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Evaluating the Use of Writing Prompts & Graphic Organizers in Middle School Mathematics: Action Research to Improve Mathematical Achievement and Students' Attitudes With Authentic Assessments

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EVALUATING THE USE OF WRITING PROMPTS & GRAPHIC ORGANIZERS IN MIDDLE SCHOOL MATHEMATICS: ACTION RESEARCH TO IMPROVE MATHEMATICAL ACHIEVEMENT AND STUDENTS' ATTITUDES WITH AUTHENTIC ASSESSMENTS

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DEDICATION

I dedicate this dissertation to everyone who has lifted me with encouragement throughout my educational journey. I would like to extend a furthered dedication to my daughter and love, Lilly, I pray you always dream big; to my amazing husband, Isaac, for the immense sacrificial care and support you have provided; and to my parents Dean and Doris, for their inspiring love, encouragement for learning, and making me who I am.

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ABSTRACT

The purpose of this action research was to evaluate the impact of writing prompts and graphic organizers on Mona school's 7th and 8th grade students' mathematical academic achievement and their attitudes towards the authentic application of mathematics. Two research questions guided the study: (1) How and to what extent, do writing prompts and graphic organizers impact 7th and 8th grade students' mathematical achievement and attitudes towards mathematics? (2) What were the 7th and 8th grade students' perceptions about the implementation of authentic writing prompts and graphic organizers in a mathematics course at Mona school? This action research followed a convergent parallel mixed methods study design and consisted of 13 participants. The innovation of implementing writing prompts and graphic organizers was blended with activities, discussions, and traditional teaching methods. Three data collection methods were used over the 13-week unit: formative and summative assessments, semi-structured focus group interviews, and questionnaires. These data sets were analyzed independently and integrated to present the findings. These data sets were analyzed independently and integrated to present the findings.

The study found learning gains in the middle school students' mathematical knowledge with the inclusion of writing prompts and graphic organizers. As well, the use of writing prompts and graphic organizers helped students see how mathematical concepts were applied in their everyday lives. Areas for future research center around the

use of mathematical writing prompts and graphic organizers as a way to determine if students at this younger, pivotal age, could advance their mathematical knowledge.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

CHAPTER 1

INTRODUCTION

National Context

Despite the importance mathematics education has on one's future (Tunstall, 2017), skills such as interpreting information, retrieving and applying formulas or processes, and communicating mathematical thoughts beyond the classroom walls can be a struggle for many students (Tunstall & Bossé, 2016). Quantitative literacy is often not a focus in many math classes (Tunstall & Bossé, 2016). Quantitative literacy includes the mathematical reasoning skills to perform, communicate, explain, and argue real-world applications of mathematics as well as the appreciation and creation of positive attitudes about mathematics (Huscrot-D'Angelo, Higgins, & Crawford, 2014; Madison, 2015).

The importance and awareness of quantitative literacy has recently increased throughout our nation. Reports have shown that many U.S. students lack the variety of mathematical knowledge and skills needed to be successful in the 21st century (Bialik & Fadel, 2015; Huscrot-D'Angelo et al., 2014). These skills are "identified as creativity, innovation, critical thinking, problem solving, communication, and collaboration" (Preus, 2012, p. 59). Additionally, many students struggle with word problems (Edwards, Maloy, & Gordon, 2009; Fuchs et al., 2016; Kyttälä & Björn, 2014) and seeing how mathematics is incorporated into their lives. Such reports of deficiencies in critical knowledge have caused concerns for numerous state departments of education (Secolsky et al., 2016). Unfortunately, it is not uncommon for many students to forget course material after the final exam. This not only creates a struggle to gain success in a following course, but it also leads to increased feelings of failure and negativity towards mathematics (Tunstall & Bossé, 2016). Poor student attitudes are hard to overcome and can be a struggle for a teacher (Russo, 2015); however, it is important to students' future prosperity and success. A relationship with mathematics and understanding of how it contributes to their futures must be present before students flourish (Althauser & Harter, 2016; Tunstall & Bossé, 2016).

Traditionally, many mathematics teachers teach using lessons that focus on practicing rote skills in content standards (Althauser & Harter, 2016), and the lessons are disconnected from students' lives and futures (Althauser & Harter, 2016; Giardini, 2016). Such lessons fall short in teaching students the content necessary for them to understand how mathematics is conducive to their lives and futures.

Seeing the importance to further develop our students, Common Core State Standards for Mathematics has aimed to increase rigor and relevance (Codding, Mercer, Connell, Fiorello, & Kleinert, 2016) with the inclusion of applied and mathematical reasoning standards associated with skill-specific standards (Huscrot-D'Angelo et al., 2014). An 8th grade geometry standard states "understand and apply the Pythagorean Theorem" ("Common Core," 2018, p. 56). This standard is then broken down into clusters that require students to prove they have gained a deeper knowledge of the theorem and its converse is as they show their ability to explain and form arguments with it, apply it to real-world problems, and apply it in conjunction with other formulas such as the distance formula. Most textbooks have only made slight revisions (Leifer & Udall, 2014; Wu, 2011), but some textbook companies have adapted to this rigor and relevant standards by including more word problems and asking students to justify their answers. Word problems can help students learn to pick out information, but it is not a full solution to accommodating these standards. Students, instead, need to play an active role in their learning to make it meaningful and lasting (Edwards, 2015).

Rigor and relevance can also be ensured through authentic assessments, which increases one's appreciation, confidence and ability to transfer problem solving skills learned in the classroom to the real world (Van Peursem, Keller, Pietrzak, Wagner, & Bennett, 2012). For instance, after learning mathematics in a fashion that focuses on authentic assessments, it was common for students to indicate they use mathematics in their daily lives through explanations (Tunstall & Bossé, 2016). When incorporating authentic assessments into one's teaching, these strategies are not the traditional lecture and listen (Sons, 2006). Instead, they include ways to get students actively involved while connecting prior knowledge (Sons, 2006). For example, content and conceptual knowledge is gained by shifting how teachers teach to include more group work (Peltola, 2018; Sons, 2006), writing (Sons, 2006), questioning, and encouraging curiosity (Althauser & Harter, 2016; Capraro, Capraro, Carter, & Harbaugh, 2010; Potter, Ernst, & Glennie, 2017). Furthermore, graphic organizers can enhance organization, comprehension, and communication (Makany, Kemp, & Dror, 2009; Urquhart & Frazee, 2012; Zollman, 2009, 2012), and writing helps gain knowledge, review and consolidate learned material, and extend ideas (Kostos & Shin, 2010).

Local Context

Located in the area's largest city of just over 100,000 people, Lillianna Doris Martin Schools is the largest private school in the state. Lillianna Doris Martin Schools serves slightly under 1,000 students from PK-12. Grades K-12 are broken into two different buildings: Mona (K-8) and Armstrong (9-12). Mona has approximately 542 students (“Billings,” n.d.).

Lillianna Doris Martin Schools is described as having a slightly higher male to female ratio (52% male, 48% female) (“Billings”, n.d.). The student body of Lillianna Doris Martin Schools is roughly 2% African American; 3% Asian; 4% Native American, 0.3% Native Hawaiian/Pacific Islander or unspecified; 7% Hispanic; and the remaining 84% is Caucasian. While half of the students receive some financial assistance, about 13% of the students receive significant scholarships for tuition assistance ("Billings”, n.d.). With an excellent reputation in academics, athletics, and morality, Lillianna Doris Martin Schools is considered a desirable school in the community.

It was my observation that many students in Mona School could perform math problems on paper proficiently, but I often felt that a deeper connection for authentic application was lacking. For example, students struggled coming up with explanations about how mathematics was used in their daily life outside of my class. Also, students appeared to have difficulties organizing and fully communicating their knowledge when writing, as many parts were left out or addressed briefly. I gathered this perception from observing students in the classroom setting and through conversations with students and teachers.

When I asked students to provide a real-world example of the mathematical concept they were learning about, I often saw a look of uncertainty. It was that initial look of confusion, or that the students were struggling, that concerned me. My next observation stemmed from asking students to solve a real-world example that was not from the book, but rather about something that impacted the community. These examples included some of the following situations: if one should get a gym membership and, if so, what gym should he or she join; how long or how far one will be driving and what the graph would look like; or how much money something will cost if there was a sale. The students appeared to understand the relevance of the examples, but there seemed to be a disconnect between understanding how I taught them to solve these problems on paper and solving the problems that might arise in their daily lives, in the world.

When discussing mathematical applications with other faculty, it seemed that I was not alone in my observations. For example, other Mona middle school teachers identified students struggling to connect mathematics to science concepts. Additionally, the teachers shared the students often required prompting and/or the ability for one student to successfully combine strategies from two classes before the rest of the students followed in understanding the concept being taught. One teacher shared with me seeing an improvement with his students grasping the connection quicker in his science classroom when the mathematical concepts involved were taught in my classroom prior to his introduction of the material. Also, discussions with other middle school mathematics teachers who teach the same or different courses, spoke of similar observations. Additionally, teachers observed, and students provided positive feedback for, increased connection of real-world applications with activities of taking pictures where content is found in everyday life or performing lifelike projects.

When I teach, I like to include a variety of methods. Often, I mix the use of traditional teaching methods that are more teacher-directed and include practicing skills, with a student-centered approach to encourage individual learning and participation with discussions and activities. Such examples of the hands-on activities were identifying objects in scavenger hunts or taking pictures; making artifacts, posters, videos, or presentations; or creating a mock store and using math to make smarter choices that adhere to their lifestyles.

To help improve my students' authentic applications of mathematics, most of my examples and homework practice problems were word problems. Beyond this, I had incorporated some authentic assessments that took the form of projects or activities as used and described in this study. While the infrequency of them made it difficult for me to make any decisions regarding their true impacts, I noticed that students showed difficulties grasping how math was used in various ways. However, I have observed that students spoke with more positive expressions when they discussed their projects, and, when talking with students I taught in prior years, they seemed to bring up these authentic assignments. A large goal that I try to keep in mind as I teach mathematics is to incorporate communication, collaboration, critical thinking, and creation whenever possible. In this study, I incorporated the current blended assessments as well as expanded them to include writing prompts and graphic organizers.

Statement of the Problem

Although performing well on achievement tests, students in my 7th and 8th grade mathematics classes at Mona were having difficulties using and explaining learned topics in real world context. Transforming mathematics into a habit of mind and having a disposition of appreciation and willingness to engage in challenging situations in a self-regulatory fashion is a desire I have for my students. However, such challenges appeared to be trying as I observed students to give up when content got difficult. In conjunction, improvements in transferring knowledge and constructing understanding to communicate and argue cognitive processes are avenues to benefit students' mathematical knowledge and, in turn, their futures.

Purpose Statement

The purpose of this action research was to evaluate the impact of writing prompts and graphic organizers on Mona school's 7th and 8th grade students' mathematical academic achievement and their attitudes towards the authentic application of mathematics.

Research Questions

The two research questions that guided the study are as follows:

1. How and to what extent, do writing prompts and graphic organizers impact 7th and 8th grade students' mathematical achievement and attitudes towards mathematics?
2. What were the 7th and 8th grade students' perceptions about the implementation of authentic writing prompts and graphic organizers in a mathematics course at Mona school?

Researcher Subjectivities and Positionality

My roots began on a farm and ranch in the beautiful northeastern part of our state. From as far back as I can remember, the appreciation and inclusion of mathematics and education have been integrated into all areas of my life. My chosen education path began with a focus on mathematics and elementary education. With technology advancing how I teach; my passions have since included the curriculum and educational technology. I have taught a variety of subjects, mostly in grades five through eight, as well as high school mathematics. During this study, I taught 7th and 8th graders pre-algebra, algebra, and geometry at a private school, Mona.

Having worked with one tablet per student at Mona, I believe technology, often integrated with writing prompts and graphic organizers, has the power to enhance our curriculum. When students take ownership of their learning, they have an engagement and anticipation to learn that cannot be denied. This is demonstrated by the enjoyment of using critical thinking, multimedia, and learning how to create imaginative and complex products. Witnessing these great qualities makes me admire and appreciate the outcomes of creating such lessons and projects.

My belief about teaching, learning, and technology are reformed by the pragmatic paradigm. Paradigms are a "matrix of beliefs and perceptions" (Kinash, 2018, p. 1). They create powerful worldviews and contexts that impact how we construct inquiry, what beliefs are considered meaningful, and what actions are deemed appropriate (Morgan, 2014b). The pragmatic paradigm best represents me and my action research topic. Pragmatism combines theory and practice by experimenting and conceptualizing to learn and improve (Nzembayie, 2017). Constructive knowledge, exploration and learning, and taking action are principles of pragmatists (Goldkuhl, 2012). Linking action and truth, it encourages the use of both qualitative and quantitative research to be conducted (Fendt & Kaminska-Labbé, 2011; Morgan, 2014a), as well as more participation from the researcher (Wisniewska, 2011). Consistent with my principles, the pragmatic paradigm supports the belief that there is no single reality (Creswell, 2013, 2014; Kivunja & Kuyini, 2017; Korte & Mercurio, 2017; Mackenzie & Knipe, 2006), and there is more than one way to find solutions (Creswell, 2013, 2014). Additionally, what is used for a solution is temporary and may need to be revisited and changed in the future (Schoonenboom, 2019), as well as the realization that it may not work every time and in every situation (Korte & Mercurio, 2017).

I considered my positionality as an insider because I was evaluating a practice implemented in my classroom. This allowed me to bring potential insights into cultures of my study (Kelly, 2014). Additionally, the insider positionality allowed me to collect quantitative and qualitative data for the study with myself as the researcher (Herr & Anderson, 2005). However, it was important that I did not recycle my own dominant feelings and perspectives (Kelly, 2014). Although I played a primary role in my action research, bias was controlled by acknowledging my role and building in self-reflection (Herr & Anderson, 2005). It was important to make sure I did not lean towards making myself look successful in the study because of the time and effort invested.

I was not overly concerned about my values and biases in this study because I was not sure if the study would produce successful outcomes. It was my hope that integrating writing prompts and graphic organizers into my curriculum would not result in a drop in test scores as have been shown to be the case at the college level (Tunstall & Bossé, 2016; Van Peursem et al., 2012), but I did not know if the same would be true at a 7th and 8th grade level. My values of education are transferred onto my students, but I also want them to have a positive outlook on mathematics and its value in everyday life. Being careful not to take a biased approach when reporting on my study, I made sure my students' perspectives and scores were accurately reflected in my findings.

Definition of Terms

Authentic assessments: Authentic assessments create an atmosphere that is more life-like for stronger engagement and connection by allowing various ways for students to construct, inquire, and find value beyond school (Dennis & O'Hair, 2010). They require students to demonstrate knowledge focused on real world applications to perform tasks rather than the repetition of practicing rote skills that are the focus of traditional assessments (Moon, Brighton, Callahan, & Robinson, 2005).

Bracketing: Bracketing is used to mitigate adverse effects as it suspends the researcher's presumptions, biases, and experiences to describe the phenomenon at hand (Gearing, 2004). Maintaining self-awareness is an ongoing process throughout the qualitative analysis as one identifies patterns and combine codes to generate meaningful themes of the participants' experiences (Tufford & Newman, 2012). Action researchers must continually check one's self and privileges to determine if and how these subjectivities may be impacting the analysis (Tufford & Newman, 2010).

Graphic organizers: Graphic organizers are aimed to help with visualizing, organizing, clarifying, inferring, communicating knowledge and strategies, and connecting relationships among concepts (Zollman, 2009).

Instructional scaffolding: Instructional scaffolds support the construction of students' knowledge and provide a foundation for independent learning (Frederick, Courtney, & Caniglia, 2014). Integrated into the learning process, scaffolds can be delivered by teachers, on paper, or through technology tools (Molenaar, van

Boxtel, & Sleegers, 2011) as advice, prompts, or learning guides (An & Cao, 2014) to assistance problem solving and competence. Scaffolds in this study, such as graphic organizers and writing prompts are aimed towards the content and student understanding.

Mathematical achievement: Academic achievement is measured by test scores that align to Common Core and follow the mathematics curriculum Mona uses.

Metacognition: Metacognition is one's awareness, consideration, and management of cognitive processes and strategies (Daher, Anabousy, & Jabarin, 2018; Özcan & Eren Gümüş, 2019). It promotes effective understanding through monitoring and regulating (Daher et al., 2018; Erickson & Heit, 2015), furthermore, forming a relationship with problem-solving performances and behaviors (Özcan & Eren Gümüş, 2019).

Natural: A natural character or ability can be inherent or organic as it comes to one, but natural can take the meaning of a setting or location where a problem is under study (Creswell, 2014). The familiar environment and context, such as the classroom, permits accurate accounts of behaviors and data (Creswell, 2014) and provides an opportunity to study decision making as it occurs (Aitken & Mardegan, 2000).

Quantitative literacy: Quantitative literacy is associated with the self-efficacy and attitudes of the utility of math as well as the ability to use and communicate math concepts as a part of everyday life (Gillman, 2004; Tunstall & Bossé, 2016; Wilkins, 2016). More specifically, qualities of strong quantitative literacy would be "a functional knowledge of mathematical content; an ability to reason mathematically; a recognition of the societal impact and utility of mathematics; an understanding of the nature and historical development of mathematics; a positive disposition toward mathematics" (Wilkins, 2010, p. 269).

Self-concept: Self-concept is the perception of one's competence (Arens et al., 2017).

Self-regulation: Self-regulation is the ability to manage cognition and emotions without the use of external intervention to set goal-directed actions (Murray, Rosanbalm, & Christopoulos, 2016). It involves using the motivation and engagement of learning to enable monitoring, metacognition and behavior strategies to direct goals that further knowledge and improvement (Semana & Santos, 2018; Wang et al., 2019).

Writing prompts: Written language promotes abstract thoughts to be represented both visually and symbolically as concepts are analyzed and clarified (Colonnese, Amspaugh, LeMay, Evans, & Field, 2018). It helps gain knowledge, review and consolidate learned material, and extend ideas (Kostos & Shin, 2010). In mathematics, writing is used to make sense of problems, describe and explain processes and reasonings, construct and evaluate arguments, and elaborate ideas and discoveries (Colonnese et al., 2018).

CHAPTER 2

LITERATURE REVIEW

The purpose of this action research was to evaluate the impact of writing prompts and graphic organizers on Mona school's 7th and 8th grade students' mathematical academic achievement and their attitudes towards the authentic application of mathematics. Two research questions guided the study: (1) How and to what extent, do writing prompts and graphic organizers impact 7th and 8th grade students' mathematical achievement and attitudes towards mathematics? (2) What were the 7th and 8th grade students' perceptions about the implementation of authentic writing prompts and graphic organizers in a mathematics course at Mona school?

Gaining knowledge about the literature and building the foundation of the project developed a deeper connection and understanding of why and how the curriculum could be adapted as well as perspectives and results of similar studies. In order to research the latest literature on this topic, I searched for sources using an assortment of keywords such as quantitative literacy, mathematics, middle school, authentic assessments, academic achievement, action research, authentic evaluations, transfer theory, and education. I also chose words with similar language to expand my searches even further. Such keywords for this step were numeracy, project-based assessments, problem-based assessments, problem-based learning, real-world application, test scores, inquiry-based learning, and educational technology as they are most similar to the language used in my topic. The assortment of my original keywords with these synonyms helped gain articles while maintaining much common language or topics like mine.

While studies that specifically addressed middle school age students were especially beneficial, I also examined articles that addressed other ages. The focus of the literature search for this study was primarily on peer-reviewed research articles, dissertations, and book chapters published since 2015. Various combinations of the keywords and Boolean phrases were used while conducting my searches such as authentic assessments [and] mathematics instruction. It was not too often that I used the specific databases *ERIC, Academic Search Complete, ProQuest, EBSCO*, or the academic search engine *Google Scholar*. Instead, I gathered the most articles using the *University of South Carolina Library* due to its wide variety of subscription databases. Additionally, many articles were found from the reference section of other sources I had read.

This literature review is organized into five primary sections: (a) mathematics education (b) quantitative literacy, and (c) theoretical underpinnings of Transfer Theory, (d) instructional methods, and (e) authentic assessments. The first section provides an overview of mathematics education and barriers of success in mathematics education. The second section discusses quantitative literacy a definition and benefits in extending mathematical concepts. A review of Transfer Theory, as a theoretical underpinning of this study, is reviewed. The fourth section explores varied methods of instruction, challenges that have been identified, and how it has been researched in the past. The final section goes into more depth concerning authentic assessments as it describes the definition, and benefits and challenges of including authentic assessments learning approaches.

Mathematics Education

Providing a lasting and learning experience is a primary goal in the world of education. With it, comes the importance of the development and application of knowledge. Bratianu and Orzea (2012) state that knowledge is "one of the most important strategic resources, and the ability to acquire, integrate, store, share, and apply it is the most important capability for building and sustaining competitive advantage both at individual level as well as organizational level" (p. 128). Success in mathematics can pave the way to functioning in everyday life, higher education, and higher paid jobs (Jansen, Schmitz, & Van der Maas, 2016; Wright & Howard, 2015), yet, many associate negative attitudes and failure with it (Russo, 2015). This section further explains barriers to traditional education.

Barriers to success in mathematics education. All students should have the right to encounter powerful mathematics that can teach them abilities to be successful in the 21st century (Hill, 2010). To accomplish this, there are many methods and approaches instructors can use. This section highlights barriers to success in mathematics education: (a) math anxiety, (b) self-concept, (c) metacognition and self-regulation skills, (d) depth and complexities of the curriculum, and (e) literacy.

Math anxiety. Math is a unique subject that can generate its own generalized anxiety (Erickson & Heit, 2015). While anxiety has effects of improving and hindering mathematical success, it is more common for students to experience the latter (Andrews & Brown, 2015). Math anxiety can be described by persistent feelings that cause avoidance, pressure, inadequacy, or having a negative relationship with mathematics that interfere with ordinary life or in academics situations (Andrews & Brown, 2015; Jansen, Schmitz, et al., 2016). While it can develop at a young age, doing math in stressful situations, such as in tests, furthers the progression of math anxiety (Erickson & Heit, 2015). By the late middle school years, many students find difficulties with algebraic concepts which can lead to problematic consequences (Andrews & Brown, 2015; Jansen, Schmitz, et al., 2016), such as low mathematical performances and avoidance.

Low math performance may be caused by anxiety if a student avoids exercising skills by rushing through work, looking for shortcuts, and postponing homework to avoid or quickly end the stressful situation (Jansen et al., 2013; Jansen, Schmitz, et al., 2016). At the middle school ages when the effects of anxiety are high and confidence levels may be low, avoiding math classes prohibit students from reaching their full potential (Andrews & Brown, 2015). Researchers found that math performance improves when students work at their own level with high success rates, but also that anxiety and perceived competence perhaps do not outweigh previous negative experiences (Jansen et al., 2013).

Self-concept. Self-concept is the perception of one's competence (Arens et al., 2017). Self-concept and engagement are positively linked to academic achievement primarily in grades but also in standardized tests scores (Arens et al., 2017; Bourgeois & Boberg, 2016). Motivation (Star et al., 2014), engagement, students' interest in mathematics, and underestimated perceptions of the importance of math often decline when students reach middle school ages (Bourgeois & Boberg, 2016). It has also been found that during this time, parents withdraw to play a less-active role as long as grades remained good (Bourgeois & Boberg, 2016). Grades and incentives are also shown to have a higher importance rather than the actual learning (Bourgeois & Boberg, 2016).

A worry regarding self-confidence hindering academic achievement is described in findings from a seminal study by Erickson and Heit (2015). They asserted that when a fear of math is found to be true in students, that math anxiety is observed and it would be assumed that one's self-confidence levels would also be lowered. Instead, their findings describe students with such fears to also be overconfident— leading to a possible explanation of overconfidence levels leaving student's to feel that mastery has been achieved (Erickson & Heit, 2015). This suggests that while self-concept is linked to grades, there is a strong possibility many students, even with math anxiety, could also be overconfident. So aiming to increase self-confidence may potentially increase avoidance (Erickson & Heit, 2015).

Metacognition and self-regulation skills. Attention, self-regulation, and motivation can be described as the mediator for learning and achievement and emotions (Daher et al., 2018). Self-regulation is the ability to manage cognition and emotions without the use of external intervention to set goal-directed actions (Murray et al., 2016). It involves using the motivation and engagement of learning to enable monitoring, metacognition, and behavior strategies to direct goals that further knowledge and improvement (Semana & Santos, 2018; Wang et al., 2019). This has been determined because when such skills are absent, students are often distracted or off task which results in falling behind (Wells, Sheehey, & Sheehey, 2017). Such skills can be improved with self-monitoring of performance as it encourages students to focus on academic achievements instead of behaviors (Wells et al., 2017).

Including both monitoring and regulating skills as crucial components to effective understanding (Daher et al., 2018; Erickson & Heit, 2015), metacognition is one's awareness, consideration, and management of cognitive processes and strategies (Daher et al., 2018; Özcan & Eren Gümüş, 2019). It is crucial to the self-knowledge of one's ability (Erickson & Heit, 2015) and integrates knowledge, skills, and experiences used in problem solving (Özcan & Eren Gümüş, 2019). Metacognition not only forms a relationship to problem-solving performances, but an additional importance is its' link to problem-solving behaviors (Özcan & Eren Gümüş, 2019). It is in this area that one's ability to monitor cognitive processes and strategies recognizes problems, resulting in the need to make necessary changes (Özcan & Eren Gümüş, 2019). Metacognition can be enhanced with practice and slowing down to think and reflect on processes (Daher et al., 2018).

Depth and complexities of the curriculum. Common Core State Standards have aligned standards so that more emphasis is placed on higher level thinking, conceptual understanding, and the connection to other topics rather than basic foundational skills (Codding et al., 2016). Madison (2015) stated that the standards are "supportive of the calculation competency, somewhat supportive of the representation competency (via modeling) and the analysis/synthesis competency, and not very supportive of interpretation and communication competencies" (p. 3). Madison continued further that algebraic thinking and logical reasoning are a strength of the development of the Common Core Standards of quantitative literacy. The applications are open to the possibilities of assessments being dominated by applications being a support, and taking the content beyond the practice standards, interpretation, conceptualization, communication, reflections of results, and suggestions for critical citizenship is weak (Madison, 2015). A weakness to the standards is that applications that could be included to increase quantitative literacy are often found in standards that include more sophisticated context than the knowledge level of the student (Madison, 2015). This makes it hard for teachers to create applications relevant to students when students have yet to know or come across the topic in real life.

Assessments in the secondary mathematics classroom are challenging as they include multiple topics, lack of relationships, as well as overarching mystery of what and how to effectively measure mathematical performance (Codding et al., 2016). Basic skills are commonly transferred passively to the degree of recalling in multiple-choice questions, but more difficult problem-solving questions that require multiple conjunctions of skills and thoughts are inert (Perkins & Salomon, 1988). A typical middle school assessment requires students to know basic facts of the four major operations both in isolation and intermixed; know and understand how to merge those facts and outcomes with concepts and formulas; and use reasoning skills to apply everything in complex ways in various problem-solving situations (Codding et al., 2016). With so much to cover in a limited amount of time, one can see how this would be difficult to piece together for struggling students.

Additionally, it is hard to ensure mastery on a topic when it is taught throughout a course and various grade levels (Codding et al., 2016). Furthermore, it is unclear if mastery in one area affects other skills (Codding et al., 2016). Students being able to interact in the classroom and perform recall tasks does not mean that literacy mastery has been established (Khalaf & Zin, 2018). Researchers have suggested that teaching with authentic assessments could help this deficiency (Dixon & Brown, 2012). Authentic assessments link real life and school as it is a meaningful measurement in the performance of strategies, skills, knowledge, or application (Fauziah & Saputro, 2018) possibly found in the workplace or situation in one's life (Egan, Waugh, Giles, & Bowles, 2017). They are an alternative to traditional assessments that allow students to use higher-order thinking to construct skills, knowledge, and attitudes by having an active and creative role in the learning process (Fauziah & Saputro, 2018; Simpson, 2017). The alternative method to measure knowledge and skills are commonly found in examples of projects, portfolios, or writing (Fauziah & Saputro, 2018; Simpson, 2017) and are described in further detail below. However, research is not secure that they affect students' performances on skill specific questions (Dixon & Brown, 2012) or standardized tests (Dixon & Brown, 2012).

Literacy. Traditionally, literacy has been linked to comprehending, communicating, connecting, and critical thinking in areas of reading and writing (Hui, 2016; Pilgrim & Martinez, 2013; Urquhart & Frazee, 2012), but reports of traditional literacy have been extended and now includes subjects across the whole schooling process (Hui, 2016; Urquhart & Frazee, 2012). Words help the construction of concepts and thoughts (Colonnese et al., 2018). The purpose, structure, and format of writing are different in each discipline so learners should write in, and for, a variety of disciplines (Burns, 2004; Colonnese et al., 2018). However, the resources and support are lacking in mathematics (Colonnese et al., 2018). Hui (2016) reports that some assessment tests showed low literacy performances in content areas while others remained stagnant for the past several years. Hui (2016) suggested that in order to maximize the fullest content comprehension, subject knowledge, which ought to be grounded on fundamental literacy skills, one should mix discipline-specific literacy into instruction. Such examples of including literacy components in mathematics could be journals, word walls, problem-solving through writing, and real-world applications with the internet or newspapers (Burns, 2004; Colonnese et al., 2018; Picot, 2017).

In mathematics, literacy plays a significant role in word problems (Kyttälä & Björn, 2014). Word problems are addressed at every age of mathematics education and are the single greatest predictor of employment and wage (Fuchs et al., 2016). However, many students struggle with word problems (Edwards et al., 2009; Fuchs et al., 2016; Kyttälä & Björn, 2014) because there are more cognitive processes involved than actual calculation skills (Fuchs et al., 2016). Fuchs et al. (2016) and Kyttälä & Björn (2014) found that language comprehension played a role in correctly solving word problems. Therefore– with word problems being a significant part of mathematics and success– giving attention to reading comprehension, vocabulary, and other literacy skills are important features to integrate into teaching mathematics.

In their study, which focused on using mathematical journals, Kostos and Shin (2010) found that all participants responded with an increase in their use of math words by writing about math, and that knowledge was improved and retained as students communicated what is and is not known. "Writing can be used both as a way to communicate and to learn mathematics" (Kostos & Shin, 2010, p. 225). Similar findings were also discovered after using the digital writing environment; where students with disabilities improved calculations and reasonings as there were fewer guesses (Huscrot-D'Angelo et al., 2014). Additionally, students were able to make more connections with prior knowledge as they went through reflections and gained clarity (Huscrot-D'Angelo et al., 2014).

Quantitative Literacy

Quantitative literacy can be characterized as a habit of mind because it intertwines factors such as disposition, beliefs, social impacts, and importance of mathematics, as well as communication, reasoning, and critical thinking skills (Scheaffer, 2003; Tunstall & Bossé, 2016; Wilkins, 2010, 2016). Being more than mathematical knowledge, quantitative literacy requires mathematics to be integrated in one's life with a positive attitude of appreciation and willingness to take on mathematical situations with confidence (Tunstall & Bossé, 2016; Wilkins, 2010, 2016). The outline of this section includes: (a) definition and benefits and (b) how quantitative literacy has been researched in the past.

Definition and benefits. From reform in mathematics education, quantitative literacy was developed in the late 20th century (Wilkins, 2010). Quantitative literacy, and its synonym numeracy, is more than computing equations (Simic-Muller, 2019). It includes problem-solving and decision-making of various complexities in all areas found in civic, academic, and leisure areas of life (Gittens, 2015; Scherger, 2013). In addition to working with and understanding how data are collected, manipulated, and represented in various formats (Gittens, 2015), quantitative literacy comprises the mathematical reasoning abilities to perform, communicate, explain, and argue real-world applications of mathematics, as well as the appreciation and creation of positive attitudes about mathematics (Huscrot-D'Angelo et al., 2014; Madison, 2015).

Quantitative literacy is important for successes in both personal lives and society (Madison, 2015). Numbers are found everywhere in one's life, such as time, reading the paper, cooking, at the doctor's office, or dealing with finances. People are mostly concerned with how issues may effect on one’s life (Ganter, 2006). How individuals transcribe and utilize mathematical skills can have boundless impacts on factors such as income level, making decisions, and risk comprehension (Ganter, 2006; Jansen, Schmitz, et al., 2016; Tunstall et al., 2016). For example, being able to fully understand mathematics found in areas of the stock market, interest rates, or reported disease outbreaks allows individuals to make educated decisions in their lives (Ganter, 2006).

Critical thinking is widely acknowledged as an essential component and educational goal of K-12 and post-secondary levels (Gittens, 2015). This goal includes the application of critical thinking to the context of mathematics, probability and numerical data analysis, as well as explaining and reflecting on one’s reasoning process (Gittens, 2015). Quantitative literacy emphasizes the inclusion of critical thinking skills that can be used to tackle mathematical problems and enhance the outcome of success both in life and future jobs (Howard, Tang, & Austin, 2015; Ward, Schneider, & Kiper, 2011). Furthermore, it promotes students with critical thinking skills to help make intelligent decisions (Tunstall, 2017).

