Exploring Similarities between Instruction in Grade 7 ELA and Mathematics Classrooms, and the Possible Benefits of Interdisciplinary Instructional Comprehension Strategies

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ABSTRACT:

This study took place in an English language arts (ELA) and mathematics classrooms at a suburban junior high school in southeastern Massachusetts. Surveys indicated that mathematical problems elicit nervousness more often than reading assignments do, and mathematical vocabulary is harder for students to understand than vocabulary of other subject. This research focused on integrating reading comprehension-strategies of vocabulary integration, graphic organizers, and visual aids within a mathematics curriculum to combat student apprehension.

The purpose of this study was to provide evidence-based, interdisciplinary mathematics and ELA lesson plans in alignment with Common Core Standards to a seventh grade algebra class. Pre-assessment results and field observation informed the development of six lesson plans integrating vocabulary, graphic organizers, and visual aids in correspondence with the curriculum map of the school district. Academic growth was determined by analyzing pre and post-test performance using a cross-comparative method. Anonymous student feedback, collected classwork, and photo documentation provided further evidence towards achievement of this research goal.

Key words: interdisciplinary instruction, algebra, graphic organizers, English language arts, middle school mathematics, Common Core Standards, PARCC
INTRODUCTION:

In light of the increasing technological demands of our global economy, careers in science, technology, engineering, and mathematics have been declared national priorities (Creager, et al., 2012, p. 2). Sammons (2013) and Gartland (2014) refer to three decades of local, state, and national studies—A Nation At Risk, Trends in International Mathematics and Science Study, and the Glenn Commission—that draw attention to “grave deficiencies” in the mathematics curriculum designed to prepare students for careers in these fields. The 2009 Program for International Student Assessment (PISA) statistically solidifies these claims, reporting that 23 of 64 countries participating in mathematical literacy testing achieved higher average scores than those of the United States (2013). Furthermore, the result of this study revealed that only 27 percent of U.S. students scored at or above a level 4 proficiency, and are therefore able to successfully demonstrate proficiency at “higher order tasks such as solving problems that involve visual and spatial reasoning in unfamiliar context and carrying out sequential processes” (Sammons, 2013, p. 19). These higher order tasks, represented in the Bloom’s taxonomy model in table 1, are at the heart of the efforts to modernize state standards and lessen the gap between what our students are taught and what they need to know to be competitors in the global workforce.
Sammons (2013) expresses that a lack of consistency in the description of mathematics and
science integration, however, will continuously lead to problems when designing, conducting,
and interpreting research in this area (Hurley, 2001, as cited in Burghardt, Hacker, Hecht, &
Russo, 2011, p. 115). Similar concern regarding the overall reading ability of students in the
United States sparked congressional intervention in 1997 and resulted in the creation of a
National Reading Panel (NPR) to assess the effectiveness of various instructional approaches.
Based on the findings and research by NPR, school systems began to heavily implement reading
and comprehension strategies into English Language Arts (ELA) curriculums by the early 1990s.
Skills aimed at decoding words and reading fluency in addition to comprehension techniques
became the foundation of literacy education at all levels. Prior to this literacy reform
The National Council of Teachers of Mathematics released “Recommendation for School
Mathematics of the 1980s,” followed by a document in 1989 entitled “Curriculum and
Evaluation for School Mathematics.” Combined, these documents stress the role of language in
problem solving, communication, and reasoning in mathematics, illustrated in Table 1 by Sammons (2014):

<table>
<thead>
<tr>
<th>Characteristics of Good Readers</th>
<th>Characteristics of Good Mathematician</th>
</tr>
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<tbody>
<tr>
<td>They call upon their prior knowledge to make meaning from text.</td>
<td>They call upon prior knowledge to understand concepts and solve problems</td>
</tr>
<tr>
<td>They are fluent readers.</td>
<td>They are procedurally fluent.</td>
</tr>
<tr>
<td>They have a mental image of what they are reading.</td>
<td>They create multiple representations of mathematics concepts and problems.</td>
</tr>
<tr>
<td>They use multiple strategies to understand and interpret text.</td>
<td>They use multiple strategies to understand concepts and solve problems.</td>
</tr>
<tr>
<td>They monitor their understanding as they read.</td>
<td>They monitor their understanding as they solve problems.</td>
</tr>
<tr>
<td>They can clearly explain their interpretation of the text to others.</td>
<td>They can clearly explain their mathematical thinking to others.</td>
</tr>
</tbody>
</table>

(Adapted from Minton, 2007, as cited in Sammons, 2014, p. 22)

Despite the multiple commonalities among the approaches outlined, these two reforms have been historically unbalanced and integrated in isolation from one another, perpetuating a disconnection between technological and literary subject areas that do not adequately represent mathematics outside of the classroom, where the manipulation of data to create and defend argument is a necessary skill.

