in relation to the focus of instruction. Currently, when a student receives a marked formative assessment, they see a percentage or letter grade representing their performance. However, I felt that this score was meaningless on its own. In my experience in teaching math, percentage based grading systems failed to provide accuracy and made little to no logistical sense to the student in the process of learning math (Guskey 2013). Telling a student they earned a grade of C+ does nothing to inform the student of what they are actually capable of doing, what they know, and to what depth they understand the mathematics.

I am currently in my sixth year of teaching secondary mathematics and creating meaningful assessments has been something I have continually struggled with in developing my teaching approach. I am not alone; many teachers struggle with how to create meaningful and informative assessments. A critical question we ask ourselves is how to develop assessments that motivate student learning – i.e. assessments that get our students to actually care about the results. Answers to the question of the development of meaningful, student-centered assessments are varied and complex. However, in this thesis, I will focus on one example of my development of this type of assessment as a means to motivate my students' learning in mathematics.

This thesis will report information from an informative study that focused on how students in a freshman level geometry class reacted to a new type of assessment feedback. This new assessment gives feedback not as a percentage or letter grade, but rather through reporting on the students' performance on skill-based questions, knowledge-based questions, and understanding-based questions. For example, a student could be asked a skill-based question on graphing a linear function. A student could be asked a knowledge-based question about describing the domain and range of a quadratic function. A student could be asked an understanding-based question of why a rational function has exclusions in the domain.

The goal of the study was to determine if students' motivation increased after engagement with this form of assessment.

Problem Statement

As educators, we view assessments as vital and informative aspects of our teaching. We use them to determine where students are struggling and where they are excelling. Using this knowledge, we can choose to move ahead in our curriculum or to revisit specific topics. Unfortunately, our students do not view assessments in this same way. Students especially view assessments as being another tedious facet of the course that they are forced to complete. They reduce studying to memorizing information long enough to regurgitate it onto an exam and then move on to the next unit. Students do not seem to care about the information provided to them or check their learning progress. In order for assessment to play a more useful role in helping students learn it should be moved into the middle of the teaching and learning process instead of being postponed as only the end-point of instruction (Shepard 2008).

If students are to improve, they must have a concept of their learning goal. Teachers are responsible for providing the feedback students need to do this. Successful students engage in self-assessment as a regular, ongoing process and actively tried to fit new information about their learning into their career as students (Brookhart 2001). Using more focused and smaller assessments (i.e. quiz) is one approach to providing ongoing feedback to students throughout the unit of instruction. Such smaller assessments are beneficial to students and educators for pinpointing various forms of inconsistencies in understandings. Quizzes are excellent tools to illuminate gaps in understandings that can be addressed prior to students taking the summative exam.

Significance of Study

The significance of this study lies in the fact that formative assessment, when used properly, can improve student motivation to learn mathematics. There is a body of research on attitudes and beliefs regarding math that demonstrates a positive correlation between students' confidence levels in regards to mathematics and their achievement (Crosswhite, 1972; Schoenfeld, 1989). Oftentimes, students' perceptions of their math ability come from instructional contexts in which students are told at a young age whether or not they are proficient at mathematics. These judgments are typically based on the student's ability to perform operations quickly, not their mathematical thinking. This is especially dangerous when these students reach secondary mathematics and are faced with the challenge of problem solving. Since they have been told they are proficient in mathematics, they are less likely to attempt a response when they are unsure of a solution.

Excellent teachers are concerned with knowing what students understand and how they learn, so they can help students integrate new ideas and transform prior conceptions (Gearhart & Saxe, 2004). Gearhart & Saxe (2004) undertook an investigation of a professional development program intended to improve teachers' pedagogical knowledge in mathematics. Their findings demonstrated that building teachers' knowledge of mathematics, students' mathematical thinking, and methods of assessing student thinking can strengthen classroom practices and increase students' mathematical understanding and skill. These findings provide solid evidence that students benefit when their teachers use sound mathematical curriculum *and* engage in ongoing assessment of understanding.

Inspired students want to learn mathematics (Schoenfeld, 1989). Instead of receiving a percentage reporting on arbitrary proficiency, if students instead received targeted and specific feedback about their ability in the realms of skill, knowledge and understanding, it could lead to a positive attitude and perception towards mathematics.

Limitations of Study

This is a qualitative self-study of the use of formative assessments to improve the quality of feedback to students learning geometry, with the larger goal of motivating student learning in geometry. Thus, there are limitations to the study I conducted with respect to generalizing my findings beyond the scope of my individual classroom setting. The research methods used were based on the examination of experience from the perspective of students in my 9th grade geometry class, in the context in which I shifted from traditional to formative assessments. The study participants comprised a relatively small sample size (twenty-six) of freshman students who were taking geometry.

What follows will be a literature review of how assessment has changed with the adoption of the Common Core State Standards; what current grading practices are being implemented; models of growth and development; varying practices of assessment; the impact of grade reform on assessment; the impact of grade reform on teacher practice; and how grade reform influences student motivation and classroom culture. All of these topics contribute to the development and implementation of assessment in the classroom and all must therefore be used to help adapt and refine assessments.

Chapter Two

Review of the Literature

Introduction

Historically, mathematics curriculum focused almost exclusively on mathematical content and procedural fluency. Then, in 1989, the National Council of Teachers of Mathematics (NCTM) introduced *Curriculum and Evaluation Standards for School Mathematics,* shifting the lens of mathematical proficiency onto one centered on problem solving, reasoning, communicating with mathematics, and making connections with mathematics (Schoenfeld 2015). The instructional practices used in the majority of our nation's classrooms will not prepare students for these new demands nationally or globally. To remain competitive, the United States needs to produce highly trained individuals who can think critically and abstractly to solve complex problems.

Within the last ten years, the shift in the definition of mathematical proficiency for K - 12 has been supported by the introduction and subsequent adoption of the Common Core State Standards for Mathematics (CCSSM) and the Common Core State Standards for Mathematical Practice (CCSSMP). The standards, particularly the practice standards, demonstrate that the expectation for students has risen from merely providing the correct solution to justifying and explaining how they arrived at that particular solution. Teachers are strongly encouraged to facilitate and deliberately orchestrate productive mathematics discussion in the classroom. The National Council of Teachers of Mathematics helped to articulate the standards, as well as means to achieve them. NCTM members Margaret S. Smith and Mary Kay Stein (2011) argue that in mathematics classrooms, high-quality discussions support student learning of mathematics by helping students learn how to communicate their ideas, making students' thinking public so it can be guided in mathematically sound directions, and encouraging students to evaluate their own and each other's mathematical ideas. These are all important features of what is means to be "mathematically literate."

With the shift in emphasis to problem solving, reasoning, communicating with mathematics, we can no longer rely on antiquated methodologies and pedagogy to continue to garner success in an increasingly competitive global marketplace. National studies have shown that American students are not routinely asked to engage in conceptual thinking or complex problem solving (Stigler & Hiebert 1999). Further, it is unrealistic to expect students to learn to grapple with the unstructured, messy challenges of today's world if they are forced to sit silently in rows, complete basic skills worksheets, and engage in teacher-led "discussions" that consist of literal, fact-based questions and answers (Smith & Stein 2011). Thus, we need to redefine what it means for a student to be "mathematically proficient" by redefining what constitutes both our approach to mathematics instruction, as well as our approach to the assessment of students with respect to the problem solving, reasoning, communicating with mathematics, and making connections with mathematics.

One way to promote students' development of these abilities is through formative assessment. Formative assessment is one of the most valuable tools possessed by an educator because it can provide an insight into each student's individual abilities, knowledge, and conceptual understanding and remains the preeminent instrument to determine how a lesson is progressing. As this thesis project focuses on an exploration of the use of formative assessment in the mathematics classroom, the following review of the literature will first investigate what formative assessment is, how it has been used in the classroom, and how the adoption of the new CCSSM has changed the image of formative assessment. Second, this review will examine what current measures of assessment reform have been introduced and how effective they have proven to be. Finally, it will explore the purpose of including knowledge and understanding based questions in formative assessment.