Common Core State Standards Initiative has taken the National Council of Teachers of Mathematics’ (NCTM) vision and recommendations to include focus in areas of quantitative literacy for the K-12 mathematics curriculum as students are expected to use “number sense and problem-solving, abstract and quantitative reasoning, argument construction and critique, structural analysis and strategic application of tools to solve math problems, and modeling with mathematics, as vital practice-based learning outcomes” (Gittens, 2015, p. 3). Going beyond reading and writing mathematics in order to develop conceptual understanding, being quantitatively literate requires individuals to additionally engage in the text that is found in all subjects and areas of life (Scheaffer, 2003). Therefore, to gain maximum benefits, mathematical concepts need to be extended to all disciplines across the curriculum and everyday life (Scheaffer, 2003).

How quantitative literacy has been researched. Our country has evolved in the way mathematics has been used and taught (Cohen, 2003). Quantitative literacy courses, and the incorporation of it into course material, has been historically scant (Sons, 2006). Even though the public's uses of numbers and arithmetic developed alongside the growing statistics inclusions in society in the 19th century, the early 20th century had a different storyline as Thorndike argued that mental discipline was not being stimulated in mathematics (Cohen, 2003). During this time, formulas and number crunching grew more complex as the arithmetic areas remained at a standstill— despite attempts to reform— which resulted in the general public's inability to understand and comprehend much of what was being delivered with statistics (Cohen, 2003).

Prior to when the 1989 QL Committee gave its report, many institutions did not include foundation courses and were not concerned if their students were able to use mathematics in their everyday lives and careers as much as if they could pass courses that focused mainly on computational skills (Sons, 2006). Little attention was given to mathematics and quantitative literacy in the early 20th century as schools even cut courses, as for some it was not seen as practical and courses were replaced with a course that taught mathematics as a working tool (Cohen, 2003). Cohen (2003) continued to explain in the mid-20th century, a new math was reformed but it was not welcomed enthusiastically and it still had little effect on quantitative literacy related to civilian or political situations. However, since 1996, and with the help of NCTM's *Standards*, many institutions increasingly offered foundation courses and have reformed other teaching content to include quantitative literacy components into the curriculum as processes of problem solving, reasoning, connections, communications, and representation continued to unfold throughout the institutional journey (Sons, 2006).

Previous studies (Russo, 2015; Tunstall, 2017; Van Peursem et al., 2012) showed that integrating more quantitative literacy into the curriculum has shown to increase knowledge and application. Using overall effectiveness on scores, typical of standardized tests, the metrics of impact are not as obvious. Research from a focus shift with college algebra students in a quantitative literacy course versus a traditional classroom did not result in a decrease in test scores (Van Peursem et al., 2012). Classrooms with one computer per student technology scored higher on two of the three tests than the traditional classroom (Harris, Al-Bataineh, & Al-Bataineh, 2016). This supports that technology can influence higher scores, but this data does not support that technology itself increases scores (Harris et al., 2016).

Theoretical Underpinnings of Transfer Theory

Transfer generally refers to learners taking ideas and knowledge from one context or situation and using it in another (Evans, 1999). It may take place in many settings, such as schools, organizations, or teams, as well as various learning environments such as face-to-face or online. Transfer is important for success in mathematics because it builds on itself (Kang, Duncan, Clements, Sarama, & Bailey, 2019), and it is connected to all subjects and areas of life. Transfer can also occur across domains as in from language to mathematics; it may occur vertically in a single domain and build on essential prior knowledge that leads to new knowledge for greater or more complex understanding of concepts or procedures; it may occur horizontally in the same domain where prior and new knowledge are connected and improve learning (Kang et al., 2019); or it can occur with learned content from the classroom and applying it in real life (Culyer, Jatulis, Cannistraci, & Brownell, 2018). Transfer focuses on the ability to recall, connect, and apply previous knowledge to new concepts or situations.

Historically, Thorndike has been primarily linked to transfer in the 20th century (Lobato, 2006; Nelissen, 2016). Labato (2006) wrote about transfer occurring when original information and transfer situations share identical elements. Later, shared identical elements were converted into the cognitive domain as symbolic representations (Lobato, 2006). Singley and Anderson (1989) claimed to evolve Thorndike's "identical elements as units of declarative and procedural knowledge" (as cited in Lobato, 2006, p. 433).

Transfer can also be linked to situated cognition as "every human thought is adapted to the environment, that is, situated, because what people perceive, how they conceive of the activity, and what they physically do develop together" (Driscoll, 2005, p. 157). Situated cognition was first introduced from Brown, Collins, and Duguid (1989) with a tie to culture and environment (Driscoll, 2005; O'Neill, 2017). Situated cognition allows one to learn through opportunities and exposure found in one's environment (O'Neill, 2017). Bridging practice with exposure, authentic activities can "tease out the way a mathematician or historian looks at the world and solves emergent problems" (Brown et al., 1989).

Transfer is used in several approaches, and methods, in teaching (Ertmer & Newby, 1993; Evans, 1999). For example, transfer is used in the behaviorist approach, which focuses on observation of objective information that can be easily communicated and efficiently learned and replicated by practicing techniques (Harasim, 2012; Reed, 2012). In the cognitivist approach, techniques of discovery learning and expository teaching (Durwin & Reese-Weber, 2018), are used as they focus on teaching strategies to construct, organize, store, and retrieve knowledge (Yilmaz, 2011). In the constructivist approach, techniques of situated cognition and cognitive apprenticeships (Durwin & Reese-Weber, 2018), are used as they focus on strategies that use decision-making, negotiating, and collaboration skills to construct a unique reality in order to complete different forms of assessments integrated into a task (Mergel, 1998). Additionally, pedagogy that includes transferring knowledge and skills across all tasks of different subjects (Koedinger, Yudelson, & Pavlik, 2016) are found in interdisciplinary assignments, project-based learning, problem-based learning, and inquiry-based learning. Although the approaches and methods have differences (Evans, 1999; Mergel, 1998), the desire of transferring knowledge onto the student is consistent.

Instructional Methods

In traditional programs, students often answer close-ended questions that require little creativity or critical thinking (Katz-Buonincontro, Hass, & Friedman, 2017). To become successful problem solvers, learners need to be flexible, intuitive, and creative (Ortiz, 2016). When learning to include creativity and self-concept, it is necessary for students to become comfortable with expanding and stretching their thoughts to provide several responses that include new knowledge in addition to pre-existing knowledge (Katz-Buonincontro et al., 2017). The best math scoring students are not always the best mathematical students because classes often focus on conceptual thinking and less on reasoning (Soroño-Gagani & Bonotan, 2017). Therefore, is important for teachers to layer the instructional support needed to help students undergo creative cognition (Katz-Buonincontro et al., 2017).

Changing teaching to include “strategy instruction; modeling of assignment tasks; peer editing, reading, listening or viewing content with quick writes and discussing; and individual conferences” (Preus, 2012, p. 66) is not simple. Students should have varied assessments to solve real world problems and communicate their processes and findings, as well as construct arguments to defend their reasonings (Mayfield & Stewart, 2019). Findings from Wagner (2006) emphasized that although students may not always use the same ideas when they encounter situations individually, it is important to teach mathematics in conjunction with real-world situations to increase transferred prior knowledge and covariance reasoning.

Findings about specific teaching methods show that they make a difference in increasing students’ mathematical understanding (Capraro et al., 2010) that allows their ability to communicate and argue processes to increase. Three Teaching Quality Measures have been researched and have shown to make a difference in contributing to mathematical conceptual understanding: “probing for student understanding, encouraging curiosity and questioning, and using accurate representational forms” (Capraro et al., 2010, p. 2). Additionally, teachers can frame participation by provoking meaningful questions and activities that foster active learning with conversation and interactions (Nelissen, 2016). Embedding critical thinking into questions improves critical thinking skills because it focuses on ideas rather than rote memorization and processes (Barnett & Francis, 2012). Higher ordered thinking skills, such as problem solving and critical thinking, are reported to increase with interventions or courses that focus on teaching these skills (Dixon & Brown, 2012; Montague, Krawec, Enders, & Dietz, 2014; Zollman, 2012). How teachers pose questions should be portrayed with an emphasis on the thought process of problem solving rather than abilities (VanTassel-Baska, 2014). For instance, open-ended questions that entail making comparisons, justifications, or inquiry help develop critical thinking skills. Lee and Lai (2017) as well as VanTassel-Baska (2014) encourages the incorporation of creative ways of thinking.

An example of questioning comes from Katz-Buonincontro et al. (2017). They reported on a college class that practiced developing various representations of concepts in the course to assess creative thinking in a way that is natural to learning with open-ended assessments emphasizing reasoning, creativity, problem-solving skills, and procedural reasoning. This study focused on STEM courses that typically centered on creativity in the course design. However, with reports of a deficit on creative thinking, it shifted the focus to emphasize creative cognition being taught in all courses in conjunction with math knowledge and concepts.

Communicating knowledge in different ways fosters inquiry and collaboration to innovate ideas or determine effective problem-solving methods (Cicconi, 2014). For example, communication found in journals or other various forms of writing prompts to learn mathematics, uses language to enhance vocabulary, mathematical thinking, and the collection of thoughts to facilitate understanding (Burns, 2004; Colonnese et al., 2018; Kostos & Shin, 2010). Being student-centered allows active learning to take place (Kostos & Shin, 2010), and “communication moves students beyond rote memorization towards a conceptual level of reasoning” (Huscrot-D’Angelo et al., 2014, p. 178).

Communication offers students the opportunities to develop inquiry, the collection of thoughts, collaboration, and problem-solve as one learns and shares their knowledge in various mediums. This section is further outlined as (a) instructional scaffolding, (b) teaching approaches to increase transfer, and (c) technology.

Instructional scaffolding. Instructional scaffolds support the construction of students' knowledge and provide a foundation for independent learning (Frederick et al., 2014). Instructional scaffolds are used to assist with the students' learning process (An & Cao, 2014; Belland, 2017; Frederick et al., 2014) and can be focused towards metacognition, strategy, motivation, or conceptual understanding (Belland, 2017). Linking to Vygotsky's zone of proximal development (Frederick et al., 2014; Valencia-Vallejo, López-Vargas, & Sanabria-Rodríguez, 2019), instructional scaffolds are used to help support students and become independent learners (Frederick et al., 2014).

Integrated into the learning process, scaffolds can help students carry out tasks, reach goals, and reach competence (Wood, Bruner, & Ross, 1976). Scaffolds can be delivered in various ways such as by teachers, on paper, or through technology tools (Molenaar et al., 2011). Further, instructional scaffolds can be delivered in the forms of advice, prompts, or learning guides (An & Cao, 2014) to assist students' with problem solving while furthering their academic capabilities. This section provides further details regarding (a) graphic organizers and (b) writing prompts.

Graphic organizers. Graphic organizers can enhance the organization and communication needed for writing processes and fostering relationships (Zollman, 2009). They help organize ideas and structure concepts, as well as improve comprehension and communication skills (Urquhart & Frazee, 2012; Zollman, 2009, 2012). For example, the personal math concept chart is a way for students to write explanations, draw diagrams, and give real life applications for each term to help with the learning process (Friedman, Kazerouni, Lax, & Weisdorf, 2011). There are many forms of graphic organizers, such as four corners and a diamond, person math concept chart, Venn Diagrams, tables, or charts. Completing a graphic organizer prior to writing a response helps students make answers that are complete and ensures their knowledge is fully communicated (Zollman, 2009, 2012). Using graphic organizers helps organize information and see problems broken down. Friedman et al. (2011) discovered a positive connection for using the concept chart for students to fill out while learning about new terms and concepts. Likewise, Zollman (2012) found positive results from using such graphic organizers as it was reported that there were improved scores when graphic organizers were used and found that some students chose to use them when not asked to.

Writing prompts. Writing is beneficial for learners as it helps gain knowledge, review and consolidate learned material, and extend ideas (Kostos & Shin, 2010). Written language promotes abstract thoughts to be represented both visually and symbolically as concepts are analyzed and clarified (Colonnese et al., 2018). Including writing in the mathematical classroom further builds metacognitive thinking and understanding while increasing problem solving abilities (Brozo & Crain, 2018).

Colonneselyn et al. (2018) wrote that Vygotsky hypothesized the importance of documenting quantity to the growth of the written language. The regular inclusion of writing, found to improve self-regulation skills, was implemented as students reflected, explored, extended, and cemented their ideas (Burns, 2004). In mathematics, writing is used to make sense of problems, describe and explain processes and reasonings, construct and evaluate arguments, and elaborate ideas and discoveries (Colonnese et al., 2018). Scaffolds of writing prompts further provide assistance with guidelines for specific content, hints regarding tasks, or reflections while fostering justification and argumentation (McNeill & Krajcik, 2009).

Teaching approaches to increase transfer. Transferring basic knowledge, as well as creativity and critical thinking, play a role in decision making and interacting with others, and these knowledge and skills are a desire for teaching (Perkins & Salomon, 1988). This includes several key factors that play a role in learning transfer, such as time dedicated to practicing and learning, the motivation of the learner, and how the problem is presented (Dixon & Brown, 2012).

Good problem solvers are able to see the deeper aspects of a problem that help relate it to other problems. Remembering content beyond surface levels, organization, and how learning relates to new content are key factors in successfully transferring knowledge (Dixon & Brown, 2012). Additionally, discussions can help learners or participants understand content, but it is unclear if they foster abilities to transfer comprehension to new tasks and readings (Resnick, Asterhan, & Clarke, 2015). Transfer in the classroom can be cued and guided throughout the entire curriculum to reach full vertical transfer possibilities to include higher-order thinking to skills and knowledge previously learned (Melzer, 2014).

It can be difficult to effectively transfer knowledge outside the classroom. Often, in order to teach the disciplinary content, education simplifies it (Dixon & Brown, 2012) and contrives situations (Scherger, 2013). For example, data is included within the textbook instead of students creating a meaningful experience researching or creating it themselves (Mayfield & Stewart, 2019). To know transfer has occurred is when students are able to connect what is current with what they will need in the future or what they have learned in the past (Perkins & Salomon, 1988). This occurs passively for everyone to certain extents. For example, one may respond to a direct probe such as a multiple-choice question (Perkins & Salomon, 1988) or add numbers in class and then add similar numbers at the store. However, pedagogies may foster transfer (Camp, 2012). "The induction or construction of abstract rules, schemata, or other mental representation has been hypothesized to serve as the primary cognitive support for knowledge transfer" (Wagner, 2006, p. 2). For example, teachers may ask questions or use activities that provoke the connection of prior knowledge (Perkins & Salomon, 1988). Additionally, the learner should be frequently taught tactics that produce successful problem-solving skills that emphasize how to successfully transfer knowledge (Perkins & Salomon, 1988).

In mathematics, many students, especially low achieving students, have difficulty realizing what they already know is replicable to many new concepts (Dixon & Brown, 2012; Nelissen, 2016). Learning new knowledge at any level is not easy, but, connecting new knowledge to old knowledge, or first recalling prerequisite previously learned knowledge, can help make that transfer easier (Driscoll, 2005).

Technology. Technology plays an active role in today's world as much of what teenagers learn in a typical day comes from a device such as a phone (Esteban-Guitart, Serra, & Vila, 2017). Therefore, it is idyllic to combine mathematics with technology to form a cohesive relationship. In this development, technology is the tool that can merge collaborative learning in the classroom (Cicconi, 2014), and mobile technology is the bridge to connect out-of-class and in-class learning (Hwang & Lai, 2017). Furthermore, by acquiring in- and out-of-class learning to be present, students have the opportunity to flourish as learning and applying mathematics becomes part of one's life no matter where they are.

Technology is an integration tool that allows differentiation for all students (Kaur, Koval, & Chaney, 2017) and promotes self-regulation skills. For example, it gives students the ability to dive deeper on any given topic and learn at their own level easier than ever before (Harris et al., 2016). Also, technology can generate computer adaptive math problems, individualized tutoring sessions (Cicconi, 2014), or learn from videos (Kaur et al., 2017). Furthermore, providing practice for communication and argumentation, it provides an online platform for discussions and learning can increase social interactions, acting as a powerful tool for those who are shy and quiet students (Cicconi, 2014). Cicconi (2014) found that lower-achieving students posted more notes on a virtual learning blog and found success in this learning environment. Therefore, engaging in technology's positive uses creates an active learning environment that produces meaningful learning.

In the 21st century, increasing literacy includes one's ability to be proficient in using technology to locate and communicate (Pilgrim & Martinez, 2013). Technology provides opportunities to arrange live communications or upload and share videos to discuss and articulate procedures and knowledge (Cicconi, 2014). Additionally, students can take pictures and use them as writing prompts (Kaur et al., 2017), and virtual worlds allow the ability to complete tasks without leaving the classroom (Cicconi, 2014). Therefore, as technology increases, incorporating it into the classroom allows students to formulate, articulate, and appreciate knowledge in various ways.

Authentic Assessments

Authentic assessments require students to demonstrate knowledge in a life-like situation or use cognitive strategies that have value beyond school (Dennis & O'Hair, 2010; Fauziah & Saputro, 2018; Moon et al., 2005). They stimulate engagement and connection using various formats instead of recalling or performing rote skills found in traditional assessments. As a fundamental piece to the study, this section contains further descriptions about the (a) worldly applications of assessments, (b) authentic assessment definition, (c) benefits of authentic assessment, and (d) challenges of including authentic assessments.

Worldly applications of mathematics. Mathematics has been constituted as *quantity*– such as budgeting money– *space* and *shape*– such as pathways from light or oil rights along canals– *change* and *relationships*– such animal speed depending on size, frequency of strides, bone size, and muscle build– and *uncertainty*– such as failing to identify or fully explain problems clearly (De Lange, 2003). Applying mathematical thinking to solve everyday problems is essential for success (Kereluik, Mishra, Fahnoe, & Terry, 2013). Rather than trying to force the relevance onto mathematics, it is recommended to get students to see this naturally by choosing problems suitable to them and their level, giving time to make discoveries and conjectures, refining arguments in a positive atmosphere, and being flexible to changes (Lockhart, 2009).

Common perceptions that mathematics is tied to science is true– such as explaining missions into space (Velasco et al., 2015) – but further, it is tied to all disciplines and various areas of life. Mathematics is an art that has qualities of being mind-blowing, creative, and allows freedom of expression (Lockhart, 2009). Looking into one’s personal future regarding financial decisions, mathematics plays a role. There are a wide range of financial products, borrowing opportunities, and complex investments (de Bassa Scheresberg, 2013), as our challenging world demands a variety of mathematical skills to be successful (Jansen, Schmitz, et al., 2016; OnwuIji & Abah, 2018). Additionally, mathematics is highly tied to careers. Although in the past, there have been attempts to link mathematics to specific jobs, but, the awareness and understanding that successful mathematical skills go beyond those that are visible and consciously taking place have furthered the belief that mathematics is highly connected to all workplaces (FitzSimons, 2013).

In the real world, phenomena do not arise as organized as they do in educational settings, and rarely are they understood within context from just one discipline (De Lange, 2003). Learning is lifelong (Schlöglmann, 2006) and uncovering knowledge occurs through discovery (Lai, 1989). With multiple ways of solving problems (Merritt, 2017), and new discoveries, it is necessary to be flexible and adaptable. ”Student self-perception, confidence, attitudes and beliefs, and anxiety are all linked to persistence and motivation to study mathematics” (Benken, Ramirez, Li, & Wetendorf, 2015, p. 15). Mathematical views need to be positively adapted to the viewpoint that struggling is essential to grow, construct, and reason understandings (Warshauer, 2015).

Students frequently believe that mathematical problems should be solved in a quick fashion rather than being prolonged (Martin & Gourley-Delaney, 2014), or involving multiple steps, make learning and understanding mathematics challenging. However, as mathematics has strong ties to activities and occupations involving many tasks and challenges (Martin & Gourley-Delaney, 2014), rather than following unrealistic perceptions that all jobs can be performed quickly and uncomplicatedly, learning mathematics is providing students with lifelong learning skills. Attempting to change these thoughts, authentic assessments stimulate engagement and connection using various formats for students to construct, inquire, and find value beyond school (Dennis & O'Hair, 2010). They require students to demonstrate knowledge focused on real world applications to perform tasks rather than the repetition of practicing rote skills that are the focus of traditional assessments (Moon et al., 2005).

Definition. Originating from an opposition to objective assessments being the primary assessment tool in the United States' K-12 school systems, school reformists sought to make assessments more realistic (Osborne, Dunne, & Farrand, 2013). Authentic assessments link real life and school as it is a meaningful measurement in the performance of strategies, skills, knowledge, or application (Fauziah & Saputro, 2018) possibly found in the workplace or situation in one's life (Egan et al., 2017). They are an alternative to traditional assessments that allow students to use higher-order thinking to construct skills, knowledge, and attitudes by having an active and creative role in the learning process (Fauziah & Saputro, 2018; Simpson, 2017). Popular types of authentic assessments are portfolios, task assessments or projects, graphic organizers, journals, discussions, or drawings (Fauziah & Saputro, 2018; Simpson, 2017). These assessments are better for higher-ordered thinking or problem-solving skills (VanTassel-Baska, 2014). Additionally, multiple varieties of oral and written forms of formative and summative assessments are collected throughout the entire process. Rubrics are ideal to assess these tasks and can be adapted to fit all learners (Simpson, 2017; VanTassel-Baska, 2014).

Authentic assessments can be carried out in various forms depending on the class and level of education. They are carried out in courses that have been transformed and commonly found in methods of problem-based learning (Oguz-Unver & Arabacioglu, 2011), project-based learning (Ernst & Glennie, 2015), inquiry-based learning (Khalaf & Zin, 2018), and a flipped classroom (D'addato & Miller, 2016; Hwang & Lai, 2017) as well as in courses that blend methods of learning by mixing traditional learning with authentic assessments.

Dixon and Brown (2012) studied courses that focused on problem and project-based learning with Project Lead the Way to determine if the program impacted students' learning. Findings from an assessment Dixon and Brown (2012) gave to students indicate that students who took courses primarily taught with projects did not significantly show a difference in subject-specific questions regarding mathematics and science, although aspects of design and overall scores improved. Additionally, Dixon and Brown (2012) showed there was not a significant difference resulting from the number of program courses the students had taken. These findings showed both groups— with and without the curriculum program – were able to make connections to previously learned material with similar understanding in standardized tests.

It is important to note that authentic assessments, although beneficial, are not recommended to be the sole form of assessment (Kaider, Hains-Wesson, & Young, 2017). Education is at its best when traditional contextualized material is complemented with multi-dimensional, applied authentic assessments (Kaider et al., 2017). To reach students of various strengths and interests, Val and Sosulski (2011) suggest to vary types of graded assignments.

Benefits of authentic assessment. Perceptions of authenticity, the implication of the task in real-life, and the experience of learning are factors that influence student engagement and strive for future retainment (Bosco & Ferns, 2014). Authentic assessments offer opportunities for students to take more control of their learning with practice-based evidence (McCrary, Brown, Dyer-Sennette, & Morton, 2017). Students can physically see and experience their work impacting real problems. This creates meaningful learning that lasts, and their attitudes of engagement continue making a difference. For example, Althauser and Harter's (2016) asked students to conduct a food drive for a school-based Family Resource Center. It grew to various grade levels and classes with enjoyment and understanding.

Authentic assessments support and challenge diverse learners (Dennis & O'Hair, 2010; Moon et al., 2005; VanTassel-Baska, 2014). They are both intellectually challenging and engaging when context is personally or socially significant for all students (Preus, 2012). Producing original work, such as with art or writing, forces inquiry to go deeper in understanding, in turn, connecting how content can be used outside of school, which are important factors of authentic assessment that can benefit learners across multiple subjects (Dennis & O'Hair, 2010).

Some cases report findings of engagement and motivation increased when learning about real problems. In Althauser and Harter's (2016) report, students learned about data analysis while conducting a food drive for the school's resource center, and the project spread to other grades and became quite large for the school. Feelings of the experience showed to be positive along with excitement to do it again (Althauser & Harter, 2016). In another study, students engaged in a "2-day camp that used hands-on and minds-on activities that aimed to engage them to think mathematically while applying it to real-life" (Soroño-Gagani & Bonotan, 2017, p. 132). The students rated high feelings about the activities as they felt it was enjoyable and fun (Soroño-Gagani & Bonotan, 2017). Supplementing traditional learning with projects or tasks that are hands on and personal can help students see concepts in real life.

Challenges of including authentic assessments. Common struggles with integrating authentic assessments involve content, students, personnel, and the school system (Edwards, 2015). Overcoming these challenges requires tenacity, remaining student focused, and being experimental in trying different instructional approaches (Edwards, 2015). Katz-Buonincontro et al. (2017) state that although "constructing open-ended assignments can be time intensive, it offers a window into student thinking for improving their mathematical competence, and potentially reveals students' motivation to learn and think creatively" (p. 297). Therefore, the benefits of improving student competence, ownership, and the assessment of their thoughts make authentic assessment important to integrate – despite the additional time and dedication.

Teachers also need to be more flexible (Dennis & O'Hair, 2010), as well as willing to take on new challenges that come with shifting to student-centered learning. They should frequently be checking for understanding and interests, revising a project accordingly (Dyjur & Li, 2010). Additionally, teachers need to recognize and anticipate that students may struggle shifting to this type of learning because it is a different way of learning than what has commonly been practiced in the past (Dyjur & Li, 2010). Therefore, teachers and students need to be flexible to take advantage of serendipitous learning that is not consistent in traditional methods (Dyjur & Li, 2010).

Chapter Summary

In summary, the implementation of mathematical concepts includes the application of mathematical reasoning skills to perform, communicate, explain, and argue real-world functions of mathematics as well as the appreciation and creation of positive attitudes about mathematics (Huscrot-D'Angelo et al., 2014). Thorndike's Theory of Transfer, applying what is already known and connecting it to new knowledge (Evans, 1999), mathematical skills are being used beyond completing worksheets in a place surrounded by four walls. Instructional scaffold techniques such as group work, asking questions, writing prompts, or using graphic organizers can assist in the organization and communication of knowledge are some instructional strategies to increase authentic mathematical application. Asking students to bring life to mathematics, taking a stand to form an argument to explain cognitive processes, and being appreciative, positively viewing mathematics as a gateway to success in life, can be accomplished during middle school when it is common for students to become disengaged.

Authentic assessments are a way for students to practice mathematics and are strategies either in, or used in, real-world settings. These may take many forms, but it is common for them to be carried out with projects, performance tasks, or portfolios that instill inquiry and communication. Some teachers transform their classrooms to move beyond simply practicing rote skills by using methods of a flipped classroom, problem-, project-, or inquiry-based learning. The implementation of authentic assessments requires teachers to alter the types of questions asked to include higher order thinking, using graphic organizers to help organize thoughts, and incorporating more writing and literacy into the curriculum. Utilizing technology affords personalized learning and other ways to include communication, creation, collaboration, and critical thinking of knowledge, which can additionally make a positive impact.

CHAPTER 3

METHODS

Mathematical proficiency and quantitative literacy are significant to many aspects in everyday life as well as success in the workforce (Roohr, Lee, Xu, Liu, & Wang, 2017). Although my 7th and 8th graders performed well on achievement tests, I have observed student deficiencies in their use of learned material in real world applications. Because authentic assessments focus on the application of skills needed in real life (Mohamed & Lebar, 2017), it is thought that authentic assessments can create a bond between academic achievement and quantitative literacy. Using a convergent parallel mixed methods study design, I included quantitative and qualitative data to determine my findings.

The purpose of this action research was to evaluate the impact of writing prompts and graphic organizers on Mona school's 7th and 8th grade students' mathematical academic achievement and their attitudes towards the authentic application of mathematics. The two research questions that guided the study are as follows:

1. How and to what extent, do writing prompts and graphic organizers impact 7th and 8th grade students' mathematical achievement and attitudes towards mathematics?
2. What were the 7th and 8th grade students' perceptions about the implementation of authentic writing prompts and graphic organizers in a mathematics course at Mona school?

Research Design

Action research was the design used in my study. Notably pioneered in the 19th century by Kurt Lewin (Adelman, 1993; Hine, 2013; Kock, Avison, & Malaurent, 2017; Mills, 2011; Nelson, 2013), action research can be described as a systematic inquiry in a teaching or learning environment that generates insights and reflective practices while promoting positive changes to improve the school's environment, student outcomes, or the livelihood of those involved (Mills, 2018). Action research, unlike traditional research methods, is not generalizable (Creswell, 2014; Huang, 2010) because it takes place at a local level from a local educator (Creswell, 2014). However, through the circle of knowledge, action research, is useful to educators everywhere and can be disseminated to a general audience over time (Johnson & Christensen, 2017). Instead of random sampling used in many traditional research methods, action research uses purposeful sampling and allowed me, the teacher, to use a pre-selected group of middle school students (Creswell, 2014).

Including all three elements of action, research, and participation, (Greenwood & Levin, 2007) action research bridges the gap between research and practice (Hine, 2013) while blending inquiry and application (Kinash, 2018). It is more continuous and tests hypotheses with procedures that include more input from the educator – often, making researchers of this kind become lifelong learners that continue to grow (Hine, 2013; Mills, 2011). In addition, action research not only finds solutions to improve a local environment or practice but, by being in the action, knowledge is developed on a deeper level with a full understanding of how and why. This empowers researchers by advancing their knowledge and theories to make important contributions to the world in which they live (McNiff & Whitehead, 2011).

The main characteristics of the study were “natural setting” and “researcher as key instrument” (Creswell, 2014, p. 234). For my study, the natural setting referred to my classroom at Mona school, while the researcher referred to me, the teacher. These characteristics are true for action research as well as in my study because all information was gathered on site by me. Using action research allowed me to find solutions, or eliminate a possible solution, to better my students’ futures. In alignment with the pragmatic paradigm (Creswell, 2013; Kivunja & Kuyini, 2017), it is important to keep in mind that solutions may not be transferrable to other situations and are not permanent. Similar in thought as to why I blended teaching practices in my study, Greenwood and Levin (2007) credit action research to have brought various approaches together with “the belief that there is no substitute for learning by doing” (p. 2).

Qualitative and quantitative methods have their individual strengths and contributions (Morgan, 2014a), but there are also disadvantages when using as a monomethod such as personal bias, omission of important constructions, or lack of understanding and reflection of study participants (Brierley, 2017). Therefore, the sum of both qualitative and quantitative research is stronger than either alone (Creswell & Plano Clark, 2018). The mixed methods approach, in alignment and often associated with the pragmatic paradigm (Brierley, 2017; Creswell, 2013; Davies & Fisher, 2018; Kivunja & Kuyini, 2017; Morgan, 2014a; Schoonenboom & Johnson, 2017), integrates qualitative and quantitative results to gain a complete picture of the topic with more detail and knowledge (Morgan, 2014a; Schoonenboom & Johnson, 2017; Wahyuni, 2012).

Taking place locally in my mathematics classroom and in the online learning environment after the COVID-19 pandemic began, qualitative and quantitative data were collected independently but merged together in a convergent parallel mixed methods study design (Creswell, 2014; Creswell & Plano Clark, 2018; Schoonenboom & Johnson, 2017), also known as triangulation mixed method designs (Mertler, 2017). This design is recommended for the pragmatic paradigm as it “provides an umbrella worldview for the research study” (Creswell & Plano Clark, 2018, p. 69). In a convergent parallel mixed methods study design, the intent and purpose of the study are to compare, combine, explain, and explore the data, while the parallel-databases variant allowed me to collect and analyze qualitative and quantitative data independently to examine, synthesize, or compare the results (Creswell & Plano Clark, 2018). This design obtained sources of qualitative and quantitative data that were analyzed together via the side-by-side method of using quantitative data to confirm or disconfirm the results from the qualitative data (Creswell, 2014; Mertler, 2017; Morgan, 2014a). Using a convergent parallel mixed methods study design in this fashion, I was able to gain a well-rounded point of view to evaluate my innovation both academically and through Mona students’ perspectives.

Setting and Participants

The setting for this study was my 7th and 8th grade prealgebra mathematics classroom. The design of the desks was primarily in horizontal rows that touched one another. Periodically, this layout changed to be arranged into smaller groups where desks were moved, so that students worked in small groups of two to four students. For either layout of the desks, I preferred my students to sit by other students to help create a learning environment that encouraged learning from one another. After the COVID pandemic began, my classroom was shifted to an online platform where the learning environment was in individual homes and included meeting as a class twice a week via web conferencing.

In 2016, Lillianna Doris Martin Schools and their patrons recognized the importance of technology so much that they purchased tablets for all students. This included the K-8 school, Mona, that I work within, where the tablets were used daily in the classroom. Measures of Academic Progress (MAP), an assessment that summarizes achievement (Weurlander, Söderberg, Scheja, Hult, & Wernerson, 2012), was completed three times throughout the year as a mechanism to increase communication and help build students' academic toolboxes to be adequately prepared for their futures. The MAP reports provide immediate results for computerized academic achievement tests as well as more accurate results with adaptive tests. Technology's role and benefits are vital pieces to my teaching as well as in education, the workforce, and students' future successes. As expectations for the use of technology increased, students were expected to take responsibility of their learning with educational videos and collaboration programs that allowed learning to occur anytime of the day or night.

