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Common Core State Standards for Mathematics (CCSSM) Curriculum Alignment: Emphasis on Formative Assessment and Metacognitive Strategies

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Abstract

The Common Core State Standards for Mathematics (CCSSM) were published in 2010 by the National Governors Association Center for Best Practices and the Council of Chief State School Officers. The 2014 – 2015 school year was CCSSM implementation year for the state of Wisconsin. As such, the responsibility of modifying current mathematics curriculums to more accurately align to the CCSSM went to the classroom teacher. The restructuring of the curriculum to align to the CCSSM was investigated in a 7^{th} grade Academically Talented classroom, which would utilize and be assessed by 8^{th} grade CCSSM standards. The class had previously used a curriculum aligned to the Wisconsin State Standards. Presented are the results of reorganizing and assessing a CCSSM-aligned curriculum through the use of pre- and post-instruction unit assessments, formative assessments and metacognitive thinking strategies.

Chapter One

Introduction to the Study

In many secondary math classrooms in the United States, the mathematics curriculum taught at each grade level was determined by a publisher's interpretation of state standards and the order in which those standards were to be taught. The amount of content presented in most textbooks was substantial, and it was difficult to devote time to in-depth discussion on all the content. As a student in middle and high school, my math instruction was consistent in that it typically followed the order that a textbook was arranged in. The concepts in chapter one were completed first because they came first in the textbook, followed by chapter two, etc. There was not much deviation from that sequence. Fast forward to several years later where I am now on the "giving" end of this instruction and the pattern is still much the same yet students in the United States are losing ground to global competitors. On the math portion of the 2012 Program for International Students Assessment (PISA), 25 countries tested better than the United States (Layton, 2013, para. 4 & para. 11). Because of the quantity of content in the textbooks currently used it was rare that significant time was devoted to the last few chapters of the book because there simply was not the time to do so. Schmidt, McKnight and Raizen (1997) note that textbooks in the United States cover a significantly greater amount of material in comparison to German and Japanese textbooks. Textbooks in the United States present 175% more content than those in Germany, and 350% more content than the textbooks used in Japanese schools. Yet the students in both Germany and Japan vastly outperformed U.S. students on the Third International Mathematics and Science Study (TIMSS). In their 2007 article, *What Are Science and Math Test Scores Really Telling U.S.?,* Alan Brown and Linda LaVine Brown note the work of William Schmidt, a researcher from Michigan State University. In his work Schmidt has published graphs that show the sequence of math topics taught in grades 1 through 8 for countries across the world. Top-achieving countries show a diagonal progression with the easiest topics taught in first grade working up to the hardest topics in eighth grade. In comparison, three sample U.S. state graphs showed no progression whatsoever in the content that was taught as nearly every topic was covered in nearly every grade. A school board most often makes the final decision on the textbook to be used in classrooms, and that book becomes "a prominent, if not dominant," part of determining what children have an opportunity to learn (Tyson-Bernstein & Woodward, 1991, p. 91). The content that received the most emphasis in a math classroom in one district could differ from another district based on the textbook publisher chosen by each particular district.

In an attempt to combat the variances in the standards taught within each state and the differences in the rigor that was given to the standards, the Common Core State Standards for Mathematics (CCSSM) were developed by the National Governors Association Center for Best Practices (NGA), the Council of Chief State School Officers (CCSSO) and included input from teachers, parents, school administrators and experts across the country. The CCSSM provided a focus and coherence to what should be taught at each grade level so that instruction from one grade level to the next (and across state lines) had continuity, covered all necessary content and continually increased the knowledge base of students while providing students the opportunity for in-depth learning (NGA & CCSSO, 2010). Schmidt and Houang (2012) conducted an analysis to determine whether or not the CCSSM had the focus, rigor and coherence that the TIMMS curriculum analysis said were characteristics of the curriculums of top-achieving countries. Schmidt and Houang believe that the CCSSM have met the levels of international standards when they state that:

> The consistency of them [CCSSM] with the benchmark derived from standards of the top-achieving countries suggests that the goal of the authors' that the CCSSM be consistent with the internationally benchmarked standards and as a result are coherent, focused and rigorous has been achieved. (2012, p. 307)

Successful implementation of national standards-based curriculums in schools have been shown in the Post, et al. (2008) study on the implementation of the Connected Mathematics Project (CMP) and MATHThematics curriculums, and Riordan and Noyce's (2001) study on the use of Everyday Mathematics (EM) and Connected Mathematics curriculums. However, in comparison to these established curriculums that have been in use for several years, the CCSSM are still in their infancy and therefore, publishers are just beginning to write textbooks specifically aligned to the standards. Furthermore, as the CCSSM-aligned textbooks are made available by publishers, districts might not allow for the purchase of these new texts because it is in a cyclical manner that school budgets often allot for the purchase of new textbooks at each grade level and subject area. If, for example, a middle school math department purchased new textbooks the year before the adoption of the CCSSM in their state, the textbook cycle of the district would not allow for the purchase of CCSSM-aligned textbooks until several years later. In such cases, the responsibility falls on the classroom teacher to update and supplement the content of textbooks and the manner in which it is taught to assist students in meeting adequate proficiency with the requirements of these new standards.

When implementing the CCSSM, teachers must keep in mind that they are provided a framework for what students need to learn, but are not being dictated the manner in which they are to teach the content standards. Classroom teachers are still the experts on the best methods and practices to utilize when instructing a particular group of students. The authors of the CCSSM leave it to the discretion of the classroom teacher to employ those methods of instruction that will provide their students the opportunity to achieve proficiency with the standards. As they explain on the Common Core website in the *About the Standards* section (2015):

> The Common Core State Standards are a clear set of shared goals and expectations for the knowledge and skills students need in English language arts and mathematics at each grade level so they can be prepared to succeed in college, career, and life. The standards establish what students need to learn, but they do not dictate how teachers should teach. Teachers will devise their own lesson plans and curriculum, and tailor their instruction to the individual needs of the students in their classrooms. (Overview section, para. 7)

Before the introduction of the CCSSM, my math classroom would follow the outline of the provided textbook. The textbook was organized by chapters each composed of six to eight sub-sections, and each chapter was typically broken down and assessed in the following manner: daily homework assignments to practice the content discussed each day, one or two short quizzes to assess understanding on small groups of content, and culminated with a chapter test to assess all skills learned throughout the entire chapter. With this manner of instruction it was not to say that learning did not occur, but as noted by Sadler (2005), “weak performance in some areas can be compensated for by superior performance elsewhere” (p. 183). When a letter grade was assigned to homework, quizzes and tests based on the number of problems answered correctly, there was no way for an outside observer to look at a final score and determine those particular areas where students were proficient and those areas where students were not meeting grade-level standards. Scriffiny (2008), noted that when she considered the question of what does a letter grade truly indicate to students, parents, and teachers she was unable to construct a definitive, concrete answer. If the same question had been asked of me in previous years, my reply would have been along the same vein as Scriffiny's. I might have been able to give broad generalizations of a student's strengths and weaknesses, but the manner in which I was presenting the curriculum in my class did not allow me to provide specific standards that were strengths or weaknesses.

As a result, my task was to re-structure the curriculum of my class utilizing a backward design method, which delayed any planning of classroom instruction until goals were set and assessments of those goals were designed (Wiggins & McTighe, 2005). The "goals" to be met were the CCSSM. However, the structure of the textbook assigned to the class was not one that was aligned to the CCSSM. Therefore, it became necessary to develop new assessments that directly assessed the CCSSM and to modify the curriculum of the class to adequately prepare students for those assessments. The textbook was still be used as a resource in teaching the CCSSM, but now considered one resource of many. Organizing classroom instruction in a manner that specifically informed students of the content they are expected to know, and subsequently would be graded on, allowed students and me as the teacher to see more specific information about their learning. In addition to a single letter grade on a summative assessment, breaking down the assessment by specific standards and assessing students' work by individual standards allowed students, parents, and teachers to recognize those areas where students were proficient or struggling.

This action research project took place in a seventh grade Academically Talented (AT) math class (students were given eighth-grade content) with a group of 26 male and female students, aged 12 – 13 years, in a Midwestern, suburban public middle school with an enrollment of approximately 750 students. The project was conducted over the course of the school year and examined student proficiency with the CCSSM through the use of formative assessment tools that allowed individual students and me to monitor progress towards achieving adequate proficiency with each standard. This project also utilized various metacognitive thinking strategies to promote deeper thinking in students, which is one of the goals of the CCSSM.

The following questions were the focus of this action research project: In what ways did aligning the curriculum to the CCSSM benefit student learning through the use of the following tools: pre- and post- instruction assessments, progress monitoring and metacognitive thinking strategies. More specifically,

1) did student scores on pre-instruction unit assessments direct instruction for a unit (such as leveling assignments for students who earned high scores on the pre-assessment on particular standards),
2) did the results of progress monitoring (warm-ups) prompt change to classroom instruction, and
3) did the use of metacognitive strategies influence student perception of the value of the strategies in achieving understanding and proficiency with the standards?