Subsection One – Shifts in assessment under the common core

Educational standards have been a topic of constant discussion for the better part of a century. Formal standards for mathematics were developed in 1989 when the NCTM published *Curriculum and Evaluation Standards for School Mathematics*. From that time, the standards centering on mathematics have changed repeatedly and rapidly in an effort to produce mathematically proficient students. Most recently, the adoption of the CCSSM has again shaped the way mathematics is to be viewed and taught in classrooms throughout the Unites States. The most significant shift under the CCSSM has been the increased focus on students' development of mathematical communication. There are reasons for this shift in emphasis: mathematical communication has been observed to engage students developing deeper understandings of mathematics (Kosko & Gao 2017).

Adabor (2013) defines formative assessment as the daily formal and informal assessment procedures conducted by teachers during the learning process in order to modify teaching and learning activities to improve student attainment. Formative assessments are one of the most powerful tools in the educator's toolbox. A well articulated formative assessment allows educators to see exactly where their students are struggling and where they are having success. Moreover, unlike a summative assessment, formative assessments can be used as a learning tool and retaken to the benefit of the student. Formative assessments can be conceived as micro summative assessment and, for that matter, they have identical of complementary objectives of determining mathematics learning outcomes. Adabor (2013) asserts that mathematics education is about the curriculum, teaching, learning, and assessment. In addition, assessing mathematical proficiency among students cannot be dissociated from mathematical comprehension or understanding (Adabor 2013). The benefits of developing a student's proficiency, comprehension, and understanding simultaneously are also supported in Wiggins and McTighe's work concerning understanding by design (2005). Understanding by design process is centered around the concept of working backwards from one's goal and using assessments throughout to determine where exactly students are on the pathway to the goal.

In addition to the new Common Core State Standards for Mathematics (CCSSM) the Common Core State Standards for Mathematical Practice (CCSSMP) state what students should know and be able to do in relation to mathematical problem solving. The eight (8) Standards for Mathematical Practice are summarized in Table #1 below.

Table #1

Common Core State Standards for Mathematical Practice
1. Make sense of problems and preserve in solving them
2. Reason abstractly and quantitatively
3. Construct viable arguments
4. Model with mathematics
5. Use appropriate tools strategically

6. Attend to precision
7. Look for and make use of structure
8. Look for and express regularity in repeated reasoning

To assess these new practice standards, the Smarter Balanced Assessment Consortium (SBAC) has not only aligned their Smarter Balanced Assessment (SBA) with the CCSSM, but also established four claims for the mathematics summative assessment (SBAC 2012). These claims are:

Claim #1 – Concepts & Procedures "Students can explain and apply mathematical concepts and interpret and carry out mathematical procedures with precision and fluency."

Claim #2 – Problem Solving "Students can solve a range of complex well-posed problems in pure and applied mathematics, making productive use of knowledge and problem solving strategies."

Claim #3 – Communicating Reasoning "Students can clearly and precisely construct viable arguments to support their own reasoning and to critique the reasoning of others."

Claim #4 – Modeling and Data Analysis "Students can analyze complex, real-world scenarios and can construct and use mathematical models to interpret and solve problems."

The shift observed in the language of the CCSSM and the claims of the SBA are an indicator of the move away from procedural fluency being the only indicator of mathematical success. To complement this movement, NCTM (2014) has established a checklist for effective teaching and learning in the new mathematical landscape:

1. Establish mathematics goals to focus learning
2. Implement tasks that promote reasoning and problem solving
3. Use and connect mathematical representations
4. Facilitate meaningful mathematical discourse
5. Pose purposeful questions
6. Build procedural fluency from conceptual understanding
7. Support productive struggle in learning mathematics
8. Elicit and use evidence of student thinking

By putting the focus more on using what students know to drive the curriculum and less on direct instruction and note taking, mathematics educators must now be concerned with finding what exactly their students know how to do. Arriving at the correct solution is no longer enough. A student must now also articulate how they arrived at their solution, defending it if necessary from the counter-arguments of others. Students must be prepared to critique the reasoning of others (both fictional and nonfictional) and identify errors in problems. In order to assess student ability in these new areas, we need new assessments; ones that have the capacity to pinpoint precisely what it is our students know and don't know, what they understand and don't understand, in addition to what they can and cannot do.

A helpful example of this would be a student solving a system of linear equations. The skill lies in being able to set up the equations and solve. However, a student could demonstrate their knowledge by explaining that two lines would never intersect because they know the lines must be parallel given that they have the same slope. Furthermore, a student could demonstrate understanding by interpreting a solution of 0 = 0 as meaning two lines have infinitely many points of intersection because any value of would give the same value of in each equation. Teachers have seen a remarkable lack of assessments (quizzes, exams, classwork, and teacher inquiry) that probe these aspects of our students' minds. Educators seem content enough with receiving the correct solution that we purposefully decide not to dig deeper into the conceptual understanding aspects of our content.

Now, sometimes this is because teachers have a considerable curriculum to cover in a truncated period. However, this initial investment of communication via formative assessment will pay massive dividends throughout the school year (Schoenfeld 2015). Schoenfeld contends that, "using formative assessment, which provides information about student understanding at a point when the teacher and students can act productively on that understanding, rather than demonstrating what students "know and can do" after instruction. (2015 p. 189)" Establishing this norm of communication between student and teacher via formative assessment is of paramount importance to create an environment of mutual understanding and the impetus behind motivating the student to improve. "Excellent teachers are concerned with knowing that students understand and how they learn so they can help students integrate new ideas and transform prior conceptions. (Shulman 1987)."

Subsection Two – Assessment benefits for the educator

Assessments targeted to the CCSSM and CCSSMP will provide the educator with more feedback than prior assessments (NCTM 2014). This is because these assessments are held against not only the content standards, but also the practice standards, therefore giving the educator a more informative view into the knowledge and understandings of their students rather than just a snapshot of their procedural fluency. Past versions of formative assessment have reported only a student's skills and neglected to give any information about a student's knowledge or conceptual understanding. These new assessments integrate the CCSSMP, thus creating a new paradigm allowing educators to see what their students know and understand in addition to what they can do. Various types of new "Common Core Ready" assessments put forth by multiple organizations, including: The Integrating Mathematics Assessment (IMA) and The Mathematics Assessment Project (MAP). Alan Schoenfeld (2015) is one of the principal investigators for the MAP and describes the assessments as: "beginning with a diagnostic problem, so that the teacher is provided information about the students' likely strengths and pitfalls." Designed to support teachers, the MAP helps to identify common misconceptions and misunderstandings student have with the content. MAP is designed to support students by revealing their misconceptions and allowing them to further engage with the content.

Gearhart & Saxe (2004) examine one of these Common Core influenced assessments: The Integrating Mathematics Assessment (IMA). The ambition of the IMA is to bridge the gap between developmental research and practice by helping teachers interpret the ways children make sense of challenging mathematical concepts (Gearhart & Saxe 2004). The researchers argue that, "teachers cannot effectively guide children toward a deeper understanding of challenging mathematical concepts without insight into children's mathematical thinking" (2004 p. 305). The researchers study focused on the results from two teachers: Mr. Waters and Ms. Snow and how their students interacting with the lesson *Seeing Fractions*. The IMA uses lessons like *Seeing Fractions* to not only assess whether or not students can successfully arrive at the correct solution, but if they can also interpret the reasoning of others. This is one of the primary areas of emphasis for these new CCSS assessments.