Students used technology in many ways in my classroom. While completing a worksheet or filling in the text does not use technology to its fullest potential, they are productivity techniques that some students favored. Although many students still preferred printed out forms, most students also liked annotating on their iPads to help with organization or eliminate the physical activity of carrying an actual book. Additionally, some students liked checking their work against the website for problem solutions and receiving additional help for questions about which they were unsure. My class also included many videos that either made the content more interesting and engaging or tutorial videos for referencing. Other examples of common applications in which students used their tablets were as follows: collaboration, word processing, screen mirroring, applications for creating presentations, spreadsheets, note-taking, pictures, or videos. I used screen casting for whole class collaboration and sharing of students' or my tablet's screen. A Learning Management System (LMS) was commonly used to host lesson plans, directions, or worksheets as well as participating in forums, activities, and submitting projects both for all students to see and comment on or for me only to access. Note-taking applications were commonly used to annotate PDF's, create new notes, and share notes.

For this action research study, I took the role of the researcher and teacher by collecting and analyzing the gathered data. These insider roles in the study necessitated that I not favor any ideas as I conducted semi-structured focus group interviews and reported findings. The desire for a positive impact of this innovation created a possible bias that I controlled through peer debriefing and meticulous notes in my researcher's journal. Furthermore, bracketing reduced researcher bias by helping me refrain from injecting personal beliefs, values, and experiences while allowing me to focus on my research questions and use cues to further my questioning (Tufford & Newman, 2012).

My study lasted approximately 13 weeks, giving it persistent and prolonged exposure. This time frame ensured that I spent enough time with the participants to gain their trust, learn about the culture of the setting, and witness the establishment of routine behavior patterns (Hadi & Closs, 2016; Mertler, 2017). Although trustworthiness was increased as my study took place over a prolonged period of time, it was important to remember that although similar situations may suggest similar results, there was no way to guarantee the same generalizations would hold true in other situations (Shenton, 2004).

Purposeful sampling was used in the selection of participants as it allowed me to choose one group of students that I anticipated would contribute rich and relevant information most beneficial to the study (Gentles, Charles, Ploeg, & Mckibbon, 2015). Prior to the study, students were divided into groups depending on the class period they had mathematics. The criteria for my study's chosen group were a mix of gender, age, and skill levels that were reflective of the larger student body demographics and abilities at Mona. The chosen class consisted of 13 7^{th} and 8^{th} grade participants. In the chosen group, the ratio of girls to boys was nine to four, five students were 8^{th} graders (four girls, one boy), and eight students were 7^{th} graders (five girls, three boys). All participants in the study were voluntary and did not receive any incentives for participating. Table 3.1 includes additional specific demographics.

Table 3.1. *Participant Demographics*

Participant (pseudonym name)	Gender	Grade
Sophia	F	8
Isabella	F	7
Ethan	M	7
Addison	F	8
Hailey	F	7
Jayden	M	8
Kaitlyn	F	7
Olivia	F	8
Abigail	F	7
Lily	F	8
Noah	M	7
Hannah	F	7
Jackson	M	7

Innovation

The merge of literacy and mathematics empowers students as they build both ideas and precision (Colonnese et al., 2018). The interventions of including writing prompts and graphic organizers (see Appendix A) were integrated into my classroom which commonly included traditional learning along with various types of activities. This type of blended learning was desired to engage students in various ways that could construct their understanding by connecting, applying, and communicating their mathematical knowledge into their everyday lives.

All writing prompts and graphic organizers were created and completed on tablets with products such as word processing or note-taking applications. Documents were intentionally created in this fashion to give students the ability to work with products they used regularly and have a document that included and fits the data entered. However, the tablets were not configured such that the students could edit the documents. Instead, the documents were converted to allow students to annotate the document instead of editing them. This section further describes the writing prompts, graphic organizers, and organization of each innovation as they were integrated into the content within my middle school mathematics curriculum.

Writing Prompts

The innovation of writing prompts was one aspect in particular that I examined in my study. As students underwent the processes of writing about their mathematical knowledge, my study intended to determine the impact writing prompts had on students' attitudes towards the authentic application of mathematics.

As identified in Colonneselyn et al. (2018), there are often four types of writing exercises: exploratory, informative/explanatory, argumentative, and creative. These types of writing exercises were included throughout my study as noted in Table 3.2. All writing exercises were completed on student tablets.

Table 3.2. *Strategies to Address Applications of Mathematical Concepts*

Strategy	Applications of Mathematical Concepts	Examples
Exploratory	Create positive attitudes and appreciation Develop thought process to help make informed decisions	Unit 4: What do you know about translations, reflections, and rotations? How would you describe their importance and connection to life outside math class? Unit 5: In language arts classes, you are taught to use various methods such as root words or context clues to help relate, understand, and learn new meanings. What words are given to you that would give you an idea what each angle relationship is. Then, using those thoughts, explain what each angle relationships is. Write this as detailed as you can- imagine you are writing to a friend who needs help.
Informative/Explanatory	Develop reasoning skills needed to perform mathematics Communicate knowledge and argue reasoning processes	Module 10: Describe why/how the different algebraic representations work for each transformation. Explain and show how to compute an example for each. Module 12: Explain how the distance formula and the Pythagorean Theorem are intertwined. You may use pictures or examples to help you explain.

Strategy	Applications of Mathematical Concepts	Examples
Argumentative	Argue reasoning processes	Module 9: When transforming figures, describe factors that would influence you to use each method (algebraic representation and graphing). Module 11: Explain two ways to find the missing angle measures from question # 6 on page 358. What might be some factors of a given problem to use one method over the other.
Creative Writing	Create positive attitudes and appreciation	Module 9: Create or find a real-world situation that includes the use of multiple transformations. Explain your reasoning for the inclusion of each transformation and what properties stand out to you as most important. Module 11: Create two real world situations that you could use similar triangles and proportions to solve. Then solve each problem. Make sure to explain your steps.

Graphic Organizers

Graphic organizers were the second innovation of this study as I examined the students' perceptions about the authentic application of mathematics. Scaffolding strategies, such as graphic organizers, are aimed to help with visualizing, organizing, clarifying, inferring, communicating knowledge and strategies, and connecting relationships among concepts (Zollman, 2009). Students used these in various forms throughout the study. All graphic organizers were created with a word processor and were completed on the student's tablets to allow personal annotating of the document.

Table 3.3 outlines which graphic organizer was included in relation to the application of mathematical concepts as well as where they are found in my study. Appendix A provides visual representations of the graphic organizers used in my study.

Table 3.3. *Graphic Organizer Strategies to Applications of Mathematical Concepts*

Graphic Organizer Strategy	Applications of Mathematical Concepts	Where Found
Word wall	• Communicating knowledge • Understanding vocabulary	Unit 4
Know, What, Learn chart	• Communicating knowledge • Argumentation for processing and reasoning • Making connections through note-taking	Unit 4
Hierarchy concept map	• Arguing mathematical thought processes • Create positive attitudes and appreciation • Understanding relationships	Unit 4
Writing graphic organizer	• Communicating knowledge • Argumentation for processing and reasoning • Create positive attitudes and appreciation	Unit 4 and 5
Four corners	• Argumentation skills for processing and reasoning • Create positive attitudes and appreciation • Understanding relationships	Unit 5
Triangle	• Argumentation skills for processing and reasoning • Create positive attitudes and appreciation	Unit 5

Organization of Innovations

The study included content from two units, each consisting of two modules. With the collection of data beginning in the middle of February, my study began with Module 9 found in Unit 4. Unit 4 discussed the overarching topic of transformational geometry, focusing on transformation of translations, reflections, rotations, and dilations. Unit 5 introduced measurement and geometry, focusing primarily on triangles. These units included geometry common core standards "understand congruence and similarity using physical models, transparencies, or geometry software" ("Common Core," 2018, p. 55) as well as "understand the Pythagorean Theorem" ("Common Core," 2018, p. 56).

The collection of data began with a pre-test of the upcoming Unit 4 material and the student questionnaire, both completed on the student's tablet. Next, students skimmed Modules 9 and 10 as they used their tablets to fill in a Know, What, Learn (KWL) graphic organizer using a note-taking application. Looking more closely at Module 9, we reviewed previous content found in the "Are You Ready" section of our textbook *Go Math*, previewed vocabulary words (making sure to include such words into both their and my own word wall graphic organizer), and took part in an exploratory writing exercise of: "What do you know about translations, reflections, and rotations? How would you describe their importance and connection to life outside math class?"

Unit 4's topic of transformations first dove into translations, reflections, and rotations in Module 9. While learning each of these three transformations, students completed a hierarchy graphic organizer that allowed students to visually see how each transformation was broken down. This same graphic organizer was continued in Module 10 as the content was closely related. The first three lessons included learning properties of each transformation individually and integrated Unit 4's content of including the algebraic representations for each transformation. While teaching these lessons, I included practice problems of writing both the algebraic rule and drawing figures that underwent each individual transformation.

An activity that related to the first lesson that I included was taking pictures at home and school of both manmade and natural translations. An activity for the second lesson was geared towards having students practice working with and seeing reflections. Looking at pictures of reflections first and discussions of where reflections were found in life led into students thinking about what they wanted to draw. Some drew landscapes, buildings, their name, or something else creative, but all students worked to their own ability level for this activity. They drew the original picture on half of a sheet of graph paper, and then reflected it over either the x or y-axis. Students increased the appearance of the reflected images with color and other enhancements they saw fit. The class quickly reviewed the fourth lesson as well as the writing prompt "When transforming figures, describe factors that would influence you to use each method (algebraic representation and graphing)." The last lesson merged the previous lesson content together and asked students to identify or apply various translations and algebraic rules in a step-by-step fashion to create a series of shapes, all congruent in size. For this lesson, I asked students to engage in a creative writing assignment: "Create or find a real-world situation that includes the use of multiple transformations. Explain your reasoning for the inclusion of each transformation and what properties stand out to you as most important." Module 9 concluded with a review followed by a module summative assessment.

Just prior to deploying Module 10, and continuing until the end of the study, online learning from our homes replaced the classroom learning environment as a result of the COVID-19 pandemic. The schedule additionally changed from seeing students every day in person to logging in via web conferencing two days a week for an hour each time. Continuing in Unit 4, Module 10 discussed the last transformation and consisted of three lessons about dilations. Included in this module were practice problems of drawing dilations, finding scale factor, writing and applying algebraic representations, similar figures, and a transformation poster. This module only had one writing exercise in the category of informative/explanatory writing that nicely included recollection of the previous module and the current module to see the connections as well as act as a good preparation for the Unit 4 summative assessment. The informative/explanatory writing prompt was "Describe why/how the different algebraic representations work for each transformation. Explain and show how to compute an example for each." The last activity for Module 10 was to create a poster that included a definition, algebraic representations, and an example that was described in words, algebraically, and with a real-world picture for each transformation. This project was completed using either their tablets or by hand. Module 10 concluded with a review and a module summative assessment followed by the Unit 4 (post-test) summative assessment. The post-test included identical questions to that of the pre-test, but it was administered online instead of in the classroom.

Unit 5, the second unit of the study, focused on triangles and began with a pre-test about upcoming content found in Modules 11 and 12. After taking the pre-test, students completed an exploratory writing assignment: "In language arts classes, you are taught to use various methods such as root words or context clues to help relate, understand, and learn new meanings. What words are given to you that would give you an idea what each angle relationship is? Then, using those thoughts, explain what each angle relationships is. Write this as if you are writing to a friend who needs help understanding each relationship."

Module 11 focused on parallel lines and their relationship to a transverse. There were discussions and practice questions for independent learning as well as activities. One activity, included creating a town that utilized parallel lines and transversal. Students included a minimum of ten locations such as a house, a church, a school, etc. with items found around the home such as toys, decorations, food, or parts of the home such as floor tiles. Students took a picture of their town, identified an example of each angle relationship found in their pictures, shared them in an online class discussion post, and then commented on classmates' towns.

The next two lessons of Module 11 explored further explored triangles. Using characteristics such as the Triangle Sum Theorem and Angle-Angle Similarity Theorem, students found missing angle measures and side lengths by setting up proportions. They practiced this with problems as well as completed an argumentative writing exercise and a creative writing exercise. The argumentative writing was: "Explain two ways to find the missing angle measures from question # 6 on page 358. What might be some factors of a given problem to use one method over the other?" The creative writing exercise was: "Create two real world situations that you could use similar triangles and proportions to solve. Then solve each problem. Make sure to explain your steps." Students used similar triangles and proportions to help them in an optional class activity of determining how tall an item around their neighborhood was, such as a tree or a telephone pole. Module 11 concluded with a digital escape room review of the content from the three lessons and taking the Module 11 summative assessment.

In the last module of Unit 5, students continued to work with triangles. The first lesson in Module 12 looked at the Pythagorean Theorem, the second lesson was about the Converse of the Pythagorean Theorem, and the third lesson related these concepts to the distance formula. Students completed independent practice questions from the first two lessons, a class concept map graphic organizer, and a writing exercise for the last lesson. The informative/explanatory writing activity helped bridge the connection of triangles to the distance formula. This writing prompt asked students to: “Explain how the distance formula and the Pythagorean Theorem are intertwined. You may use pictures or examples to help you explain.” The end of Module 12 concluded with reviewing the content from all three lessons and students completed the Module 12 summative assessment. This also ended Unit 5, so I administered the Unit 5 post-test followed by a repeat of the student questionnaire. The last part of my study was conducting two semi-structured focus group interviews, which took place online the same day the questionnaire was completed. Table 3.4 details the alignment of lessons/modules, topics/objectives, activities, etc.

Table 3.4. *Organization of Innovations*

Lesson/Module	Topics/Objectives	Activities	Writing Prompt (Formative Assessment)	Graphic Organizer
		Pre Student Questionnaire		
Unit 4	• Transformational geometry	Unit 4 Pre-test		Word Wall Know, What, Learn Chart for Modules 9-10
Module 9 (Unit 4)		Are you Ready, Vocabulary, Skim	Exploratory Writing Prompt: What do you know about translations, reflections, and rotations? How would you describe their importance and connection to life outside math class?	Writing graphic organizer
9.1 Properties of Translations	• Describe properties of translation • Explain the effect on congruence and orientation • Identify and apply algebraic representations for translations	Translation collage task		Fill in hierarchy concept map with translation properties

Lesson/Module	Topics/Objectives	Activities	Writing Prompt (Formative Assessment)	Graphic Organizer
9.2 Properties of Reflections	• Describe properties of reflections • Explain the effect on congruence and orientation • Identify and apply algebraic representations for translations	Reflection drawing		Fill in hierarchy concept map with reflection properties
9.3 Properties of Rotations	• Describe properties of rotations • Explain the effect on congruence and orientation • Identify and apply algebraic representations for translations	In class discussion and practice		Fill in hierarchy concept map with rotation properties
9.4 Algebraic Representations of Transformations	(Integrated into other lessons)		Argumentative Writing Prompt: When transforming figures, describe factors that would influence you to use each method (algebraic representation and graphing).	Writing graphic organizer

Lesson/Module	Topics/Objectives	Activities	Writing Prompt (Formative Assessment)	Graphic Organizer
9.5 Congruent Figures	• Identify, describe, and apply combined transformations		Creative Writing Prompt: Create or find a real-world situation that includes the use of multiple transformations. Explain your reasoning for the inclusion of each transformation and what properties stand out to you as most important.	Writing graphic organizer
		Module 9 Summative Assessment		
Module 10 (Unit 4)	Learning Environment Changed to Online			
10.1 Properties of Dilations	• Describe properties of dilations • Explain the effect on congruence and orientation	Video and independent practice		Fill in hierarchy concept map with dilation
10.2 Algebraic Representations of Dilations	• Describe properties of reflections • Explain the effect on congruence and orientation • Identify and apply algebraic representations for translations	Video	Informative/ Explanatory Writing Prompt: Describe why/how the different algebraic representations work for each transformation. Explain and show how to compute an example for each.	Writing graphic organizer

Lesson/Module	Topics/Objectives	Activities	Writing Prompt (Formative Assessment)	Graphic Organizer
10.3 Similar Figures	• Describe properties of rotations • Explain the effect on congruence and orientation • Identify and apply algebraic representations for translations	Video and independent practice		
		Transformation project		
		Module 10 Summative Assessment		
		Unit 4 (Post-test) Summative Assessment		
Unit 5	Measurement and geometry	Unit 5 Pre-test		

Lesson/Module	Topics/Objectives	Activities	Writing Prompt (Formative Assessment)	Graphic Organizer
Module 11 (Unit 5)			Exploratory Writing Prompt: In language arts classes, you are taught to use various methods such as root words or context clues to help relate, understand, and learn new meanings. What words are given to you that would give you an idea what each angle relationship is. Then, using those thoughts, explain what each angle relationships is. Write this as detailed as you can- imagine you are writing to a friend who needs help.	Writing graphic organizer
11.1 Parallel Lines Cut by a Transversal	• Identify angles cut by a transversal • Explain the relationship between angles cut by a transversal	Your town task		Fill in Four Corners
11.2 Angle Theorems for Triangles	• Calculate missing angles in a triangle. • Describe and apply the Triangle Sum Theory	Independent practice	Argumentative Writing Prompt: Explain two ways to find the missing angle measures from question # 6 on page 358. What might be some factors of a given problem to use one method over the other.	Writing graphic organizer (optional)

Lesson/Module	Topics/Objectives	Activities	Writing Prompt (Formative Assessment)	Graphic Organizer
11.3 Angle- Angle Similarity	• Explain what it means if two triangles are similar. • Know and apply similar triangle properties with proportions to calculate missing length.	Video and independent practice Extra credit: Goal post (or another object) task Escape room review Module 11 Summative Assessment	Creative Writing Prompt: Create two real world situations that you could use similar triangles and proportions to solve. Then solve each problem. Make sure to explain your steps.	Writing graphic organizer Triangle graphic organizer
Module 12 (Unit 5) 12.1 The Pythagorean Theorem	• Know and apply the Pythagorean Theorem to solve problems. • Prove the Pythagorean Theorem.	Video and independent practice		
12.2 Converse of the Pythagorean Theorem	• Know and apply the converse of the Pythagorean Theorem to solve problems.	Independent practice (with other lessons)		

Lesson/Module	Topics/Objectives	Activities	Writing Prompt (Formative Assessment)	Graphic Organizer
12.3 Distance Between Two Points	• Understand how the Pythagorean Theorem is used to find the distance in a coordinate plane. • Know and apply the distance formula.	Video and independent practice (with other lesson) Module 12 Summative Assessment Unit 5 (Post-test) Summative Assessment Post Student Questionnaire	Informative/ Explanatory Writing Prompt: Explain how the distance formula and the Pythagorean Theorem are intertwined. You may use pictures or examples to help you explain.	Modified four square writing graphic organizer (optional)

Data Collection

In this action research study, I gathered qualitative and quantitative data to evaluate the impact of writing prompts and graphic organizers on mathematical academic achievement and attitudes towards the application of mathematics. Quantitative data was gathered from student questionnaires (Likert-scale questions) as well as formative and summative assessments. Qualitative data was gathered from student questionnaires (open-ended questions) as well as semi-structured focus group interviews. The qualitative data was used to determine how students perceived the implementation of authentic assessments (writing prompts and graphic organizers) into the mathematics curriculum while the quantitative data assessed the effects integrated authentic assessments had on their academic achievement and attitudes towards mathematics. Table 3.5 shows the alignment of my data collection methods to the two research questions.

Questions from both the semi-structured focus group interviews and the open-ended questions in the student questionnaires focused on the students' perceptions about the implementation of writing prompts and graphic organizers into the mathematics course curriculum. Additionally, these questions gave insights regarding the student's attitudes towards mathematics and how the instruction utilizing the authentic assessments impacted their learning from their perspective. Other questions focused on quantitative literacy factors that encompassed questions Wilkins (2010) used to interpret students' intrinsic motivation, perception of mathematics ability or self-concept, the role and value of mathematics in society, and their beliefs about mathematics changing or being dynamic.

Table 3.5. *Research Question and Data Collection Alignment Table*

Research Question	Data Collection Method
RQ1. How and to what extent, do writing prompts and graphic organizers impact 7th and 8th grade students' mathematical achievement and attitudes towards mathematics?	• Formative assessments • Summative assessments • Student questionnaire
RQ2. What were the 7th and 8th grade students' perceptions about the implementation of authentic writing prompts and graphic organizers in a mathematics course at Mona school?	• Semi-structured focus group interviews • Student questionnaire

Semi-Structured Focus Group Interview

Semi-structured focus group interviews were used in this study to help gain insights into participants' attitudes (Hui, 2016; Liu, 2016; Ritchie & Lewis, 2003) about mathematics and perceptions about the implementation of authentic assessments in the curriculum. Focus groups allowed participants to interact with each other and gave a range of views and feelings during the same interview that illuminated their different perspectives (Efron & Ravid, 2014; Rabiee, 2004) about the impact integrated authentic assessments had on their learning. Because this part of my innovation took place within the COVID-19 pandemic, we were unable to meet in person; therefore, the semi-structured focus group interviews occurred via web conferencing.

Two semi-structured focus group interviews, consisting of my 7th and 8th grade study participants, were conducted at the end of the study. Six and seven participants made up each focus group according to the student's ability levels. Further, participants were arranged according to their writing exercises such that those with similar literacy and mathematical communication skills were grouped accordingly. The majority of students scoring similarly in areas of Communication and Overall were placed in the same group. Students who could be placed into either group, were dispersed according to my reflections on their writing prompts. The semi-structured focus group interviews took place during an online class session, were recorded, and lasted approximately 15 minutes per interview. Once completed, all recorded responses were then transcribed through the website service Rev. I closely reviewed the transcribed narrative to assure no data was left out. The focus groups' interview questions (see Appendix B) were semi-structured and open-ended to allow for any expansion or follow-up questions to help gain a deeper and more well-rounded understanding of their perceptions and the experiences the students went through in the study (Creswell, 2014; Mertler, 2017). An example question in the semi-structured focus group interview was "Do you feel that any type or types of instruction(s) helped you retrieve, connect, and apply content knowledge so you could understand and use in it now or in your future life outside the classroom? Can you provide examples to help you explain why or how?"

Student Questionnaires

Questionnaires afforded me as the researcher the ability to ask an array of questions about my middle school student's attitudes towards mathematics, perceptions about the implementation of authentic assessments, and their experiences with using the writing prompts and graphic organizers as a part of the mathematics curriculum. Student questionnaires (see Appendix C) were administered to all participants using a variety of Likert-type scale questions and open-ended written questions to clarify the impacts of integrated authentic assessments from the students' perspectives. I chose a questionnaire with both types of questions to allow open-ended responses to portray an accurate representation of the participants' thoughts while the Likert-type scale responses to reflect their level of agreement (Mertler, 2017). Data was gathered from all participants during an in-person class session at the beginning of the study and during an online class session at the end of the study. Both pre and post student questionnaires were identical for all participants and were administered using computer survey technology.

Questions from Wilkins (2010) were included in this study's questionnaire regarding quantitative literacy. The two Belief sections included in Wilkins original questionnaire, Memorization and Problem, did not align with the focus of this research. While the data was gathered for use in future research, the seven questions that composed those two sections of the Belief subscale were removed from the data analysis of this study. Students were to respond to each question using a 5-point Likert scale, where a response of (5) was for *Strongly Agree* and a response of (1) was for *Strongly Disagree*. Four questions were adjusted to include an open-ended answer and they are included in italics in Appendix C. Exploratory factor analysis and subsequent confirmatory factor analysis, as conducted by Wilkins (2010), indicated three second-order factors of (a) mathematical beliefs, (b) mathematical cognition, and (c) mathematical disposition. The reliability coefficients ranged for five of the constructs from .79-.85 while three constructs ranged .50-.57.

Formative and Summative Assessments

All of the formative assessments and summative assessments applied to the first research question. While I gathered a variety of assessments for this study, all of data was collected as naturally occurring documents as they were part of my class and did not take any extra arrangements to be created or included (Efron & Ravid, 2014). Student work and test scores contained in my classroom were used to quantitatively understand what was occurring in the study (Mertler, 2017) and generated viable data sources that showed any changes in student work associated with the integration of writing prompts and graphic organizers.

Formative assessments. A type of formative assessment chosen for this study were classroom artifacts. All participants created artifacts, such as writing exercises and graphic organizers (see Appendix D), that were used throughout the study. The Exemplars' Standards-Based Math Rubric, with my additions, were used to assess the artifacts– writing exercises and graphic organizers– in the innovation as it had been updated to reflect CCSS and NCTM (Exemplars, 2012). Appendix E includes the adjusted version of the rubric criteria used for the study. However, due to copyright restrictions, the actual Exemplars' Standards-Based Math Rubric cannot be provided in this manuscript.

In the rubric, seven areas were given a zero, one, two, three, or four-point score: Problem Solving, Reasoning and Proof, Communication, Connecting, Representation, Overall and Given Communication. A frequency count was calculated to show the number of mathematical concepts used as well as a total word count per student artifact.

Summative assessments. Summative assessments were used to document grades and student's final understanding after the material had been taught (Mertler, 2017). Upon completion of each module, students took a module summative assessment. In this study, both Unit 4 and Unit 5 consisted of two modules in the *Go Math* textbook series that Mona purchased. At the beginning and end of each unit, a written pre-test and post-test was administered. The summative assessments included multiple-choice questions that were worth two points each and open-ended questions were worth three points using a scoring rubric where a score of one being that the student had attempted the problem, a score of two for understanding and generated the correct procedures, and a score of three for correctly carrying out the procedures and answering the problem correctly. Calculating the total points of questions directly related to the standards are as follows: Module 9 totaled 33 points; Module 10 totaled 24 points; Module 11 totaled 25 points; Module 12 totaled 26 points; Unit 4 totaled 31 points; and Unit 5 totaled 32 points. An example of a question from the Unit 4 pre- and post-test was: "Apply the transformation given by the rule below to triangle *DEF*. Write the ordered pair for the new coordinate for point *D*. $(x, y) \rightarrow (x, y + 4)$. Describe the results of the transformation." One example question from a Module 12 summative assessment was: "A carpenter added a diagonal brace to a gate. The gate is 80 inches wide and 60 inches tall. How long is the brace?"

All quantitative data ensured validity as I made sure my data was assessing the correct content using "evidence of validity based on test (or instrument) content" (Mertler, 2017, p. 155). All summative assessments were Common Core aligned and followed the curriculum associated with the textbook Mona school has approved. The identical pre- and post-tests, as well as the module assessments, were first created by the textbook company and then edited by myself to ensure language and content was parallel to what I taught. Additionally, two other Mona faculty members reviewed the summative assessments to verify the instruments were assessing the intended material before administration in this study (Mertler, 2017; Mills & Gay, 2016).

Also included are the documents from the innovations and consent forms for the participants (see Appendices F, G, and H). Appendix A (Figures A.1–A.7) contain the study's graphic organizers and Table A.1 includes the writing exercises. Appendix B includes the semi-structured focus group interview. Appendix C includes the student questionnaire questions that were administered to participants. Appendix D (Figures D.1-D.3) shows examples of student's completed work of a writing prompt and graphic organizer.

Data Analysis

To analyze quantitative data, I used descriptive statistics and inferential statistics and to analyze qualitative data, I used inductive analysis to discover and describe the students' attitudes towards mathematics, and what was the students' perceptions about the inclusion of writing prompts and graphic organizers in the curriculum. Quantitative data collected from student questionnaires, formative assessments, and summative assessments were analyzed using descriptive statistics, with Unit 4 and Unit 5 pre and post summative assessments additionally analyzed using inferential statistics. Qualitative data collected from the semi-structured focus group interviews and the open-ended questions on the student questionnaire were analyzed using inductive analysis methods by undergoing several rounds of coding as it is "a deep reflection about and, thus, deep analysis and interpretation of the data's meanings" (Miles, Huberman, & Saldaña, 2013, p. 72). Following the design of a convergent parallel mixed methods study, both qualitative and quantitative data was analyzed separately, and the findings were compared to see if the two types of data confirmed each other's findings (Creswell, 2014). Table 3.6 shows the alignment of my two research questions to the data collection sources and analysis methods. Each of these methods is described in more detail below.

Table 3.6. *Alignment of Research Questions, Data Sources, and Analysis Method*

Research Question	Data Collection Method	Data Analysis Method
RQ1. How and to what extent, do writing prompts and graphic organizers impact 7th and 8th grade students' mathematical achievement and attitudes towards mathematics?	• Formative assessments • Summative assessments • Student questionnaire	• Descriptive statistics • Inferential statistics
RQ2. What were the 7th and 8th grade students' perceptions about the implementation of authentic writing prompts and graphic organizers in a mathematics course at Mona school?	• Semi-structured focus group interviews • Student questionnaire	• Inductive analysis

Quantitative Analysis

Four module and two unit summative assessments were conducted in this study. In all assessments, the questions were first created by the *Go Math* textbook company and then altered to ensure the language and content aligned with what I taught. For each summative assessment, the internal consistency was measured using Cronbach's alpha. While widely desired ranges of coefficients are .70 to .95, with higher scores indicating higher quality (Rudner & Schafer, 2001; Taber, 2018; Tavalok & Dennick, 2011), this is not always possible in classroom assessments and the study sufficed with a reliability coefficient of .50 to .60 (Rudner & Schafer, 2001). The two unit assessments, given as a pre- and post-test, measured the internal consistency separately for each administration and were reported together.

All quantitative data collected in the study was analyzed using descriptive statistics. The mean, a measure of central tendency, was useful for me, the researcher, to summarize my data and reveal how students responded academically as a whole (Leech, Barrett, & Morgan, 2005; Mertler, 2017). With the measure of central tendency showing what is similar within the group, the calculated measures of dispersion, the range and standard deviation, revealed the variability within the group (Leech et al., 2005).

In addition to descriptive statistics, inferential statistics were conducted on the identical pre-test and post-test administered for both Unit 4 and Unit 5. Since I had one group, a dependent *t*- test was used to compare scores from the pre-test and post-test (Mertler, 2017). The significance level, or *p* value, was calculated and compared to the set alpha level of .05.

Qualitative Analysis

Throughout the inductive analysis of qualitative data, I employed systematic steps of coding to produce categories on which I pondered until themes emerged that connected the categories (Creswell, 2014; Gläser & Laudel, 2013). Researchers describe six steps to analyze qualitative data as: (1) familiarizing with the data while organizing and preparing the data for analysis, (2) reading the data and generating initial codes, (3) start coding the data with a sentence by sentence unit of analysis and writing possible categories in a search for themes, (4) reviewing themes to generate a description of the setting as well as categories, (5) defining and advancing the descriptions and themes as they are represented in the narrative, and lastly (6) making an interpretation of the results while producing the report (Braun & Clarke, 2006; Creswell, 2014). The following paragraph further explains my analysis.

In the beginning, as well as throughout the process, it was important to think about and use my research questions to help guide the storyline (Stuckey, 2017) while familiarizing myself with the material by transcribing the data, reading and re-reading the content, and making notes of ideas for initial codes (Braun & Clarke, 2006). I continued to conduct several rounds of coding to further condense the volume of qualitative data (Mertler, 2017) while highlighting priorities to provide focus (Vaughn & Turner, 2016). During the first cycle coding methods (Saldaña, 2016), I utilized the computer-aided qualitative data analysis (CAQDAS) program, Delve. After completing *Structural Coding, Process Coding, In Vivo Coding, and Emotion Coding* and reducing the vast amount of data, I printed out the codes to reassemble the broken-down text by mediums of paper and sticky notes. Using *Pattern Coding* I examined the codes for similarities or replicated patterns and then grouped those codes into categories (Rabinovich & Kacen, 2010). I then repeated this process to group categories into themes. I formed the descriptions of the setting, people, and categories followed by advancing, defining, and refining how they are represented to create connections to the themes in relation to the research questions (Braun & Clarke, 2006; Creswell, 2014). I met with my dissertation chair weekly to process my thinking as categories and themes emerged. Additionally, I provided rich, thick descriptions of all emerging themes and fully explained them in the findings to paint a clear picture for the reader (Creswell, 2014; Zohrabi, 2013). The detailed description increased trustworthiness as it “helps to convey the actual situations that have been investigated and, to an extent, the contexts that surround them” (Shenton, 2004, p. 69). It also allowed others to evaluate the extent of the conclusions and help determine if my findings fit into other contexts (Hadi & Closs, 2016; Mills & Gay, 2016), while permitting the reader to independently assess how well the data embraced the findings (Shenton, 2004). To present my themes visually, I included a table to show the connection between the data and the discovered themes. Lastly, I generated the report as I interpreted the research and included further questions and a call for action (Braun & Clarke, 2006; Creswell, 2014).