With the implementation of the CCSSM in the state of Wisconsin, it was necessary to examine the content that was being taught in our textbooks and compare it to the content knowledge of the Common Core Standards. Simply stated, some of the content we were teaching aligned with the CCSSM, but much of what was being taught did not go into as much depth as was being required by the CCSSM. For example, in the Common Core Expressions and Equations (EE) standard for eighth-grade, which is the content covered in seventh-grade AT math, solving systems of linear equations by the methods of substitution, elimination and graphing is one of the eight strands highlighted in this standard. Before the Common Core, this was not a topic to be introduced to students until the following year in Algebra. Similarly, the Common Core Functions (F) standard is broken down into five strands including determining whether a function is linear or non-linear and graphing and describing functions, yet the textbook currently used only discusses functions in one section of one chapter throughout the entire book.

My hypothesis was that through the implementation of CCSSM-based units instruction throughout the school year, with each unit broken into specific standards, and providing students with more opportunities to self-assess their work by means of progress monitoring (formative assessments) and metacognition strategies, there would be an increase in scores from pre-instruction to post-instruction assessments. The implementation of CCSSM in the state of Wisconsin for the 2014 – 2015 school year required a close examination and comparison of the content of the textbook to the content of the CCSSM. Simply stated, some of the content of the textbook aligned to the CCSSM, but much of what was being taught did not go into as much depth as was required by the CCSSM.

Chapter Two

Review of the Literature

Mathematics education in the United States has been under scrutiny for decades because the students of this country, even the best and brightest, are not scoring in the top of the world rankings. The 2003 Program for International Student Assessment (PISA), which tested mathematics proficiency of students across the globe and focused on how well students can apply their knowledge and skills, resulted with students in the United States ranked 18th (Devlin, 2010). In 2012, the same PISA comparative education study had students in the United States fall in the rankings to 26th in Mathematics Literacy, below average among the world's most developed countries (PISA, 2012). In order that this slide in the world rankings might be combatted, the Common Core State Standards for Mathematics (CCSSM) were created and introduced to schools across the United States. The CCSSM were an initiative to provide schools with standards that have a greater focus on fewer topics, and because of the reduction in the number of topics to be covered, greater rigor in the work expected of students. This would require them to think critically, creatively and flexibly in applying what they learn to real-life scenarios (NGA & CCSSO, 2010). The PISA survey, which U.S. students have traditionally performed poorly on, was designed to test those same skills – can students use what they have learned in school and apply that knowledge to real-life situations and problems. Literature on the background of national standards in United States education, examples of the use of standards-based curriculums in schools, and the benefits of progress monitoring and metacognitive thinking strategies use in the classroom are reviewed.

Background

In August of 1981, then Secretary of Education, T. H. Bell, created the National

Commission on Excellence in Education. The committee was comprised of eighteen individuals whose task was to report on the status of education in American schools. The final report, published in April of 1983, began with a simple, yet telling statement: "Our nation is at risk" (National Commission on Excellence in Education (NCEE), 1983). Findings were reported on four categories: content, expectations, time and teaching. Focusing on content, the report stated that "…curricula have been homogenized, diluted, and diffused to the point that they no longer have a central purpose" (NCEE, 1983, p. 12). From this, national standards were created by various professional organizations including the National Council of Teachers of Mathematics (NCTM), which published the *Curriculum and Evaluation Standards for School Mathematics* in 1989. This publication provided a more focused set of learning objectives for schools and teachers to follow in determining where to direct their math instruction. However, "by the early 2000s, every state had developed and adopted is own learning standards that specify what students in grades 3-8 and high school should be able to do. Every state also had its own definition of proficiency" (Common Core State Standards Initiative, 2015b, para. 2).

The *A Nation at Risk* report certainly kick-started the development of concise educational standards across subject areas, but as noted above, consequent years saw the creation of standards that differed from one state to the next. In their 2005, *The State of State MATH Standards* review, Klein et al. scored state math standards on a 0 – 4 point scale on four criteria: clarity, content, reason and negative qualities. A score of 4 indicated excellent performance whereas a score of 0 indicated failing performance. State standards were scored on each of the four categories and a scale was used to convert the average of the weighted grades into a letter grade: 3.25 – 4.00 = A, 2.50 – 3.24 = B, 1.75 – 2.49 = C, 1.00 – 1.74 = D and 0.00 – 0.99 = F. States such as California, Indiana and Massachusetts earned an "A" while Connecticut, Florida and Kansas were amongst several other states that earned an “F”. Students were not necessarily learning concepts in the same grade levels from one state to the next, and the expectations and rigor of the standards were not consistent across state lines. State tests did not assess the same content nor did they assess the content in the same manner, which made it a near impossible task to compare the performances of students from one state to another. It was from reports such as this, which indicated a clear disparity in the rigor of mathematics standards from one state to the next that the Common Core State Standards were created with the hope:

> that all students, no matter where they live or what obstacles they face, receive a consistent, high-quality education from school to school and state to state, and upon graduation are prepared for success in their continuing education and their entry into the workforce. (Allyn, 2012, p. 3)

Students should be “graduating high school prepared for college, career, and life” (Common Core State Standards, 2015b, para. 1). Preparing students for the “real-world” is one task of many required of the classroom teacher, and the CCSSM aim to provide a focused path for teachers to use as a guide in accomplishing this task.

The standards were designed as a coherent body of topics that are “connected across grades so that students can build new understanding onto foundations built in previous years” (Common Core State Standards Initiative, 2015a, para. 5). This constructivist approach to learning, constantly creating new knowledge for students based on what they know and what was previously learned, will foster a strong environment for learning in the classroom (Naylor & Keogh, 1999). By placing an emphasis on fewer topics and engaging students in meaningful activities to instruct the standards, it will help them construct understandings and develop their thinking skills more deeply (Wilson, 1996).

Standards-based curriculum

Standards-based (SB) curriculum, "emphasizes the importance of thinking, understanding, reasoning, and problem solving with an emphasis on connections, applications, and communication," while traditional curriculum "emphasizes the memorization and recitation of decontextualized facts, rules, and procedures" (Cai, Moyer, Nie, & Wang, 2009, p. 692). The Connected Mathematics Program (CMP) (Lappan, 2009) is an example of a curriculum that from its inception has been created using national mathematics standards. It is the philosophy of CMP to construct a curriculum focused on 'big ideas' (national standards) and the connections that can be made between these big ideas within a grade level and across grades. Relying on national standards rather than individual state standards in the creation of its curriculum allowed CMP authors to fluidly connect units to produce a coherent whole. Schmidt, Wang and McKnight (2005) support the philosophy of CMP authors to solely rely on national standards because over time individual state standards arrived at a compromise of being all-inclusive, a "characteristic (that) reflects the fact that it is politically safer to include topics than to exclude them" (p. 530). The result was an endless repetition of the same standards being taught across grade levels for fear of leaving anything out. Because state standards required so much to be taught at each grade level, the phrase "a mile wide and an inch deep", became synonymous with describing the math curriculum in any American classroom. Credit for the phrase was given to William Schmidt, Michigan state University researcher and coordinator of U.S. participation in TIMMS, who used the phrase to reference how state standards jump from one topic to the next without providing a clear picture of how the topics should fit together (Brown & Brown, 2007).

In their 2009 report, Schmidt, Houang and Shakrani, noted that most U.S. state standards lack focus, rigor and coherence. They claimed that:

> What has typically characterized state standards are topics put together arbitrarily in a process governed more by politics than substance. Thus middle school mathematics in most high-performing countries focuses on algebra and geometry, but in the U.S. these areas are typically deferred to the high school level. (p. 24 – 25)

The CCSSM have taken steps to remedy this lack of rigor and focus. In the eighth-grade Algebra strand, students are asked to graph and solve systems of linear equations, which was traditionally not taught in the district that is the focus in the present project until ninth-grade because that was the sequence prescribed by the textbook. In the Geometry strand, students are required by the CCSSM to not only understand the Pythagorean Theorem but to also apply the principles of the theorem in calculating the distance between points on a coordinate plane (NGA & CCSSO, 2010).