The example from Mr. Waters' class was students partitioning three brownies for six people such that each person receives an equal amount of brownie. Two different solutions were presented: splitting each of the three brownies into a half and distributing each half to each person. The other solution involved splitting each brownie into sixths and then giving each person an equal amount of pieces (three). Each solution is valid, yet some students disagreed that each partition represented the same amount. One student argued that three sixths is more *pieces* than one half. While another student argued, that one half is a *bigger piece* than three sixths. Each student is mistaken in their reasoning, whether they are comparing whole numbers to fractional parts, or the qualitative difference in sizes. The reason is that neither student is seeing the fractional values of the individual partitions. This is of concern because the students are misunderstanding the conceptual aspect of a fraction. The students might be able to memorize a pattern for adding and/or subtracting fractions, however without a conceptual grasp of the content, they will be unable to extrapolate their knowledge to further and more complex topics concerning fractions: multiplication, division, improper, and impartial fractions.

The researchers suggest three roles for the educator: as a learner and reflective critic, as a researcher, and as a professional educator. To formally address scenarios in which student thinking departs from the teachers, the researchers suggest that teaching for understanding requires three domains of knowledge. Knowledge of mathematics, knowledge about children's developing mathematical thinking, and knowledge of pedagogy that helps students use that they understand to build new and more powerful mathematical ideas (Gearhart & Saxe 2004). The case of Mr. Waters is a great example of the teacher as a learner and reflective critic in that he learned where student thinking diverged from his intended learning objective. Moreover, it highlights the teacher as a researcher as he navigated and interpreted student thinking to draw conclusions about misunderstandings and false extensions of mathematical thinking.

In the case of Ms. Snow, she asked her class to visually represent quantities such as one half, one fourth, and one eighth on a 4x4 grid. However, she became concerned when students began referring to one half as *eight squares*, one fourth as *four*, and an eighth as *two*. She wanted to know if students actually understood fractions as a proportion of a whole, or if they simply memorized a counting pattern. She implemented the teacher as a professional educator role and designed an assessment to determine the accuracy of her suspicions. The assessment revealed that in fact some students had merely memorized a pattern and did not fully grasp the concept of proportions to whole.

The cases of Mr. Waters and Ms. Snow provide solid evidence that students benefit when their teachers use sound mathematics curriculum and engage in ongoing assessment of children's understanding (Gearhart & Saxe 2004). Both of these case studies align with David Niemi's (1996) research into assessing conceptual understanding. Niemi's research expresses a new vision for mathematics achievement, in which conceptual understanding plays a central role and mathematical knowledge conceived as a system of relations among mathematical symbol, concepts, operations, activities, and situations (1996). Similarly to Gearhart & Saxe, Niemi also focuses on the conceptual aspect of teaching fractions to primary school students. However, there is a major difference in the researcher's approach to his study. Niemi used a quantitative model to approach fraction instruction, whereas Gearhart & Saxe employed a part-whole model.

Niemi used students from twenty-two fifth grade classrooms (540 students total). These students spent two class periods answering six symbolically presented fraction problems requiring them to: compare fractions of distance, evaluate truth statements, and finding fractions between two other fractions (1996). The researcher's hypothesis, "students who can identify a greater number of correct representations and avoid misidentifying incorrect fraction representations should be able to generate and use representations more effectively in problem solving and explanation tasks and should express more concepts and principles and fewer misconceptions in their explanations" (1996, p. 353). What Niemi found was that there was "clearly a relation between representational fluency and success in problem-solving justification and explanation" (1996, p. 355).

Niemi and Gearhart & Saxe both assessed students' understanding of fractions. However, the methods in which the researchers assessed these understandings were different. Gearhart & Saxe assessed students' understanding of fractions as a part-to-whole relationship and invited the students to justify their reasoning with graphics in addition to their mathematics. While Niemi assessed students' understanding of fractions using a quantitative model, in which the "whole" is some measured or partitioned quantity (Niemi 1996). Although the method of *how* the assessment was carried out sees little change from study to study, the *what* that is being assessed is an entirely different level of conceptual understanding. Both researchers argue that it is imperative for an educator to be clear and precise with not only how they intend to assess their students, but also what they intend to assess.

Walker & Molisani (2014) continue the argument that teacher-driven assessments can provide important information to encourage, expand, or enrich student learning. State standards for mathematics give educators goals to achieve during each lesson or unit, but they do little to nothing to help provide those same educators with the means of how to assess the progress of students towards these learning objectives. Furthermore, assessments used to measure student knowledge about a concept measure other student abilities (Walker & Molisani 2014, p. 470). Many times these assessments provide students with feedback regarding what is expected of them and doesn't necessarily value the mathematics they used to find a solution. Take, for example, the classic word problem of a school play selling both adult and student tickets to a performance. If the students are given information about the price of each ticket, the total number sold, and the total revenue from ticket sales, then they should be able to set up a system of equations and find their point of intersection, thus giving the number of adult and student tickets sold. However, assume that instead of setting up two equations and using a valid method of solving a system, the student instead uses guess and check until they find a solution. The student knows what they are supposed to be finding and they used a method that, along sometimes ineffective, gives them the correct solution. The assessment was meant to gauge the student's level of understanding and correct application of systems of equations, however, without explicit direction it allows for alternative methods and tells us nothing about the student's level of understanding concerning systems of equations.

The researchers make the point that the ability to apply conceptual ideas to new problems is a primary goal for learning (2014). Similar to Gearhart & Saxe and Niemi, the researchers also used the concept of ratios and proportions to investigate the depths of student understanding. Conversely, their research does have significant deviations in that their sample size was middle school students and they did not use a direct assessment on fractions but rather a performance task where the students needed to build a garage matching the scale of a toy car. Although students were also being assessed on their conceptual understanding of fractions, Walker & Molisani's task asked the students to extend their knowledge and to find which procedures can be used efficiently to arrive at a solution for the task. Because the students involved in the task were not familiar with participating in performance tasks, the study began with giving the students three smaller tasks which addressed the concepts of: scaling, how to determine errors in scaling, and unit ratios. The students were then shown a video, given a toy car and it's actual measurements, and then asked to build a garage to match that scale.

Many students found that the unit ratios comparing different parts of their model car to the full-size car were close but not the same. This led to rich mathematical discussion about rounding, tolerance, and human error (2014). To reconcile these discrepancies, the students utilized four primary methods: average the ratios, select the largest unit ratio, select the smallest unit ratio, or select a ratio in the middle of the smallest and largest. All of the students successfully finished a product that matched the scale of their cars. At the end of the assessment all student had made satisfactory progress toward the learning goals of determining the scale of a model compared with an actual object and applying that scale to create something proportional to the model (2014).

All three of the researchers' studies focused on *how* students are assessed on their respective tasks, while also using a similar lens to locate student understandings and misconceptions. Gearhart & Saxe (2004) examined student thinking and finding where it departed from the goals of the educator. Niemi (1996) investigated how students expanded their thinking past the part-whole relationship of a fraction into a quantitative generalization. Walker & Molisani (2014) observed students push their thinking and use their knowledge of mathematics to find which methods were effective and which were ineffectual. All the researches help to illustrate how formative assessment informs the educator about the progress of their students. This information concerning student understanding and misconceptions is vital to the educator's decision about whether or not to proceed with the curriculum. However, the educator is not the only beneficiary of this information. Students also benefit from knowledge of their understandings and areas of growth.