Throughout the coding process, I used a more traditional qualitative route to allow codes, categories, and themes to emerge, rather than using pre-existing or *a priori* codes (Bernard, Wutich, & Ryan, 2017; Creswell, 2017; Gläser & Laudel, 2013). I purposefully left out how many comments made up each code and how many codes made up a category because all codes were given equal emphasis (Creswell, 2017), and I respected my reflexivity as I became aware of my own influences (Darawsheh, 2014). I bracketed my knowledge and assumptions (Tufford & Newman, 2012) throughout each step of the inductive analysis (Mertler, 2017) by keeping a detailed researcher's journal and having weekly discussions with my dissertation chair to better understand what was happening (Darawsheh, 2014) and to keep my insider positionality from influencing what I was seeing emerge from the data.

The analysis of the artifacts created in the innovation "explore[d] the attributed values, attitudes, and beliefs about them from the participants perspectives" (Saldaña & Omasta, 2017, p. 66). In this study, my analysis focused on facets of the number of examples used in descriptions, the articulation and argumentation of thought processes, and the communication of mathematical knowledge. Quantitative content helped interpret the latent and manifest text (Saldaña & Omasta, 2017).

Procedures and Timeline

The procedures and timeline section lay out more specific information regarding timeframes and phases of the study. There were ten phases of the study further explained and shown in this section. Furthermore, Table 3.7 shows a timeline of the ten phases as they took place throughout the study. Both description and timeline consist of explanations of when and how the study was organized collecting, analyzing, distributing, creating, and editing data and documents.

My study began with Phase 1 that included obtaining consent for the study. This began with the Institutional Review Board approval from the University of South Carolina (see Appendix F), then approval from Lillianna Doris Martin Schools (see Appendix G) and then followed by consent for participant from the parents of my 7th and 8th grade participants (see Appendix H). After parental consent was obtained, the first piece of data collected was to have the students complete the student questionnaire. I distributed the link for students to complete the student questionnaire during their mathematics class session. This did not require specific content knowledge and was administered prior to the beginning of the actual study on February 10, 2020.

Table 3.7. *Timeline of Innovation*

Phase and Date	Inclusion of Others	My Actions
Phase 1 February 10, 2020	Collect Consent forms Student questionnaire	Analyze Student questionnaire (quantitative and qualitative)
Phase 2 February 18 – March 6, 2020	Collect Unit 4 pre-test Module 9 writing exercises Module 9 summative assessment	Analyze Unit 4 pre-test (quantitative) Writing (artifact - quantitative) Module 9 summative assessment (quantitative)
Phase 3 March 18- 31,2020 (change to online learning)	Collect Module 10 writing exercises Module 10 summative assessment Unit 4 post-test	Analyze Writing (artifact - quantitative) Module 10 summative assessment (quantitative) Unit 4 post-test (quantitative)
Phase 4 March 31- April 28, 2020	Collect Unit 5 pre-test Module 11 writing exercises Module 11 summative assessment	Analyze Unit 5 pre-test (quantitative) Writing (artifact - quantitative) Module 11 summative assessment (quantitative)
Phase 5 April 30- May 12, 2020	Collect Module 12 writing exercises Module 12 summative assessment Unit 5 post-test	Analyze Writing (artifact - quantitative) Module 12 summative assessment (quantitative) Unit 5 post-test (quantitative)
Phase 6 May 14, 2020	Collect Student questionnaire Semi-structured focus group interviews	Analyze Student questionnaire (quantitative & qualitative)

Phase and Date	Inclusion of Others	My Actions
Phase 7 May 14 – October 17, 2020	Member check with participants	Analyze Transcribe, familiarize, and coded the semi-structured focus group interviews and open-ended responses on the student questionnaire (qualitative) Write findings of themes Editing and make any needed changes Perform quantitative analysis (quantitative)
Phase 8 October 18 - November 9, 2020	Present to dissertation committee	Generate Write dissertation report Create and deliver PowerPoint presentation of my dissertation research
Phase 9 Fall 2020	Present to administration and stakeholders	Editing Make revisions Create simplified version of the manuscript to be shared
Phase 10 Fall 2020	Present to teachers Submit to journals, conventions	

Phase 2 was when the study's innovations began. On February 18, 2020, students completed the Unit 4 pre-test followed by filling out the KWL and word wall graphic organizers for Unit 4. I reviewed the outcomes of the Unit 4 pre-test while students began to learn about Module 9. Within Module 9, students learned through activities, worksheets, graphic organizers, writing exercises, and finished the module with a summative assessment. I analyzed the writing exercises as artifacts after they were assigned, and the Module 9 summative assessment was analyzed upon its completion. The analysis of the module summative assessment had a short overlap period as I had students begin Module 10. Phase 3 through 5 was the same format as Phase 2 with two differences: Phases 3 and 5 had only a post-test to conclude each unit instead of a pre-test to begin. Phase 3, following a break in the school calendar that also coincided with the onset of the COVID-19 pandemic resulted in fully online learning beginning. Phase 3 took place from March 18- 31, 2020, Phase 4 was March 31- April 28, 2020, and Phase 5 took place April 30- May 12, 2020, each also occurring in the online learning environment.

Phase 6, May 14, 2020, was when the innovation ceased and simultaneously the student questionnaire and semi-structured focus group interviews took place. As I was deploying one semi-structured focus group interview using web conferencing, the other group of students completed the student questionnaire. Then when each group completed their task, they were switched. Phase 7 took place May 14-October 17, 2020 and included the qualitative analysis of the student questionnaire open-ended questions, transcriptions of semi-structed focus group interviews, multiple rounds of coding, and writing the emerged themes. Quantitative analysis of the data collected from the student questionnaires, formative, and summative assessments was conducted. Additionally, this phase incorporated going back to the participants to member check with them about the qualitative outcomes. To ensure I was accurately representing their thoughts and experiences, I edited any changes that needed to be made. Phase 8 took place between October 18 – November 9 and included the finished writing of my dissertation and the PowerPoint presentation, which I delivered to my dissertation committee on November 9, 2020. In the Fall of 2020, Phase 9, I will present my findings to the stakeholders and to Mona administration. During these presentations, I will discuss future plans for moving forward. Afterwards, I will use the information on the dissertation to create a more simplified version of the document. Lastly, Phase 10, which will also take place in the fall of 2020 and with acceptance from my administration, I will present the study to the teachers of Lillianna Doris Martin Schools and explore options for submitting my study to a journal for publication.

Rigor & Trustworthiness

Validity and reliability are strategies of rigor and trustworthiness for quantitative designs and these have been described previously in the sections about the individual data collection instruments. Consistent to Krefting (1991), I expected variability in my qualitative research; therefore, I defined consistency in terms of thick, rich descriptions. Trustworthiness is thought to be a matter of persuasion with practices being visible because a study is trustworthy only if the reader judges it to be worth paying attention to (Golafshani, 2006; Gunawan, 2015). Rigor and trustworthiness methods ensured that the results of my study were accurate, believable, and consistent with the collected data (Merriam, 2009; Shenton, 2004).

It is often recommended to have multiple instruments to collect data (Creswell, 2014; Mertler, 2017); however, the quality of the data gathered from the sources is equally vital to the accuracy of the study (Creswell, 2014; Morse, 2015; Zohrabi, 2013). Rigor and trustworthiness were safeguarded throughout my study as I (1) collected quantitative and qualitative data from multiple sources forming a triangulation; (2) wrote rich, thick descriptions; (3) collected a variety of data over a prolonged period of time; (4) used member checking; (5) used peer debriefing; and (6) kept an audit trail (Lietz & Zayas, 2010; Mertler, 2017; Morse, 2015; Zohrabi, 2013). While rich, thick descriptions and collecting data over a prolonged period of time have been described in other sections, below are the remaining methods in further detail.

Triangulation

The powerful strategy of triangulation includes the convergence of multiple perspectives and findings to cross-check data and confirm all viewpoints have been examined (Krefting, 1991) and the study has acquired an exhaustive response for each research question (Lietz & Zayas, 2010). This strategy is emphasized in ensuring trustworthiness because it provides the reader with the data to construct their own level of emergence, reducing investigator bias (Gunawan, 2015). With the inclusion of data from multiple sources, triangulation is an inherent component of mixed methods and is closely aligned with action research (Mertler, 2017). As well, triangulation allows the researcher to engage in multiple methods that lead to a "valid, reliable, and diverse construction of reality" (Golafshani, 2006, p. 604).

I used triangulation in my action research, convergent parallel mixed methods study design, to take various quantitative and qualitative data and create a dialogue of seeing, interpreting, and knowing (Maxwell, 2010). Rigor and trustworthiness was increased as data from student questionnaires, semi-structured focus group interviews, and formative and summative assessments cross-checked data to help minimize any errors in my findings (Mertler, 2017; Mills, 2014; Zohrabi, 2013).

Member Checking

Member checking permits the participants to comment on or asses the data, findings, categories, interpretations, and conclusions to ensure the information and viewpoints are true (Krefting, 1991; Thomas, 2006). Member checking took place in my study as I checked with the participants to verify that my reports accurately represented their ideas and that misrepresentation had been avoided (Krefting, 1991; Mertler, 2017; Thomas, 2006). Rigor and trustworthiness was ensured as I checked my transcripts to make sure there were no errors and codes were consistent (Creswell, 2014) in addition to participants checking for any mistakes in the recording and verification of emerging themes (Mills & Gay, 2016; Shenton, 2004). Member checking took place during the study and then again at the end of the study before my final report was produced.

Peer Debriefing

Peer debriefing is commonly intended to prevent bias and assist in gaining conceptual development, clarity, or quality as investigators present and discuss procedures, data, and findings with other researchers or peers (Hadi & Closs, 2016; Lietz & Zayas, 2010; Morse, 2015). Throughout the process of my study, I interacted with other professionals who provided critiques, insights, and suggestions to enhance my study (Mertler, 2017; Mills & Gay, 2016). I met weekly with my dissertation chair who reviewed and critiqued my process of data collection, analysis and interpretation as a means of peer debriefing, verifying my processes as a professional and auditor of my research (Creswell, 2014; Mertler, 2017). Having this auditor not only added credibility, but served as a source of recommendation for additional ways the data could be analyzed, enhancing the quality of the study overall, and ensuring my research was as rigorous as possible in order to reach its full potential (Mertler, 2017).

Audit Trail

An audit trail is keeping a detailed, written account of the research process (Carcary, 2009; Lietz & Zayas, 2010; Shenton, 2004). Increasing rigor, an audit trail cannot be accomplished without the demonstration of reflexivity (Darawsheh, 2014; Lietz & Zayas, 2010). An audit trail ensures trustworthiness and quality as it allows the reader to audit and examine events, influences, and actions in order to assess the study's significance (Carcary, 2009) and determine how well the researchers' constructs are accepted (Shenton, 2004). I utilized self-reflection and clarification as the study unfolded, including an audit trail that allowed external readers to easily follow each stage (Carcary, 2009) via detailed description of procedures and decisions as they occurred (Lietz & Zayas, 2010; Shenton, 2004). In my study, both intellectual and physical audit trails were accounted for in my decisions and activities in addition to memos, reflections, and in the data collection and analysis procedures (Carcary, 2009).

Plan for Sharing & Communicating Findings

Action research is designed to understand and improve practice (McAteer, 2013). Therefore, it is important for the practice to be interrogated with questions and critiques (McAteer, 2013). Sharing and communicating findings of all research is important because it creates opportunities to reflect, refine ideas, and often form thoughts of future research from myself as well as others (Mertler, 2017; Seifert & Sutton, 2009) as it helps close the gap between research and practice (Mertler, 2017). Sharing experiences gives the research a voice and validates its significance (McAteer, 2013) while providing professional growth (Mertler, 2017). This section explains how I plan to share my study with the administration, students, and teachers of Lillianna Doris Martin Schools, as well as possibly be published in an academic journal.

As the study is completed, I plan to use presentation software to share my findings and supporting data with all participants involved in the study. I will begin with my participants - because they were most invested - before continuing on to my principals. With both audiences, reporting my findings shall transition into a reflection of the study which helps determine needs for further research and an action plan moving forward in addition to providing voice, recognition, and validation (McAteer, 2013).

I will encourage my administration to allow me to present a revised version of the dissertation presentation to the rest of the Lillianna Doris Martin Schools' teachers on a pupil-instruction related (PIR) day. During my presentation, I will encourage all K-12 teachers to take my reflections and recommendations to continue the study for other subjects and grade levels.

Beyond the local level, I potentially wish to submit my written report to appropriate academic journals, such as *Numeracy* and *Action Research*, to benefit teachers everywhere. Additionally, I would appreciate the opportunity to personally share my findings at a national convention such as the National Catholic Educator Association convention or the National Council of Teachers of Mathematics conference, or the Conference on Academic Research in Education as these conferences include improving and learning more about areas of education, mathematics, and research. At a state level, I would be keen to share my report with educators at the Montana Federation of Public Employees educator's convention.

In all forms of sharing my findings, it is important that I protect my students. In doing so, I have made sure to combine and use aggregate forms of data (Creswell, 2014; Mertler, 2017). Moreover, I have used fictitious names to control the ethical concern of keeping all names and identities anonymous and confidential (Creswell, 2014; Mertler, 2017). When sharing and reporting in ways beyond the local level of my school, I additionally included fictious names of my school and town to add another layer of protection (Mertler, 2017).

CHAPTER 4

ANALYSIS AND FINDINGS

The purpose of this action research was to evaluate the impact of writing prompts and graphic organizers on Mona school's 7th and 8th grade students' mathematical academic achievement and their attitudes towards the authentic application of mathematics. The two research questions that guided the study are as follows:

1. How and to what extent, do writing prompts and graphic organizers impact 7th and 8th grade students' mathematical achievement and attitudes towards mathematics?
2. What were the 7th and 8th grade students' perceptions about the implementation of authentic writing prompts and graphic organizers in a mathematics course at Mona school?

This chapter includes the following sections: (a) quantitative analysis, (b) qualitative analysis, (c) convergence of the findings, and (d) chapter summary.

Quantitative Analysis

Quantitative data for the study was gathered from three main sources: (a) student questionnaires, (b) Unit 4 and Unit 5 formative assessments in the form of writing exercises, and (c) Unit 4 and Unit 5 pre- and post-test summative assessments. All elements of data were inserted into a spreadsheet and analyzed using JASP, an open-source statistical software analysis program. An alpha level of .05 was used for all statistical tests to determine significance unless otherwise described (Marshall & Jonker, 2011; Mertler, 2017). To ensure reliability, Cronbach's alpha was calculated for each data set. The following paragraphs explain each source in more detail.

Student Questionnaires

Quantitative literacy, as an underpinning of this study, encompassed students' self-efficacy, attitudes of everyday inclusion, and communication of mathematics (Gillman, 2004; Tunstall & Bossé, 2016; Wilkins, 2016). A questionnaire from Wilkins (2010) was used to measure middle school student's attitudes towards the authentic application of mathematics, which is considered difficult to assess (Gittens, 2015; Ward et al., 2011),. Included in the original questionnaire by Wilkins were 32 Likert scale items broken into two subscales: Disposition and Belief. Table 4.1 shows the composition of the student questionnaire.

Table 4.1. *Student Questionnaire Subscales and Sections*

Subscale: Section	Number of Questions
Disposition	22
Disposition: Motivation	11
Disposition: Self	4
Disposition: Society	7
Belief	10
Belief: Memorization	4
Belief: Problem Solving	3
Belief: Dynamic	3

On each item, students rated themselves from Strongly Agree to Strongly Disagree. For data analysis purposes, a response of Strongly Agree was converted to a value of 5; a response of Agree was converted to a value of 4; a response of Neither Agree or Disagree was converted to a value of 3; a response of Disagree was converted to a value of 2; and a response of Strongly Disagree was converted to a value of 1. To keep data consistent, there were 10 items that measured disagreement. The student's response to these questions were reverse coded and inverted numerically prior to any analyses conducted. The student questionnaires were administered in full prior to the study commencing as well as at the end of the study. Two Belief sections, Memorization and Problem, did not align with the focus of this research. While the data was gathered for use in future research, those seven questions were removed from the data analysis of this study.

The Cronbach's alpha coefficient was calculated to measure the reliability, also referred to as internal consistency, of the students' responses on both the pre and post student questionnaire. Conducting a test of internal consistency is a common way to test the reliability of a questionnaire (Tavalok & Dennick, 2011). Calculating the Cronbach's alpha coefficient (Cronbach, 1951; Tavalok & Dennick, 2011) revealed there to be good reliability, or internal consistency, of both the pre (a = .82) and post (a = .84) student questionnaires. Table 4.2 includes the reliability scores for each component of the questionnaire. I used the mean, a measure of central tendency, as well as the standard deviation, a measure of dispersion, to reveal the possible effects (Mertler, 2017) of implementing writing prompts and graphic organizers into the middle school mathematics curriculum.

Table 4.2. *Student Questionnaire Reliability Statistics*

Questionnaire Subscales: Sections	Cronbach's α	
	Pre	Post
Disposition	.79	.81
Disposition: Motivation	.56	.51
Disposition: Self	.92	.95
Disposition: Society	.79	.80
Belief: Dynamic	.82	.69

Table 4.3 reports the questionnaire's descriptive statistics for each question of the student questionnaire. It should be noted that the participants' identification in the responses were not aligned from the pre to post questionnaires. This prohibited me to further analyze this data with inferential statistics.

Table 4.3. *Student Questionnaire Descriptive Statistics*

Question by Subscale: Section	Pre-test		Post-test	
	M	*SD*	*M*	*SD*
Disposition: Motivation				
1. Working with numbers makes me happy.	3.08	0.64	3.23	0.73
2. I think mathematics is fun.	3.15	0.90	3.23	0.83
3. I am looking forward to taking more mathematics classes.	3.23	0.83	3.39	1.04
4. I like to help others with mathematics problems.	3.46	1.05	3.39	0.87
5. If I had my choice I would not learn any more mathematics.	4.08	1.04	3.46	1.45
6. I refuse to spend a lot of my own time doing mathematics.	3.08	1.19	3.15	0.70
7. I will work a long time in order to understand a new idea in mathematics.	3.92	0.76	3.77	0.60
8a. I really want to do well in mathematics.	4.69	0.48	4.92	0.28
What are some reasons why you feel this way?				
9a. I feel good when I solve a mathematics problem by myself.	4.39	0.77	4.46	0.66
Why does it make you feel this way?				

Question by Subscale: Section	Pre-test		Post-test	
	M	*SD*	*M*	*SD*
10. I feel challenged when I am given a difficult mathematics problem to solve.	3.77	0.60	3.92	0.64
11. I would like to work at a job that lets me use mathematics.	2.69	1.03	3.08	1.19
Disposition: Self				
12. I usually understand what we are talking about in mathematics class.	3.85	0.80	3.85	0.90
13. I am not very good at mathematics.	2.92	1.55	2.85	1.28
14. Mathematics is harder for me than most people.	3.08	1.50	3.15	1.41
15. No matter how hard I try, I still do not do well in mathematics.	3.69	1.32	3.54	1.27
Disposition: Society				
16. It is important to know mathematics to get a good job.	4.62	0.51	4.69	0.48
17. Most people do not use mathematics in their jobs.	4.23	0.60	4.46	0.52
18a. Mathematics is useful in solving everyday problems.	4.46	0.66	4.54	0.52
What are some examples that explains why you think this way?				
19. I can get along well in everyday life without using mathematics.	4.00	0.71	4.39	0.65
20. Most applications of mathematics have practical use on the job.	4.08	0.76	4.23	0.83
21. Mathematics is not needed in everyday living.	4.00	1.16	4.39	0.51
22. A knowledge of mathematics is not necessary in most occupations.	4.08	0.76	4.39	0.65
Belief: Dynamic				
30a. Mathematics will change rapidly in the near future.	3.62	0.87	3.62	0.77
What makes you think this?				
31. New discoveries in mathematics are constantly being made.	4.00	0.58	3.54	0.52
32. There have probably not been any new discoveries in mathematics for a long time.	3.85	0.69	3.62	0.65

In order to condense the data into a simple summary, I utilized descriptive statistics (Yellapu, 2018). Most questions (64%) showed results of an increase in mean scores from the pre and post student questionnaire responses. An example was question 11 regarding the motivation for applying mathematics, “I would like to work at a job that lets me use mathematics.” The mean results of the students’ responses from this question increased from 2.69 (*SD* = 1.03) on the pre student questionnaire to the 3.08 (*SD* = 1.19) on the post student questionnaire. Another example was question 20 regarding the application of mathematics in society, “Most applications of mathematics have practical use on the job.” The mean results from this question increased from 4.08 (*SD* = 0.76) on the pre student questionnaire to the 4.23 (*SD* = 0.83) on the post student questionnaire.

Disposition subscale. Using descriptive statistics for the Disposition subscale of the pre and post student questionnaires, the students’ post student questionnaire scores (*M* = 3.84, *SD* = 1.04) were slightly higher than their pre student questionnaire scores (*M* = 3.75, *SD* = 1.07). Within the three sections of the Disposition subscale (Motivation, Self, and Society), the Motivation and Society section of responses showed an increase in the mean scores from the pre to the post student questionnaire while the remaining section, Self, showed a slight decrease in the mean scores from the pre to the post student questionnaire (see Table 4.4). The greatest mean difference was shown to occur in the section of Society where the students’ post questionnaire scores (*M* = 4.44, *SD* = 0.60) were slightly higher than their pre questionnaire scores (*M* = 4.21, *SD* = 0.77). An example from the Disposition subscale’s section of Society was question 19, “I can get along well in everyday life without using mathematics.” With reverse coding applied to this question, the mean score of the responses increased from 4.00 (*SD* = 0.71) on the pre student questionnaire to 4.39 (*SD* = 0.65) on the post student questionnaire. Additionally, it is noteworthy that the converted raw data for question 19 showed all of the student responses on the pre student questionnaire were a score of 4 “Agree” on a 5-point Likert scale.

Table 4.4. *Descriptive Statistics of the Disposition Subscale and each Section of the Pre and Post Student Questionnaires*

	Disposition Subscale		Motivation Section		Self Section		Society Section	
	Pre	Post	Pre	Post	Pre	Post	Pre	Post
Mean	3.75	3.84	3.59	3.64	3.39	3.35	4.21	4.44
Standard Deviation	1.07	1.04	1.03	1.01	1.35	1.25	0.77	0.60

Of the 11 Motivation section questions encompassed within the Disposition subscale of the student questionnaires, the students’ post questionnaire scores (*M* = 3.64, *SD* = 1.01) were slightly higher than their pre questionnaire scores (*M* = 3.59, *SD* = 1.03). An example from the Disposition subscale’s section of Motivation was question 10, “I feel challenged when I am given a difficult mathematics problem to solve.” The mean results of the students’ responses from this question increased from 3.77 (*SD* = 0.60) on the pre student questionnaire to the 3.92 (*SD* = 0.64) on the post student questionnaire.

The Self section within the Disposition subscale of the student questionnaire contained four questions. Overall, the students’ post student questionnaire scores (*M* = 3.35, *SD* = 1.25) were slightly lower than their pre student questionnaire scores (*M* = 3.39, *SD* = 1.35). An example from the Disposition subscale Self section was question 15, “No matter how hard I try, I still do not do well in mathematics.” With reverse coding applied to this question, the mean results from this question decreased from 3.69 (*SD* = 1.32) on the pre student questionnaire to 3.53 (*SD* = 1.27) on the post student questionnaire.

Belief subscale. From the original questionnaire by Wilkins (2010), only the Dynamic section of the Belief subscale was used for data analysis purposes of this study. Of the three Dynamic section questions encompassed within the Belief subscale of the student questionnaires, the students' post student questionnaire scores (M = 3.60, SD = 0.64) were slightly lower than their pre student questionnaire scores (M = 3.82, SD = 0.72) (see Table 4.5). An example from the Belief subscale Dynamic section was question 31, "New discoveries in mathematics are constantly being made." The mean results of the students' responses from this question decreased from 4.00 (SD = 0.58) on the pre questionnaire to the 3.54 (SD = 0.52) on the post questionnaire.

Table 4.5. *Descriptive Statistics of the Belief Subscale Dynamic Section of the Pre and Post Student Questionnaires*

	Belief Subscale: Dynamic Section	
	Pre	Post
Mean	3.82	3.60
Standard Deviation	0.72	0.64

Formative Assessments

Formative assessments require feedback of improvement that supports learning (Taras, 2005; Weurlander et al., 2012). Writing in mathematics can serve as a method to improve mathematical knowledge, construct concepts and understanding, extend ideas, and enhance problem-solving (Colonnese et al., 2018; Kenney, Shoffner, & Norris, 2013; Kostos & Shin, 2010). In this study, formative assessments were comprised of three Module 9 writing prompts and one Module 10 writing prompt within Unit 4, and three Module 11 writing prompts and one Module 12 writing prompt within Unit 5. The various writing styles — exploratory, argumentative, creative, and informative/explanatory (Colonnese et al., 2018) — were assessed using a rubric created by Exemplars (2012) that I modified for this study. On the rubric, students were scored from 0 “Novice” to 4 “Expert” in the areas of: Overall, Problem Solving, Reasoning and Proof, Communication Overall, Connections, Representations, the number of Mathematical Concepts, Communication Given for what they have, and Word Count. The writing prompts followed the same pattern of exploratory, argumentative, creative, and informative/explanatory writing styles for each unit unless otherwise indicated.

The Cronbach’s alpha was calculated to measure the writing prompt rubric data for reliability, also referred to as internal consistency (Cronbach, 1951). Calculating the Cronbach’s alpha coefficient (Cronbach, 1951; Tavalok & Dennick, 2011) revealed there to be a range from poor (Connections, a = .534) to good (Overall, a =.850) internal consistency (see Table 4.6). Since the areas of Connections and Representation within the writing prompt rubric had poor internal consistency Cronbach’s alpha scores, interpretations should be tentative in those areas (Devellis, 2016). In one writing prompt, all students earned the same number of points within the Connections area of the rubric. Due to zero variability, this total had one prompt excluded from the calculation. Additionally, one writing prompt did not include a score for Reasoning and Proof as it was not applicable to the writing prompt assignment. Lastly, some writing prompts were not completed by all students.

Table 4.6. *Cronbach's Alpha Values for the Writing Prompt Rubric Areas*

Rubric Area Assessed	Cronbach's α
Overall	.850
Problem Solving	.772
Reasoning and Proof	.760
Communication Overall	.770
Connections	.534
Representation	.572
Communication Given	.812

Descriptive statistics. Data from within the different areas in the writing prompt were analyzed using descriptive statistics. The mean, a measure of central tendency, summarized how the students responded academically as a whole (Leech et al., 2005; Mertler, 2017). The standard deviation, a measure of dispersion revealed the variability of the data collected within the different areas of the writing rubric (Leech et al., 2005). For rubric areas of Number of Mathematical Concepts and Word Count, the sum was calculated as these rubric areas were scored based on the number of mathematical concepts or words included in the student's writing passages.

Rubric area: Overall. A closer look at students' writing progression was best reflected in the rubric area, Overall. The mean scores in the rubric area Overall between Unit 4 and Unit 5, across each writing style (exploratory, argumentative, creative, and informative/explanatory), increased (see Table 4.7). More specifically for the exploratory writing, the students' scores on the Unit 5, Module 11 introduction (M = 2.86, SD = 1.05) were higher than their Unit 4, Module 9 introduction scores (M = 1.92, SD = 1.24). The students' scores for argumentative writing from the Unit 5, Module 11.2 writing prompt (M = 2.67, SD = 0.86) were higher than their Unit 4, Module 9.4 writing prompt scores

(M = 2.19, SD = 1.03). The students' scores for creative writing from the Unit 5, Module 11.3 writing prompt (M = 3.05, SD = 1.04) were higher than their Unit 4, Module 9.5 writing prompt scores (M = 2.20, SD = 0.59). Lastly, the students' scores for informative/explanatory writing from the Unit 5, Module 12.3 writing prompt (M = 2.79, SD = 0.78) were slightly higher than their Unit 4, Module 10.2 writing prompt scores (M = 2.29, SD = 0.72).

Table 4.7. *Descriptive Statistics for the Rubric Area Overall*

	Exploratory		Argumentative		Creative		Informative / Explanatory	
	Unit 4	Unit 5	Unit 4	Unit 5	Unit 4	Unit 5	Unit 4	Unit 5
Valid	12	11	13	12	10	11	12	12
Missing	1	2	0	1	3	2	1	1
Mean	1.92	2.86	2.19	2.67	2.20	3.05	2.29	2.79
Standard Deviation	1.24	1.05	1.03	0.86	0.59	1.04	0.72	0.78

Rubric area: Problem Solving. The students' writing progression - as assessed through the rubric area Problem Solving - had an increase in students' mean scores between Unit 4 and Unit 5 across each writing style (exploratory, argumentative, creative, and informative/explanatory) (see Table 4.8). More specifically, the students' scores for exploratory writing from the Unit 5, Module 11 introduction (M = 3.00, SD = 1.10) were higher than their Unit 4, Module 9 introduction scores (M = 2.08, SD = 1.31). The students' scores for argumentative writing from the Unit 5, Module 11.2 writing prompt (M = 2.58, SD = 0.79) were slightly higher than their Unit 4, Module 9.4 writing prompt scores (M = 2.46, SD = 0.78). The students' scores for creative writing from the Unit 5, Module 11.3 writing prompt (M = 3.09, SD = 1.14) were higher than their Unit 4, Module 9.5 writing prompt scores (*M* = 1.90, *SD* = 0.57). Lastly, the students' scores for informative/explanatory writing from the Unit 5, Module 12.3 writing prompt (*M* = 2.92, *SD* = 0.79) were slightly higher than their Unit 4, Module 10.2 writing prompt scores (*M* = 2.50, *SD* = 0.98).

Table 4.8. *Descriptive Statistics for the Rubric Area Problem Solving*

	Exploratory		Argumentative		Creative		Informative / Explanatory	
	Unit 4	Unit 5	Unit 4	Unit 5	Unit 4	Unit 5	Unit 4	Unit 5
Valid	12	11	13	12	10	11	12	12
Missing	1	2	0	1	3	2	1	1
Mean	2.08	3.00	2.46	2.58	1.90	3.09	2.50	2.92
Standard Deviation	1.31	1.10	0.78	0.79	0.57	1.14	0.98	0.79

Rubric area: Reasoning and Proof. The students' writing progression - as assessed through the rubric area Reasoning and Proof — had equal to or an increase in students' mean scores between Unit 4 and Unit 5 across each writing style (exploratory, argumentative, creative, and informative/explanatory) (see Table 4.9). It should be noted that the Module 9 introduction writing prompt, used for evaluation of exploratory writing, was not scored in the rubric area of Reasoning and Proof due to the wording of the question. The students' scores for argumentative writing from the Unit 5, Module 11.2 writing prompt (*M* = 2.83, *SD* = 0.84) were higher than their Unit 4, Module 9.4 writing prompt scores (*M* = 1.69, *SD* = 0.95). The students' scores for creative writing from the Unit 5, Module 11.3 writing prompt (*M* = 2.91, *SD* = 1.45) were higher than the Unit 4, Module 9.5 writing prompt scores (*M* = 1.70, *SD* = 0.68). Lastly, the students' scores for Informative/Explanatory writing in the Unit 5, Module 12.3 writing prompt (*M* = 2.67, *SD* = 0.89) remained the same as the Unit 4, Module 10.2 writing prompt scores (*M* = 2.67, *SD* = 1.16).

Table 4.9. *Descriptive Statistics for the Rubric Area Reasoning and Proof*

	Argumentative		Creative		Informative / Explanatory	
	Unit 4	Unit 5	Unit 4	Unit 5	Unit 4	Unit 5
Valid	13	12	10	11	12	12
Missing	0	1	3	2	1	1
Mean	1.69	2.83	1.70	2.91	2.67	2.67
Standard Deviation	0.95	0.84	0.68	1.45	1.16	0.89

Rubric area: Communication Overall. The students' writing progression - as assessed through the rubric area Communication Overall - had an increase in the students' mean scores between Unit 4 and Unit 5 across each writing style (exploratory, argumentative, creative, and informative/explanatory) (see Table 4.10). More specifically, the students' scores for exploratory writing from the Unit 5, Module 11 introduction (*M* = 2.82, *SD* = 1.08) were higher than their Unit 4, Module 9 introduction scores (*M* = 1.83, *SD* = 1.34). The students' scores for argumentative writing from the Unit 5, Module 11.2 writing prompt (*M* = 2.75, *SD* = 0.87) were slightly higher than their Unit 4, Module 9.4 writing prompt scores (*M* = 2.23, *SD* = 0.99). The students' scores for creative writing from the Unit 5, Module 11.3 writing prompt (*M* = 3.09, *SD* = 1.14) were higher than their Unit 4, Module 9.5 writing prompt scores (*M* = 1.95, *SD* = 0.55). Lastly, the students' scores for informative/explanatory writing from the Unit 5, Module 12.3 writing prompt (*M* = 2.67, *SD* = 0.89) were slightly higher than their Unit 4, Module 10.2 writing prompt (*M* = 2.42 *SD* = 1.06).