Standards-based curriculums, such as the CMP curriculum mentioned above, have been utilized in schools with success. In their standards-based curricula study, Post et al. (2008) examined approximately 1400 middle school students enrolled within schools of five different districts. This study extended existing knowledge of student achievement in standards-based programs. Each of the five districts in the study had used one of two pre-determined standards-based curriculum programs (Connected Mathematics Project and MATHThematics) for a minimum of three years. The achievement patterns of the students enrolled in these standards-based classes were assessed using the Stanford Achievement Test, Ninth Edition (Stanford 9) and the New Standards Reference Exam in Mathematics (NSRE). The Stanford 9 subtests are designed to measure traditional content. The results of these tests indicated that the students enrolled in the standards-based curricula performed above the Normal Curve Equivalent (NCE) mean of 50 on two of the three subtests, Open Ended and Problem Solving, with only District B failing to score above the NCE mean of 50 in the subtest area of Open Ended questions (Post, et al., 2008). Just one district, District E, elected to administer the NSRE, an assessment more closely aligned to the National Council of Teachers of Mathematics (NCTM) Standards. As with the other four districts, this district employed the use of standards-based curricula and the students scored well above the national norms. Students enrolled in standards-based curriculum demonstrated achievement patterns that were above the means of the national samples that the Standford 9 test was normed on. When a standards-based curriculum is implemented with fidelity, students can achieve high success rates.

In their analyses of the Connected Mathematics Program (CMP) standards-based curriculum and Non-CMP curriculum, Cai, et al. (2009) found a significant difference between the two curriculums when closely examining the area of algebra. The Non-CMP curriculum was introduced to students using additive and multiplicative properties – a method that often involves teacher-led, whole class instruction with students recording the examples in a math notebook or journal. In contrast, the CMP curriculum allowed for the equation solving process to become a discovery problem with the equation situated within real-life contexts. When students are provided the time to engage in such a discovery process they employ the *Common Core Standards for Mathematical Practice*: students are able to persevere in solving the problem, reason abstractly and quantitatively (creating a logical representation of the problem), and construct viable arguments when presenting a possible solution (NGA & CCSSO, 2010). In this study, researchers concluded that in the standards-based CMP curriculum instructional tasks were more likely to occur in small groups, multiple solution strategies were three times more likely to be used in the CMP classroom and CMP teachers were more than three times as likely to employ high – level tasks during classroom instruction (Cai, et al., 2009).

Riordan and Noyce (2001) conducted a quasi-experimental study on the impact of two standards-based curriculum, aligned to the National Council of Teachers of Mathematics (NCTM) national standards, in comparison to traditional curricula, which utilized state standards, at both the elementary and middle school levels in Massachusetts. There were a total of 200 schools and 16,332 students represented in the study. Massachusetts standardized test score data was examined between the target schools (standards-based curriculum, Everyday Mathematics (EM) K-6 and Connected Mathematics Project (CMP) 6-8) and the matched comparison schools (i.e. similar school population, demographics, etc.), or control group (traditional curricula), to identify the impact of each curriculum. Scores earned by students on the Massachusetts Comprehensive Assessment System (MCAS) were compared. Raw scores on the test are converted to scaled scores that ranged from 200-280 (a score below a 220 is Failing, a score between 220-239 is rated as Needs Improvement, a score between 240-259 is considered Proficient and a score of 260 or above is considered Advanced). The students using EM or CMP outscored their counterparts with score differences ranging from 2.5 points to 5.7 points on the 80-point scale, and all differences were statistically significant (Riordan & Noyce, 2001). Carroll (1995) noted that Everyday Mathematics curriculum schools, which claimed the greatest number of disadvantaged students, scored above both comparison schools and the state average on the Illinois statewide standardized testing (as cited in, Riordan & Noyce, 2001, p. 375). In 2001, McCaffrey, et al. published a study that also used the Stanford 9 achievement test to compare the achievement of tenth grade students enrolled in two national standards-based curricula courses, Interactive Mathematics Program (IMP) and College Preparatory Mathematics (CPM), to those enrolled in traditional high school math course sequence, which utilized state standards. The results "revealed a positive relationship between teachers' reported use of reform practices and student achievement for integrated math courses but not for traditional courses" (McCaffrey, et al., 2001, p. 514).

A TIMMS curriculum study showed the US mathematics curriculum to be unfocused, repetitive and to be undemanding by international standards (Schmidt et al., 1999). The CCSSM was created with the intent of dispelling this view. Aligning curriculum to the national CCSSM allows educators at each grade level to focus instruction on a small number of topics, which in turn, allows for those topics to be covered in depth (Schmidt, Houang & Shakrani, 2009). As is always the case with change, it will be a difficult road to implement the new standards, but as international tests have shown, U.S. students need change in order to make progress in international rankings. Schmidt and Houang (2012) explained these challenges,

> Those states that have adopted the CCSSM are now confronted with the reality of implementing them across districts and schools. Once adopted, it is relatively easy to declare that the CCSSM are the new standards for the state, but given that the districts and schools have presumably aligned themselves to the old standards, a challenging effort will be required, especially if the CCSSM differ greatly in focus and coherence from the state's most recently implemented set of standards. (p. 300)

Challenging though it will be, the implementation of the CCSSM, which align with international standards more closely than U.S. national standards have ever before, provide the potential to be exceptionally beneficial to student learning.

Progress Monitoring

If students are to adequately self-assess their progress with the content standard goals, and teachers are to assess student proficiency with those same standards prior to administering summative assessments, it is essential that formative assessments and progress monitoring are utilized. Burke (2010) suggested that formative assessments include:

> Informal techniques like conversations with students, class interactions, questioning, daily work, observation, interviews, conferences, and graphic organizers, as well as more formal techniques like quizzes, performance assessments, and portfolio assessments to monitor student progress and modify instruction accordingly. (p. 21)

Black and Wiliam (1998a) completed a review of the literature on classroom formative assessments with the principal reason of showing that formative assessments are all-encompassing activities that do not have a tightly defined meaning. Formative assessments are undertaken by both students and teacher and are meant to provide feedback on any necessary modifications that need to be made to instruction. Classroom evaluation practices often encourage “superficial and rote learning” (p. 17), and students, upon receiving a scored assessment, are strictly concerned with the letter grade and not why they earned the grade. Formative assessments allow teaching and learning by students to be an interactive process (Black & Wiliam, 1998b). Teachers are continuously aware of the progress, or lack thereof, of each student as they work to obtain the goals of the standards, and subsequently, with adequate feedback, students are able to self-assess their progress in meeting standards goals rather than solely being focused on a letter grade. The formative assessment process is assessment for learning with the purpose of providing ongoing feedback in order to improve student learning (Burke, 2010).

Elawar and Corno (1985) studied the feedback of teachers’ on student homework in three schools, involving 18 math teachers and over 500 Venezuelan students. A control group corrected homework as normal without making any comments on student work. The treatment group was trained on concentrating feedback on student work to specific computational and strategy errors with suggestions on how to improve. A third group marked half of the students' work with the trained comments and the other half with only correct and incorrect answers marked. All groups completed a pre-test and one of three similar forms of a post-test, and an analysis of the results showed that students in the treatment groups had higher scores on the achievement post-tests and had higher average attitude scores at post-test in comparison to the control group students.

Meaningful feedback is an essential component to any formative assessment implementation technique, and must be present for the assessment to have any significant impact on students' learning. Natriello and Dornbusch (1984) found that when students observed the feedback of their school work to be inaccurate and not to the level of effort that they put into the assignment, they were more likely to hold the feedback in low regard and consequently, less likely to put forth the same effort on subsequent tasks (as cited in Natriello, 1987). Thus, simply correcting work for right or wrong answers is not providing students with the necessary tools needed to make gains in their learning as "feedback to any pupil should be about the particular qualities of his or her work, with advice on what he or she can do to improve, and should avoid comparisons with other pupils" (Black & Wiliam, 1998b, p. 6).

Crooks (1988) suggested that formative assessment affects students in short, medium and long term ways. Formative assessment allows teachers to check that students have the necessary prerequisite skills to learn the content to be covered, it allows teachers to guide the focus for future learning activities that will promote mastery of a standard and allows teachers to influence students' ability to retain and apply skills in various contexts. Formative assessments measure students' skills and knowledge throughout the course of study, which provides teachers the opportunity to continually adapt teaching to student needs (Sharkey & Murnane, 2006). Unlike usual mathematics classroom instruction, which follows the pattern of quizzes and chapter tests, "progress monitoring assessments are brief and time-limited" making it possible to administer them often so as to continuously assess student progress (Foegen & Morrison, 2010, p. 96).

In their review of 20 studies (that included students ranging from age five to university undergraduates), Black and Wiliam (1998b) found that there was an indication in each study that, "strengthening the practice of formative assessment produces significant and often substantial learning gains" (p. 3). Formative assessment works because it increases students' 'mindfulness' (Black & Wiliam, 2003). They become deeper thinkers because they are continually being asked to correct and understand the errors in their work.