Subsection Three – The benefits of formative assessment for student learning

Similar to the knowledge gained by teachers via progress monitoring, students benefit from knowledge of their progress throughout a particular lesson or unit. Formative assessment provides students with feedback about what they understand and can do as well as information about areas they still need to improve upon. However, there appears to be a detachment between assessment and instruction (Graue 1993). The purpose of formative assessment is to inform students and educators about progress and to inform the educator about whether they can proceed with the curriculum or if it is necessary to revisit certain topics. This purpose is defeated if the educator moves ahead with curriculum regardless of the outcome of the assessment. In fact, due to the increased usage, and importance, of standardized testing in the 1980’s to 2010’s, curriculum has become almost entirely concerned with teaching content exclusively assessed by these standardized exams (Shepard 2000). Educators have little choice but to continue with instruction despite their interpretations from formative assessments.

In their research, Bliem & Davinroy (1997) concerning teacher beliefs about assessment, the researchers found that educators believed that assessments had to be targeted to a specific learning goal. Meaning that educators are more likely to give objective assessments rather than subjective ones in an effort to increase their assessments impartiality. Teachers believed that assessments had to be uniform (1997). These discoveries are fascinating and at the same time, terrifying. They help to describe the climate of education and how the culture of many classrooms and schools is still deeply rooted in the curriculum of social efficiency, scientific measurement, and a hereditarian theory of education. Shepard (2000, p. 98) argues that, “any attempt to change the form and purpose of classroom assessment to make it more fundamentally a part of the learning process must acknowledge the power of these enduring and hidden beliefs.” This is precisely what the CCSSMP attempts to achieve.

Shepard’s (2000) research discusses the historical perspectives concerning assessment in the classroom, introduces a new conceptual framework, and offers ways to improve the content and form of classroom assessment. The researcher takes the foundation of the CCSS and uses it to articulate what she believes will be the future paradigm that classrooms operate within. Contending that,

> “To be compatible with and to support this social-constructivist model of teaching and learning, classroom assessment must change in two fundamentally

important ways. First, its form and content must be changed to better represent important thinking and problem solving skills in each discipline. Second, the way that assessment is used in classrooms and how it is regarded by teacher and students must change." (Shepard 2000, p. 99).

Brookhart (2001) echoes this notion, stating that, "If students are to improve they must have a concept of their leaning goal." (p. 154). Students must have an understanding of what their learning goal is, both internally and externally. It is the role of the educator to provide their students with the concept of the goal, or learning objective, but hopefully, each student will adopt this goal and employ self-monitoring to achieve it. Brookhart's (2001) research describes the formal process of formative assessment and the impact, both positive and negative, that it can have on students and how students view formative assessment. Her research consisted of observations and interviews with high school students about their feelings toward formative assessment, if they felt it was important, and their feelings concerning their performance.

Formative assessment affects students directly by providing them with an indicator of their current performance (i.e. a grade, percentage, or other indicated score). This report tells students where they are in relation to what is expected of them at this point in the unit. How students react to this information is critical in determining how they choose to proceed through the remainder of the unit. If they are unhappy with their score/mark, they might become withdrawn and decide to forgo any effort for the remaining lessons. Or, they might work to improve upon their score. This reactionary attitude is formed by the culture of the classroom and the feedback given on the formative assessment. If the feedback is beneficial (useful, informative, and inspiring), then the student is more likely to improve their efforts. Sadler (1989) articulates the difference between *feedback* and *self-monitoring*. Formative assessment benefits students if it provides information that allows them to self-monitor their progress and find ways to improve upon past performances. Thus, providing students with the tools to identify the gaps in their learning and how to take steps to fill those gaps.

While formative assessment is a tremendous tool for reporting on student progress throughout a unit, it is the manner and quality of the feedback that drives the student. Simply marking a quiz or exam gives the educator a sense of where each student is, but it does nothing to communicate to the student what he or she needs to improve upon, other than stating which problems they got wrong. If feedback is instead given in the form of helpful hints, prompts, and questions (not just stating what the answer is or how to get there) then the student can use this as a jumping pad to further their understanding. Another positive method the educator can use is allowing students to retake the formative assessment once they've mastered the content being assessed. Demonstrating to the student that learning is a process of growth and not a snapshot of where he or she is at one particular moment.

Conclusion

Formative assessment is an enormous category and one of tremendous importance in any classroom environment. Our principal responsibility as educators is to motivate our students to pursue their passions. Proper use of formative assessment is one of the most powerful tools available to accomplish this. Providing students with accurate, honest, non-judgmental feedback allows them to form their own understandings about their gaps in knowledge and potential ways to meet these gaps (Natriello 1987). Using the CCSSMP as a foundational upon which to stand, secondary mathematics educators have a platform to build this bridge of knowledge and communication with students, parents, and other stockholders. The process of changing formative assessment and shifting classroom and school culture to a place where these changes can not only take place, but also thrive is a daunting task.

The research presented in this literature review examine the changes in the mathematics content standards, the addition of the practice standards, the ways formative assessment can benefit the educator, and how these benefits can be applied to student learning. Principally, Schoenfeld (2015), Adabor (2013), Kosko & Gao (2017), and NCTM (1989, 2014) have helped illuminate how the adoption of the CCSSMS/P has and will continue to change the role of formative assessment in the mathematics classroom. Gearhart & Saxe (2004) and Niemi (1996) give case studies of the classroom and how teachers are using formative assessment to draw conclusions about their students' reasoning and ability.

Going forward, educators will be greatly challenged to use assessments in new ways, anticipate areas of struggle, and find methods of motivation that allow students to develop systems of self-monitoring. This study will examine one possible usage of formative assessment in this new and exciting paradigm of education.

Chapter Three

Methodology of Inquiry

Introduction

The new focus of the mathematics curriculum is on problem solving, reasoning, communicating with mathematics and making connections with mathematics, the current instructional practices used in the majority of our nation's classrooms will not prepare students for these new demands nationally or globally. To remain competitive, the United States needs to produce highly trained individuals who can think critically and abstractly to solve complex problems.

As a high school mathematics teacher, I recognized that I needed to make significant changes in the way I teach in order to prepare my students to meet the new curriculum standards. To facilitate improvements in my approach to teaching math, I engaged in a self-study of my use of formative assessment in my 9th grade geometry class. I hoped that doing so would motivate my students, as research has demonstrated that classrooms in which teachers regularly employ formative assessment strategies, student learning is enhanced (Black & Wiliam, 2010; Ehrenberg et al., 2001, Popham, 2013). I implemented this shift to formative assessments with the goals of 1) improving my ability to determine where my students were in their learning and thinking of in terms of my instruction in geometry, 2) aligning my teaching with where they needed to go next to develop their understandings of geometry and 3) better determining how to get them to this destination (Wiliam, 2011, p. 45).

The following questions guided this self-study on the effects implementing formative assessments in my own mathematics instruction in a 9th grade geometry class:

1. Do formative assessments that provide student-centered feedback in the categories of skill, knowledge and understanding help students understand the learning goals and benchmarks for success that inform my instruction?
    a. Does the feedback provided on such formative assessments enhance students' progress in my class?
2. Do student-centered, individual growth model assessments that target the development of knowledge, skills and understanding support more successful classroom discussions and student questions regarding key concepts in geometry?
3. Do these types of formative assessment foster greater student ownership of their learning?

For this self-study, I introduced a new form of marking assessments in three categories: knowledge, skills and understanding. I chose these three categories in order to create more transparency for students by making visible to them the areas in which I was assessing their performance in geometry. Using this formative assessment, I intended to shift from using assessments that provided students with feedback in the form of a percentage or letter grade; instead I would report back to students their performance in relation to math problems in terms of the three categories of assessment: knowledge, skills, and understanding. To clarify my shift in instructional focus for my students, I informed them regarding the manner in which I planned to provide feedback on their exams and what my feedback meant.

Setting

This study took place at a 9-12 mid-sized high school with approximately fourteen hundred students. The high school currently employs freshman teams, which help acclimate new students to the campus and high school culture. The high school also has pathways, which are designed to give students an alternative to the traditional high school curriculum.