Table 4.10. *Descriptive Statistics for the Rubric Area Communication Overall*

	Exploratory		Argumentative		Creative		Informative / Explanatory	
	Unit 4	Unit 5	Unit 4	Unit 5	Unit 4	Unit 5	Unit 4	Unit 5
Valid	12	11	13	12	10	11	12	12
Missing	1	2	0	1	3	2	1	1
Mean	1.83	2.82	2.23	2.75	1.95	3.09	2.42	2.67
Standard Deviation	1.34	1.08	0.99	0.87	0.55	1.14	1.06	0.89

Rubric area: Connection. The students' writing progression - as assessed through the rubric area Connection — had an increase in the students' mean scores between Unit 4 and Unit 5 across the argumentative, creative, and informative/explanatory writing styles. For the exploratory writing style, there was a decrease in the students' mean scores between Unit 4 and Unit 5 (see Table 4.11). More specifically, the students' scores for exploratory writing from the Unit 5, Module 11 introduction (M = 1.09, SD = 1.45) were slightly lower than their Unit 4, Module 9 introduction scores (M = 1.67, SD = 1.88). The students' scores for argumentative writing from the Unit 5, Module 11.2 writing prompt (M = 1.17, SD = 1.34) were higher than their Unit 4, Module 9.4 writing prompt scores (M = 0.00, SD = 0.00). It should be noted that all students were scored a zero on the Unit 4, Module 9.4 writing prompt. Thus, no student showed outside connections to other subjects and experiences. The students' scores for creative writing from the Unit 5, Module 11.3 writing prompt (M = 3.46, SD = .082) were also higher than their Unit 4 Module 9.5 writing prompt scores (M = 2.60, SD = 0.70). Lastly, the students' scores for informative/explanatory writing from the Unit 5, Module 12.3 writing prompt (M = 0.83, *SD* = 1.03) were higher than their Unit 4, Module 10.2 writing prompt scores (*M* = 0.25, *SD* = 0.87).

Table 4.11. *Descriptive Statistics for the Rubric Area Connection*

	Exploratory		Argumentative		Creative		Informative / Explanatory	
	Unit 4	Unit 5	Unit 4	Unit 5	Unit 4	Unit 5	Unit 4	Unit 5
Valid	12	11	13	12	10	11	12	12
Missing	1	2	0	1	3	2	1	1
Mean	1.68	1.09	0.00	1.17	2.60	3.46	0.25	0.83
Standard Deviation	1.88	1.45	0.00	1.34	0.70	0.82	0.87	1.03

Rubric area: Representation. The students' writing progression - as assessed through the rubric area Representation — had an increase in the students' mean scores between Unit 4 and Unit 5 across only the exploratory writing style. For the three remaining writing styles (argumentative, creative, and informative/explanatory) there was a decrease in the students' mean scores between Unit 4 and Unit 5 (see Table 4.12). More specifically, the students' scores for exploratory writing from the Unit 5, Module 11 introduction (*M* = 2.36, *SD* = 1.75) were higher than their Unit 4, Module 9 introduction scores (*M* = 0.92, *SD* = 0.67). The students' scores for argumentative writing from the Unit 5, Module 11.2 writing prompt (*M* = 1.33, *SD* = 1.23) were lower than their Unit 4, Module 9.4 writing prompt scores (*M* = 1.92, *SD* = 1.12). The students' scores for creative writing from the Unit 5, Module 11.3 writing prompt (*M* = 2.27, *SD* = 1.90) were lower than their Unit 4, Module 9.5 writing prompt scores (*M* = 2.60, *SD* = 0.52). Lastly, the students' scores for informative/explanatory writing from the Unit 5, Module 12.3

writing prompt (*M* = 0.50, *SD* = 1.24) were lower than their Unit 4, Module 10.2 writing prompt scores (*M* = 1.33, *SD* = 1.50).

Table 4.12. *Descriptive Statistics for the Rubric Area Representation*

	Exploratory		Argumentative		Creative		Informative / Explanatory	
	Unit 4	Unit 5	Unit 4	Unit 5	Unit 4	Unit 5	Unit 4	Unit 5
Valid	12	11	13	12	10	11	12	12
Missing	1	2	0	1	3	2	1	1
Mean	0.92	2.36	1.92	1.33	2.60	2.27	1.33	0.50
Standard Deviation	0.67	1.75	1.12	1.23	0.52	1.90	1.50	1.24

Rubric area: Number of Mathematical Concepts. The students' writing progression - as assessed through the Number of Mathematical Concepts - had a decrease in mathematical concepts between Unit 4 and Unit 5 across only the informative/explanatory writing style. For the three remaining writing styles (exploratory, argumentative, and creative) there was an increase in students' mean scores between Unit 4 and Unit 5 (see Table 4.13). More specifically, the students' scores for exploratory writing from the Unit 5, Module 11 introduction (*M* = 9.18, *SD* = 4.05) were higher than their Unit 4, Module 9 introduction scores (*M* = 4.67, *SD* = 3.00). The students' scores for argumentative writing from the Unit 5, Module 11.2 writing prompt (*M* = 11.08, *SD* = 7.34) were higher than their Unit 4, Module 9.4 writing prompt scores (*M* = 5.54, *SD* = 4.48). The students' scores for creative writing from the Unit 5, Module 11.3 writing prompt (*M* = 12.73, *SD* = 9.12) were higher than their Unit 4, Module 9.5 writing prompt scores (*M* = 3.80, *SD* = 1.23). The students' scores for informative/explanatory writing from the Unit 5, Module 12.3 writing prompt (*M* = 6.50, *SD* = 9.00) were lower than their

Unit 4, Module 10.2 writing prompt scores (*M* = 17.75 *SD* = 10.09). Lastly, the number of mathematical concepts increased from Unit 5 compared to Unit 4 across three writing style: exploratory Unit 5 (*M* =101) and Unit 4 (*M* = 56); argumentative Unit 5 (*M* = 133) and Unit 4 (*M* = 72); and creative Unit 5 (*M* = 140) and Unit 4 (*M* = 38). The number of mathematical concepts decreased from Unit 5 (*M* = 78) compared to Unit 4 (*M* = 213) for the informative/explanatory writing style.

Table 4.13. *Descriptive Statistics for the Rubric Area Number of Mathematical Concepts*

	Exploratory		Argumentative		Creative		Informative / Explanatory	
	Unit 4	Unit 5	Unit 4	Unit 5	Unit 4	Unit 5	Unit 4	Unit 5
Valid	12	11	13	12	10	11	12	12
Missing	1	2	0	1	3	2	1	1
Mean	4.67	9.18	5.54	11.08	3.80	12.73	17.75	6.50
Standard Deviation	3.00	4.05	4.48	7.34	1.23	9.12	10.09	2.61
Sum	56.00	101.00	72.00	133.00	38.00	140.00	213.00	78.00

Rubric area: Communication Given. The students' writing progression - as assessed through the rubric area Communication Given - had equal to or an increase in the students' mean scores between Unit 4 and Unit 5 across each writing style (exploratory, argumentative, creative, and informative/explanatory) (see Table 4.14). More specifically, the students' scores for exploratory writing from the Unit 5, Module 11 introduction (*M* = 3.14, *SD* = 0.90) were higher than their Unit 4, Module 9 introduction scores (*M* = 2.08, *SD* = 1.49). The students' scores for argumentative writing from the Unit 5, Module 11.2 writing prompt (*M* = 2.93, *SD* = 0.90) were higher than their Unit 4, Module 9.4 writing prompt scores (*M* = 2.31, *SD* = 1.09). The students' scores for creative writing from the Unit 5, Module 11.3 writing prompt (*M* = 3.18, *SD* = 1.08) were higher than their Unit 4, Module 9.5 writing prompt scores (*M* = 2.35, *SD* = 0.82). Lastly, the students' scores for informative/explanatory writing from the Unit 5, Module 12.3 writing prompt (*M* = 2.83, *SD* = 0.84) remained the same as their Unit 4, Module 10.2 writing prompt scores (*M* = 2.83, *SD* = 0.94).

Table 4.14. *Descriptive Statistics for the Rubric Area Communication Given*

	Exploratory		Argumentative		Creative		Informative / Explanatory	
	Unit 4	Unit 5	Unit 4	Unit 5	Unit 4	Unit 5	Unit 4	Unit 5
Valid	12	11	13	12	10	11	12	12
Missing	1	2	0	1	3	2	1	1
Mean	2.08	3.14	2.31	2.83	2.35	3.18	2.83	2.83
Standard Deviation	1.49	0.90	1.09	0.84	0.82	1.08	0.94	0.84

Rubric area: Word Count. The students' writing progression - as assessed through the rubric area Word Count — had a decrease in the students' mean scores between Unit 4 and Unit 5 across only the informative/explanatory writing style. For the three remaining writing styles (exploratory, argumentative, and creative) there was an increase in the students' mean scores between Unit 4 and Unit 5 (see Table 4.15). More specifically, the students' scores for exploratory writing from the Unit 5, Module 11 introduction (*M* = 145.82, *SD* = 77.72) were higher than their Unit 4, Module 9 introduction scores (*M* = 65.50, *SD* = 47.37). The students' scores for argumentative writing from the Unit 5, Module 11.2 writing prompt (*M* = 114.92, *SD* = 88.36) were higher than their Unit 4, Module 9.4 writing prompt scores (*M* = 77.08, *SD* = 41.57). The students’ scores for creative writing from the Unit 5, Module 11.3 writing prompt (*M* = 150.64, *SD* = 80.28) were higher than their Unit 4, Module 9.5 writing prompt scores (*M* = 57.30, *SD* = 96.00). The students’ scores for informative/explanatory writing from the Unit 5, Module 12.3 writing prompt (*M* = 70.83, *SD* = 34.06) were lower than their Unit 4, Module 10.2 writing prompt scores (*M* = 168.92, *SD* = 112.22). Lastly, the students’ word count increased in Unit 5 compared to Unit 4 across three writing styles: exploratory Unit 5 (*M* = 1604) and Unit 4 (*M* = 786); argumentative Unit 5 (*M* = 1379) and Unit 4 (*M* = 1002); and creative Unit 5 (*M* = 1657) and Unit 4 (*M* = 573). The students’ word count decreased in Unit 5 (*M* = 850) compared to Unit 4 (*M* = 2027) for the informative/explanatory writing style.

Table 4.15. *Descriptive Statistics for the Rubric Area Word Count*

	Exploratory		Argumentative		Creative		Informative / Explanatory	
	Unit 4	Unit 5	Unit 4	Unit 5	Unit 4	Unit 5	Unit 4	Unit 5
Valid	12	11	13	12	10	11	12	12
Missing	1	2	0	1	3	2	1	1
Mean	65.50	145.82	77.08	114.92	57.30	150.64	168.92	70.83
Stand. Dev.	47.37	77.72	41.57	88.36	31.58	80.28	112.22	34.06
Sum	786	1604	1002	1379	573	1657	2027	850

Summative Assessments

Summative assessments are the end of a learning unit, which encapsulates evidence up to a final point of judgement (Taras, 2005) and summarize achievements (Weurlander et al., 2012). Summative assessments were conducted for Module 9, Module 10, Module 11, and Module 12 and Unit 4 and Unit 5. Two experienced mathematics teachers at Mona school reviewed each summative assessment, and their feedback provided for specific test questions was integrated into the summative assessments distributed for this study. See Table 4.16 for the composition of each summative assessment.

Table 4.16. *Summative Assessments*

Module or Unit	Mathematical Concept	Number of Questions	Maximum Score Possible
Module 9	Transformations of translations, reflections, and rotations	13	36
Module 10	Transformation dilation	11	24
Module 11	Angle relationships and triangles	10	25
Module 12	Pythagorean Theorem	11	26
Unit 4	Transformations	13	31
Unit 5	Angle relationships, triangles, and the Pythagorean Theorem	13	32

Due to student absences, some students did not complete all summative assessments. Module 9 had one missing student score, and the Unit 5 pre-test had two missing student scores. Because these students did not complete the pre-tests, I excluded their post-tests from this study.

The Cronbach's alpha was calculated to measure internal consistency of each summative assessment (Cronbach, 1951). A widely desired range of Cronbach's alpha coefficients would be .70 to .95 (Rudner & Schafer, 2001; Taber, 2018; Tavalok & Dennick, 2011). Because obtaining such coefficients is not always possible in classroom assessments; the study sufficed with a reliability coefficient of .50 to .60 (Rudner & Schafer, 2001) – as exampled in Module 9's Cronbach's alphas coefficient (a = .52) (see Table 4.17). The Unit 5 pre-test Cronbach's alpha coefficient was unacceptable (a = .36);

therefore, interpretations should be tentative with this level of reliability (Devellis, 2016). It should be noted that two questions from Module 9, two questions from Module 10, and one question from Module 12 summative assessments had the same number of points earned for all students. Due to having a zero variance, these questions were excluded from the Cronbach's alpha calculations. For example, question 6 in the Module 12 summative assessment "Which set of three numbers can be used to make a right triangle?" and question 10 in Module 10 "Rectangle PQRS and its image under a dilation. If the dilation is by a factor greater than 1, is the image larger or smaller?"

Table 4.17. *Cronbach's Alpha Coefficients for the Summative Assessment*

Summative Assessment	Cronbach's α
Module 9	.52
Module 10	.83
Module 11	.86
Module 12	.87
Unit 4 Pre-test	.73
Unit 4 Post-test	.81
Unit 5 Pre-test	.36
Unit 5 Post-test	.87

Descriptive statistics. All summative assessments were analyzed with descriptive statistics. The mean, a measure of central tendency, summarized how the students in this study responded academically as a whole (Leech et al., 2005; Mertler, 2017). The range and standard deviation, as measures of dispersion, revealed the variability among the student's scores (Leech et al., 2005). Specific scores from the module summative assessments (see Table 4.18) revealed the following: The range of Module 9 students' scores were from 27 to 36 with a mean of 30.67 (*SD*= 2.87); the range of Module 10 students’ scores were from 12 to 24 with a mean of 20.15 (*SD*= 3.44); the range of Module 11 students’ scores were from 11 to 25 with a mean of 19.92 (*SD*= 5.30); and the range of Module 12 students’ scores were from 14 to 26 with a mean of 23.15 (*SD*= 4.10). Specific scores from the Unit 4 and Unit 5 assessments were: The range of Unit 4 students’ pre-test scores were from 12 to 27 with a mean of 18.54 (*SD*= 5.08); the range of Unit 4 students’ post-test scores were from 17 to 31 with a mean of 27.39 (*SD*= 4.23); the range of Unit 5 students’ pre-test scores were from 15 to 23 with a mean of 18.36 (*SD*= 2.50); and the range of Unit 5 students’ post-test scores were from 14 to 32 with a mean of 27.91 (*SD*= 5.01).

Table 4.18. *Summative Assessments Descriptive Statistics*

	Unit 4				Unit 5			
	Pre	Post	Mod 9	Mod 10	Pre	Post	Mod 11	Mod 12
Valid	13	13	12	13	11	11	13	13
Missing	0	0	1	0	2	2	0	0
Mean	18.54	27.39	30.67	20.15	18.36	27.91	19.92	23.15
Standard Deviation	5.08	4.23	2.87	3.44	2.50	5.010	5.30	4.10
Range	12-27	17-31	27-35	12-24	15-23	14-32	11-25	14-26
Points Possible	31	31	36	24	32	32	25	26

Inferential Statistics. Inferential statistics were used to test the hypotheses and draw conclusions (Lee, Dinis, Lowe, & Anders, 2016). Specifically, inferential statistics were used to test the hypothesis that the use of writing prompts and graphic organizers would impact 7th and 8th grade student’s mathematical achievement scores. Unit 4 and Unit 5 pre- and post-tests were additionally analyzed with inferential statistics. A normality test (Shapiro-Wilk) (Razali & Wah, 2011; Shapiro & Wilk, 1965) with a *p* value less than .05 was used to determine if a significant deviation from the normal curve occurred (see Table 4.19). Based on these assumptions, the results from Unit 4 did not suggest a deviation from normality (p = .106), whereas, the results from Unit 5 did suggest a deviation from normality (p = .014).

Table 4.19. *Test of Normality (Shapiro-Wilk)*

			W	*p*
Unit 4 PRE	-	Unit 4 POST	0.893	.106
Unit 5 PRE	-	Unit 5 POST	0.813	.014*

**Note.* Significant results suggest a deviation from normality.

Since Unit 4's results from the normality test (Shapiro-Wilk) (Razali & Wah, 2011; Shapiro & Wilk, 1965) suggested no significant results deviated from normality, a paired samples *t*-test was conducted to compare Unit 4 student pre-test and Unit 4 student post-test mean scores for knowledge gained, t = -6.778, p < .001. Since the Unit 5's results from the normality test (Shapiro-Wilk) (Razali & Wah, 2011; Shapiro & Wilk, 1965) suggested significant results deviated from normality, the nonparametric Wilcoxon signed rank test (Taheri & Hesamian, 2013; Wilcoxon, 1945) as conducted to compare Unit 5 student pre-test and Unit 5 student post-test mean scores for knowledge gained, W = 1.000, p = .005. Table 4.20 shows the results from the paired samples *t*-tests.

Table 4.20. *Paired Samples Tests*

			Test	Statistic	df	*p*
Unit 4 PRE	-	Unit 4 POST	Paired Samples *t*-test	-6.78	12	< .001
Unit 5 PRE	-	Unit 5 POST	Wilcoxon signed rank test	1.000		.005

For the overall data on the Unit 4 pre-test and post-test, the analysis indicated that students scored significantly higher on the Unit 4 post-test (M = 27.39, SD = 4.23) than the students scored on the Unit 4 pre-test (M = 18.54, SD = 5.08), t = -6.78, p < .001. For the overall data on the Unit 5 pre-test and post-test, the analysis indicated that students scored significantly higher on the Unit 5 post-test (M = 27.97, SD = 5.01) than the students scored on the Unit 5 pre-test (M = 18.36, SD = 2.50), W = 1.00, p = .005. Pre-test and post-test students' scores from both Unit 4 and Unit 5 summative assessments showed to have statistically significant results suggesting growth in student's mathematical knowledge.

Qualitative Analysis

Qualitative data from my study was collected from semi-structured focus group interviews as well as the open-ended questions in the student questionnaires and were analyzed though several coding lenses. Utilizing inductive analysis, the volume of data was reduced and organized into categories then themes, while ensuring the narrative data had not been minimized or misrepresented (Mertler, 2017). The following paragraphs provide the following: (a) a detailed breakdown of the qualitative data, (b) a description of the processes undergone for each cycle of coding, and (c) a discussion of emerging themes.

Quantity of Qualitative Data

The qualitative data from two semi-structured focus group interviews and the open-ended responses from the student questionnaire were coded using inductive analysis to allow themes to emerge (Creswell, 2014). The interviews were transcribed using a transcription software program, Rev, and I reviewed each to ensure accurate transcriptions occurred. Both documents were then uploaded into the Computer-Aided Qualitative Data Analysis (CAQDAS) program, Delve, to undergo first and second cycle coding methods (Saldaña, 2016). Table 4.21 shows the collective word count of the two semi-structured focus group interviews (3637 words) and the collective word count of student responses to the four open-ended student questionnaire questions (2338 words). Having removed language not congruent with the research (e.g. Lily's statement "yeah"), the word count of the two semi-structured focus group interview data sources was reduced to 1170 words with the word count of student responses to the four open-ended student questionnaire questions reduced to 2134. The number of first cycle codes generated from the corpus of qualitative data was 231 codes.

Table 4.21. *Qualitative Data Analysis Totals*

Data Source	Number of Sources	Total Word Count	Useful Word Count	Number of Codes
Semi-structured focus group interview	2	3637	1170	89
Questionnaire	1	2338	2134	142
Total	3	5975	3304	231

Analysis of Qualitative Data

Coding is just one way of analyzing qualitative data (Saldaña, 2016); however, for this novice qualitative researcher, it was the most implicit in nature. Before coding began, in addition to reviewing transcripts for accuracy, the reading of the transcripts introduced me to the qualitative data collected. In the following paragraphs, I describe the Elemental and Affective coding methods used during first cycle coding (Saldaña, 2016). The Elemental methods utilized, which are considered to be foundational approaches, included *Structural Coding, Process Coding*, and *In Vivo Coding* (Saldaña, 2016) The One Affective method was utilized, *Emotion Coding*, which investigated the subjectivity of students' experiences (Saldaña, 2016). An eclectic approach to second cycle coding furthered the analysis process, allowing categories and themes to emerge. Deciding on the proper coding scheme to group the coded data (Mertler, 2017) was reflected upon and discussed with my chair to ensure that best practices would be utilized. All coding described below was conducted using a sentence-by-sentence unit of analysis.

First cycle coding. Taking place in Delve, the initial round of coding began with *Structural Coding* as it applied a conceptual phrase to a part of data (Saldaña, 2016) related to my research questions; specifically the different properties within each research question. Reading the data for the first time in Delve, also refamiliarized myself with my qualitative data and allowed my mindset to become immersed in the content being read. Figure 4.1 is a snapshot of the generated codes in Delve after having completed *Structural Coding*.

The next round of coding methodology undertaken was *Emotion Coding* to capture the emotions experienced by the participants during the study (Saldaña, 2016).

During this method, I supplemented the code with a positive or negative symbol to identify positive or negative overall feeling expressed from the student. For example, Sophia's statement, "It made it easier to like remember," was coded as +*beneficial* because the participant was sharing a positive statement regarding her perception of content's value. Additionally, Jackson stated, "I liked it when you gave us the option that we didn't have to do the graphic organizer because then I could just get the writing done." I coded this as -*not beneficial* because the participant was expressing that the graphic organizer took extra time and did not improve his writing process. Figure 4.2 is a snapshot of generated codes in Delve of *Emotion Coding*.

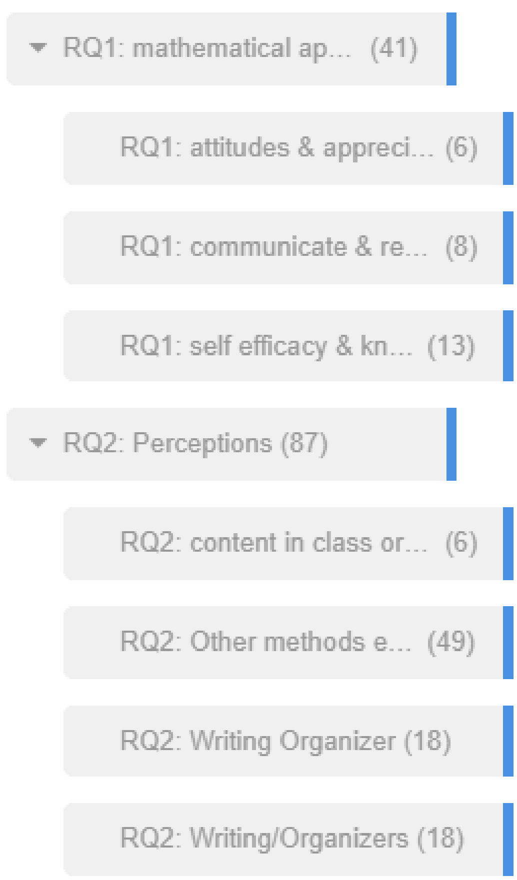

Figure 4.1. Structural coding in Delve.

Figure 4.2. Emotion coding in Delve.

Following *Emotion Coding*, I used *Process Coding* to "connote actions in the data; simple observable activity as well as more general conceptual action" (Saldaña, 2016, p. 111). Gerunds also helped connect actions, how participants interacted, and their feelings about the innovation as well as forming a brief trajectory to assist in the process of writing (Saldaña, 2016). For example, Sophia said the following:

> It was really organized…Like the way that um you would like, make us get our work done, like if you said okay, do the worksheet and then do the graphic organizer and then do the writing, it was easier to go step by step instead of assigning everything in like 15 minutes and having to get it done.

I coded Sophia's comment as *valuing organization* because the participant was discussing the assistance of an organized setup and delivery procedures to allow a smooth process for her to learn. Figure 4.3 is a snapshot of the generated codes in Delve after having completed *Process Coding*.

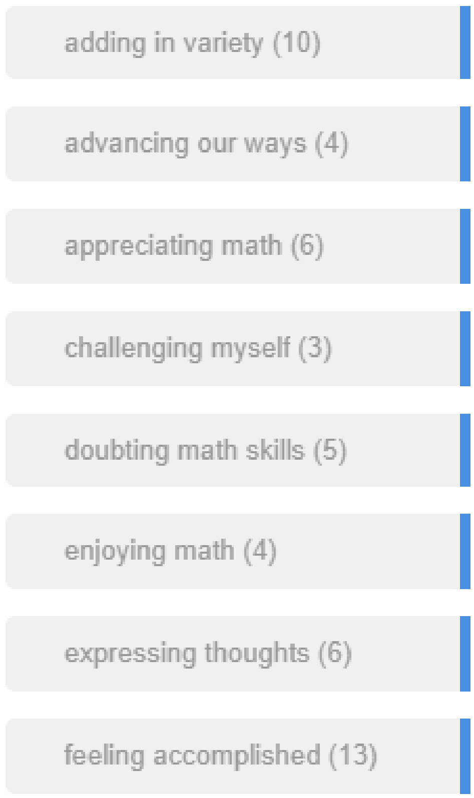

Figure 4.3. Process coding in Delve.

To complete the first cycle of coding, the analysis method of *In Vivo Coding* was used. This method generated codes from the participants' actual language (Creswell, 2014; Saldaña, 2016). With this method of coding, participants' language was used to ensure their thoughts and experiences were not lost, breaking down, synthesizing, and rebuilding the data to tell a story of establishment (Stuckey, 2017). For example, Hailey stated, "I thought it was fun." I coded this as *it was fun* because the student was sharing feelings of enjoyment from activities. Additionally, Jackson stated, "It's nice to do something besides write." I coded this as *do something besides write because* the participant was sharing the benefit of using multiple ways of learning. Figure 4.4 is a snapshot of generated codes in Delve after having completed *In Vivo Coding*.

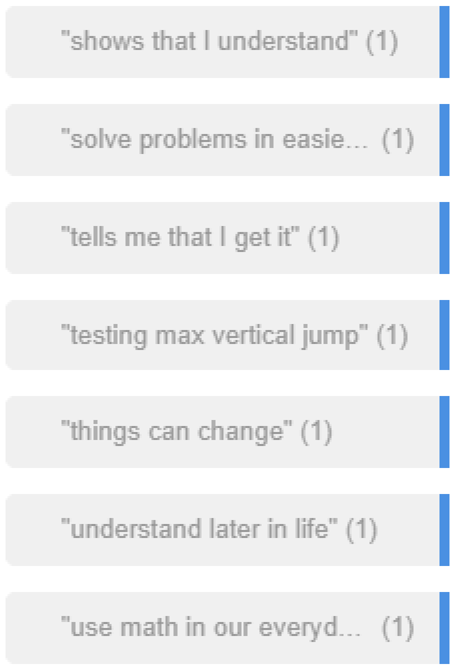

Figure 4.4. In Vivo coding in Delve.

Second cycle coding. In the second cycle coding process, I used an eclectic, or a combination of the *Tabletop* technique, *Pattern Coding* and *Axial Coding* methods, to develop categories and themes from the codes created from the first cycle coding methods. Using the *Tabletop* technique, I physically printed off, touched, moved and arranged the codes on my living room floor to visualize how the codes fit together (Saldaña, 2016).

While arranging codes, I used *Pattern Coding* to look and find patterns, commonalities, and relationships among the codes (Saldaña, 2016). Creating an organized layout then assisted in attributing meaning to the organization chosen. Use of *Axial Coding* provided dimension and properties while locating related concepts that furthermore helped me transition from the initial to a theoretical process (Saldaña, 2016). Shifting to a broader, more abstract view allowed for the creation of categories and themes, which I wrote on different colored sticky notes. Concurrent to coding, I also furthered my thinking with analytic memos (Saldaña, 2016) and reflective thinking. To maintain the composition of my thinking, I inserted the codes, categories, and themes into an Excel spreadsheet. Table 4.22 shows the categories and themes that emerged from the second cycle coding analysis.

Table 4.22. *Data Examples to Themes*

Coded Excerpts	Category	Theme
• cooking or baking • everyday life • around the house • testing max vertical jump	Applying mathematics	Through the use of authentic assessments, students understood and applied mathematical concepts into worldly applications.
• compare prices • give someone change • shopping, pay taxes and bills, buying houses • money and bills and debt	Mathematics in money	
• every job in the world uses math • military require math • jobs that involve or use mathematics	Mathematics in careers	
• prepare myself for college • good classes in the future • science has a bunch of math	Succeeding in school	

Coded Excerpts	Category	Theme
• good to know what you're doing • fun way of doing math • want to learn it • appreciate it more	Learning with a positive attitude	Students expressed appreciation, awareness, and eagerness to learn with the integration of authentic assessments.
• math is not easy for me • hard to follow • maybe it will • It was okay	Learning with a neutral/ambivalent attitude	
• proud of myself • more confident in my skills • feel accomplished and happy	Gaining confidence through accomplishments	
• aware of what you know and don't know • have to know it to get it down • shows I understand • on my own without any help	Expressing understanding	
• easier to remember • chance to ask questions and understand • good thing to fall back on if you needed help	Assisting learning	
• more interactive • we could do actual things • lets us use our imagination • speak your mind	Variety of learning	

Coded Excerpts	Category	Theme
• mathematics is changing • always need to be adapting • we have to adapt • always changing	Adaptions in mathematics	Use of the authentic assessments allowed students to interact, imagine, and become adaptable thinkers about how mathematics is an ever-changing process.
• find new formulas • new equations almost every day • discover something	New discoveries	
• learning and growing • [always] have something to learn • learning never ends	Learning is lifelong	

Presentation of Findings

The outcomes of the qualitative data analysis produced out of two semi-structured focus group interviews and four open-ended student questionnaire questions, included 231 codes, 13 categories, and three themes. Use of inductive analysis allowed me to gain an understanding of the participants' attitudes and perceptions regarding the implementation of authentic assessments in the curriculum of my middle school mathematics course. After completing four rounds of first cycle coding, two rounds of second cycle coding, and processing the data corpus with my dissertation chair, three themes emerged: (a) Through the use of authentic assessments, students understood and applied mathematical concepts into worldly applications, (b) Students expressed appreciation, awareness, and eagerness to learn with the integration of authentic assessments, and (c) Use of the authentic assessments allowed students to interact, imagine, and become adaptable thinkers about how mathematics is an ever-changing process. Following the inductive analysis of interpreting what has been simplified and organized (Mertler, 2017), each theme is examined in more detail in the following paragraphs to gain the insights into the experiences of 7th and 8th grade participants' journey of learning. All evidence examples are verbatim from the participants; with pseudonyms used to protect the privacy of the participants.

Through the use of authentic assessments, students understood and applied mathematical concepts into worldly applications. Understanding mathematics is an important factor in one's daily and professional life (Jansen, Schmitz, et al., 2016; Madison, 2015; Reyna & Brainerd, 2007), where effective knowledge transfer is vital to acquiring a lasting fundamental and economical success (Argote, Ingram, Levine, & Moreland, 2000; Schmidt & Muehlfeld, 2017). Authentic assessments often connect course material to life-like situations or imitate work environments (Althauser & Harter, 2016; Bosco & Ferns, 2014; Kaider et al., 2017), and can positively impact student engagement and lasting effects (Althauser & Harter, 2016). This theme– Through the use of authentic assessments, students understood and applied mathematical concepts into worldly applications – discusses the importance of mathematics and its contributions to various occupations, everyday uses, and connections to feeling successful. Five categories were subsumed into this theme: (a) applying mathematics, (b) mathematics in money, (c) mathematics in careers, (d) applications for school, and (e) striving for success. Each of these categories are described in further detail in the following paragraphs.

Applying mathematics. The application of mathematical concepts is abundantly found in multiple social science, economic, and health care disciplines (Ganter, 2006). Additionally, having proficient mathematical abilities is essential in one's daily life activities (Reyna & Brainerd, 2007). The category, applying mathematics, was created from codes that explored real world mathematical applications. This is shown from students in their questionnaire open-ended responses as they made connections with mathematics being observed beyond the classroom. One student expressed a general understanding that "mathematics is really important," and another expressed that "math is everywhere, you might not even realize you are doing it." Three student's comments more specifically expressed the connections with how mathematics in the real world is applied.

> "Take a regular day crisis. If you were a parent that had to drop off your kid somewhere, but you have a meeting. You will use a clock, which is math, to help you get through it."
>
> "Heating up lasagna. You have to heat it up and then estimate how many more seconds you need to heat it up."
>
> "We use mathematics when doing the simplest things like going to the store."