Metacognitive Thinking

One of the goals of the CCSSM is for students to become independent thinkers who are able to persevere in problem solving until they understand and can make sense of the math they are learning. Incorporating tasks into daily instruction that teach students how to practice the skill of thinking about their own thinking processes (metacognition) will help create independent thinkers in the classroom (NGA & CCSSO, 2010). However, it is a difficult task in a classroom to cultivate an environment where students can independently monitor their learning and evaluate their progress in meeting content standard goals. In order to establish and maintain this environment, "at the point of beginning a course of study, students deserve to know the criteria by which judgments will be made about the quality of their work" (Sadler, 2005, p. 178). When students are cognizant of exactly how they will be judged on their work, this allows for students to self-evaluate their own understanding of the material. Self-evaluation is not a skill that comes naturally to all students, but nonetheless, is necessary if students are to be successful learners.

It again falls on the classroom teacher then to teach students how to self-evaluate their learning and how to be independent thinkers. More importantly, and even more difficult, it also becomes the duty of the teacher to show students how to choose thinking strategies that work best in their own learning process. Teachers need to move students away from the thoughts that reflect, "I'm just not smart enough," and instead empower students with "the belief that ability is a continuously expandable repertoire of skills, and that through a person's efforts, intelligence grows incrementally" (Costa & Kallick, 2008, p. 7). Such techniques as Costa's (2008) *Habits of Mind*, thinking strategies highlighted in Ritchhart, Church and Morrison's (2011) *Making Thinking Visible*, and self- assessment techniques such as ipsative assessment, which compares a student's performance on an assessment to their prior work (Hughes, 2011), all provide students with the tools they need to become independent, motivated learners.

First, teachers must encourage students to focus on their personal performance in the classroom, and help them develop goals to achieve their personal best scores rather than beating the score of another student. Teachers need to supply students with quality feedback so that they can close any gaps that might exist between their performance and the desired performance standards. In their 2006 article, Nicol and Macfarlane-Dick, (as cited in Hughes, 2011), noted the characteristics that define what good feedback looks like in the classroom. Feedback should help clarify what good performance is, facilitate reflection in learning, encourage high-quality information about student learning being delivered to students through peer and teacher discussions, and provide information to teachers that will help shape instruction.

To create reflective learners in the classroom, Ritchhart, et al. (2011) suggested that teachers must create opportunities for thinking by asking good questions, including questions that do not already have a definitive answer, and provide students with, "constructive questions. . . that ask students to connect ideas, to make interpretations, to focus on big ideas and central concepts" (Ritchhart, et al., 2011, p. 33). After close observation of classroom teachers at work, Ritchhart, et al., observed that one, simple question that often garnered in-depth, thoughtful responses from students was, "What makes you say that?" Teachers who use such facilitative questions are getting inside the heads of students and asking them to make their thinking visible. When visible thinking is seen as a valued practice within a classroom, there is an, "environment that creates trust; allows risk taking; and is experimental, creative, and positive" (Costa & Kallick, 2009, p. 99).

When the classroom environment rich in thinking strategies further encourages use of a specified vocabulary, such as the vocabulary of the *Habits of Mind*, which are, "the attributes that human beings display when they behave intelligently…[and] are the characteristics of what intelligent people do when they are confronted with problems" (Costa & Kallick, 2009, p. 15), the thinking that is occurring within a classroom can be quickly and specifically identified. A student who solves a complex math problem differently from her classmates would be recognized for *Thinking Flexibly*; a student who is consistently checking that the final answer makes sense in the context of the problem would be acknowledged for *Striving for Accuracy* in their solution; and a student who made connections from a prior topic to the current topic of conversation would be applauded for *Applying Past Knowledge to New Situations* (Costa & Kallick, 2009). In schools and classrooms where the *Habits of Mind* are used consistently and successfully, “students keep track of their learning” (Costa & Kallick, 2009, p. 103), and are able to see the personal gains and growth in their knowledge.

Including strategies (such as those mentioned above) into daily classroom routines, create students who are independent, reflective thinkers. When presented with challenging problems the “learning strategies students adopt [to solve the problem] are powerful predictors of educational outcomes, so that expertise in the selection and application of learning strategies is an important education outcome” (Crooks, 1988, p. 441). If teachers are to create students who are college and career ready by the time they graduate high school, they are then tasked with the challenge of providing students with a repertoire of skills that can be used across content areas and in any context. As teachers introduce students to the standards of their content area through the use of the *Habits of Mind* vocabulary, the use of metacognitive thinking strategies and the use of self-assessment techniques such as ipsative assessment, teachers are providing students’ with learning tools that they can access at any time to advance their learning (Ritchhart, et al., 2011).

Summary

Standards direct the attention of students to those elements of math that they will be held accountable for learning (Natriello, 1987). As the literature indicates, standards-based instruction provides a focus to instruction because it gives specifics in regards to the content that should be taught within each grade and across grade levels. This focus allows for more time to be devoted to formative assessments, student self-monitoring and the use of metacognitive thinking strategies.

Chapter Three

Methods

The purpose of this action research study was to analyze the effect of Common Core State Standards for Mathematics (CCSSM) – based curriculum on the learning of middle school-aged students. Within the development of this curriculum, the use of progress monitoring tools and metacognitive thinking strategies were emphasized in order to promote the deeper thinking in students. These strategies are explained in the procedures section of this chapter, after first discussion the context, participants and data collection instruments.

Context

This study was completed in my Academically Talented (AT) seventh grade math class at a middle school during the entire school year, September 2, 2014 – June 10, 2015. This was a large suburban school located in Wisconsin with an enrollment of 775 students in grades 7 and 8. The makeup of the school was primarily Caucasian (93%) and included a Hispanic population of 5% and a 2% Multi-racial population. Also, 16% of the school's population was eligible for free or reduced-priced lunch. The school was the only middle school in the district and was where the students of the six elementary schools of the district first came together in one school.

Participants

The participants of this study included 26 seventh-grade students (16 male and 10 female), aged 12 to 13 years. All students in the study were one year advanced in their math track, and would complete the eighth grade mathematics curriculum throughout their seventh grade year. This class was denoted as an Academically Talented (AT) math course. Students were tested at the elementary level to determine if they should be placed on the AT track at the elementary level, which then continued at the middle school. All elementary schools in the district use Everyday Mathematics as the mathematics curriculum so all students have a similar background in the content received in sixth grade. Of the three different courses I taught this school year, any one of them could have been selected for this project as none of the courses had curriculum that was directly aligned with the CCSSM. This particular class was chosen amongst the three courses for two reasons: firstly, it was a class I taught only once a day and therefore I felt I could better manage the time commitment that was involved in this project; and secondly, it was not a class that was eligible to receive high school credit and thus afforded me more freedom to implement different instruction strategies.

Questions

The following questions were the focus of this project:

1) Did student scores on pre-instruction unit assessments direct instruction for a unit (such as leveling assignments for students who earned high scores on the pre-assessment on particular standards)?
2) Did the results of progress monitoring (warm-ups) prompt change to classroom instruction?
3) Did the use of metacognitive strategies influence student perception of the value of the strategies in achieving understanding and proficiency with the standards?

It was hypothesized that pre-instruction unit assessments would prompt differentiation in homework assigned to students based on the results of the pre-instruction assessment. Also, pre-instruction assessments might show if there were skills that students were already proficient with. National standards like the CCSSM are meant to eliminate the repeated instruction of topics from one grade level to the next, thus if there were topics that students demonstrated proficiency with on the pre-instruction unit assessment, it would not be necessary to re-teach that topic. The use of formative assessment tools would more accurately identify students struggling with particular standards. If a large percentage of the class showed on formative assessment pieces that they were not proficient with a standard goal, it would prompt a re-teaching of the standard for the class as a whole. Finally, by placing a greater emphasis in classroom instruction on the use of metacognitive strategies students might recognize a positive correlation between the use of the strategies and their personal understanding of the content standards.

Instruments for Data Collection

The instruments used in this study were as follows: pre- and post- instruction unit assessments, progress monitoring warm-ups to measure students' progress in meeting standard proficiency and the Metacognition Strategies Rating Scale.

The pre- and post- instruction unit assessments (see Appendices A and B) were sectioned by standards addressed within each unit to specifically denote to the student and teacher those standards (if any) that students were not proficient with. Students were given a class period (50 minutes) to complete both the pre- and post- instruction unit assessments. Students' performance on summative assessments was measured by comparing the results of pre-instruction unit assessments to those of the post-instruction unit assessments.

Throughout each unit a formative assessment tool in the form of daily student warm-ups was administered to assess student understanding of the content of the lesson presented the day prior. The warm-ups were collected and scored, and a teacher journal was maintained to note modifications made in instruction based on the results of the warm-ups (and subsequent re-do's) administered. I also maintained teacher field notes to comment on how current students compared to students in the same class from prior years. Some of the content taught this school year was the same as previous school years, but the manner in which the content was delivered this school year was different due to the greater emphasis on progress monitoring through warm-ups and the use of metacognitive strategies. The teacher field notes focused on observations documenting my perceptions of how students worked with the content taught this school year in comparison to other years; however, students' grades from previous years were not compared.