This is the only comprehensive high school in the district. The district focuses on students being college and career ready by the time they graduate high school, this is accomplished through having the A-G requirements for graduation and using interim benchmarks throughout students' primary and secondary education. These benchmarks determine whether a student is at grade level in a particular subject, and if not, then intervention strategies will be used to help that student reach grade level.

The surrounding community is very involved in the activities that go on at the high school. Many volunteers from the community help out at the high school, including: being a classroom aide, helping with campus beautification, attending school functions, helping build class floats, offering donations, and other services. The high school has a parade and rally for homecoming, which is widely attended and supported by the community.

This study is primarily conducted in a relatively small classroom size, with tables, and twenty-seven students. The primary text is College Preparatory Mathematics' (CPM) Core Connection Geometry, but I am constantly supplementing with additional resources and secondary sources. These are mainly physical group activities that I've borrowed from fellow teachers or the Internet to help develop the skills and concepts that are presented in the CPM text. The majority of students have an indifferent disposition to mathematics, but they also want to perform well and be successful.

My classroom is bright throughout the day and has a variety of posters on the walls, mainly student created, as well as many informational papers posted around the classroom. Students have easy and immediate access to scissors, paper, rulers, pencils, calculators, tape, staplers, and other classroom materials and resources. Our learning objectives and agenda are posted in the same space on the same whiteboard everyday, homework and classwork is turned into the same place everyday, a list of our past and current assignments are located on the grade book website (PowerSchool) and on our Google Classroom, and the students have become familiar with these routines and procedures.

I decided that my freshman geometry class would be the best choice for my qualitative study because of the range of student disposition concerning mathematics and because the problems in geometry are easier to denote as: skill, knowledge, or understanding.

Participants

This study followed a protocol approved by the Institutional Review Board at Sonoma State University. There were twenty-seven students in the 9th grade geometry class that was the focus of this self-study. Of the total class population, 40% of the students were identified as Hispanic, 59% were identified as white, with 1% other. The overall high school population was closer to 50% Hispanic, 48% white, and 2% other, so the class was slightly skewed. There were three students who are enrolled in GATE; one student with an IEP, and two with 504's for ADD/ADHD. In addition, 28% of the students were RFEP (Re-designated Fully English Proficient), 72% are English only, and 0% ELL. 54% of the students were female and 46% were male. The students were part of a freshman team, so the students had (almost) all the same core (English, math, science, and physical education) teachers, and were able to form a small learning community. I found that the team environment helps boost student morale, teacher-student relationships, social skills, and their overall disposition about the school. All of the students knew each other fairly well and were comfortable working within a group setting.

Design of the Geometry-Based Formative Assessments

Each of my assessments had questions labeled as a skill-based, knowledge-based, or understanding-based question. A sample exam (Appendix A) has been included to demonstrate the difference between these types of questions.

Table #2. Format of the 9th Grade Geometry Formative Assessment

<table>
<tr><td colspan="2">Each formative assessment question is labeled as skill-based (S), knowledge-based (K), or understanding-based (U).</td></tr>
<tr><td colspan="2">Each question was scored from 0 to 10 (excluding 1, 2, 3, and 4)
Teacher used the individual question score to give categorical scores for S, K, and U
Teacher provided written feedback on the assessment in the form of comments and questions</td></tr>
<tr><td>10</td><td>Demonstrates mastery</td></tr>
<tr><td>9</td><td>The student had a very good idea of how to solve the problem, but made small mistakes that led to an incorrect solution.</td></tr>
</table>

8	The student had a good idea of how to solve the problem, but made multiple small mistakes.
7	The student had an idea of how to attempt the problem, but made major errors in reasoning.
6	The student made a good attempt at the problem and had an idea of how to begin the problem
5	The student was unsure of how to approach the problem, but it was attempted and the context of the problem is present and understood
4	The student was unsure of how to begin, but tried something.
0	The problem was not attempted

Data Collection Procedures

The data that I analyzed for this self-study are comprised of the following: 1) a student survey implemented at the beginning of the fall semester to gather information on students' disposition towards mathematics, as well as what their previous mathematical experiences had been like (Appendix B), 2) a task asking the students to identify question types, 3), a formal interview process for a diverse selection of the students and 4) narrative data collected through observations. Four main types of data were collected using discussion prompts, a survey, exams and quizzes, and interview questions. The researcher utilized an online survey (Mathography & Appendix B), an interview protocol (Appendix C), and an observational checklist (Appendix D) to collect data. The narrative data collected through observations and interviews was transcribed, coded, and organized in relation to its relevance to the research questions. Because of the relatively small size of my 9th grade geometry class and the willingness of all students to participate in interview sessions, I decided to interview all twenty-seven of my students. This method of sampling was chosen for convenience and because all of my students met the predetermined important characteristic of having a well-defined disposition of mathematics, regardless of positive or negative. The interviews were transcribed and coded by type of answer given, i.e. a student believing they were doing well in class thus far would be denoted as (+), whereas a student who also has a positive disposition towards mathematics would be denoted as a (+/+). The survey was coded in a similar way and then compared to the interview responses. I chose this method because I wanted to capture the complete breadth and depth of my class. However, using a method of sampling that only selected individuals based on one distinct characteristic could potential invalidate my findings by ignore the experiences of those students without that particular characteristic (Palinkas, Horwitz, Green, Wisdom, Duan, & Hoagwood 2015).

The data were collected through observations, interviews, and an online survey. The observations were collected under normal classroom circumstances using an observational checklist (Appendix D). The participants were observed in the normal classroom setting, which is the natural setting. The researcher was a participant observer and during observations of students avoided interference by conducting them from the side of the room. The data collection took place over a four-week period. The observations were conducted twice a week during a fifteen-minute time period (for a total of two hours of observation time). The interviews were conducted with willing participants during lunch, teacher prep period, teacher off period, and an intervention period in the same classroom using the interview protocol (Appendix C). The interview process took place over three weeks and involved four thirty-minute interview sessions (for a total of two hours) and was tape-recorded for accuracy. The recording was later turned into a transcript to make coding easier.

In Chapter 4, I present the findings of my self-study in relation to the research questions I asked to guide my self-study of the use of formative assessments in my 9th grade geometry classroom.

Chapter Four

Findings of the Study

I undertook this self-study of a shift in practice to the use of formative assessments in my 9th grade geometry class with the goals of 1) improving my ability to determine where my students were in their learning and thinking of in terms of my instruction in geometry, 2) aligning my teaching with where they needed to go next to develop their understandings of geometry and 3) better determining how to get them to this destination (Wiliam, 2011, p. 45). The following questions guided this self-study:

1. Do formative assessments that provide student-centered feedback in the categories of skill, knowledge and understanding help students understand the learning goals and benchmarks for success that inform my instruction?
    i. Does the feedback provided on such formative assessments enhance students' progress in my class?
2. Do these types of formative assessment foster greater student ownership of their learning?

Methods of Analysis

This qualitative study utilized interviews, observations, and surveys (Appendix B) to determine the degree to which the formative assessments helped students understand the learning goals and benchmarks for success that inform my instruction. I also wished to know if the feedback provided on the formative assessments enhanced students' progress in my class. A purposive sampling method was used to develop a set of individual student cases for this qualitative study (Patton, 2002). A total of 7 cases were sampled from the population of 27 students in my 9th grade geometry class that were representative of the total population of students. The cases consisted of three students who were white males, one who was a Hispanic male, two who were Hispanic females, and one who was a white female.

The data collected were stored in the Google form and then categorized in terms of research questions and developing themes. The researcher used a coding method to organize the data with respect to major themes that emerged in relation to the research questions. Direct quotations are cited from the data to support the thematic trends that emerged across the cases. Data from the student survey was also compared with the data from the informal observations to see if they supported the themes that were identified.