Klein and Shanahan summarize the largest misconception responsible for such separation. They argue that “while reading and language arts are typically easy to integrate with other subjects, some have cautioned that integrating mathematics with other subjects may be
difficult to do in ways that lead to deep understanding of mathematics content” (Klein, 1996, Shanahan, 1997 as cited in Koellner et al., 2009). Sammons (2013), however, discredits this belief, acknowledging that “while reading strategies are seen as keys to success, they are rarely taught in subjects other than reading” (p. 20). The notion to infusion literacy in the mathematics classroom has received more attention in recent years, and researchers Thompson, Kersaint, Richards, Hunsader, and Rubenstein (2008) have begun to expose the opportunities literacy in a mathematics classroom presents to students to develop and defend ideas orally and in writing. If the decoding and analytical skills and strategies that influenced so much of their elementary education are carried through each technical classroom, students will be equipped with tried and true techniques to confidently decipher and explore mathematical concepts despite their increasing difficulty.

Connections between literary and technical subject areas can be thoroughly developed through the implementation of disciplinary literacy. Shanahan and Shanahan (2008) define disciplinary literacy as “advanced literacy instruction embedded within content-area classes such as math, science, and social studies,” which “offers cognitive strategies for any subject area, such as questioning, visualizing, and summarizing” (as cited in Hillman, 2013, p. 40). These cognitive strategies are critical components of all subject areas within the middle school years, and especially prevalent in the 7th grade curriculum. However, these cognitive strategies are rarely transferred to mathematics at the middle school level. An article published by the National Council of Teachers of Mathematics, “Principles to Actions, Ensuring Mathematical Success for All,” highlights the argument from Martin (2009) that students may be able to “carry out mathematical procedures” but will not truly be able to achieve proficiency in mathematics until they “know which procedure is appropriate and most productive in a given situation, what a
procedure accomplishes, and what kind of results to expect” (as cited in National Council of Teachers of Mathematics [NCTM], 2014, p. 42). Described as “computational fluency”, that the ability to reason with these concepts and decide which is the best for a given situation is strongly related to number sense and involves the same reasoning strategies so heavily relied upon in an ELA classroom. Students achieve this by “using objects, visual representations…and then [students] progress to reasoning strategies using number relationships and properties (NCTM, 2014, p. 43). Students “need procedures that they can use with understanding on a broad class of problem,” but can only achieve this if they are able to comprehend and visualize the reason why a certain procedure is used (NCTM, 2014, p. 45). Approaching mathematics without integrating fluency alongside the memorization of facts and procedural practice “undermines students’ confidence and interest in mathematics and is considered a cause of mathematics anxiety” (Ashcraft, 2002, Ramirez et al., 2013, as cited in NCTM, 2014, p. 43).

At this peak age of self-discovery and self-awareness, Butterworth (2006) surmises that great anxiety begins to surround mathematics as a result, and students associate success with luck or the natural left-brain, linear thinking tendencies of some of their peers (as cited in Smith & Turner, n.d., para. 7). This belief can be reevaluated if mathematical concepts are discussed through more familiar topics, and if these lessons can be recognized as functional and meaningful outside of a traditional workbook. The Organization for Economic Cooperation and Development (OECD) claims that students will gain “the capacity to identify and understand the role that mathematics plays in the world, to make well-founded judgments, and to use and engage with mathematics in ways that meets the needs of that individual’s life as a constructive, concerned, and reflective citizen” (as cited in Sammons, 2014, p. 19). The goal of the Common
Core State Standards is to improve students’ reasoning, communicating and problem solving through more flexible, yet rigorous standards.

THE INFLUENCE OF THE CCSS

The Common Core State Standards (CCSS) is a national effort towards educational reform. The CCSS aim to bridge the gap between subject areas in every state to ensure all American public school students are prepared for college or career readiness. Furthermore, these standards provide an equal opportunity for students to excel within a specific curriculum and for teachers to flexibly deliver specific content instruction. Though each state in the U.S. has been responsible for developing, adopting, and revising learning standards specific to what students in grades 3-12 should be capable of upon graduation since the early 2000, the definition of proficiency varied greatly from state to state until the Common Core standards were released. As of June 2014, forty-three states and territories adopted the CCSS in English Language Arts (ELA) and mathematics. Massachusetts is among the first of these states to begin the process of implementing the standards locally, resulting in the revision of a curriculum relied upon since the early 1990’s. This is accompanied by reservations from teachers who feel as though demands are unclear and inconsistent, and that tried and proven models of instruction is lacking.