When students make a lasting connection with learned material, they use it actively in their daily lives (Altay, Yalva, & Yeltekin, 2017). The following statement from Noah in a semi-structured focus group interview, "They kind of like gave us some real-world situations," showed how using authentic applications bridged his understanding of mathematics taking place outside of the classroom.

Mathematics in money. It is not uncommon for students to have abilities to relate mathematics to money (Martin & Gourley-Delaney, 2014). For example, keeping a budget, on a large and small scale, requires mathematical skills that assist decision making abilities for financial planning (Jansen, Schmitz, et al., 2016). Furthermore, financial management and responsible decision making in both daily life and over the long term is crucial to one's financial well-being (de Bassa Scheresberg, 2013).

The category, mathematics in money, reflected the students' understanding that mathematics is highly connected to daily financial decision making. For example, understanding the value of products, was shared by one student on an open-ended student questionnaire response "When you go buy things, you need to figure out how much it's worth." Two student's responses from the open-ended student questionnaire offered an example of the need for budgeting enough money, "If you want some coffee, like most people, you have to know how much you have on your card." or "You can compare prices." Some codes generated out of the qualitative data (i.e. *give someone change; money and bills, and debt*) also identified how applying mathematical concepts learned in the classroom can transfer to students' daily lives, especially in regards to monetary usage.

Mathematics in careers. Mathematics has been highly incorporated into the work place historically as well as across cultures (FitzSimons, 2013). Learning mathematics goes beyond rote skills to learning the aspects of analysis and problem-solving needed in multiple professions (Torpey, 2012). The category, mathematics in careers, was formed predominantly from *In Vivo* codes such as *"any job that you can have"* and *"need it for your job"* that identified the importance of learning mathematics has on their future occupations. Additional codes generated from the open-ended student questionnaire responses represented their understanding that mathematics is important to the success within many jobs. One student responded, "I want to do well in mathematics so that I can have a nice job someday" as well as another student shared, "I want to be able to have a good job [so] that I can support myself." One other students' response:

> In every job or in every piece of work there is some element of math. Like construction workers, you have to get the exact measurements to fully and usefully map out the whole building by just using a few lines and a few angles. Or scientists who have to develop curing medicine or vaccines. They have to develop formulas of this plus this equals that.

showed their connecting the vitality of mathematics into their future.

Succeeding in school. Finding success in mathematics at an early age can jumpstart trajectories that can contribute to further success in college (Benken et al., 2015). Therefore, the teaching of mathematics should be extended to all disciplines and everyday life (Scheaffer, 2003). The category, succeeding in school, surfaced from codes such as *needing for other subjects* and *preparing for college* as students found connections to the success in mathematics playing a role in their academics, both currently as well as in their future. Regarding being successful, one student responded to an open-ended student questionnaire question with "I think it will help me to be a successful person." Another student offered, "I want to do good in school." These statements conveyed more about their personal expectations, yet still showed their understanding of the importance of worldly applications of mathematical concepts. In connecting mathematics to educational interests, it was offered by one student in their open-ended student questionnaire response that concepts learned in the mathematics classroom is cross curricular:

> I love science so I have to sort of know math because science has a bunch of math and formulas and problems, so I want to know all of the formulas and problems I need to know so I can do better in both classes.

Another group of codes subsumed into this category (i.e. "*prepare myself for college"*) identified the relationship students made between the role of mathematics and their goal of going to college. This is found in one student's open-ended student questionnaire response, "I want to prepare myself for college and get a scholarship and a lot of that comes from doing math." Another student offered, "Because without being good at math you will never get into college." The response of a student to an open-ended student questionnaire question, "I think it's important to do well in all subjects including math," captures mathematical concepts being thought about in their future. Such sharing is yet another example of how students identified worldly applications of mathematical material being taught even at this middle school level.

Students expressed appreciation, awareness, and eagerness to learn with the integration of authentic assessments. The second theme to emerge out of the qualitative data–Students expressed appreciation, awareness, and eagerness to learn with the integration of authentic assessments– was centered around the student attitudes towards learning mathematics with the implementation of writing prompts and graphic organizers into the curriculum. Writing prompts can impact mathematical knowledge as it affects student's abilities to effectively problem-solve, to develop a conceptual understanding, and to seek opportunities to monitor and reflect upon strategies and processes introduced (Kenney et al., 2013). Moreover, using writing prompts can promote both mastery and performance while enhancing achievement of mathematical learning (Ng, 2018).

Furthering concepts allows students to have fun and make connections between what is concrete and what is abstract (Furner, Yahya, & Duffy, 2005). Graphic organizers can be designed to serve broad applications such as instructional guides or enhance understanding of concepts (Ives, 2007; Ives & Hoy, 2003). When discussing in the semi-structured focus group interviews the various integrated graphic organizers, Jayden shared a positive feeling towards the use of them, “they were a good way of, you know, going back and looking how to do things.” Abigail further shared, “At first, I thought maybe it would be hard, but after we started doing them more, it got easier and I figured it out.” This described how some learning strategies, such as the graphic organizers, were first seen as challenges but students like Abigail ended up finding learning reward.

To demonstrate what they learned as being correct and the importance of discussions, two students, Hailey and Jackson respectively, offered during the semi-structured focus group interviews to “practice what you just talked about” and have “a chance to put what we learned in our own words”. These open expressions also served as an affirmation that mathematical skill and knowledge significantly contributes to one’s ability to write about it (Hebert & Powell, 2016; Urquhart, 2009). Furthermore, students such as Jackson shared his gaining a deeper awareness and more thorough knowledge of what he knew, “You kind of just express your knowledge, get it out on the paper, and you're aware of what you know and don't know.” Additionally, Jayden and Sophia offered respectively, “you actually see like how it's done” and “It's easier to ask questions … and figure things out more… it’s interactive so you can see how other people work and the ways that they do it. And it might help you on tests and stuff.” These examples of student’s expressions showed how they transformed learned content into their own words– in both oral and written forms– which permitted them to gain confidence and preparation for upcoming mathematical concepts being introduced.

The theme– Students expressed appreciation, awareness, and eagerness to learn with the integration of authentic assessments– subsumed the following five categories: (a) learning with a positive attitude, (b) learning with a neutral/ambivalent attitude, (c) gaining confidence through accomplishments, (d) expressing understanding, and (e) assisting learning. These categories are further explained and explored in the following paragraphs.

Learning with a positive attitude. Writing and the mathematics curriculum are not entities of their own, rather writing is part of mathematics (Urquhart, 2009). In this study, students were able to see rewards with use of the authentic assessments while learning mathematics. This was shared by a student in an open-ended student questionnaire response “there are many cases when you have to use several different types of math so it’s good to know what you’re doing.” Students viewed the writing prompts as helpful and pertinent to their learning as explained by Jackson during a semi-structured focus group interview, “personally, I've never been a huge fan of writing itself, just like entire life, but I didn't mind it.” Ethan’s comment, “I didn't really mind the writing,” additionally showed signs of acceptance for the writing prompts implemented into the curriculum.

Students’ learning mathematics in regards to their motivation becomes complex as it encompasses constructs of their needs, goals, and beliefs (Ng, 2018). Mathematical achievement, and keeping the information in students’ mind long term, is extremely affected by mathematical engagement (Deveci & Aldan Karademir, 2019). Mathematical engagement occurs when students enjoy learning, value their learning and see its relevance to their lives, and recognize connections outside the classroom (Attard, 2012). Abigail's comment offered in a semi-structured focus group interview reflects these scholarly opinions, "it's a fun way of doing math outside, like in the real world." Two statements from the open-ended student questionnaire questions, "I also just want to learn it" and "it's the motivation when I solve that and I can understand this and will keep learning about it," further reflect such opinions.

Learning with a neutral/ambivalent attitude. Emotions of perplexity drift learners along positive or negative pathways, but if a lack of progress becomes perceived, negative feelings of frustrations can become intrusive unless a new approach can generate a positive affect (Gómez-Chacón, 2017). Engaging in difficult concepts or complex learning that forces the revision of knowledge to new ways or if unexpected findings occur, it is natural for emotions of confusion and perplexity to occur (Gómez-Chacón, 2017). The category, learning with a neutral/ambivalent attitude, was created from generated codes such as *doubting math skills, feeling neutral,* and *confusing.* These codes generated were fewer than positive student comments, yet they still brought forth the awareness regarding the student's uncertainty about their mathematical abilities, performing a mathematical process correctly, or having neutral or ambivalent attitudes towards mathematics in general and the implementation of the authentic assessments.

Confusion commonly hovers around mathematics as it is a difficult language, composed of an abundant amount of polysemous terms and the way word problems are structured (Bulaon, 2018). Other difficulties can include assessments that contain multiple topics (Codding et al., 2016), problem-solving (Perkins & Salomon, 1988), word problems that combine linguistic and numerical complexities (Daroczy, Wolska, Meurers, & Nuerk, 2015), and mathematical writing that merges complexities of writing and mathematical computation (Hebert & Powell, 2016). While struggling to make sense of problems is an important aspect of learning (Pasquale, 2016), it has instead become negatively viewed as a problem in the classroom (Warshauer, 2015). Carrying over to the students' perceptions, a response offered from an open-ended student questionnaire question stated, "I am not good at math," indicated this students' hardship and difficulties in completing mathematical concepts.

Similar to McCarthy (2008), although benefits were found, the level of success with the implementation of graphic organizers and writing prompts in the mathematics classroom varied among the students. McCarthy indicated that students identified challenges in using graphic organizers, most notably regarding having a full understanding where content goes. This can be seen from Sophia's statement offered during a semi-structured focus group interview, "[they were] hard to follow." She offered a suggestion of "making the graphic organizer less general and to include a specific graphic organizer that fits with each writing [prompt implemented]." When asked in the semi-structured focus group interview about the inclusion of the graphic organizers, Kaitlyn's opinion, "it's not necessary," showed that the graphic organizers were not needed for transferring her thoughts into writing,

Gaining confidence through accomplishments. Learning mathematics can be both challenging and rewarding (Akhter & Akhter, 2018; Ricks, 2009). Typically, progress is made at an unsteady pace with cognitive thoughts stalling until suddenly an understanding surfaces and leaps in cognitive growth mature (Ricks, 2009). Learners need time to repeat processes to gain understanding and familiarity similar to how a young child will continue to build a skyscraper of blocks until it is understood that the base is wider than the top (Resnick, 2007). The category, gaining confidence through accomplishments, included codes such as *gaining confidence* and *feeling proud* about students attitudes towards mastering their mathematical challenges. Two statements offered in the open-ended student questionnaire responses, “When I solve a math problem on my own I feel accomplished because it means that I have learned and understand it” and ” It makes me feel accomplished because I did something on my own without any help” showed how my students felt accomplished in this study.

Expressing understanding. People have an innate need to endeavor feelings of competence, autonomy, and social relatedness, and furthermore, need feedback about specific processes or learning strategies, which can impact motivation and achievement (Rakoczy, Klieme, Bürgermeister, & Harks, 2008). As a key foundation of building new knowledge, accuracy is a vital awareness attribute that is constructed from practice and knowledge-deepening activities (Marzano, 2007). Gaining and improving frequency towards mathematical skills and procedures allows the ability to transfer, and advance, the application of those skills to more complex tasks (McTiernan, Holloway, Healy, & Hogan, 2016). This category, expressing understanding, was created from the data regarding “we [the students] could understand it [mathematical concepts]” as shared by Abigail in the semi-structured focus group interviews.

Practicing with mathematics is essential for developing mathematical skills (Jansen, Hofman, Savi, Visser, & Van der Maas, 2016) and writing reinforces thought processes (McCarthy, 2008) to gain clarity. Furthermore, writing develops mathematical skills, improves communication, orders thoughts, and evolves conceptual and higher-order thinking (Fuentes, 1998). Better understanding concepts contributes to their self-confidence (Nurhayati, Rosmaiyadi, & Buyung, 2017). The following codes, *gaining awareness, showing understanding* or *how to do it correctly,* aligned with student responses from a semi-structured focus group interview regarding their understanding of the material that was assisted by use of writing prompts. This was seen in a comment by Jackson, "You had to, have to know that to get it done." Jackson also shared, "It gave us a chance to express what we were learning in our own words." Students were affirmed that their problem-solving efforts were rewarded by correct answers and their mastery of the mathematical concept was captured.

With feedback as well as opportunities to practice and demonstrate their knowledge, feelings of competence are enhanced along with positive emotions (Schweinle, Meyer, & Turner, 2006). The following codes generated *I can understand* and *shows I understand* aligned with responses from students' regarding their knowledge growth. This was seen in the comment shared by Jayden in the semi-structured focus group interview, "you actually see… how to do it correctly." As well from a student response on the open-ended student questionnaire "it shows that I understand what I'm learning, and it feels good that I can understand it on my own." When reaching this level of mastery, it brings forth the students' awareness about the benefits of performing mathematics.

Assisting learning. The category, assisting learning, included generated codes such as *easier for understanding and remembering* as well as *go back and refer to again,* where the focus was on organizing the content, such that a student could reference it later, and making the learning process easier. In this study, the implementation of the graphic organizers was used to help students to explore, create, and argue findings while helping them minimize their struggles yet remain engaged. Addison shared in a semi-structured group interview how the graphic organizers allowed her to "go back and look at" content which aided her in remembering as well as knowing where to look for help. Graphic organizers can assist with areas in the writing that include problem-solving as they guide students to break down the problem, organize data, and brainstorm solution strategies while visually separating content parts (Sian, Shahrill, Yusof, Ling, & Roslan, 2016). Graphic organizers utilize a scaffolding approach to learning and are designed to help with visualizing, organizing, clarifying, inferring, communicating knowledge and strategies, and connecting relationships among concepts (Zollman, 2009). Processing new information with various strategies, such as concept maps or structured overviews, helps math students store and organize the new material covered in a fashionable way while increasing their comprehension, retention, and the use of information long-term (Fuentes, 1998). Noah's comment from a semi-structured focus group interview when asked about the implementation of graphic organizers was, "good way to help us remember things" or Abigail's statement, "it gives you a chance to like ask questions and understand it better." These statements provided support for what was found in the existing literature regarding the benefits of graphic organizers in helping organize the content being taught.

In this study, I used graphic organizers as Dye (2000) explains them, to act as visual displays to assist with notetaking and to both link and review prior knowledge. When designing the graphic organizers used for this study, they were crafted in the form of an organized document where students could easily store concepts learned while also looking back at topics learned from within that module as well as previous modules. Additionally, completing graphic organizers together as a class provided a segue for discussion, review, additional clarification, or cultivating new ideas for activities, each being measures to enhance student learning. Sophia's comment, "the ones that we did, like, in class, where we would write it on the board was actually really helpful," provides evidence that this learning strategy was accepted and beneficial for the students.

Written language can help visualize abstract ideas, clarify conceptions, and develop ideas (Colonnese et al., 2018). Authentic assessments such as word walls, writing word problems, or following a problem-solving process are a few strategies all students can use to enhance learning mathematics (Furner et al., 2005). As Noah stated about the use of the writing prompts strategy in learning and remembering mathematics, "It was a good way to … help us learn." As well, Hailey's statement, "they weren't my favorite, but they helped me", which reflects her open-mindedness in using the writing prompts and graphic organizers as a written learning strategy that helped her knowledge grow.

Use of the authentic assessments allowed students to interact, imagine, and become adaptable to how mathematics is an ever-changing process. Talking, writing, and collaborating enhances learning because each includes higher-order thinking skills (Dolan & Collins, 2015). Marzano (2007) proclaimed that learning begins with actively processing information while engagement in various methods push students to learn and work with others. Effective teaching strategies can be exampled by hands-on instruction and activities, communication and collaboration among students, learning by questioning, justifying answers, or remaining open to differing opinions (Fuentes, 1998). Such tactics of reading, writing, talking, exploring, and discovering together creates an exciting space in mathematics to share ideas and learn concepts (Fuentes, 1998). This active learning process can also enhance student creativity and create open mindedness in their scholarship.

Structuring a sequence of learning activities in an organized, purposeful, manner can help students understand mathematical content (Khairunnisa, 2018). Methods that ask students to explore, collaborate, rediscover formulas, and understand concepts in their own words builds a foundation for critical thinking and articulating one's own opinions (Khairunnisa, 2018). Furthermore, teaching students to problem solve, reason, communicate, and use creativity are guides not only to do mathematics, but can be applied in other aspects of their daily lives as well (Firmender et al., 2017). Captivating the material in a manner that encouraged exploration was expressed by Jackson in his semi-structured focus group interview comment "Yeah, you can be kind of creative with how you do it, instead of just writing plain black and white with a pencil." The theme – Use of the authentic assessments allowed students to interact, imagine, and become adaptable to how mathematics is an ever-changing process – describes the variety of learning experiences the students encountered with the implementation of authentic assessments into the course curriculum. This theme emerged from four categories (a) variety of learning, (b) adaptations in mathematics, (c) new discoveries, and (d) learning is lifelong. These categories are further explored and explained in the following paragraphs.

Variety of learning. Children learn from others in socially structured activities and conversations (Marcus, Haden, & Uttal, 2018). Teaching mathematics has been suggested to include methods of group work, projects, writing, and other ways to get students actively involved while connecting prior knowledge (Sons, 2006). Small groups incorporated into classrooms have been found to increase student dispositions towards mathematics, increase performance, as wells as offer socialization benefits (Merritt, 2017). Working together, students learn multiple strategies about problem solving, while also developing autonomy in completing work efficiently (Merritt, 2017). The category, variety of learning, was formed from the generated codes of *interacting with others* and *solving problems multiple ways.* Working together can enhance interest and motivation in addition to creating a cooperative and supportive environment (Schweinle et al., 2006). As shared by Noah in a semi-structured focus group interview when prompted about how classroom discussions availed new insights into how math concepts could be found in their daily life, “you're actually like talking to someone.” Additionally, the authentic assessments were viewed as a way of exploring each other’s ideas and cooperative learning as seen in Sophia’s comment “it's more interactive with everyone.” Even when learning was online, utilizing structured activities that required students’ active participation allowed the students to engage with each other as well as engaging with the content.

Zollman (2009) proclaims that no single method directly affects learning. Therefore, to know where the complete effect of one method without consideration of another is difficult to distinguish because the methods blend together. Use of both writing prompts and graphic organizers reinforced how to organize, apply, communicate, and learn mathematics and was an advantageous platform of learning within both the brick and mortar classroom as well as the online learning environment. Student responses from the semi-structured focus group interviews identified the writing prompts to most impact their literacy and self-efficacy skills, as shared by Jackson, “The writing activities and kind of some of the activities, but more so the writing helped me.” Noah also provided the explanation “it was like, writing I guess.” Additionally, when asked which method(s) effected how to communicate and argue their mathematical thought processes, Noah responded, “probably the writing activities.” Through the various opportunities to practice their learning, the student’s comments in the semi-structured focus group interviews were predominantly positive, as exampled by Olivia, “I like doing them” or Hailey, “I liked the activities.” As a means of practicing mathematical concepts being learned and the discussions that followed through use of the authentic assessments, aligned with Addison, Ethan, and Sophia’s responses in the semi-structured focus group interviews regarding “lik[ing] the lecture and practice and discussion over the other activities.” Overall, Noah and Jayden descriptions, “a good system” and “very organized,” expressed the inclusion of both the writing prompts and the graphic organizers were seen to be advantageous.

Adaptions in mathematics. Focusing on the merging of real-world situations and academics exercises with the learner located at its center (Peltola, 2018), authentic assessments incorporated a range of applications into the classroom to assist learners view of the material in a diverse or organized manner. With employability driving initiatives for a change and assessments being the vehicle, authentic assessments target employability skills that go beyond answers that focus on factual knowledge (Osborne et al., 2013). The category, adaptations in mathematics, was formed by the In Vivo codes *“few ways to do it,”* and *“always need to be adapting”* as students referred to mathematical problems having numerous ways to be solved as well as the need for being flexible in their thinking.

Just as the educational system has evolved (Vinovskis, 2019), mathematics education has changed over time with adaptions of new content and standards as well as learning practices (Woodward, 2004). Fostering students to think flexibly requires engaging in activities with creativity, inspirations, and exploring why mathematics works, just as it is important to teaching art students to go beyond color by numbers (Lockhart, 2009). Teaching students to think about problems in various ways can prepare them for future successes as they become critical thinkers who can adapt to new ideas and solutions. Recognizing how mathematic applications needs to evolve was identified by one student's statement on an open-ended student questionnaire, "People are figuring out how to solve problems in easier ways." Similarly, other students' responses in the questionnaire open-ended questions showed their recognition of evolutions in mathematical applications:

> "Everything in the world changes and people find new ways to do stuff."
>
> "We might find new formulas for things that already have one."
>
> "As we as humans go beyond our wildest imaginations, our education (including math) will have to continue to evolve, and also our surroundings are constantly changing, so we have to adapt in order to survive as a civilization."

New discoveries. Mathematical tools are adopted to use in our world (Livio, 2011). Uncovering knowledge with discoveries includes having new ideas (Lai, 1989). Entire fields of mathematics can and have been created with no application in mind, but in actuality, explain real world phenomena either yet to be discovered or explain what is in existence (Livio, 2011). The category, new discoveries, was formed from *In Vivo* codes *"discover new ideas"* and *"yet to discover"* as students exhibited an understanding that new discoveries are constantly being made. In relation to these codes, one student shared in a response to an open-ended student questionnaire question, "we don't know everything and since there are so many smart and curious people they will discover new ideas." With new inventions, another response to an open-ended student questionnaire question was similar to how mathematical formulas and models provided explanations and impacts on a manned mission to Mars (Velasco et al., 2015). The student wrote:

> With the new development of dark matter and not knowing what it is in the near future there could be billions of other things in the ocean and in space that we have yet to discovered that could help us solve physics chemistry and math equations with each new discovery comes another problem or formula,

further showing the connection between mathematics in future scientific discoveries.

Learning is lifelong. Education is a lifelong undertaking that cannot be thought of as a process that ends– such as with graduation (Schlöglmann, 2006). Learning how to apply knowledge and why it is important is a key to 21^{st} century success (Kereluik et al., 2013). For students to pursue learning and to flourish, they need to view content as relevant, valuable, and be able to identify with it (Tunstall, 2017). Mathematics plays a role to lifelong learning because it is a tool used to help organize everyday life as well as in our careers and it has a high relationship with areas of rational operations and procedures (Schlöglmann, 2006). The category, learning is lifelong, was formed from the generated codes *learning never ends* and *learning and growing,* Students in the study shared their thoughts how mathematics applies to becoming a lifelong learner. This was seen in response to a student questionnaire open-ended question regarding mathematics changing in the future, “As we get smarter math will get harder so we awaits have something to learn.” Additionally, the statement “Because we are learning and growing every day” identified how that students are aware that they are setting their mathematical foundation as they prepare for future growth.

Convergence of the Findings

Quantitative findings revealed that use of real-world application of mathematical concepts, as offered through the use of writing prompts and graphic organizers, was received positively from the students in my middle school mathematics course. The high mean scores in the Disposition subscale in the student questionnaire reflects how the students began to transform their mathematical thinking with an appreciation and willingness to connect mathematical concepts into worldly examples, as was conveyed in their semi-structured focus group interview responses. The students writing progression, mainly in their exploratory and creative writing styles, also demonstrated how they made daily life connections with use of the mathematical constructs.

Predominantly, my students identified having a positive attitude towards mathematics. Three questions on the student questionnaire pertaining to their intrinsic motivation, believing in their abilities, and feeling successful in connecting mathematical concepts into societal situations, started with high mean scores of agreement and there was still a slight improvement in their amount of agreement following the innovation. An area of neutral agreement among the mean scores on the student questionnaire responses was about their perceptions of mathematics changing. While students articulated an understanding of the adaptability of mathematics during the semi-structured focus group interviews, their score on the Dynamic section in the Belief Subscale of the student questionnaire did not change after the inclusion of the writing prompts and graphic organizers into the curriculum.

Chapter Summary

Quantitative and qualitative data from student questionnaires, semi-structured focus group interviews, formative assessments, and summative assessments were analyzed independently. Students questionnaires regarding attitudes of mathematics were broken into two subscales: Disposition and Belief. Using descriptive statistics, most questions (64%) increased in mean scores from the pre- to post- student questionnaires. Eight formative assessment writing exercises were scored in the areas of Overall, Problem Solving, Reasoning and Proof, Communication Overall, Connections, Representations, the number of Mathematical Concepts, Communication Given for what they have, and Word Count with a rubric throughout learning Unit 4 and Unit 5. Each writing prompt targeted a specific style of writing– exploratory, argumentative, creative, and informative/explanatory– and was distributed in the same order once for each unit. Descriptive statistics indicated the student's writing progression occurred as shown from increased mean scores in all styles of writing. Summative assessments occurred in the form of an assessment for each unit as well as four module assessments. All assessments were analyzed with descriptive statistics, but the pre and post unit assessments were additionally analyzed with inferential statistics. Both unit assessments underwent a normality test with Unit 4 suggesting no significant results deviated from normality and Unit 5 suggesting results deviated from normality. Therefore, Unit 4 was analyzed with the paired samples *t*-test and Unit 5 used the nonparametric Wilcoxon signed rank test. Both assessments revealed a significant difference in the learned content between the pre- and post-test data (Unit 4, $t = -6.778$, $p < .001$; Unit 5, $W = 1.000$, $p = .005$).

Qualitative data followed the inductive analysis as data from two semi-structured focus group interviews and open-ended questions on the questionnaire were reduced and organized into categories and then themes. First cycle coding methods of *Structural Coding*, *Emotion Coding*, *Process Coding*, and *In Vivo Coding* were performed using Delve. Second cycle coding methods of a *Tabletop* technique, *Pattern Coding*, and *Axial Coding* were conducted by hand as I physically printed off and moved codes to allow the formation of categories and themes to emerge. In finality, 13 categories and three themes emerged as a result of the numerous rounds of coding. The three themes were: (a) Through the use of authentic assessments, students understood and applied mathematical concepts into worldly applications, (b) Students expressed appreciation, awareness, and eagerness to learn with the integration of authentic assessments, and (c) Use of the authentic assessments allowed students to interact, imagine, and become adaptable thinkers about how mathematics is an ever-changing process The data supports overall positive perceptions and attitudes from the students as they shared feelings and demonstrations of appreciation as well as benefits from the learning strategies and methods practiced in the course– both online and in person. The themes and categories were explained as students communicated their perceptions with processes and the applications of mathematics.

CHAPTER 5

DISCUSSION, IMPLICATIONS, AND LIMITATIONS

This chapter linked my findings and the existing literature regarding the students attitudes towards mathematics and how instruction utilizing authentic assessments impacted their learning. The purpose of this action research was to evaluate the impact of writing prompts and graphic organizers on Mona school's 7th and 8th grade students' mathematical academic achievement and their attitudes towards the authentic application of mathematics. Quantitative and qualitative data were gathered and analyzed from student questionnaires, formative and summative assessments, and semi-structured focus group interviews. From the qualitative data, three themes emerged: (a) Through the use of authentic assessments, students understood and applied mathematical concepts into worldly applications, (b) Students expressed appreciation, awareness, and eagerness to learn with the integration of authentic assessments, and (c) Use of the authentic assessments allowed students to interact, imagine, and become adaptable to how mathematics is an ever-changing process. This chapter goes into further details regarding the (a) discussion, (b) implications, and (c) limitations of my research.

Discussion

Following the convergent parallel mixed methods study design (Creswell, 2014; Creswell & Plano Clark, 2018; Schoonenboom & Johnson, 2017), qualitative and quantitative data have been analyzed and merged together via the side-by-side method with quantitative data to confirm or disconfirm the results from the qualitative data

(Creswell, 2014; Mertler, 2017; Morgan, 2014a). This section goes into further depth in addressing research questions (1) How and to what extent do writing prompts and graphic organizers impact 7th and 8th graders' mathematical achievement and attitudes towards mathematics? (2) What were the 7th and 8th grade students' perceptions about the implementation of authentic writing prompts and graphic organizers in a mathematics course at Mona school?

Research Question 1: How and to what extent do writing prompts and graphic organizers impact 7th and 8th graders' mathematical achievement and attitudes towards mathematics?

Both quantitative and qualitative data collected and analyzed in this study were used to answer this question. More specifically, formative assessments, summative assessments, and student questionnaires were utilized in the merging of data. To answer this question broadly, the outcomes of my data suggests that my middle school students' mathematical knowledge progressed and their attitudes regarding mathematics were predominantly positive. An increased mean score on the post student questionnaire in comparison to the pre student questionnaire mean score identified the students to have a positive attitude towards mathematics. Their writing progression scores increased from Unit 4 to Unit 5 which was reflective of changes in the student's work associated with the integration of writing prompts and graphic organizers. The student's understanding of the mathematical content taught was found in increased posttest unit summative assessment scores across both Unit 4 and Unit 5. In the following paragraphs, I explain in more depth the answer to this research question with (a) attitudes of mathematical applications, (b) applications of mathematics, and (c) mathematical content knowledge.

Attitudes of mathematical applications. Being more than mathematical knowledge, quantitative literacy requires mathematics to be integrated in one's life with a positive attitude of appreciation and willingness to take on mathematical situations with confidence (Tunstall & Bossé, 2016; Wilkins, 2010, 2016). Transforming mathematics into a habit of mind and having a disposition of appreciation and willingness to engage in challenging situations in a self-regulatory fashion was a desire I had for my students. My students' attitudes towards mathematics at the start of this study started out fairly positive and remained positive throughout the duration of the study. Specifically, the mean scores from the student questionnaire Disposition subscale pre (M =3.59) to post (M =3.64) reflects a slight increase in their positive disposition toward mathematics. Breaking down of the Disposition subscale in the student questionnaires into areas of Motivation, Self, and Society allowed for a look into the students understanding of mathematical concepts on these three areas. The increase in mean scores on the post student questionnaires regarding both the Motivation and Society sections suggests that students' intrinsic motivation and the perception of the value of mathematics in society to be important. This aligns with the outcomes of Althauser and Harter (2016) who found a relationship with mathematics and understanding of how it contributes to their futures must be present before students' flourish. The Self section of the student questionnaire Disposition subscale post mean scores decreased slightly, where student's self-confidence in their ability to grasp mathematical concepts were neutral. A response offered on the student questionnaire also reinforced why the Self subscale score was neutral, "math is not easy for me." Therefore, in attempts to improve confidence, Nurhayati et al. (2017) found positive results of including active participation from students and variations of learning.

In reviewing the students' writing progression, while hesitation in interpreting word and frequency counts is offered (Saldaña, 2016), my students' growth in the areas of more mathematical concepts applied and number of words used, can be seen as the students became comfortable writing about mathematics. Tunstall and Bossé (2016) found a similar level of their students' comfortableness when writing about mathematics. Additionally, when exploring Representation as a characteristic of their writing progress (Kostos & Shin, 2010), my students improved their abilities to interpret and show a representation of the question to explain or support their mathematical knowledge. Jackson spoke to this in his semi-structured focus group interview comment "It gave us a chance to express what we were learning in our own words."

Mathematics is an art that has qualities of being mind-blowing, creative, and allows freedom of expression (Lockhart, 2009). When learning mathematics includes creativity, it is necessary for students to become comfortable in expanding and stretching their thinking to provide answers that include new knowledge in addition to their pre-existing knowledge (Katz-Buonincontro et al., 2017). As Jackson shared in a semi-structured focus group interview, "Yeah, you can be kind of creative with how you do it, instead of just writing plain black and white with a pencil." Creative writing, one of four writing styles assessed in the formative assessments, allowed students to use higher-order thinking to construct skills, knowledge, and attitudes by having an active and creative role in the learning process (Fauziah & Saputro, 2018; Simpson, 2017). It offered a peak into the students thinking for improving their mathematical competence, and potentially reveals students' motivation to learn while thinking creatively. The writing style of creativity was found to have increased mean scores on Unit 5 modules in comparison to their Unit 4 counterpart activities across four of the seven writing prompts offered. However, in comparison to the other three writing styles, the creative writing styles universally showed to have the largest mean score improvements from the students writing in Unit 4 compared to their writing in Unit 5. In many situations, the students mean creative writing scores increased by almost two points.

Applications of mathematics. Students' learning was supported through the use of authentic assessments which expanded their mathematical views about how mathematics is found in their daily experiences. Application of mathematics is integrated into quantitative literacy (Gillman, 2004; Tunstall & Bossé, 2016; Wilkins, 2016) as an important component. The regular inclusion of writing was found by Burns (2004) to improve student's self-regulation skills as they reflected, explored, extended, and cemented their ideas; further supporting as students undergo the processes of writing, their knowledge about mathematics improves. The results of the Module 9, 10, 11, and 12 formative assessments revealed the students writing progression to have advanced. For each formative assessment, the student's mean scores in the rubric areas, across each writing style (exploratory, argumentative, creative, and informative/explanatory), increased from Unit 4 to Unit 5. Among five of the seven formative assessment constructs measured, the mean scores of the students exploratory writing increased from Unit 4, Module 9 to Unit 5, Module 11. Of the four writing styles, this was the only style that revealed consistent improvements in the students means scores. Exploratory writing allows students to retrospectively find out about a problem and then introspectively form some preliminary conclusions about how it might be solved. Exploratory writing supports learning rather than writing to prove what you know. A student's response to an open-ended student questionnaire question supports this finding, “we are learning and growing every day.” This improvement in my students exploratory writing revealed their proficiencies in merging characteristics of literacy and mathematics.