Presentation of the Findings

The themes that emerged from the mathographies and the interviews were: Student perception of the relevance of what they are learning is that "it will be important later," with an emphasis on being needed in a future mathematics course and what is necessarily for adulthood; student enjoyment was high and student disposition towards mathematics was positive; and, feedback from assessments is one of the most valuable tools for students to learn their best. I will expand on each theme.

Theme one: student perception of the relevance of what they are learning is that "it will be important later," with an emphasis on being needed in a future mathematics course and what is necessarily for adulthood.

Students believed that what they were learning was important even if it did not directly relate to their lives. Mathematics was discussed as being important for people interested in pursuing a career in mathematics, science, or engineering, but not as necessary for someone interested in pursuing a less scientific career. All students agreed that the basic aspects of mathematics were important to everyone. Four of the seven students mentioned that everyone needs mathematics to do their taxes and to maintain a budget.

Although some students do mention the importance of mathematics as it pertains to their lives, "*I use math in my life today mostly for cooking. I have done fundraisers like base sales to help raise money for field trips. My math skills help me keep my checking account balanced and live within a budget"* (student G). Student B mentioned how mathematics related to his love of music. Student C summed his thought about the relevance of mathematics as, *"…two different types of mathematics: everyday math and character math. Everyday math is math that is applicable to everyday life and you use it everyday. Character math is math that I don't see myself ever using and have no idea what it is for but it builds character because your patience is being tested by doing it because you don't understand why you have to do it."* Every student mentioned some aspect of his or her life that related to mathematics. Understanding the importance of a subject is of tremendous importance when a student decides whether or not the subject has any value to them as an individual.

The sixth interview question: do you feel it is important for you to know how to do what it is you are being assessed on? Why? How do you decide if something is important to you? Begins to scratch the surface of this relationship between is something important to a student because they want to understand it, or because they want to get a good grade on the assessment? While the question can be interpreted in either of these ways, every student answered it with regardless to doing well on the assessment. Some students focused primarily on their grade, mentioning features such as: *"…you need to* *know what to do to get a good grade"* (student A); *"… if you don't understand it then you do poorly and your grade will reflect that"* (student C); and, *"…if you didn't know then you might fail the test"* (student D). However, other students discussed the idea of success without directly relating it to their grade: "…because it helps me succeed on that assessment" (student B); *"…because if I don't, I would get really stressed out"* (student E); and, *"It is important for us to know and understand what we are assigned because math is built up on what we've learned from the beginning"* (student G).

Student responses to the second part of the question: how do you decide if something is important to you were all based around the future, if they needed to know it for a future class or if it would be important to them outside of school.

Theme two: overall, student enjoyment was high and student disposition towards mathematics was positive. The level of enjoyment seemed to stem directly from the student's teacher. *"I have enjoyed some of my past math classes… I believe this has to do with the teacher and how they explain it to me"* (student A). Although student G stated, *"I am neutral when it comes to mathematics, over the years the majority of my teachers have made math boring."* No student explicitly said that they dislike mathematics, which can be at least slightly expected given that these students are all in an accelerated class and are writing a paper they know will be read by a mathematics teacher. Although prior to the assignment I did state that I would not downgrade them based on their fondness of my subject. I wanted them to be as honest as they wanted to be.

Aside from their teacher, another supporting factor in the students' enjoyment of mathematics is that is a practical or useful field of study. Student F discusses how mathematics pertains to the videogames he plays and how he uses mathematics to improve his strategies, saying, *"Math helped me figure this out, otherwise I would be really bad at the game."* Unfortunately, none of the seven students expressed interest in pursing a mathematics heavy field, but many did mention the value of rudimentary skills being valuable in their future jobs and adult life.

Student A, C, D, and G all specifically state in their answers to the third interview question: how do you feel about mathematics in general? Why do you feel that way? That their enjoyment of mathematics is related to their understanding and/or success in the subject. Student E begins the divergence in her response, *"I like mathematics because the concepts it goes over are very interesting and there are always many possibilities in different situations."* The assumption being made is that she is referring to problems always having multiple avenues to find a solution.

Theme three: feedback from assessments is one of the most valuable tools for students to learn their best. This theme emerged solely from the interview questions due to the fact that the mathographies were only geared to evaluated students past and current experiences and disposition towards mathematics. Student responses to the fifth interview question: are you interested in taking assessments in this class? Would you be interested in taking assessments even if you did not receive a grade? Why or why not? Produced the broadest gap out of all the interview questions. However, they still managed to all point to assessment feedback as being an important aspect of the process. Regardless if the student only cared about their grade compared to their understanding.

Students A and C shared the opinion that grade-less assessments were *"pointless"* and they would not *"gain anything from them."* However, four other students disagreed: *"…still be interested if I did not receive a grade for them because I feel they are good* *ways of tracking my progress in the subject"* (student B), with students D, E, and G agreeing. Every student, except student G, stated that the feedback on assessments was the aspect that helped them learn best. *"…because I am always able to see what I did wrong"* (student F).

Student responses to the fourth interview question: do you typically know what I expect you to do for an assessment in this class? How do you know that? Helped to elaborate the argument that students don't need to worry about being exposed to questions that are unexpected. Thus, they can benefit from the feedback given on questions they had prior knowledge would be on the assessment. My assessments are not designed to *trick* my students, although the questions can be challenging, they are questions within the students' realm of possibility. Students agreed that I had been "…*consistent*…" (student A) with my expectations and because the "…*instructions are clear and well-written"* (student B). Student D adds, *"…you usually tell us what sorts of things are going to be on the exams."*

In this section, I address the following questions of the self-study:

1. Do formative assessments that provide student-centered feedback in the categories of skill, knowledge and understanding help students understand the learning goals and benchmarks for success that inform my instruction?
    i. Does the feedback provided on such formative assessments enhance students' progress in my class?

Before we can talk intelligently about student *progress* in my class, we must define what we mean by *progress*. I want to define *progress* as an increase in either: student participation during group work and/or class discussions; a student's desire to deepen their understanding of mathematics; or, an increase in student motivation with specific regardless to my class.

The second and third themes shed light on this question by bringing to light student attitude and disposition in addition to how they utilize assessments to further their learning and understanding. The second theme does not directly demonstrate progress in my class, but it does indirectly show how interested, motivated, and dedicated the students are to improving their learning and deepen their understanding. When a student says, *"The subject [math] makes more sense to me than some of my other classes so it makes it easy to enjoy"* (student G). The student is also commenting on their drive to *want* to understand the content. If a student enjoys a class because they understand the content, they will want to continue to understand the content. This comes about by using feedback to enhance their progress.

Theme three definitely addressed whether or not students are aware of the learning goals and benchmarks I've set for them on each assessment. There was resounding support that students are well informed about what content they should expect to see on their formative assessments.

In addition, the third theme certainly helps to examine how students perceive and employ assessment feedback, especially since students mention, *"The aspects of assessment that help me learn best are the ones that help show where I'm at and where I can improve"* (student E). The fact that students are mentioning their usage of feedback enough to warrant it being a theme from the research is strong support that it is at least associated with student progress in my class. While it is difficult to know for sure if the fact that my assessments are broken down into specific categories of questions: skills, knowledge, and understanding, I can say with confidence that based off of student responses, the feedback has been increasing student progress in my class.

In this section, I address the following question:

2. Do these types of formative assessment foster greater student ownership of their learning?

Although all three themes help to support a greater student ownership of their learning, the first and third themes do this more explicitly. The first theme of student perception of the relevance of what they are learning is that "it will be important later," with an emphasis on being needed in a future mathematics course and what is necessarily for adulthood demonstrates naturally builds an ownership of learning. Students want to learn what they believe is important to them. Just as students who are motivated by achieving good grades will take ownership of their learning because they want to maintain their good grades. The context of this research study was during the build up to and the class immediately following a unit exam (the eighth exam taken by the class that year). The observational checklist cites evidence of increased student participation during group work. Specifically data collected during the March 8 observation, which revealed greater instances of *students asking more "why" questions, requiring more justification from their peers;* and, *students assist each other in pointing out their misconceptions and the misconceptions of others*. This observation took place while students were working on a performance task building on the ideas of the unit they had just been assessed on.