To help students gain proficiency with the standards, metacognitive thinking strategies that assisted students in understanding the standards taught in each unit were used frequently throughout the course of all 11 units (Units 1a and 1b, Units 2a, 2b and 2c, Units 3a and 3b, Units 4a, 4b and 4c, and Units 5a). Upon completion of Unit 1a, in order to determine those strategies that students identified as contributing most to their learning, students completed the Metacognitive Strategies Rating Scale (see Appendix E). Students used approximately five minutes to complete the rating of each strategy and the explanation piece that followed the ratings.

Procedures

At the commencement of each unit, a pre-instruction unit assessment was administered to establish a baseline of students' knowledge, and a similar post-instruction unit assessment was administered upon unit completion in order that student growth could be measured (see Appendices A and B). Throughout each unit students completed warm-up questions the day after the content was learned in class, which monitored students' proficiency with each standard. For each question that a student incorrectly answered, they were required to complete re-do warm-up questions of a similar nature until the question(s) was answered correctly (see Appendices C and D). Working with students on an individual basis to assist them with content they were struggling with was not something new to my teaching, but requiring them to show that they were able to complete a task without my guidance was not something I had required of students in past school years (per teacher field notes). By requiring them to complete re-do warm-ups without my assistance demonstrated to me that they had an understanding of the content. Throughout the teaching of the content students utilized various metacognitive thinking strategies. Upon completion of Unit 1a students completed a metacognitive strategies rating scale (see Appendix E), which assisted them in specifically recognizing those strategies they found useful to their learning and why those strategies helped their learning of a particular concept.

The first trimester, composed of grading periods 1 and 2, focused on The Number System (NS) Domain for the first 6 weeks (Units 1a and 1b), and the Expressions and Equations (EE) Domain for the second 6 weeks (Units 2a and 2b). The second trimester, composed of grading periods 3 and 4, consisted 3 more weeks focused on the EE Domain (Unit 2c), 6 weeks on the Functions (F) Domain (Units 3a and 3b) and 3 weeks on the Geometry (G) Domain (Unit 4a). Finally, trimester 3, composes of grading periods 5 and 6, focused on the Geometry (G) Domain for 8 weeks (Units 4b and 4c), and the Statistics and Probability (SP) Domain for 4 weeks (Units 5a and 5b). A week of instruction was lost during Trimester 3 due to state-wide Badger Testing.

At the start of the school year, it was my intent to place a greater emphasis on the use and benefit of metacognitive thinking strategies throughout the entire school year. By placing a greater emphasis on these strategies, it promoted deeper thinking in students about the ‘why’ behind their learning of each standard. The first week of class began by introducing the Habits of Mind (HOM) along with 4 thinking strategies that would be used over the course of the school year. The thinking strategies that were used to introduce the HOM include: 3-2-1 Reflection Bridge, Think-Puzzle-Explore Reflection, CSI: Color, Symbol, Image (Ritchart, Church, & Morrison, 2011), and Carousel Brainstorm (Santa, Havens, & Valdes, 2007).

It is required of the math department that a minimum of two summative assessments be administered during a grading period (6 weeks). In order that this requirement is fulfilled, each unit was broken into two parts or three parts (see Table 3.1).

Table 3.1

Organization of Units

Dates	**Description**
Week 1	Introduced Habits of Mind vocabulary and Metacognitive Strategies: 3-2-1 Reflection Bridge, Think/Puzzle/Explore, CSI: Color, Symbol, Image and Carousel Brainstorm
Weeks 2 – 4.5	• Administered Unit 1a: The Number System (Integers) pre-instruction assessment (7 subsections on unit) • Administered 2 mini-assessments (quizzes), one after first half and one after second half of the unit to check understanding • Metacognitive Strategies: Think/Puzzle/Explore, Rallytable, Corners, Think/Pair/Share, See/Think/Wonder • Administered Unit 1a post-instruction assessment
Weeks 4.5 – 6	• Administered Unit 1b: The Number System (Rational Numbers) pre-instruction assessment (6 subsections in unit) • Metacognitive Strategies: Think/Pair/Share • Administered Unit 1b post-instruction assessment
Weeks 7 – 9.5	• Administered Unit 2a: Expressions pre-instruction assessment (4 subsections in unit) • Administered 2 mini-assessments (quizzes), one after first half and one after second half of the unit to check understanding • Metacognitive Strategies: Chalk Talk, See/Think/Wonder • Administered Unit 2a post-instruction assessment
Weeks 9.5 – 11	• Administered Unit 2b: Equations pre- instruction assessment (5 subsections in unit) • Administered 2 quizzes • Metacognitive Strategies: 4 x 4 puzzles, activating background knowledge, Concentric Circles • Administered 2b post-instruction assessment
Weeks 12 – 15	• Administered Unit 2c: Multi-Step and Systems of Equations pre-

instruction assessment (7 subsections in unit)
- Administered 2 quizzes
- Metacognitive Strategies: Think/Pair/Share, Concentric Circles, Group Level Challenge
- Administered Unit 2c post-instruction assessment

Weeks 16 – 18
- Administered Unit 3a: Functions (Identifying Functions, Domain & Range) pre-instruction assessment (4 subsections in unit)
- Administered 2 quizzes
- Administered Unit 3a post-instruction assessment

Weeks 19 – 21
- Administered Unit 3b: Functions (Linear vs. Non-linear functions and Writing function rules) pre-instruction assessment (4 subsections in unit)
- Administered 2 quizzes
- Administered Unit 3b post-instruction assessment

Weeks 22 – 24
- Administered Unit 4a: Geometry (Transformations) pre-instruction assessment (5 subsections in unit)
- Administered 2 quizzes
- Metacognitive Strategies: Triangle Sort, See/Think/Wonder, Polygon Sort, Headlines Summarizing Activity, Concentric Circles
- Administered Unit 4a post-instruction assessment

Weeks 25 – 28
- Administered Unit 4b: Geometry (Pythagorean Theorem) pre-instruction assessment (5 subsections in unit)
- Administered 2 quizzes
- Metacognitive Strategies: Pythagorean Theorem proof, Group Investigations, Concentric Circles

Weeks 29 – 32
- Badger Testing (state test) was conducted during this time period
- Administered Unit 4c: Geometry (Surface Area & Volume) pre-instruction assessment (5 subsections in unit)
- Administered 2 quizzes
- Metacognitive Strategies: Think/Pair/Share, Concentric Circles
- Administered Unit 4c post-instruction assessment

Weeks 33 – 34
- Administered Unit 5a: Probability and Odds pre-instruction assessment (4 subsections in unit)
- No quizzes administered this unit
- Metacognitive Strategies: Think/Pair/Share, Concentric Circles
- Administered Unit 5a post-instruction assessment

Analysis

Pre- and post-instruction unit assessments were broken into subsections based on each standard addressed in a unit. Each subsection consisted of four questions, with some questions being broken into multiple parts. For example, in Unit 3a, question 1 was broken into parts a, b, c and d, question 2 was one multiple choice question, question 3 was broken into parts a and b, while question 4 was just one question. A score was given based on the number of questions answered correctly within each section. The questions were marked as correct or incorrect, there was no partial credit given. Each section assessed student proficiency on a particular standard. In the example noted above, those 4 questions composed Standard 3.1 in the Functions Domain, and assessed CCSSM Standard 8.F.1, "Understand that a function is a rule that assigns to each input exactly one output" (NGA & CCSSO, 2010). Students needed to correctly answer at least three of the four questions, which denoted adequate to thorough command, or proficiency, of the standard. The overall scores of each student were recorded as well as a score for each individual section of the assessment.

The warm-ups were used to show student proficiency with the basics of the standard and their ability to apply those basic skills to deeper application problems (see Appendix C). Warm-ups were scored in order that any students who did not receive a 100% were required to complete re-do questions on the incorrectly answered problems until they demonstrated 100% proficiency (see Appendix D). Each warm-up varied in the number of questions dependent on the nature of the content being assessed – the number of questions on a warm-up ranged anywhere from 1 – 4 questions. The scores of the warm-ups were used to determine if changes needed to be made to whole group classroom instruction or whether additional instruction on a standard needed to be provided to individual students.

The Metacognitive Strategies Rating Scale was completed by students only for Unit 1a, and was analyzed for those strategies that received a rating of a three or four from students. I recorded the frequency that each strategy received a score of a 3 (helpful) or 4 (extremely helpful) from students. For those strategies that received high marks, I examined students' explanations by looking for trends in their comments, such as: "it helped me study what I didn't know", "it gave me more practice" or "allowed me to share ideas with others". The results are presented in Chapter Four.

Chapter Four

Implementation

In this chapter, I describe the organization of units that were implemented for this project, and then I present the results that correspond to each question of the study.