Overall and problem solving. Two areas of writing evaluated in these formative assessments that aimed at the application of mathematics were Overall and Problem Solving. Critical thinking is needed to help students make intelligent decisions (Tunstall, 2017) and to assist them in solving mathematical problems (Howard et al., 2015; Ward et al., 2011). The area of Overall shows when mathematics is applied, it includes putting everything together (Scheaffer, 2003). The area of Problem Solving was included because this is an area that made sure students understood the question and knew how to create and carry out a plan. The outcomes of research by Ortiz (2016) showed students advanced their abilities to understand questions when they devised a plan and demonstrated proper execution. Graphic organizers can assist with areas in the writing that include problem-solving as they guide students to break down the problem, organize data, and brainstorm solution strategies with visually separate parts (Sian et al., 2016). Word walls, writing word problems, or following a problem-solving process are a few strategies all students can use to enhance learning mathematics (Furner et al., 2005). Written language can help students visualize abstract ideas, clarify conceptions, and develop ideas (Colonnese et al., 2018). Strategies and processes used for problem solving were also found to be bolstered with the inclusion of reflection and responding to writing prompts (Kenney et al., 2013). My student’s thoughts about the application and learning of mathematical concepts were noted in the semi-structured focus group interviews where

Jayden stated, “you actually see like how it's done and how to do it correctly” and Hailey said, “you get to practice like what you just talked about and stuff.”

Communicating and reasoning mathematical knowledge. Mathematical writing emphasizes communication and beyond as it supports the construction and extension of concepts and understanding (Colonnese et al., 2018). Moreover, completing a graphic organizer prior to writing a response helps ensure the problem is complete and fully communicated (Zollman, 2009, 2012). Three rubric areas of the formative assessments associated with communication and reasoning skills are Reasoning and Proof, Communication Overall, and Communication Given. Reasoning and communication go hand in hand and can be improved through writing in mathematics (Huscrot-D’Angelo et al., 2014). Adding words with the power of numbers builds quantitative literacy that enhances curriculum and life (Steen, 2003). The students’ means scores for argumentative writing from Unit 4 to Unit 5 increased in the area of Reasoning and Proof. This progress in the students’ writing furthered their argumentations of mathematical processes and thoughts, which is supported in the research findings of Wright and Howard (2015) as well. The rubric areas Communication Overall and Communication Given showed additional progress towards students being able to convey and explain their knowledge for the problem as a whole (Gillman, 2006)– including accounts of answering all parts of the question as well as for explaining what they had written. In the semi-focused group interviews, Hailey and Noah respectively shared positive attitudes and insights into how the methods used in the study impacted their communication and argumentation with the statements, “you get to talk about your opinion” and “you were like given like a platform to just speak your mind.”

Mathematical content knowledge. Summative assessments were used at the end of learning Unit 4 and Unit 5 as a means of encapsulating evidence in support of mathematical content knowledge growth. Results of both Unit 4 and Unit 5 summative assessments, in comparison of the pre unit test mean scores to their post unit test mean scores, indicated students learned mathematical content with the implementations of writing prompts and graphic organizers. Specifically, mathematical knowledge showed statistically significant growth regarding transformational geometry– Unit 4 pre-test to posttest (t = -6.778, p < .001)– as well as measurement geometry– Unit 5 pre-test to posttest (W = 1.000, p = .005). Both of these units incorporated the use of graphic organizers and writing prompts. The research outcomes of Zollman (2012) found that using graphic organizers increased their math students' scores on an extended-response test measuring Mathematical Knowledge, Strategic Knowledge, and Explanation. Additionally, Kostos and Shin (2010) found that students gained and retained knowledge with written communication of what was, and was not, known. While there could be other factors that contributed to the student's mathematical knowledge growth, the use of graphic organizers and writing prompts could also be inferred as having had a positive impact on their learning this content.

A qualitative data finding of this study - Students expressed appreciation, awareness, and eagerness to learn with the integration of authentic assessments – was a theme that provided insight into the students' attitudes regarding the implementation of authentic assessments into the curriculum and the impact of these strategies had on their learning. While not dismissing the attitudes of confusion and ambivalence, the overall attitude of the students showed positive associations between the implementation of both writing prompts and graphic organizers into the curriculum, how each were pertinent to their learning, and how these strategies also assisted them towards gaining confidence in their mathematical application abilities. This was found in the semi-structured interview statements from Abigail, “When you think it and then you write it on the page, you basically learn it twice.” While mathematics is an area that can be challenging for many students (Akhter & Akhter, 2018; Tunstall & Bossé, 2016), the results of Akhter and Akher (2018) uncovered that when such challenges were accomplished, students experienced emotions of fulfillment and wanting more. This was exampled by my student in their response on the open-ended student questionnaire “I feel very accomplished and it makes me want to do more” in response to how it makes them feel when they are able to solve problems independently.

Research Questions 2: What were the 7th and 8th grade students’ perceptions about the implementation of authentic writing prompts and graphic organizers in a mathematics course at Mona school?

Qualitative data from semi-structured focus group interviews and student questionnaire open-ended responses were used to answer this research question. My student’s perception about the implementation of authentic writing prompts and graphic organizers into the mathematics curriculum overall was positive. The two themes that emerged out of the qualitative data analysis– Through the use of authentic assessments, students understood and applied mathematical concepts into worldly applications – and Use of the authentic assessments allowed students to interact, imagine, and become adaptable thinkers about how mathematics is an ever-changing process– connected well with this research question as they identified from the student's perspectives the numerous ways that authentic applications of mathematics occurred in their daily lives.

The value of the organized learning platforms spotlighted various authentic applications of mathematics in school as well as in the student's lives outside the classroom. Incorporating opportunities to understand, practice, and create mathematics in the various platforms also provided meaningful learning experiences as students tested approaches to interpret, discover, and transform mathematics (Kenney et al., 2013). Use of the writing prompts assisted my students in making sense of a problem, while learning to make connections and explore how to apply mathematical concepts. Note-taking forms, such as graphs and concept maps, can aid in selecting, encoding, and organizing data to better aid in remembering content (Makany et al., 2009). Utilizing graphic organizers integrated organization and referencing into the mathematic curriculum. This was supported by Noah who shared in a semi-structured focus group interview "[they were] a good thing to fall back on if you needed help." Furthermore, graphic organizers can help learners understand concepts and relationships as verbal elements which can be replaced with symbols, expressions, or equations (Ives, 2007). The following paragraphs further describe their understanding of mathematical applications in my student's daily experiences and the students' worldly interactions with mathematical applications.

Mathematical applications in daily experiences. Using a mathematical perspective to understand one's life experiences is impacted by one's engagement with mathematics (Attard, 2012). Incorporating tactics of reading, writing, talking, exploring, and discovering together created an exciting mathematics space to share ideas and learn concepts (Fuentes, 1998). This active learning process enhanced my student's creativity and provided opportunities for them to become more open minded in seeing how mathematics is applied in their daily lives. Additionally, the use of writing prompts and graphic organizers, as an example of learning engagement strategies with the content, was a positive experience that allowed the students both exploration and reinforcement of their knowledge.

Gaining and improving frequency to mathematical concepts allows the ability to transfer, and advance, the application of those skills to more complex tasks (McTiernan et al., 2016). Teaching students to problem solve, reason, problem pose, communicate, and use creativity are guides not only to doing mathematics, but also to take part in mathematical communication and share ideas as mathematicians do (Firmender et al., 2017). Tunstall and Bossé (2016) found that when teaching with a focus on quantitative literacy, it was common for students to explain more about how they use mathematics in their daily lives. The theme– Through the use of authentic assessments, students understood and applied mathematical concepts into worldly applications– combines aspects of both application and process as a curriculum, as well as the medium of both in the classroom and online learning environments. The writing prompts emphasized communication as a construct and an extension of concepts in support of furthering student understanding (Colonnese et al., 2018). Moreover, completing a graphic organizer prior to writing a response helped ensure the problem was both complete and being communicated accurately (Zollman, 2009, 2012).

The research of Althauser and Harter's (2016) highlighted economics taking place in the real world. My students identified mathematical applications taking place in their everyday lives– such as in monetary exchanges– as well as the essentialness of mathematics impacting their future success– such as in their careers. de Bassa Scheresberg (2013) identified a wide range of financial products, borrowing opportunities, and complex investments to show how mathematics plays a role in one's daily life. Students were asked to comment on two open-ended questions on the student questionnaire to capture mathematical applications taking place in their everyday lives: "Math is used in everyday life, whether subconsciously or consciously, and we will always need it." and "Math is really important in my opinion to learn and at least know the basics of because we usually use math in our everyday lives even if we don't always realize it." Specifically, the open-ended question on a student questionnaire was: *Think about your answer to the previous questions and describe some examples that explains why you think this way?* Many students offered concrete examples "At a restaurant for the check. Grocery shopping."; "When you are cooking or baking. When you have to split something up."; "If you have to give someone change."; "it helps with helping others with their everyday math stuff."; "Everyday people drive in their cars, and when you have a half tank of gas you have to figure out how many miles you have left until you need to figure it out."; or you can "find out how much you save on sales in stores." Whether it was through the use of the writing prompts, the graphic organizers, or a combination of both, my students shared ways they saw mathematics taking place in their lives.

Worldly interactions with mathematical applications. Methods that ask students to explore, collaborate, rediscover formulas, and understand concepts in their own words builds a foundation for critical thinking and articulating one's own opinions (Khairunnisa, 2018). Common perceptions that mathematics is tied to science is true

(Velasco et al., 2015), however, my student awareness of mathematical applications beyond physical submissions of work in the classroom were additionally exhibited in their shared perspectives. In such, they provided perspectives of mathematical applications in their daily activities as well as in the world. Making connections outside of the classroom for how mathematical concepts are found was identified by Ethan in a semi-structured focus group interview "It's actually like a real-world problem that you're doing." Captivating the material in a manner that encouraged exploration was expressed by Noah in the semi-structured focus group interviews, "I liked you, how you like let us use our imagination for the town thing."

Mathematical achievement, and keeping the information in mind long term, is extremely effected by mathematical engagement (Deveci & Aldan Karademir, 2019). Mathematical engagement occurs when students enjoy learning, value their learning, see its relevance to their lives, and recognize connections outside the classroom (Attard, 2012). Attard (2012) found popular tasks that implement aspects of interactions, choice, and creativity, links to the real world to permit differentiation in addition to feelings of empowerment. Including creativity to further their learning of mathematical concepts allowed my students to have fun and make connections between what is concrete and abstract (Furner et al., 2005). Emotions of appreciation and enjoyment were expressed by my students in the semi-structured focus group interviews as they saw how mathematics appeared in the real world. This was seen in two students' statements, Addison, "those [activities] were fun" and Abigail "it makes you appreciate it more."

Thinking futuristically on how mathematical concepts are applied to their potential academic or career paths was shared best by a student response on the open ended student questionnaire, “There are a lot of jobs that involve or use mathematics so in order to succeed later in life it’s important to understand the concepts we’re talking about.” Understanding how the application of mathematics is everchanging, as our world is a continual evolution of technology involving mathematical knowledge (Israel, 2016; Jansen, Schmitz, et al., 2016; Velasco et al., 2015), one student captured this well in their open-ended student questionnaire response “as new things are being invented there will need to be explanations on how it was made and math will describe most of it.” Furthermore, as students engaged with the authentic assessments in the study, they identified there were multiple ways to solve problems. Connecting with how mathematics can be constituted through quantity, space and shape, change and relationships, and uncertainty (De Lange, 2003) allows students to understand the worldly application of mathematics from what they hear in the news, talk about within their community spheres, or resonate within their imaginations of someday experiencing. Transferring their understandings of the need to evolve, or to stay current with innovations (Israel, 2016; Ramadani & Gerguri, 2011), my students’ perceptions of mathematics was there are new ways of performing mathematics consistent with what is constantly being innovated.

Implications

Implications arose for me, the researcher and practitioner, as well as for other math educators and scholarly researchers. This section further explains (a) personal implications, (b) implications for teaching 7th and 8th grade mathematics, and (c) implications for future research.

Personal Implications

This study has had a personal impact on me as a (a) researcher and as a (b) practitioner. The following paragraphs describes each area of implication in greater detail.

Researcher. Undergoing this action research study gave me a new understanding of the action research process as well as maintaining the view that my solutions are not certain (Mertler, 2017). In this study, the pragmatic paradigm (Nzembayie, 2017) and the action research methodology (Mills, 2018) merged theory and practice to promote change while also calling for continued research as solutions to thinking some might have considered to be temporary (Creswell, 2017). This is relevant to me because I share these same beliefs and feel education is never ending and is always changing. Further, as a researcher, the benefits and advances of this study stimulates many of my curiosities to further examine the effects of using writing prompts and graphic organizers to improve middle school students' applications of mathematics. I would also like to further explore quantitative literacy, whether continuing with writing prompts and graphic organizers or another intervention, to advance best practices in the teaching of mathematical concepts to my students.

Practitioner. While action researchers often become lifelong learners that continue to grow (Hine, 2013; Mills, 2011), it is difficult for me to distinguish where the practitioner and the researcher in me diverge. This study allowed me to see and hear from my students the benefits of writing prompts and graphic organizers as strategies for improving their attitudes towards mathematics, which has inspired me to continue use of both in my pedagogy. The other area that this study spoke to me was in the organization and diverse learning strategies that aimed to reach all students on multiple levels. While the variety of learning strategies capitalized on the advancement of diverse skills, abilities, and preferred learning styles of the students (Edwards, 2015), the innovations further fostered a natural differentiation for each student that allowed me, the teacher, to identify the depth of each student's knowledge and help them continue improving at their level. Reflecting on the practices, the successes give me confidence to continue with such methods in either the online or in class learning environment.

Implications for Teaching 7th and 8th Grade Mathematics

Utilizing writing prompts and graphic organizers are shown to benefit students in mathematics (Hui, 2016; Kenney et al., 2013) both in class and through online learning. In either learning environment, there are benefits in using writing prompts and graphic organizers that other teachers could integrate into their teaching to create a well-rounded mathematics class. I encourage others in my profession to benefit through the outcomes of this study and utilize all, or portions of it, into their own teaching. As seen in the outcomes of this study, the writing prompts and graphic organizers can empower students to think in ways that are cross curricular and connected to the real world. In the following paragraphs I have explain these thoughts as it could apply to the use of (a) writing prompts and (b) graphic organizers.

Writing prompts. The inclusion of writing prompts was a variable of my study I would recommend for teaching in both online or in-class mathematics curriculum. The writing prompts can offer full transparency to students and teachers in the areas that students need further review as well as demonstrating when they have acquired full understanding. Transferring language to mathematics promotes vertical and horizontal learning as students deepen their existing knowledge or make connections with new concepts (Kang et al., 2019). Further appreciations other mathematics teachers can find in using writing prompts is in how their use fosters reflection and skill monitoring that can contribute to their ability to make connections (Kenney et al., 2013) to both mathematical concepts and life situations. Moving forward, I would make a recommendation to teachers to integrate writing prompts into their mathematic curriculums, especially when it comes to teaching triangle relationships and the connection of the Pythagorean Theorem's uses in life with similar triangles, a lesson plan that was used in this research intervention.

Graphic organizers. Graphic organizers were the other variable of this study that I encourage other middle school mathematics teachers to use, both in online and in physical classroom learning environments. Graphic organizers help organize data for problems (Zollman, 2009, 2012) because they are complex and utilize a multitude of skills that go into solving problems (Codding et al., 2016). Graphic organizers can help break down problems into easier, more manageable parts. They can also be beneficial for note-taking (Friedman et al., 2011) as they help learners encode and organize data to assist in remembering content (Makany et al., 2009). In this study, there was a noticeable value from using graphic organizers as they became a good reference point for students to return to as well as helping them organize their thinking, and thus, their learning. Additionally, the discussions between students and their engagement that arose from using graphic organizers were amazing. For example, when completing the word wall graphic organizer in Module 9, students searched for new concepts and vocabulary as the lesson unfolded so they could write it on the wall. In using graphic organizers with middle school students, I recommend that teachers make them specific and to incorporate the use of graphic organizers in a group setting to ensure students' comfort and understanding is furthered. Additionally, as my students expressed the benefits of using graphic organizers, teachers can use this strategy to build discussion and communication opportunities within the students (Sian et al., 2016).

Implications for Future Research

The existing research supports whether teaching online (Tunstall & Bossé, 2016) and in person (Van Peursem et al., 2012), that teaching mathematics and quantitative literacy for college students was successful. However, my student population was middle school students. Therefore, an area that other researchers should consider future research about is the examination of quantitative literacy at a middle school level. While my outcomes of focusing on mathematical applications and attitudes did not reveal sizable growth, I believe there was enough positive gains to warrant additional research to determine if students at this younger, pivotal age, could advance their mathematical knowledge if writing prompt and graphic organizer innovations were included for a longer duration, across additional mathematical concepts, as well as being used within other academic disciplines. Research into extending the length of time these strategies were used in teaching mathematical concepts to middle school students should propel the advantages that were preliminarily explored in this research study.

Another aspect about this study where I recommend further research would be on the intentional juxtaposition of the in-class compared to the online learning environments in utilization of writing prompts and graphic organizers and their impact on growth in mathematical knowledge. Having endured the sudden shift and transition of learning environments secondary to the COVID pandemic, it amazed me to still see students' scores showing improvement. Yet I wonder what the students' scores would have been had the learning environment shift not occurred. Still, an experimental research design that was intentional to explore the use of writing prompts and graphic organizers in both learning environments concurrently and compare the change in learned content would be a fascinating study to see.

This study focused on how the use of writing prompts and graphic organizers influenced mathematical applications in regards to achievement, attitudes, and perceptions. While there are difficulties of mathematical writing (Hebert & Powell, 2016), the advantages of including writing prompts in teaching mathematics (Colonnese et al., 2018; Kenney et al., 2013; Kostos & Shin, 2010) were found in this study. The direction I recommend for future researchers is to continue to examine further effects.

Limitations

Limitations in this study have occurred and are noted in this section. By addressing them in this study, I warn readers of generalization and offer reassurance that I am aware of the flaws in my methodology (Pyrkzak, 2017). Limitations that were associated with this study include (a) methodological approach, (b) the findings, and (c) the disrupted learning environment, which are described in the following paragraphs.

Limitations in the Methodological Approach

The methods I used in this study are commonly found in action research (Creswell, 2014; Mertler, 2017). Equally, the limitation of action research found in research (Huang, 2010; Mills & Gay, 2016) were areas specific to my study as well. In alignment with the pragmatic paradigm, my findings are temporary and need to be revisited and changed in the future (Schoonenboom, 2019); as action research results are tentative solutions for the current observations and require further monitoring and observations (Mertler, 2017). Action research is not generalizable (Creswell, 2014; Huang, 2010) and, as required in action research methodology, I was both the researcher and teacher; therefore, this study was limited to the location of my middle school mathematics classroom (Creswell, 2014; Mills & Gay, 2016).

Mixed methods are arguably stronger than either quantitative or qualitative studies independently, but limitations still exist (Creswell, 2014). Sample size for my study followed the concept of saturation instead of an exact required number (Mason, 2010; Mertler, 2017); yet still, the small sample population was a limitation to this study. While the duration of this study took place over a prolonged period of time, which allowed me to gain trust and establish behavior patterns of my students (Hadi & Closs, 2016; Mertler, 2017), the combination of introducing new strategies (writing prompts and graphic organizers) mixed with the sudden transition to online learning, can be viewed as a limitation to the study. Lastly, the length of the semi-structured focus group interviews were a limitation to the study as they were a smaller duration than what is typical (Dilshad & Latif, 2013). Additionally, they took place in a virtual environment, rather than in the natural setting of the classroom, which resulted in not all participants engaging equally (Creswell, 2014).

Limitations in the Findings

The unveiling of a not having alignment of students who completed the student questionnaire pre and post the intervention was a notable limitation on the analysis of my data. While descriptive statistics were used to analyze the results of both the pre and post student questionnaire in this study, the ability to align the participants responses for the pre and post student questionnaires responses would have allowed for inferential statistics to occur. Descriptive statistics, an appropriate analysis for action research (Mills & Gay, 2016), used the data to provide descriptions of the population through numerical calculations, to describe what was taking place (Leech et al., 2005; Mills & Gay, 2016). However, inferential statistics would have allowed me to compare the means of the two samples of related data and to reach conclusions that extend beyond the immediate data alone; to determine whether the means of pre and post student questionnaire responses were statistically different from each other (Lee et al., 2016).

The next limitation found was in the design of the formative and summative assessments. First, I did not create a different graphic organizer for each of the writing prompts utilized across the two units of curriculum identified for this study. Having created graphic organizers, instead, that were more specific to the mathematical concepts being taught likely would have benefitted the students learning even more. Second, some formative and summative assessments were not completed by all of the students and the missing scores could have impacted the quantitative outcomes (Creswell, 2014). Third, reliability coefficients on two summative assessments were low while the rest of the summative assessment's reliability was desired and within acceptable values (Rudner & Schafer, 2001). However, because two of the assessments reliability coefficients were below a desired range, caution is therefore suggested in the interpretation of those results.

The last limitation of this study was found in the semi-structured focus group interviews. For 7th and 8th grade students, I was pleased with the quantity of qualitative data the interviews produced; however, the quality or depth of the students' perceptions and experiences offered was scarce. While not atypical of what can should be expected from a pre or early adolescent participant (Bassett, Beagan, Ristovski-Slijepcevic, & Chapman, 2008), it was not uncommon when one student answered the question, that other students agreed by stating “yeah” without further explanation. Perhaps having individual interviews or more probing for further explanation would have helped with this limitation.

Limitations about the Disrupted Learning Environment

Limitations that were out of my control and forced me to flexibly carry out the study seemed to be a common occurrence. From the beginning of the study, time was an issue. In Module 9, the number of days students were in the classroom was fewer than expected due to assemblies and other school related absences that the students endured. Additionally, from Module 10 to the end of the study, the reality of having the study carried out in the physical classroom, was impacted as a result of the COVID-19 pandemic. Not only did the change in learning environment impact my teaching, it impacted the student’s engagement and learning as learning online, solely from their homes, was a foreign concept to these middle school students, and something Mona schools had not participated in prior to March 2020. The change of learning environment, for the duration of the study, also meant I was not seeing my students every weekday. Instead, I was literally seeing students two days a week, for one hour blocks of time, via web conferencing and answering questions about the material provided via email messages.

The decreased amount of time teaching my students via web conferencing also shifted the curriculum to eliminate non-essential topics and activities. Additional writing prompts and graphic organizers were planned to be implemented, completed, and shared in class with further discussion about each, but rich discussions in particular did not take place with the shift in learning being more independent in the student's home. While I did still try to engage the students who showed up for the online classroom sessions with discussions centered around the activities provided for them to complete independently at home, the lack of them being physically present together impacted how the students worked together. Students could no longer sit around a table to view, manipulate, and complete the same document with the same ease that was taking place when we were together, in person, in the classroom. Using the escape room as an example, it was a fun experience, but students had to have one person log in and share their screen while everyone else described where to have the person in charge look to select what was needed. Although blessed to have the technology available to engage in interactions and learning opportunities, these differences did take both myself and the students some time to get used to, and I learned to gage what could be realistically be completed in the time allocated.

Lastly, adjusting to the new, online learning forum made my innovation no longer the only changed aspect of the course. Students truly took charge of their learning as they independently managed their time at home and disciplined themselves to resist the urge of tempted distractions to stay on pace. Learning content from videos and turning assignments in online became a new norm in a short amount of time. I could no longer walk around the classroom to answer questions, watch them perform procedures, and correct misconceptions in real time. For example, in summative assessments, it was frustrating for students to ask me questions of clarification because they would have to leave the assessment to call me. Furthermore, even the semi-structured focus group interviews were difficult to have all students participating and offering their ideas in a personal and comfortable manner that I believe had we all been together could have produced additional qualitative data.

Conclusion

My study was designed from a broad lens seeking to understand why students struggled with connecting mathematics to the real world. Identifying similar research regarding these struggles on various mathematical levels nationally was established and recorded in the first chapter. Upon identifying my specific research purpose and research questions, the second chapter focused on reviewing the existing literature to support how the use of writing prompts and graphic organizers have benefitted student's learning. In the third chapter, I detailed my research design and methods where I could put my research study ideas into action with my middle school student participants. The fourth chapter analyzed the quantitative and qualitative results gathered from the students, and the fifth chapter interpreted the findings to answer my research questions while integrating in existing research.

Upon reflection of the results, the use of writing prompts and graphic organizers impacted my students on differentiated, personal, levels for several areas— specifically quantitative literacy, academic achievement, and having positive experiences in this study. To know the exact degree of impact for each authentic assessment chosen was difficult to distinguish due to limitations of the study as well as understanding no single method of teaching alone affects learning (Zollman, 2009). Being uncertain what the results of my study would reveal, I was pleased to see the ways that the implementation of writing prompts and graphic organizers positively impacted my students mathematical knowledge, attitudes about mathematics, and their understanding how mathematics is applied into their daily lives, into the real world. All of this taking place within both in the physical classroom as well as when learning online.

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APPENDIX A

GRAPHIC ORGANIZERS AND WRITING PROMPTS IN THE INNOVATION

Name: _______________

Complete the Word Wall graphic organizer to help identify words that below to mathematical operations. Additionally, include other terminology you feel is important to remember and efficiently use and understand. Make sure to add additional boxes or charts as needed.

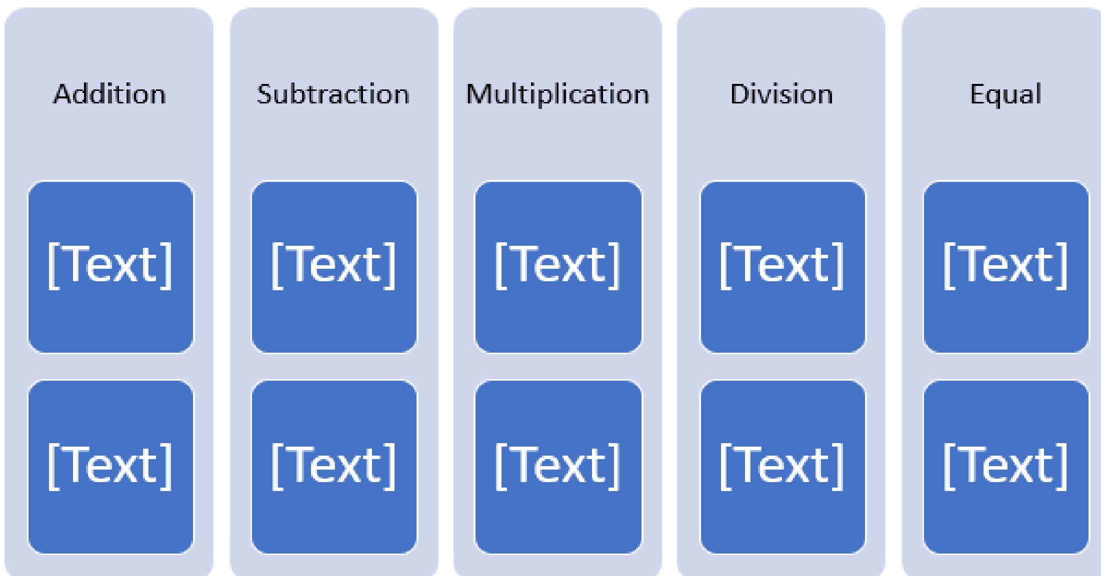


Figure A.1. Word wall

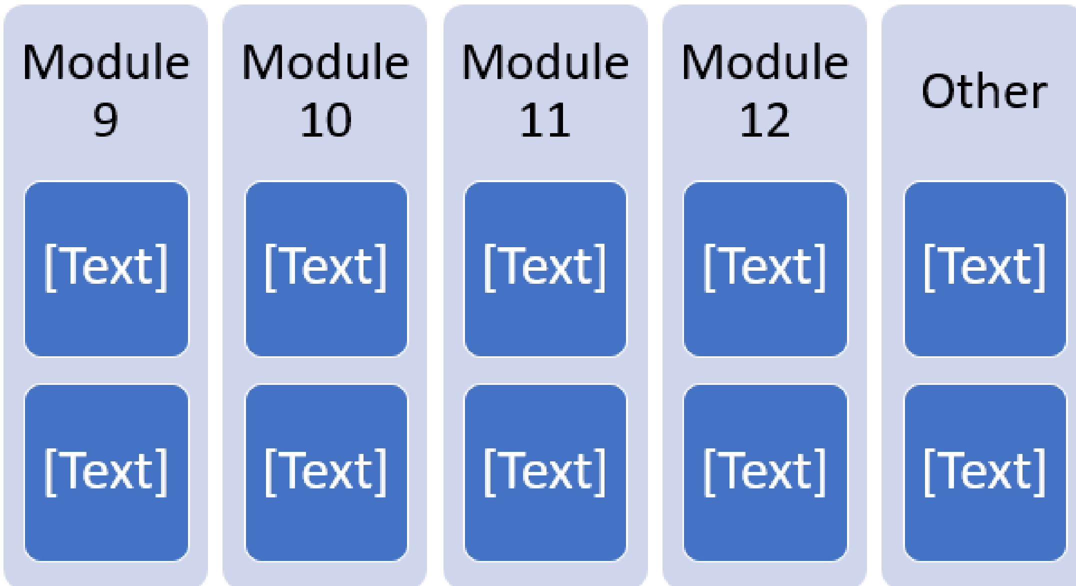
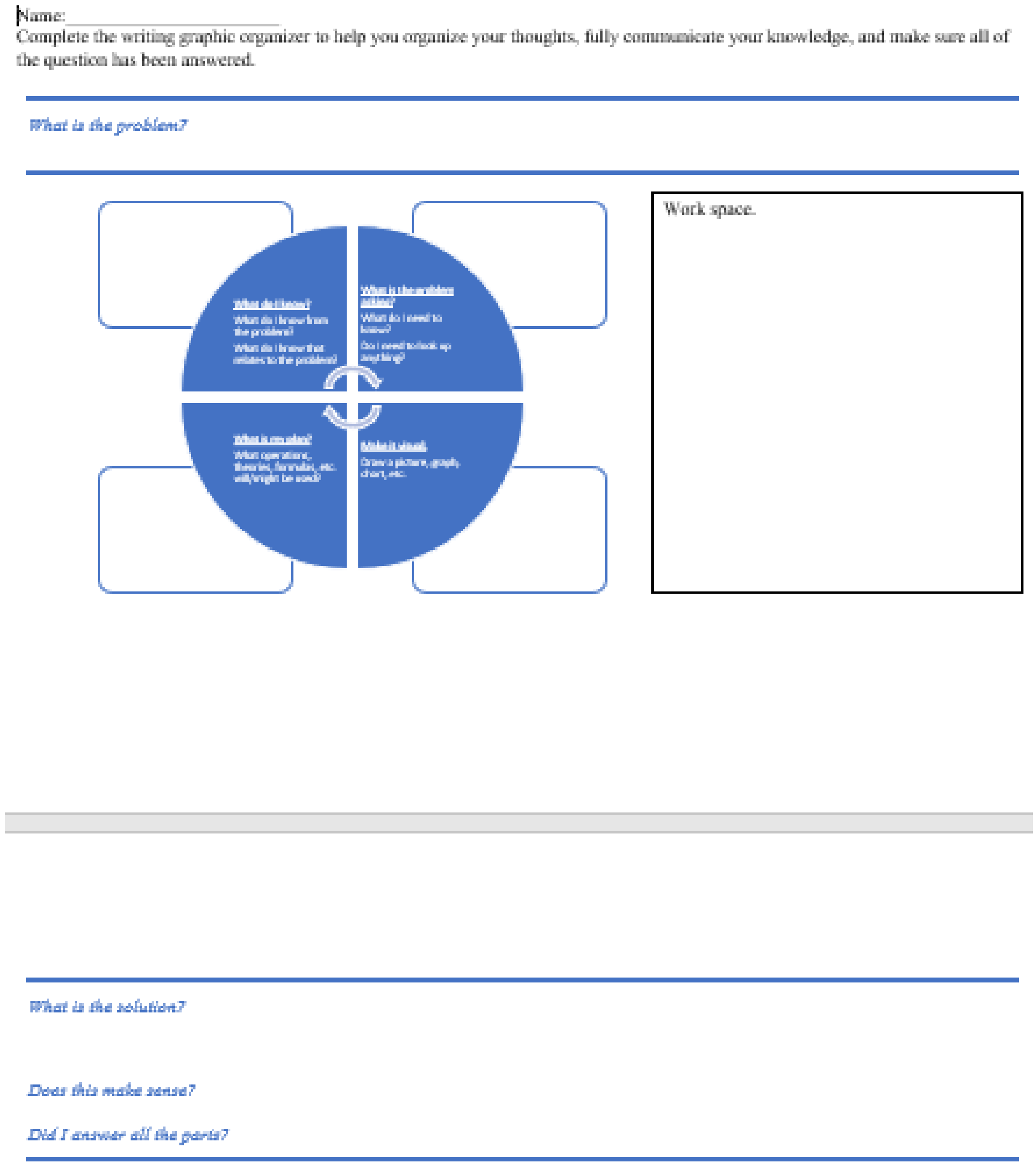


Figure A.2. Module word wall.