The third theme of the research is the most directly related to answering this question. Every student mentioned in some regard how the feedback from assessments helps him or her learn from their mistakes and to do better in the future. The major takeaway from these responses was that students are not simply looking at their score and then tossing the assessment into the recycling or their backpack. They are actually going over the questions and noticing where they were successful and where they made mistakes. The feedback provided was not simply slash marks through an incorrect solution or method, but rather used questions to help guide the students towards understanding the problem better. The feedback was not designed to teach the students how to do the problems they missed, but instead to help coax them into a better approach and possible ways to "attack" the problem in the future. This is especially prominent when the students come in to retake the assessment and first they must go over the entire exam (aside from questions they scored a nine or ten on) with me. Going over the feedback together is an additional powerful tool for them to ask questions if they are still confused by the problem even after reading the feedback. It is important to note that even student who opt not to retake their assessment still ask these questions, either immediately after receiving their assessment back, or shorty thereafter.

When students respond to the eleventh interview question: what aspects of the assessment in this class help you learn best? Why do you think that? With statements like, *"having different types of problems on the test help me learn better because they reflect what I need to work harder on"* (student C). It demonstrates that they are concerned about their progress in the class and they want to do what they can to help develop their understandings and enhance their learning. There are many factors, some known and others unknown, that help to generate student interest, both intrinsically and extrinsically, it is clear that this type of student-centered feedback in the categories of skill, knowledge and understanding help students to foster greater student ownership of their learning.

Chapter Five

Conclusion

Relevance of the Study

A critical aspect of teaching is knowing how one's feedback is being interpreted and utilized by one's students. Discovering the ways in which students absorb feedback into their learning experiences shifts the paradigm of one's classroom and allows for pedagogical refinement. The data analyzed for this qualitative self-study helped to answer the questions I had regarding my students' interpretation of the assessment feedback I provided to them using a formative assessment approach. My goals in conducting this research were to 1) improve my ability to determine where my students were in their learning and thinking of in terms of my instruction in geometry, 2) align my teaching with where they needed to go next to develop their understandings of geometry and 3) better determine how to get them to this destination (Wiliam, 2011, p. 45).

I believe my research inquiry has been successful in answering my focus questions because it has illuminated students' thought about assessment and assessment feedback. All three of the identified themes: importance/relevance of mathematics; enjoyment of mathematics; and, student value placed on assessment, help to uncover the ways in which students incorporate their past experiences, attitudes, and current progress into a learning archetype. This is powerful information for an educator to have. Understanding student perception of our content area is of upmost importance because it helps us to find ways to build appreciation and to motivate our students. The association drawn from theme two, student enjoyment of mathematics, of student enjoyment being directly tied to their teacher was of particular interest. Building positive relationships with students who typically struggle in mathematics is essential to cultivating success.

How does this build on the current literature?

Mathematics has become a subject dominated by procedures, with little depth (Schmidt, Houang, & Cogan p. 2-4). Students are not being challenged with figuring out *how* to solve a problem, but more so with what formula to use and in which context. One of the purposes of the adoption of the Common Core State Standards for Mathematics has been the inclusion of the practice standards (Common Core Standard Initiative, 2014, p. 6-8). These practice standards are included to encourage and develop student curiosity. As mathematics educators, we are responsible for guiding students through this process of inquiry and discovery. Giving meaningful feedback on our assessments is a powerful tool in this regard. Handing a student a graded assessment with just a percentage score at the top does very little to engage that student in their own learning.

Moreover, evidence from the themes also points to student usage of assessment feedback being a strong indicator of their success. Perhaps more meaningful feedback could result in increased student understanding and progress in mathematics. Knowing more about student response to assessment feedback is the most important consequence of this inquiry. Brookhart (2001) examined how successful students utilized feedback from assessments, and this inquiry helps to better define, specifically, what aspects of feedback students value.

What conclusions can be drawn from this work?

This study helps to build on the literature of what students do with their assessment feedback. What aspects of feedback do they find useful and how do they use that feedback to further their understandings. According to Brookhart (2001), successful students integrate assessment feedback into their personal learning systems in an effort to deepen their understandings and procedural fluency. Therefore, the more specific the feedback given, the more information these successful students will have to create their new learning systems. Specifically, what these students are doing is taking the information given to them from their formative assessment and identifying their areas of strength and growth and developing personal methods based off of the formative feedback to strengthen their weaknesses (Brookhart, 2001). While Brookhart's research is based off of students in English classes, there is no reason to doubt that this successful student methodology would be significantly different when applied to other courses of study. My research relates to Brookhart's by examining how my students choose to use the feedback given to them. In addition to the questions driving my inquiry, I was able to also provide a preliminary answer to the question of: *do my students actually read and incorporate my formative assessment feedback into their own paradigms of learning?* The answer to this question based on the case studies would be yes. The measures of how and to what degree are left to a future inquiry.

As an educator, understanding *how* students are using our feedback is of paramount importance when deciding how to proceed after a formative assessment. The process of teaching is an ongoing process of assessing student understanding (Gearhart & Saxe, 2004). This process is enhanced when the feedback is specific to each student and targeted to improve his or her personal understandings of each topic or problem. My inquiry was designed to see if and how students would use this targeted and specific feedback, or if they would simply check for their grade and toss their assessment aside.

Shepard (2000) points out that changing the placement and timing of assessment into the middle of instruction gives assessment a more useful role in informing students about their learning process. Giving students multiple access points to this feedback is as important as the quality of feedback itself. The context of the formative assessment I used for my research was after the major aspects of the unit were covered, but prior to a performance task and extensions of the unit. Allowing my students a slightly beyond midway look into their understandings. These understandings were then pushed further the next class period by having them work on a performance task with their groups. Providing my students this specific and targeted feedback immediately after their assessment and prior to challenging it with a problem solving based performance task is integral to having them push their own levels of understanding.

Moving forward, I can use this information to better my own practice, and hopefully other mathematics educators can use it as well, by knowing, specifically, what it is about my assessments that help my students learn best. Being able to effectively communicate to my students my knowledge about where they are and where they should be is a dynamic learning tool that can dramatically increase their performance. I've presented literature that illustrates how successful students utilize assessment feedback (Brookhart 2001, Natriello 1987, Niemi 1996, & Sadler 2010), as well as how educators use student performance (Adabor 2013, Bliem & Davinroy 1997, Gearhart & Saxe 2004, & Shepard 2000); I believe my research inquiry is the beginning of a bridge between these two pillars of assessment feedback.

Next Steps

A new approach I have begun to take it is attaching questions to my feedback. Instead of merely highlighting their mistakes, I have been writing down questions designed to help them get started on a problem or to push them towards what to do next. Helping students to see what the potential “next step” in a problem rather than simply marking it as incorrect might help students see where their reasoning was taking them and what they can be aware of on future assessments. Treating classwork, assessment study guides, and even their first attempt at a formative assessment as “rough drafts” can help students be bolder in their attempts at a particular problem.