Organization of Units

One of the first changes to my classroom instruction was the administration of a pre-instruction unit assessment. In developing these pre-instruction assessments for each unit, it was necessary for me to employ a backwards design method in first determining how best to group the strands of each standard into more manageable units. The CCSSM for Grade 8 included the following: The Number System (NS) sub-divided into two strands, Expressions and Equations (EE) sub-divided into eight strands, Functions (F) sub-divided into five strands, Geometry (G) sub-divided into nine strands, and Statistics and Probability (SP) sub-divided into four strands. In teaching these standards, it was necessary to keep in mind the grading system guidelines that needed to be maintained as they were followed department-wide: 15% of the grade given to homework scores, 35% of the grade given to quiz scores and 50% of the grade given to test scores. Since half of the grade is devoted to the scores of tests, it was my intention that each grading period (6 weeks) include two test assessment grades in order that students had an average of two scores in that category.

In order that a minimum of two unit summative assessments were administered within each grading period (GP), the year was broken down into 5 units based on the CCSSM. The Number System unit was broken into two sub-units, Unit 1a and Unit 1b, and took five weeks to complete. The Expressions and Equations unit was broken into three sub-units, Unit 2a, Unit 2b and Unit 2c, and took nine weeks to complete. The Functions unit was broken into two sub-units, Unit 3a and Unit 3b, and took six weeks to complete. The Geometry unit was broken into three sub-units, Unit 4a, Unit 4b and Unit 4c, and took eleven weeks to complete. Finally, the Statistics and Probability unit was broken into two sub-units, unit 5a and Unit 5b, and took four weeks to complete.

Within each unit, I created pre-instruction assessments that addressed the strands of each standard, and as I felt necessary, included additional instruction outside of the standards that past experience has shown were areas of weakness for students. For example, in Unit 1 (The Number System), I included work on integer and rational number operations. These have traditionally been areas of weakness for students entering their seventh grade year, and knowing that these were skills that would be utilized frequently in solving equations, I deemed it as instruction that would benefit student learning in future units.

The implementation of the CCSSM also required a more thorough dive into real-world application. In past years, following the direction of the textbook, students had solved one-step, two-step and multi-step (variables on both sides) equations. However, solving multi-step equations occurred three chapters after the initial introduction of solving one- and two-step equations, which often resulted in having to reteach skills. Now, with the reorganization of how content was taught, students spent nine weeks applying algebraic skills as noted above, and unlike in past years, included solving equations with proportional relationships, equations involving square and cube roots and calculating solutions to systems of two linear equations in two variables. Furthermore, students were asked to write equations in all these forms to model real-life situations more than had been asked in years prior. Because the unit was spread out over the course of nine weeks, there was the time to devote to applying the skills to real-life scenarios, when in previous school years, the time was not there to do so. Here is an example of a question that this year's students were expected to understand, but in past years was never introduced to my students:

> On Monday, the office staff at Park View Middle School bought 4 bagels and 7 cups of coffee for $16.93. On Tuesday, they bought 8 bagels and 10 cups of coffee for $29.90. Let x represent the number of bagels and let y represent the cups of coffee. What is the cost of one bagel and one cup of coffee?

Linear System: _________________ **Bagel cost: _____________**

_________________ **Coffee cost: ____________**

Each sub-unit within the larger unit was broken down into subsections to inform students exactly the skill they were expected to be proficient within each subsection, and so that I could identify specific standards of weakness. An "I can…" reflection (see Appendix F) was administered upon completion of each chapter to guide students in their review, which was self-directed based on where they felt they needed work. Students were given several options on how they could review (see Appendix G), and it was their choice on what they worked on during review time.

Question 1: Did student scores on pre-instruction unit assessments direct instruction for a unit (such as leveling assignments for students who earned high scores on the pre-assessment on particular standards)?

As mentioned, each student completed a pre-instruction assessment that was scored for the number of correct answers. There was no prior instruction given or background knowledge activated before administering the assessment. Following the completion of each unit, the post-instruction assessment was formatted the same so that results could be compared. The maximum number of points possible (a score of 4 earned on each standard was the maximum number of points possible) is indicated next to each unit. The class mean scores for each unit are given.

Table 4.1

Pre- and Post-Instruction Average Assessment Scores

Unit # (max. possible score)	Pre-Instruction Score	Post-Instruction Score
1a (28)	9.19	24.33
1b (24)	11.94	19.73
2a (16)	2.82	13.80
2b (20)	1.74	17.30
2c (28)	3.38	22.13
3a (16)	1.57	13.75
3b (16)	5.58	14.39
4a (20)	2.75	18.55
4b (20)	0.21	16.73
4c (20)	1.55	14.21
5a (12)	1.05	10.17

Administering the pre-instruction assessments indicated students whose background knowledge was stronger than others, which prompted adjustments to be made to the instruction for that unit. In Unit 1b, for example approximately 65% (17 students) of the class scored a 3 or 4 on standard 1.8, which assessed simplifying and ordering rational numbers. If the cut score was dropped to a 2.5, 0.5 of a point lost because a negative was left off of a solution, approximately 88% (23 students) earned that score or better. Thus, this was a standard that was not given its own day of instruction as was originally intended because the pre-instruction assessment indicated that it was a skill most students were proficient with. Also, there were three other standards in Unit 1b where approximately 30% (8 students) of the class earned a score of a 3 or better: Standard 1.9 (Add/Subtract mixed numbers and fractions), Standard 1.10 (Multiply mixed numbers and fractions, and Standard 1.12 (Add/Subtract Decimals). For these standards, the assigned practice (homework) that followed the lesson for that standard was leveled so that students who pre-assessed with a score of a 3 or 4 were given work that was more application-based as opposed to just practicing the skill (see Appendix H).

As indicated by my teacher field notes, an unexpected occurrence was the visible change in students' attitudes upon completion of a unit pre-instruction assessment. There was a general feeling of frustration and comments made by students indicated their frustrations:

- "I don't think I'm in the right class."
- "I'm stressed out from that!"

I wanted to provide students as much exposure to content as possible and so beginning in Unit 2a, students were given the option to retake any quizzes from a unit. Students, no matter what their score on the first quiz, always had the option to retake a different version of the quiz in order that they might improve their score. This was not a strategy I had used before in previous school years, but found it to be a great tool in taking the opportunity to meet with individual students and discuss problem areas before they completed a re-take quiz. Students were asked the following question after the completion of Unit 3a (approximately half-way through the school year): "Do you like that you have the option to retake quizzes to improve your score?"

- "Yes!! I love being able to retake quizzes because I can learn what I did wrong, understand it and improve my score."
- "Yes, I think it's totally fair because you can learn from your mistakes, and apply what was right. It gives an opportunity to ask questions and provide more practice."
- "The option to retake quizzes is a good idea. It gives us a chance to see what we did wrong and fix our mistakes."

- “Yes I believe that it is very helpful because sometimes we will make silly mistakes and it’s nice that we can retake them and it is also a good thing to practice.”

Question 2: Did the results of progress monitoring (warm-ups) prompt change to classroom instruction?

Upon completion of the instruction and homework practice of a particular section within a sub-unit, students were required to complete anywhere from 1 – 5 warm-up questions to review the content from the previous section. If a student did not earn a 100% on the warm-up they were required to complete a warm-up redo on the questions they did not answer correctly the first time. It is required that students continue to complete re-do’s until 100% success was achieved. These warm-ups were never entered as a grade as they were utilized as a formative assessment, progress monitoring tool.

From my perspective, this progress monitoring tool was invaluable. In past years, students had always completed warm-up questions, but never to be corrected and re-done if answered incorrectly. When students arrived to a point of being on the fourth re-do for a particular standard, it was an excellent indicator that the understanding of the content was not at proficient levels. If a majority of the class was struggling with a concept and incorrectly answering the warm-up questions, it was necessary to go back and re-teach the skill. For example, as was indicated by my field notes, early in the year the warm-ups indicated that much of the class, approximately 80% (21 students), was struggling with Standard 1.9: Adding/Subtracting mixed numbers and fractions. It was necessary to take an extra day to clear up the confusions they were experiencing.

Throughout each unit, scores were recorded on the warm-ups for each student so as to ensure that each student was achieving a 100% correct completion rate. The number of questions per warm-up is indicated in parentheses under each standard listed in Table 4.2. Below is a sample of 5 students' progress monitoring warm-up scores for Unit 4c.