Name:____________________
Complete the writing graphic organizer to help you organize your thoughts, fully communicate your knowledge, and make sure all of the question has been answered.

What is the problem?

Work space.

What is the solution?

Does this make sense?

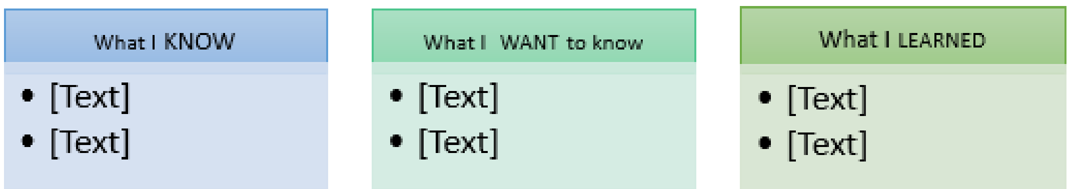
Did I answer all the parts?

Figure A.3. Writing graphic organizer: Know, ask, plan, and visual.

Name ________________________________

Fill in the graphic organizer with what you know, what you want to know, and what you have learned. Be sure to add any additional things if needed.

Module 9



Module 10

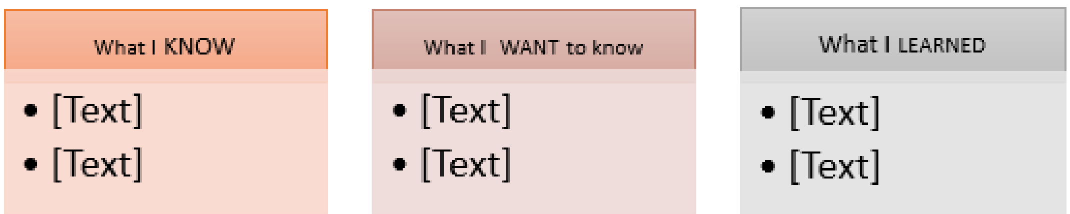


Figure A.4. Know, what, learn graphic organizer unit 4.

Fill in the hierarchy concept map. Be sure to add more boxes and levels when needed.

Module 9 and 10

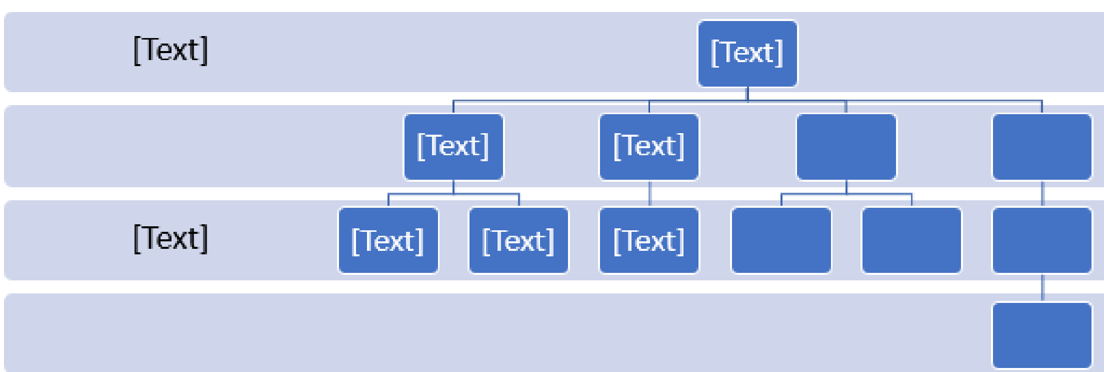


Figure A.5. Hierarchy concept map graphic organizer unit 4.

Fill in the four square and segmented pyramid graphic organizer. Be sure to add more boxes, levels, etc. when needed.

Module 11

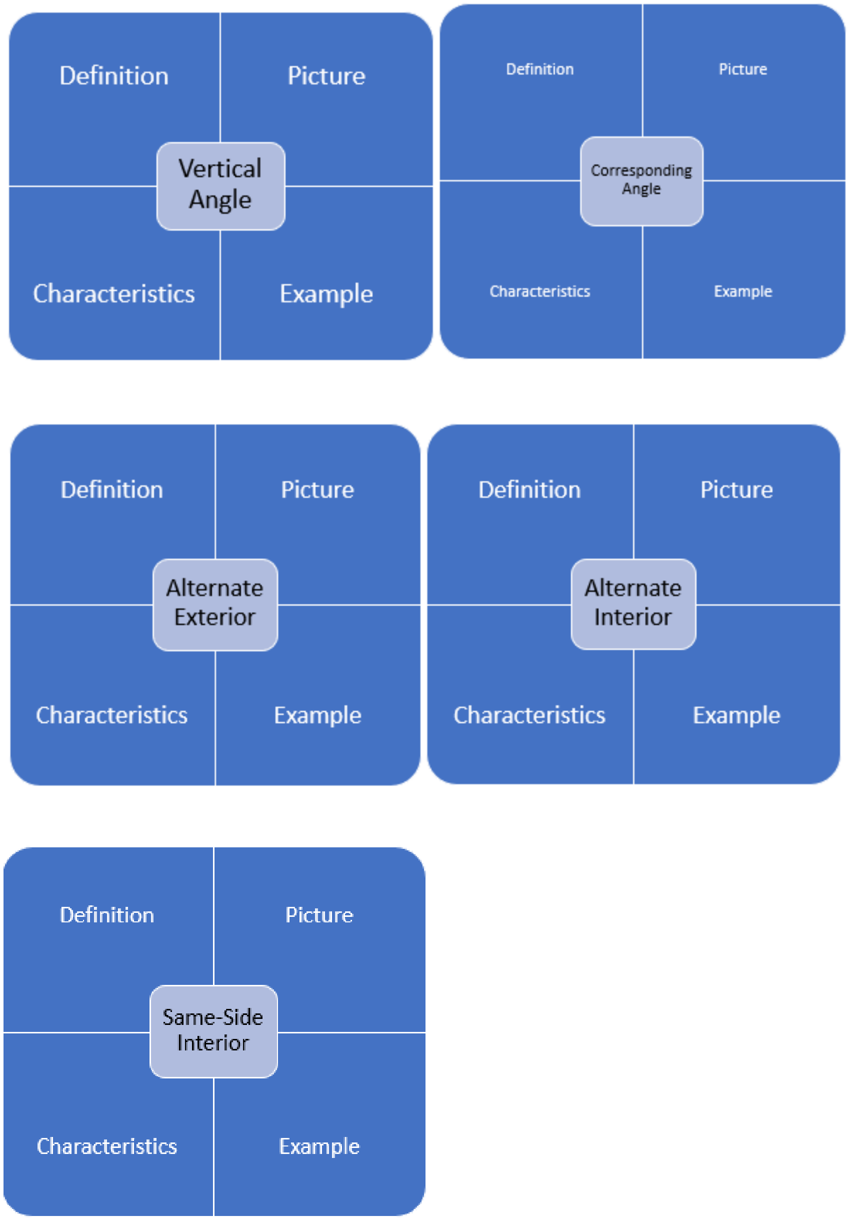


Figure A.6. Four corners graphic organizer Unit 5.

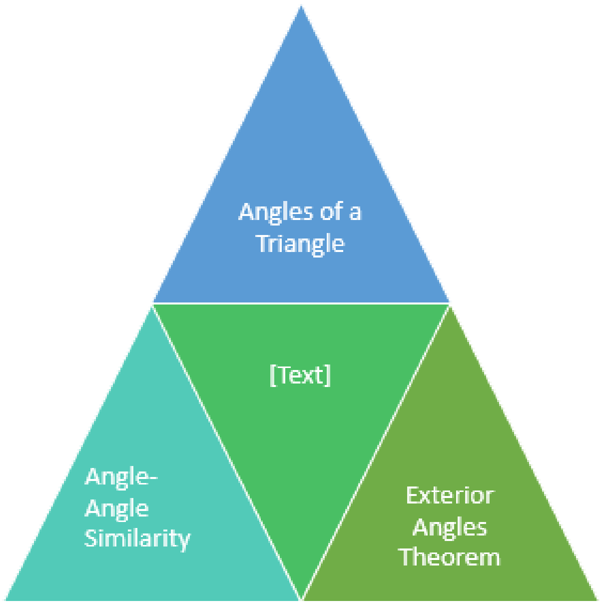


Figure A.7. Triangle graphic organizer unit 5.

Table A.1. *Writing Prompts*

Module	Prompt
Module 9	Exploratory Writing What do you know about translations, reflections, and rotations? How would you describe their importance and connection to life outside math class? Argumentative Writing When transforming figures, describe factors that would influence you to use each method (algebraic representation and graphing). Creative Writing Create or find a real-world situation that includes the use of multiple transformations. Explain your reasoning for the inclusion of each transformation and what properties stand out to you as most important.
Module 10	Informative/ Explanatory Writing Describe why/how the different algebraic representations work for each transformation. Explain and show how to compute an example for each.
Module 11	Exploratory Writing In language arts classes, you are taught to use various methods such as root words or context clues to help relate, understand, and learn new meanings. What words are given to you that would give you an idea what each angle relationship is? Then, using those thoughts, explain what each angle relationships is. Write this as detailed as you can- imagine you are writing to a friend who needs help. Argumentative Writing Explain two ways to find the missing angle measures from question # 6 on page 358. What might be some factors of a given problem to use one method over the other? Creative Writing Create two real-world situations that you could use similar triangles and proportions to solve. Then solve each problem. Make sure to explain your steps.
Module 12	Informative/ Explanatory Writing Explain how the distance formula and the Pythagorean Theorem are intertwined. You may use pictures or examples to help you explain.

APPENDIX B

SEMI-STRUCTURED FOCUS GROUP INTERVIEW QUESTIONS

Focus Group Interview

1. What were your feelings towards the lecture and practice?
    a. Did you feel this was pertinent to your learning?
2. What were your feelings towards the activities such as taking pictures, making posters, etc.?
    a. Did you feel this was pertinent to your learning?
3. What were your feelings towards the writing exercises?
    a. Did you feel this was pertinent to your learning?
4. What were your feelings towards the graphic organizers?
    a. Did you feel this was pertinent to your learning?
5. What were your feelings towards the discussions?
    a. Did you feel this was pertinent to your learning?
6. What which type of instruction did you most favor?
    a. Can you provide examples to help you explain why?
7. Which type of instruction did you feel was most beneficial to your *learning the content*?
    a. Can you provide examples to help you explain why?
8. Do you feel that any type or types of instruction(s) do you feel helped you retrieve, connect, and apply content knowledge so you could *understand and use* in it now or in your future life outside the classroom?
    a. Can you provide examples to help you explain why or how?
9. Do you feel that any type or types of instruction(s) do you feel helped you transfer content into ways you could *appreciate* mathematics in your life outside the classroom?
10. Do you feel that any type or types of instruction(s) do you feel helped you better *communicate and argue* your knowledge and thought processes?
    a. Can you provide examples to help you explain why or how?
11. Do you feel that any type or types of instruction(s) do you feel helped you impact *literacy (reading or writing) or self-monitoring skills (aware of your knowledge and thought processes)* as it?
    a. Can you provide examples to help you explain why or how?
12. Do you have anything else to add?

APPENDIX C

STUDENT QUESTIONNAIRE

Questions
Please answer the following questions about intrinsic motivation.
Working with numbers makes me happy.
I think mathematics is fun.
I am looking forward to taking more mathematics classes.
I like to help others with mathematics problems.
If I had my choice I would not learn any more mathematics.
I refuse to spend a lot of my own time doing mathematics.
I will work a long time in order to understand a new idea in mathematics.
I really want to do well in mathematics. *What are some reasons why you feel this way?*
I feel good when I solve a mathematics problem by myself. *Why does it make you feel this way?*
I feel challenged when I am given a difficult mathematics problem to solve.
I would like to work at a job that lets me use mathematics.
Please answer the following questions about ability or self-concept.
I usually understand what we are talking about in mathematics class.
I am not very good at mathematics.
Mathematics is harder for me than for most people.
I could never be a good mathematician.
No matter how hard I try, I still do not do well in mathematics.
Please answer the questions about the role and value of mathematics in society.
It is important to know mathematics to get a good job.
Most people do not use mathematics in their jobs.
Mathematics is useful in solving everyday problems. *What are some examples that explains why you think this way?*
I can get along well in everyday life without using mathematics.
Most applications of mathematics have practical use on the job.
Mathematics is not needed in everyday living.
A knowledge of mathematics is not necessary in most occupations.
Please answer the following questions mathematics as memorization and rule driven.
Mathematics helps one think according to strict rules.
Learning mathematics involves mostly memorization.
There is always a rule to follow in solving a mathematics problem.

Questions
Mathematics is a set of rules.
Please answer the following questions regarding your beliefs about problem solving.
There is little place for originality in solving mathematics problems.
There are many different ways to solve most mathematic problems.
A mathematics problem can always be solved in different ways.
Please answer the questions about your beliefs of mathematics changing or being dynamic.
Mathematics will change rapidly in the near future. *What makes you think this?*
New discoveries in mathematics are constantly being made.
There have probably not been any new discoveries in mathematics for a long time.

APPENDIX D

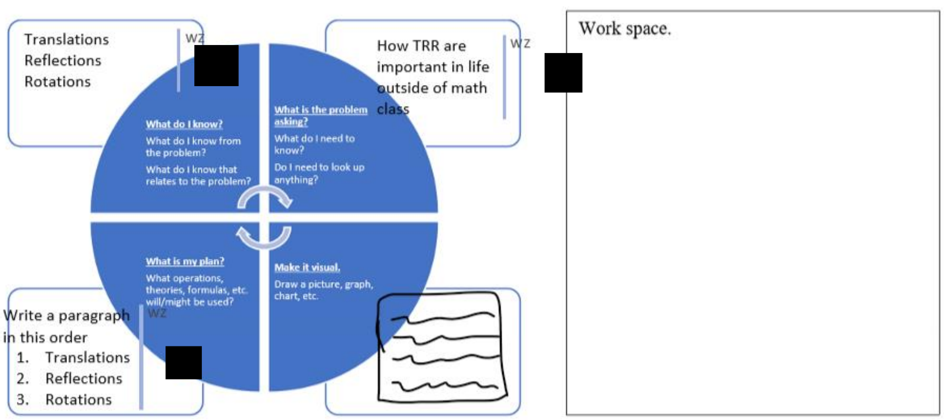
STUDENT AUTHENTIC ASSESSMENT EXAMPLES

Introduction
Exploratory Writing What do you know about translations, reflections, and rotations? How would you describe their importance and connection to life outside math class?

Name:________________________

Complete the writing graphic organizer to help you organize your thoughts, fully communicate your knowledge, and make sure all of the question has been answered.

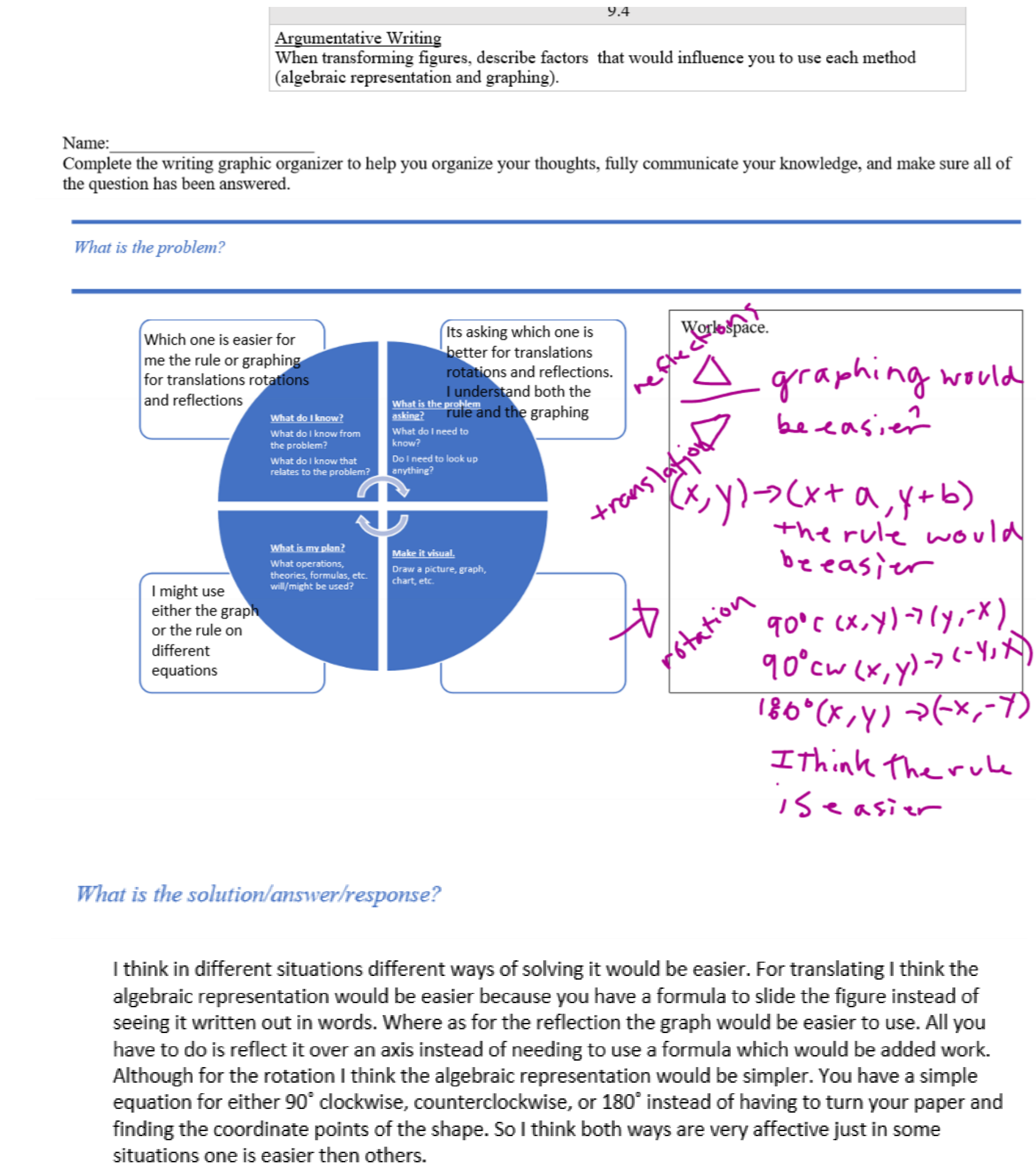
What is the problem?



What is the solution/answer/response?

How are Translations, Reflections, and Rotations important in life outside of class? That is the topic I will be addressing today. Let's start with Translations. Translations are movements, on the coordinate plane Translations are the movements of shapes represented by Algebraic Transformations. (x, y,)->(x+4, y-5) or something along those lines. In everyday life Translations help us tell computers or machines where to move something how to move it there (Ex. 5 ft. Left and 2 ft. Forward). Now let's move on the Reflections. Reflections are used in art in so many ways lots of Zentangles and designs have shapes reflected against each other as part of the pattern. Now I know that's a lot simpler than what I just wrote about Translations but it's the truth! Reflections are really simple. Last thing let's talk about Rotations. This is even simpler than Reflections. Almost everyday somebody rotates something or something rotates on its, like the Earth! If Rotations weren't a thing life would be pretty weird. In conclusion that is why I think Translations, Reflections and Rotations are important in everyday life.

Figure D.1. Student exploratory writing example for Introductory Unit 4.



9.4

Argumentative Writing
When transforming figures, describe factors that would influence you to use each method (algebraic representation and graphing).

Name:______________________
Complete the writing graphic organizer to help you organize your thoughts, fully communicate your knowledge, and make sure all of the question has been answered.

What is the problem?

Which one is easier for me the rule or graphing for translations rotations and reflections

Its asking which one is better for translations rotations and reflections. I understand both the rule and the graphing

I might use either the graph or the rule on different equations

Workspace.

reflection
graphing would be easier
translation
$(x,y) \to (x+a, y+b)$
the rule would be easier
rotation
$90°c\ (x,y) \to (y,-x)$
$90°cw\ (x,y) \to (-y,x)$
$180°(x,y) \to (-x,-y)$
I think the rule is easier

What is the solution/answer/response?

I think in different situations different ways of solving it would be easier. For translating I think the algebraic representation would be easier because you have a formula to slide the figure instead of seeing it written out in words. Where as for the reflection the graph would be easier to use. All you have to do is reflect it over an axis instead of needing to use a formula which would be added work. Although for the rotation I think the algebraic representation would be simpler. You have a simple equation for either 90˚ clockwise, counterclockwise, or 180˚ instead of having to turn your paper and finding the coordinate points of the shape. So I think both ways are very affective just in some situations one is easier then others.

Figure D.2. Student writing example for Argumentative Unit 4.

What is the solution/answer/response?

When you are trying to find missing angle measures, like the one on question 6, there are two ways that you can do it. The first way is called the triangular sum theorem. To use the triangular sum theorem, you need two angle measures. If we have triangle abc, and the angle measurement of angle a and b are both 45 degrees we can use the triangular sum theorem. We do this adding angles a and b together. They equal 90. Now we subtract 90 from 180, because there are 180 degrees in a triangle. They equal 90. So angle c equals 90 degrees. The second way you find find missing measurements in a triangle is by using the exterior angle theorem. To use the exterior angle theorem, you need to have and exterior angle. If you have a triangle with an exterior angle that is 116 degrees and angle e(7y+6) and angle f(4y), this is how the equation would go. You combine like terms, so you now have 11y+6=116. Next you subtract 6 from 6 and 116, leaving the equation like this: 11y=110. Then, you divide 11 from 11 just leaving the y, and you also divide 110 by 11 which is 10. However, you are not done yet, you still have to plug in the values. Angle e is 76 because 7 times 10 plus 6 equals 70. Angle f is 40 because 4 times 10 equals 40. Angle d, the missing angle, is 64 because 180 minus 116 equals 64. In conclusion, I believe that the triangular sum theorem works best for finding missing angle measures. I like using this theorem because it is easy to use when you also have an exterior angle in your equation. The triangular sum theorem is also easy because all that you do is add the angles.

Does this make sense?

Figure D.3. Student writing example for Argumentative Unit 5.

APPENDIX E

REVISED RUBRIC FOR WRITING PROMPTS

Table E.1. *Revised Rubric for Writing Prompts*

	Problem Solving	Reasoning and Proof	Communication	Connections	Representation	Overall	Communication Given
Novice 0-1	No/wrong strategy No previous knowledge	No/Incorrect mathematical reasoning	Little/no awareness of purpose Everyday language	Incorrect/No connections	Incorrect/No representation	Mostly novice level scores Needs a lot of assistance	Little/no awareness of purpose Everyday language
Apprentice 2	Partial correct strategy Some previous knowledge	Some correct reasoning	Some awareness (paraphrasing task) Some formal language	Some attempt to relate to own experience	Attempted representation for problem solving	Mostly apprentice level Needs assistance beyond basic levels	Some awareness (paraphrasing task) Some formal language
Practitioner 3	Correct strategy and plan	Adequate reasoning	Sense of purpose Communication of approach	Connections recognized	Accurate representation for problem solving	Mostly practitioner levels	Sense of purpose Communication of approach

	Problem Solving	Reasoning and Proof	Communication	Connections	Representation	Overall	Communication Given
	Showed prior knowledge Correct answer		Formal math language			Understands and applies independently	Formal math language
Expert 4	Correct strategy Adjustments/ alternate strategies shown Extended prior knowledge	Justification and support	Communication of approach and supported argument Precise math language	Connections used to extend to a deeper understanding	Abstract to analyze relationships and interpretations	Mostly expert levels Above and beyond to independently look for further exploration	Communication of approach and supported argument Precise math language

Note. Adapted example from the copyrighted Exemplars' Standards-Based Math Rubric.

APPENDIX F

INSTITUTIONAL REVIEW BOARD CONSENT

UNIVERSITY OF
SOUTH CAROLINA

OFFICE OF RESEARCH COMPLIANCE

INSTITUTIONAL REVIEW BOARD FOR HUMAN RESEARCH
DECLARATION of NOT RESEARCH

Kyla Steppler
[redacted]

Re: **Pro00091710**

Dear Kyla Steppler:

This is to certify that research study entitled ***Evaluating the use of Writing Prompts & Graphic Organizers in Middle School Mathematics: Action Research to Improve Quantitative Literacy, Mathematical Achievement, and Students; Experiences*** was reviewed on **10/14/2019** by the Office of Research Compliance, which is an administrative office that supports the University of South Carolina Institutional Review Board (USC IRB). The Office of Research Compliance, on behalf of the Institutional Review Board, has determined that the referenced research study is not subject to the Protection of Human Subject Regulations in accordance with the Code of Federal Regulations 45 CFR 46 et. seq.

No further oversight by the USC IRB is required. However, the investigator should inform the Office of Research Compliance prior to making any substantive changes in the research methods, as this may alter the status of the project and require another review.

If you have questions, contact Lisa M. Johnson at lisaj@mailbox.sc.edu or (803) 777-6670.

Sincerely,

Lisa M. Johnson
ORC Assistant Director and IRB Manager

APPENDIX G

LOCAL CONSENT

[redacted]

I give permission for Kyla Steppler, as part of the University of South Carolina, to conduct research at [redacted]

[redacted]

[redacted]

7/18/19
Date

Printed Name

Signature of Research Site (Building)

Date

[redacted]

Figure G.1. Local consent 1.

I give permission for Kyla Steppler, as part of the University of South Carolina, to conduct research at [redacted]

[redacted]

Printed Name

[redacted]

Signature of Research Site (District)

7-19-19

Date

[redacted]

Printed Name

[redacted]

Signature of Research Site (Building)

7-19-19

Date

Figure G.2. Local consent 2.

I give permission for Kyla Steppler, as part of the University of South Carolina, to conduct research at [redacted]

[redacted]

Printed Name

[redacted] 7-20-2019

Signature of Research Site (District) Date

Printed Name

Signature of Research Site (Building) Date

Figure G.3. Local consent 3.

APPENDIX H

CONSENT FORMS FOR PARTICIPANTS

UNIVERSITY OF SOUTH CAROLINA

ASSENT TO BE A RESEARCH SUBJECT

Evaluating Writing Prompts and Graphic Organizers

8 – 12 Year Olds

I am a researcher from the University of South Carolina. I am working on a study about writing prompts and graphic organizers and I would like your help. I am interested in learning more about writing prompts and graphic organizers. Your parent/guardian has already said it is okay for you to be in the study, but it is up to you if you want to be in the study.

If you want to be in the study, you will be asked to do the following:

- Answer some written questions about mathematics. It will take place as a part of the class for about eight weeks beginning in January.
- Meet with me individually and talk about the writing prompts and graphic organizers that have been included in the curriculum. The talk will take about 20 minutes and will take place at school during class.

Any information you share with me (or study staff) will be private. No one except me will know what your answers to the questions were. Interviews will be audio recorded for transcribing, but only I will hear the recordings.

You do not have to help with this study. Being in the study is not related to your regular class work and will not help or hurt your grades. You can also drop out of the study at any time, for any reason, and you will not be in any trouble and no one will be mad at you.

Please ask any questions you would like to about the study.

My participation has been explained to me, and all my questions have been answered. I am willing to participate.

_____________________________________ ____________

Print Name of Minor Age of Minor

_____________________________________ ____________

Signature of Minor Date

UNIVERSITY OF SOUTH CAROLINA

CONSENT TO BE A RESEARCH SUBJECT

Evaluating Writing Prompts and Graphic Organizers

If participants include those under 18 years of age: 1) The subject's parent or legal guardian will be present when the informed consent form is provided. 2) The subject will be able to participate only if the parent or legal guardian provides permission and the adolescent (age 13-17) provides his/her assent. 3) In statements below, the word "you" refers to your child or adolescent who is being asked to participate in the study.

KEY INFORMATION ABOUT THIS RESEARCH STUDY:

You are invited to volunteer for a research study conducted by Kyla Steppler. I am a doctoral candidate in the Department of Education, at the University of South Carolina. The University of South Carolina, Department of Education is sponsoring this research study. The purpose of this action research is to evaluate the impact of writing prompts and graphic organizers on [redacted] school's 7th and 8th grade students' mathematical academic achievement and their attitudes towards the authentic application of mathematics. You are being asked to participate in this study because you are a student in my pre-algebra class chosen for this study This study is being done at [redacted] and will involve approximately 15 volunteers.

The following is a short summary of this study to help you decide whether to be a part of this study. More detailed information is listed later in this form.

Summary:

- The study will take place for a duration of about eight weeks beginning in January.
- There will be no additional assistance needed for the study beyond what is completed as part of the pre-algebra course.
- The procedures of collected data will include a questionnaire regarding student perceptions of mathematics, specifically in regards quantitative literacy, completed both at the beginning and end of the study. There will also be focus group interviews about student experiences that should last a duration of about 15-20 minutes completed during class. This interview will be audio and video recorded. It will then be transcribed for accuracy purposes of details.
- The rest of the data will be collected from the course in the forms of writing exercises, graphic organizers, projects, discussions, and both formal and summative assessments.
- I do not see any troubling discomforts students would experience. However, I cannot control how one feels during focus group interviews of discussing thoughts with their peers.
- Added benefits to the participants of the study would be to help gain a better understanding of their perceptions of mathematics as they experience activities in the classroom and transfer it to their lives. This will help me as their teacher as well as our school advance as we gain an understanding of how and if improvements their learning experience should be changed. In addition, participants will gain the better understanding of themselves as they reflect upon their learning experiences and determine activities that help make themselves better learners.

DURATION:

Participation in the study will be conducted over a period of approximately eight weeks.

RISKS/DISCOMFORTS:

Risks for this study are minimal, however, there is never any guarantee. Two risks or discomforts identified are:

Focus Groups: Others in the group will hear what you say, and it is possible that they could tell someone. The researchers cannot guarantee what you say will remain completely private, but the researchers will ask that you, and all other group members, respect the privacy of everyone in the group.

Loss of Confidentiality: There is the risk of a breach of confidentiality, despite the steps that will be taken to protect your identity. Specific safeguards to protect confidentiality are described in a separate section of this document.

BENEFITS:

You may benefit from participating in this study by gain a better understanding of your perceptions of mathematics as you experience activities in the classroom and transfer it to life. In addition, participants will gain the better understanding of themselves as they reflect upon their learning experiences and determine activities that help make themselves better learners.

COSTS:

There will be no costs to you for participating in this study.

PAYMENT TO PARTICIPANTS:

You will not be paid for participating in this study.

COLLECTION OF IDENTIFIABLE PRIVATE INFORMATION

Your information as part of the research study will not be used or distributed for future research studies.

COMMERCIAL PROFIT:

There will be no form of commercial profit for the study.

RETURN OF RELEVANT RESEARCH RESULTS:

I will share all findings with participants of the study.

USC STUDENT PARTICIPATION:

Participation in this study is voluntary. You are free not to participate, or to stop participating at any time, for any reason without negative consequences. Your participation, non-participation, and/or withdrawal will not affect your grades.

CONFIDENTIALITY OF RECORDS:

Unless required by law, information that is obtained in connection with this research study will remain confidential. Any information disclosed would be with your express written permission. Study information will be securely stored in locked files and on password-protected computers. Results of this research study may be published or presented at seminars; however, the report(s) or presentation(s) will not include your name or other identifying information about you.

VOLUNTARY PARTICIPATION:

Participation in this research study is voluntary. You are free not to participate, or to stop participating at any time, for any reason without negative consequences. In the event that you do withdraw from this study, the information you have already provided will be kept in a confidential manner. If you wish to withdraw from the study, please call or email the principal investigator listed on this form.

I have been given a chance to ask questions about this research study. These questions have been answered to my satisfaction. If I have any more questions about my participation in this study, or a study related injury, I am to contact Kyla Steppler at [redacted] or email [redacted]

Questions about your rights as a research subject are to be directed to, Lisa Johnson, Assistant Director, Office of Research Compliance, University of South Carolina, 1600 Hampton Street, Suite 414D, Columbia, SC 29208, phone: (803) 777-6670 or email: LisaJ@mailbox.sc.edu.

I agree to participate in this study. I have been given a copy of this form for my own records.

If you wish to participate, you should sign below.

Signature of Subject / Participant Date

Signature of Qualified Person Obtaining Consent Date

My participation has been explained to me, and all my questions have been answered.

I am willing to participate.

Print Name of Minor Age of Minor

Signature of Minor Date