Appendix A: Sample Exam

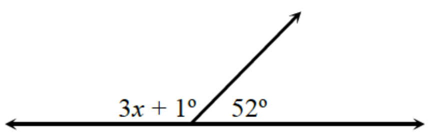
Geometry	Geometer:______________________________

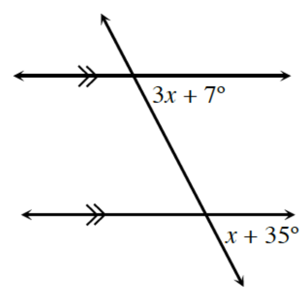
Chapter Eight Exam A	Date:_____________________Period:_______

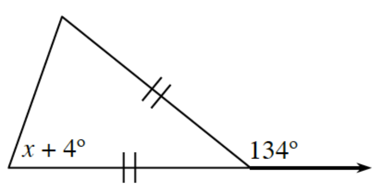
1. Complete the table below.

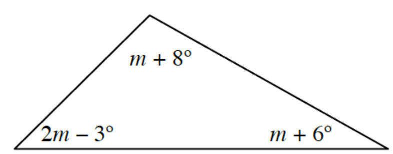
Number of polygon sides	Measure of **one** interior angle	Measure of an exterior angle
5		
	144°	
		40°

2. Solve for the variable in each diagram below.



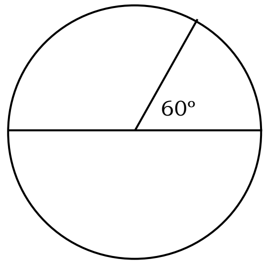




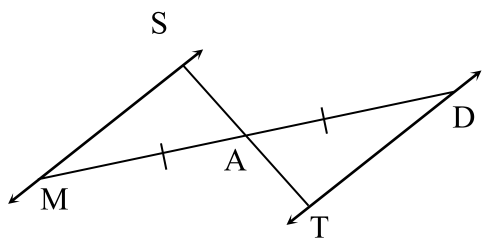


3. Find the area and perimeter of a regular octagon with a side length of 24 cm.

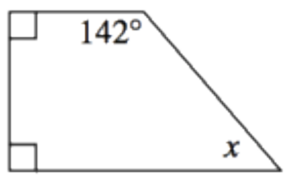
4. Find the arc length and sector for a circle with a diameter of 14 cm and a central angle of 60°.

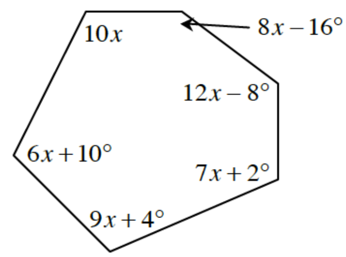


5. Given that $\overline{MA} \cong \overline{DA}$ and $\overline{MS} \cong \overline{TD}$, show that $\overleftrightarrow{MS}$ is parallel to $\overleftrightarrow{TD}$.



6. Solve for *x* in each diagram below.





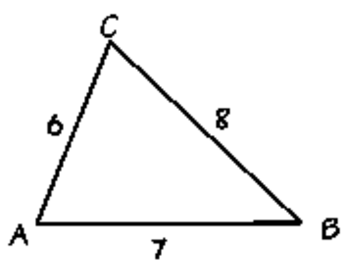
7. Solve for the indicated variable(s).

a. $x^2 - 3x - 4 = 0$

b. $y = 2x + 3$

$x - 3y = 6$

8. Find $m\angle A$



Appendix B: Mathography Assignment

Mathematical Literacy Project #1

Date Due: August 27th or 28th 2017

What:
You will reflect on your journey through mathematics thus far.

How:
You will write a short paper (approx. 500 words) concerning past experiences with mathematics.

Please choose at least FOUR of the following prompts to begin your reflection (you may answer more if you choose to).

1. Would you describe your experiences with mathematics as being positive or negative? Explain why.

2. If mathematics was not a required course, would you still take it? Why or why not?

3. Have you enjoyed your past mathematics classes? Why or why not?

4. Do you feel that the mathematics you've learned so far is useful? Explain why or why not.

5. Why do you think we teach and learn mathematics in school?

6. Do you feel that your hobbies or interests are related to mathematics? In what way(s)?

7. How has mathematics affected your life?

8. How do you feel mathematics will affect your life in the future?

Your project will be graded on these criteria:
- ✓ The completeness, that is, you've written at least 500 words
- ✓ Your correct usage of grammar, punctuation, and spelling
- ✓ Your **in-depth and meaningful** reflection into your relationship with mathematics

Why:
I want to see how you view mathematics. What your experience has been thus far in your educational career and why you feel the way you do.

Appendix C: Interview Protocol

1. What is your name?

2. How do you feel you are doing in this class so far? Why do you feel that way?

3. How do you feel about mathematics in general? Why do you feel that way?

4. Do you typically know what I expect you to do for an assessment in this class? How do you know that?

5. Are you interested in taking assessments in this class? Would you be interested in taking assessments even if you did not receive a grade? Why or why not?

6. Do you feel it is important for you to know how to do what is it you are being assessed on? Why? How do you decide if something is important to you?

7. How difficult was the most recent assessment for you? Why do you feel that way?

8. How did you do on the last assessment? How do you judge your performance on assessments in this class?

9. Do you care about how others in this class did on the most recent assessment? Why or why not?

10. Do you care about what other students think about how you did? Why or why not?

11. What aspects of assessment in this class help you learn best? Why do you think that?

12. Is there any additional information you would like me to know?

Appendix D: Observational Checklist

Anspach Masters Thesis Project Date:____________________Period Being Observed:_______

Type of Task Being Observed:__________________________

Classroom discussion and student questionings	**Level 1**	**Level 2**	**Level 3**	**Level 4**
	• Students are easily frustrated with the task and "shut down" when they become stuck • Students require a lot of prodding and attention in order to make significant progress towards a solution • Students work individually and/or copy the work of a group member • Students engage with the problem	• Students are engaged in the task, but work is mostly completed individually • Students seek teacher assistance if they are stuck • Students are able to grasp and make use of the important aspects of the task • When prompted, students have difficulty explaining the reasoning of their group mates	• Students seek assistance from their group prior to asking for teacher assistance • Students ask questions similar to "is this right?" showing concern only for the correct solution	• Students are working together and building off of each other's ideas • Students are questioning the methods and ideas of each other in a way that deepens their own understandings
Additional evidence (observations, quotes, etc…)				

Sources of mathematical thinking and ideas	Level 1	Level 2	Level 3	Level 4
Students progressively clarify and communicate their mathematical ideas	• Students are satisfied with simply finding the solution(s) • Students are unable or barely able to explain their process	• Students elaborate on their thinking only when prompted by another group member or the teacher • Students only provide brief explanations of their thinking • Students are unable to provide reasoning behind another student's method	• Students begin to compare and contrast multiple methods for arriving at the same solution • Students probe each other for deeper explanations of their thinking • Students are able to approximate another student's thinking by examining his or her method of solving	• Students can clearly explain the steps of their thinking and are able to justify their choices mathematically • Students are able to visualize connections between various methods of solving • Students are able to see connections to other problems of similar type • Students know they will be challenged to clearly explain their methods
Additional evidence (observation, quotes, etc…)				

Student ownership of their learning	Level 1	Level 2	Level 3	Level 4
Students gradually take responsibility for learning in addition to the evaluation of themselves and others	• Students are content to copy the work of a group member • Students wait until the class goes over the problem • Students are passive participants in the task	• Students listen to and help each other at the request of the teacher • Student help is interpreted primarily as "here's how I solved the problem" • Students replicate each other's work with little understanding of their process	• Students ask many "how" questions of each other and the teacher • Students begin to understand the mathematical ideas of others • Students are able to explain the thinking of another student by examining their work • Students begin to demonstrate agreement and disagreement of mathematical ideas through their own reasoning	• Students are constantly asking questions of their group, class, and teacher to fully clarify certain concepts • Students are asking many "why" questions that require justification from their peers • Students help the class by clarifying others' methods for themselves and for others • Students evaluate all methods as a class • Students assist each other in pointing out their misconceptions and the misconceptions of others
Additional evidence (observations, quotes, etc…)				

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