Table 4.2

Sample Warm-Up Scores

	Standard 4.11: Area/Classify 3D Solids (3)	Standard 4.12: Surface Area of Prisms (2)	Standard 4.13: Surface Area of Cylinders, Pyramids, Cones (2)	Standard 4.14: Volume of Prisms & Cylinders (2)	Standard 4.15: Volume of Cones, Pyramids, Spheres (2)
Student A	1+1+1	1+1	1+1	1+1	2
Student B	3	0+1+1	2	1+1	2
Student C	2+1	0+2+1	1+1	1+1	0+2
Student D	1+0+1+1	0+2	1+1	1+1	1+1
Student E	2+1	2	2	2	1+1

On the Standard 4.11 warm-up, Student A only answered 1 of 3 questions correctly on the first attempt. Therefore, because a 100% was not earned, Student A was required to complete Standard 4.11 warm-up re-do #1. On re-do #1, the two questions answered incorrectly were the ones to be attempted a second time. On re-do #1 Student A correctly answered 1 of 2 questions and thus was given a second re-do on the Standard 4.11 warm-up. It was on this second re-do attempt that Student A was able to correctly answer the third question, and was able to move on from completing warm-ups for this standard.

Question 3: Did the use of metacognitive strategies influence student perception of the value of the strategies in achieving understanding and proficiency with the standards?

Metacognitive strategies were most often used throughout the course of the year to activate student background knowledge on a topic or to recognize patterns in order that generalizations might be made. For example, to introduce multiplying and dividing exponents the *See/Think/Wonder (S/T/W)* strategy was used to show students examples of how the properties work and then, in their own words, they were asked to describe the pattern. In past years, I had simply shared the pattern with students and moved on with practicing the skills of multiplying and dividing exponents. Allowing students to come up with what they interpreted the general rules to be produced an excellent discussion. The "wonders" the students had were ideas that I had never considered. *Think/Pair/Share (T/P/S)* was a strategy used in class on an almost daily basis in order that all students had an opportunity to discuss their thoughts and ideas rather than just one student discussing with the teacher.

Students completed the Metacognitive Rating Scale (see Appendix E) for Unit 1a and I recorded the frequencies with which a strategy earned a score of 3 (helpful) or 4 (extremely helpful) from students (see Table 4.3). On the day that the rating scale was administered, 22 students were present in class to complete the scale.

Upon completing the rating scale for each of the strategies used in Unit 1a (Table 4.3), students were asked to comment on the strategies. They were asked to explain more thoroughly why they rated the strategies as they did. Table 4.4 indicates the three most frequently made comments and the number of times students made those particular comments.

Table 4.3

Metacognitive Strategies Rating Scale Frequencies

Strategy	**Frequency (scored 3+)**
Warm-ups	22
"I can…" review reflection	13
Corners	13
See/Think/Wonder	11
Think/Pair/Share	10
Think/Puzzle/Explore	10

Table 4.4

Metacognitive Strategies Rating Scale Comment Frequencies

Comment	**Frequency**
"It helped me study what I didn't know"	7
"It gave me more practice"	9
"It allowed me to share ideas with others"	7

Chapter Five

Conclusions

Standards-based curriculum aims to narrow the focus of what is taught at each grade level in math classrooms to allow for more in-depth thought processes to occur, and ultimately, produce math students who are college and career ready (NGA & CCSSO, 2010). The process of designing units based on the CCSSM allowed me to focus instruction for several weeks on broader topics. For example, spending nine straight weeks in the Expressions and Equations Domain allowed for much more in-depth instruction as had not occurred in past school years. When instruction occurs in such a manner, students are more likely to construct understandings and develop their thinking skills more deeply (Wilson, 1996) because they are being asked to *Apply Past Knowledge to New Situations* (Costa & Kallick, 2009) as skills within a unit continued to build on one another.

Students in the United States are below average among the world's most developed countries (PISA, 2012), and the most glaring difference between the United States and other leading countries was the lack of national standards in the U.S. When the 1997 TIMMS results were released, both the United States and Germany were shocked at the poor results of their eighth grade students. Germany's response was to introduce national standards to their education system while in the United States even talk of such an idea was met with strong opposition (Schmidt, Hoaung & Shakrani, 2009). However, as Schmidt, Wang and McKnight (2005) noted, the all-inclusive nature of state standards, with the incredible number of topics to be taught at each grade level, was not getting the job done. The CCSSM provide focus and direction needed at each grade level to allow for students to be college and career ready once they graduate high school (NGA & CCSSO, 2010).

Utilizing pre-instruction unit assessments provided students with an initial look at the standards they were expected to be proficient with in a particular unit. When they saw the content presented to them in class, it was not an entirely new concept. The pre-assessments also provided me with information on standards that the class as a whole or individual students were already able to demonstrate proficiency with and thus, prompted adjustments to instruction as needed.

Within each unit, the progress monitoring warm-ups used provided quality feedback to students with what he or she needed to do in order to improve on their work. It did not compare their work to other students nor did it count as a grade, which created a low-stress environment (Black & Wiliam, 1998b). The warm-ups promoted mastery of the standards and were a constant measure of students' skills and knowledge (Crooks, 1998, Sharkey & Murnane, 2006). They provided an opportunity to have conversations with students regarding specific aspects of their work rather than just giving general comments (Burke, 2010).

The use of metacognitive thinking strategies throughout the course of the school year was not documented as consistently as the pre- and post-instruction assessment scores and progress monitoring, but was nonetheless important. Ritchhart, et al. (2011) stated that teachers must create opportunities for thinking by asking good questions, including ones that do not possess a definitive answer. This was something that I was more cognizant of throughout the school year, and some of the most lively discussions were ones that I purposely selected because I had yet to find the solution or even attempt the problem. Because I was not quick to provide the students with a solution and would not continue on with the discussion until we found an answer, they were more invested in working towards a solution.

Utilizing the language of the *Habits of Mind* promoted a classroom culture that welcomed discussions on the types of thinking that occurred during any given lesson. There was no right answer in these discussions because everyone thinks differently. This created an environment of trust and openness within the classroom that gave all students an opportunity to participate and engage in discussion (Costa & Kallick, 2009).

Implications for Teaching

Within my own classroom, I will definitely be structuring my other classes into larger units rather than following the outline suggested by the textbooks used in class. By organizing classroom structure in such a manner, more time is spent on one topic in a continuous manner rather than spreading topics out over random chapters of a textbook. This continuity and organization of instruction allowed for the time to explore topics more deeply. Organizing the content into a small number of units provides a more focused structure for students to follow.

Progress monitoring is necessary to ensure that all students are proficient with the standards of a unit. To only look at a final grade on the summative assessment at the end of a unit or chapter allows for weak performance in some areas to be masked by strong performance in other areas of the unit of chapter (Sadler, 2005). By continuously monitoring students' work, those weaknesses will be seen and can be managed.

Limitations

Although pre-instruction and post-instruction assessment scores from each unit could be compared for each student, this is only one year of work. Because the content and the manner in which it was taught was different from any other year I taught this course, direct comparisons to summative assessment scores could not be made.

The sample size of this group was small and was also a group of advanced math students. The curriculum used in this study is the same that would be used in any regular education eighth-grade math classroom, but might the results have been different for non-advanced students? Every unit saw large gains from pre- to post-instruction unit assessments. I would conjecture that gains would be made in a regular education eighth-grade math class, but possibly not as significant. However, I am of the belief that this crosses into questions on the motivation levels of an advanced versus a regular education student.

Recommendations

There were times throughout the course of the year when I felt that certain students could have benefited from a more individualized structure where they were able to work through the curriculum at a faster pace. Modifying the curriculum to allow students to do more individualized work would require the creation of lessons that would further expand on the goals of a unit once students have met the unit expectations. These extra lessons would be more enrichment work for students – not anything they would be assessed on. Pre-instruction unit assessments, particularly with the first three units, indicated that there were students who most likely could have become proficient with the content in less time than was allotted for it during classroom instruction time. Thus, creating enrichment opportunities for these units would provide an opportunity for those students to expand their knowledge of the standards even further.

Metacognitive thinking strategies were used throughout the course of the school year, but student perceptions of these strategies were only recorded from Unit 1a. Overall, student comments were positive, indicating that they perceived the strategies to be useful to their learning. Future recommendations are to record more thoroughly students' perceptions on the usefulness of strategies throughout the course of the year. By doing this, more information could be gathered on the strategies that were more beneficial to student learning of particular standards, and those strategies that were useful in general no matter the content being taught.

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Appendix

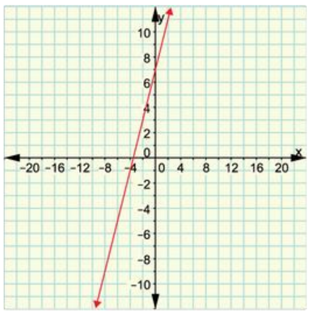
Appendix A
Pre-instruction unit assessment

Math 7AT Unit 3b: Functions
Pre-Unit Assessment

Standard 3.5:
______/4

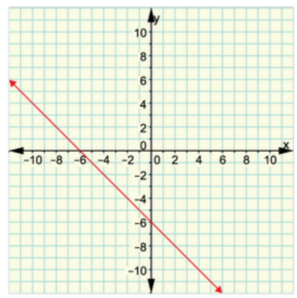
Directions: In 1, write an equation that represents the graph.

1a.)



Equation: ____________________

1b.)



Equation: ____________________

Directions: In 2, for each table of values write an equation in slope-intercept form that relates *x* to *y*.

2a.)

x	y
-35	2
-30	12
-25	22
-20	32
-15	42

Equation: ____________________

2b.)

x	y
-3	1
-1	3
1	5
3	7
5	9

Equation: ____________________

2c.)

x	Y
-5	-27
-1	-15
3	-3
7	9
11	21

Equation: ____________________

2d.)

x	y
-6	-4
-2	-2
0	-1
2	0
6	2

Equation: ____________________

Directions: In 3, circle the choice that represents the given information.

3a.) Which equation has a rate of change of $\frac{-2}{5}$ and an initial value of 7?

a.) $x = \frac{-2}{5}y + 7$ b.) $y = \frac{-2}{5}x + 7$
c.) $x = 7y - \frac{2}{5}$ d.) $y = 7x - \frac{2}{5}$

3b.) Which equation has a rate of change of $\frac{1}{4}$ and an initial value of -3?

a.) $y = -3x + \frac{1}{4}$ b.) $x = \frac{1}{4}y - 3$
c.) $x = -3y + \frac{1}{4}$ d.) $y = \frac{1}{4}x - 3$

3c.) Which equation describes a line that is parallel to $y = 3x - 5$ and includes the point (2, 12)?

a.) $y = 3x + 10$ b.) $y = 3x + 6$
c.) $y = 3x - 5$ d.) $y = 3x - 10$

3d.) Which equation describes a line that is parallel to $y = -2x + 1$ and includes the point (4, -11)?

a.) $y = -2x + 1$ b.) $y = -2x - 5$
c.) $y = -2x + 3$ d.) $y = -2x - 3$

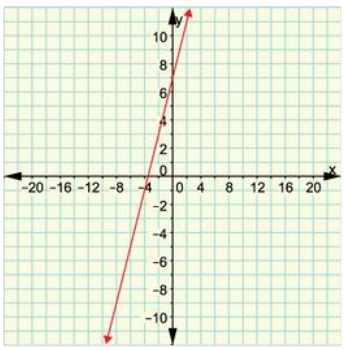
Appendix B
Post-instruction unit assessment

Math 7AT Unit 3b: Functions Assessment

Standard 3.5:
______/4

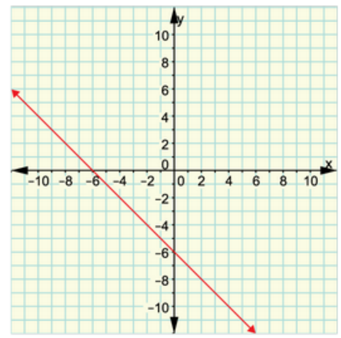
Directions: In 1, write an equation that represents the graph.

1a.)



Equation: ____________________

1b.)



Equation: ____________________

Directions: In 2, for each table of values write an equation in slope-intercept form that relates *x* to *y*.

2a.)

x	y
-35	2
-30	12
-25	22
-20	32
-15	42

Equation: ____________________

2b.)

x	y
-3	1
-1	3
1	5
3	7
5	9

Equation: ____________________

2c.)

x	y
-5	3
-1	-9
2	-18
7	-33
9	-39

Equation: ____________________

2d.)

x	y
-6	6
-2	4
0	3
4	1
10	-2

Equation: ____________________

Directions: In 3, circle the choice that represents the given information.

3a.) Which equation has a rate of change of $\frac{-2}{5}$ and an initial value of 7?

a.) $x = \frac{-2}{5}y + 7$ b.) $y = \frac{-2}{5}x + 7$
c.) $x = 7y - \frac{2}{5}$ d.) $y = 7x - \frac{2}{5}$

3b.) Which equation has a rate of change of $\frac{1}{4}$ and an initial value of -3?

a.) $y = -3x + \frac{1}{4}$ b.) $x = \frac{1}{4}y - 3$
c.) $x = -3y + \frac{1}{4}$ d.) $y = \frac{1}{4}x - 3$

3c.) Which equation describes a line that is parallel to $y = 3x - 5$ and includes the point (2, 12)?

a.) $y = 3x + 10$ b.) $y = 3x + 6$
c.) $y = 3x - 5$ d.) $y = 3x - 10$

3d.) Which equation describes a line that is parallel to $y = -2x + 1$ and includes the point (4, -11)?

a.) $y = -2x + 1$ b.) $y = -2x - 5$
c.) $y = -2x + 3$ d.) $y = -2x - 3$

Appendix C
Progress Monitoring Warm-Up

Standard 4.7: Apply the Pythagorean Theorem Warm-Up

Name: _____________________________________

1.) Find the perimeter of the right triangle given its area and the length of one leg. Round to the nearest hundredth, if necessary.

a = 5.6 ft
Area = 33.6 ft^2

1.) Perimeter = _____________

2.) Do the following form a Pythagorean Triple? **6, 8, 10**

Appendix D
Progress Monitoring Warm-Up Re-do

Standard 4.7: Apply the Pythagorean Theorem Warm-Up REDO #1

Name: ______________________________________

1.) Find the perimeter of the right triangle given its area and the length of one leg. Round to the nearest hundredth, if necessary.

a = 6 m
Area = 24 m^2

1.) Perimeter = _____________

2.) Do the following form a Pythagorean Triple? **37, 12, 35**

Appendix E
Metacognition Strategies Rating Scale

Page 1

Unit 1a **Metacognitive Thinking Strategy**	**Content**	**Rating** (1 = not helpful, 2 = somewhat helpful 3 = helpful, 4 = extremely helpful)
1) Think/Puzzle/Explore	Order or Operations	
2) Think/Pair/Share	All standards	
3) See/Think/Wonder	Multiply and Divide Integers	
4) Corners	Classifying Real Numbers	
5) Warm-Ups (including re-do's)	All standards	
6) "I can…" Review Reflection	Used in deciding what your review should be focused on	

Page 2

Look at the ratings you made in the third column. To those strategies that you gave a '3' or '4', explain why that strategy received that rating. How did that particular strategy help your thinking when learning the content?

____

____

____

____

Appendix F
"I can…" Review Reflection

Standard #	"I Can…"	Know It	Not Sure	Need More Practice
2.10	Solve and write multi-step equations.			
2.11	Solve and write equations with variables on both sides.			
2.11	Use the *distributive property* to solve equations with variables on both sides.			
2.12	Solve proportions			
2.13	Solve *square root* equations			
2.13	Solve *cube root* equations			
2.14	Solve and write systems of linear equations *using substitution*.			
2.15	Solve and write systems of linear equations *using elimination*.			
2.16	Solve and write systems of linear equations that have *no solution*.			
2.16	Solve and write systems of linear equations that have *an infinite number of solutions*			

Appendix G
Unit Review Options

Review Options

TenMarks

- Understanding the Pythagorean Theorem
- Apply the Pythagorean Theorem: Distance Between Points
- Applying the Pythagorean Theorem: Identify Side Lengths

Quiz Retakes

- Retakes are available for 4.6 – 4.8 and 4.9 – 4.10 quizzes

ClassZone (textbook website)

- eWorkbook – Chapter 9
  - Lessons #3, 4, 5, 6

Whiteboard Practice

- Cover up answers from old quizzes and re-do them on a whiteboard…you have the right answer on your quiz to check your own work

Khan Academy

- Special Right Triangles

Worksheet Practice

- Special Right Triangles
- Trig Ratios

Appendix H
Leveled Assigned Practice

Unit 1b Assigned Practice

A: score of 3 or 4 on pre-assessment
B: score of less than 3 on pre-assessment

Standard 1.9 AP: Add/Subtract Fractions & Mixed Numbers (complete starred sections)

- pg. 200; #21, 22
- pg. 240; #6-13
- pgs. 240-241; #10-13, 36-38

Standard 1.10 AP: Multiply Fractions & Mixed Numbers
A: pgs. 245-246; #9-13, 18, 20, 21, 28-30, 33, 34
B: pgs. 245-246; #7-11, 17, 19, 20, 25-27, 33, 34

Standard 1.11 AP: Divide Fractions & Mixed Numbers
Same assignment for all: pgs. 249-251; #8-14(e), 28-34(e), 53-57

Standard 1.12 AP: Add/Subtract Decimals
A: pgs. 262-263; #14-16, 32-34, 38
B: pgs. 262-263; #8-16(e), 37, 44

Standard 1.13 AP: Multiply/Divide Decimals
Same assignment for all: pgs. 267-268; #3-6, 13, 16, 17, 19, 48