Gartland (2014), a middle school mathematics coordinator and classroom teacher as well as a visiting lecturer at Lesley University, speaks for herself and many teachers when she suggests that the phrase “a mile wide and an inch deep” accurately depicts traditional mathematics curriculum in the United States (p.11). As students embark on their middle school years, the number of topics mathematics teachers are expected to cover increases simultaneously with the complexity, difficulty and specificity of the instruction. Efforts to enrich the subject
with integration of languages arts, social studies, history, art, or music is rare; subjects “move
toward more process-oriented, holistic, and collaborative approaches, [and] mathematics is often
left behind with its traditional workbooks, drills, and tests” (Kleiman, 1991, p. 48). The CCSS
mathematical standards no longer leave any room for what Gartland (2014) describes as
superficial memorization of concepts and algorithms. A large component of the CCSS reflects
the belief that disciplinary literacy can be utilized to improve adolescent literacy and critical
thinking across all content areas. This is most evident through the implementation of anchor
standards, which strategically highlight reading and writing complements to all subject areas, as
well as standards for literacy in technical subjects. Phrases such as “logical inferences”, “textual
evidence”, “analyze the structure of texts”, and “delineate and evaluate the argument,” are woven
through these standards, providing a roadmap to tie in literary through language and
communication strategies (MADOE, 2011a, p. 47).

**CHALLENGES OF SECONDARY MATHEMATICS: MIDDLE SCHOOL**

Critical mathematical concepts must be learned as a series of related ideas that progress
across grades rather than through disconnected and isolated exposure (Gartland, 2014). The
middle years represent dramatic increase in the cognitive flexibility that allows a deeper
conceptual understanding of subjects to flourish within this structure. However, Blakemore and
Choudhury (2006) note that adolescents move from concrete to abstract thinking and to the
beginnings of metacognition (the active monitoring and regulation of thinking processes) at
different paces. Furthermore, “the transition to middle school is a particularly daunting event
because of the shift in emphasis from the supportive, mastery-based orientation…to a
performance-focused setting characterized by increased expectations for academic productivity,
more intensive and teacher-directed instruction, and a greater focus on normative comparisons
and high-stakes outcomes” (Chen & Cleary, 2009, p. 292). The impact that this is likely to have on self-perception and motivation are further analyzed through Lent, Brown, and Hackett’s research, which claims “individuals are more likely to develop interest in an activity if they believe they are competent at the task and believe that performing the activity will produce valued outcomes” (as cited in Creager, et al., 2010, p. 2). Students often have difficulty making meaningful connections within and across mathematical experiences both in and out of the classroom, especially in comparison to literary based subject areas, which have standards that allow for more freedom to creatively incorporate student experiences and current events. The common core standards present new and considerable challenges in regards to skill level and engagement for the teachers of middle school students.

Most importantly, middle school students are at the peak age of self-discovery and self-awareness, and are thus likely candidates to feed into what Burns describes as math bias if topics are abstract and initially daunting to grasp (as cited in Smith & Turner, n.d., para. 7). Butterworth believes that the anxiety surrounding mathematical competence relies on the false societal belief that “certain basic mathematical abilities are inborn” (as cited in Smith & Turner, n.d.). This further emphasizes Hines (1985) exposure of “western society[’s] emphasi[s]” on a split between left brain and right brain thinking tendencies: the left brain is traditionally thought to be said to be responsible for ‘inductive, logical, linear thinking,” while the right brain is said to focus on “deductive, intuitive, and non-linear thinking” (p. 33). This divided way of thinking undoubtedly impacts teaching by allowing content to be “taught in a way that relies too heavily on rote memorization isolated from meaning,” thus catering to students who view concepts more linearly (Richardson, Sherman, & Yard, 2014, para. 3). But when mathematics is taught as a series of concepts rather than just a series of memorized rules, educators and students are capable
of integrating reasoning, communicating, and problem solving on a more abstract and realistic level.

MATHMATICAL LITERACY FOR A 7TH GRADE CURRICULUM:

An opportunity to implement disciplinary literacy for potential mathematical improvement can be very helpful for 7th grade algebra students. In 7th grade, mathematics becomes a combination of concrete operations and abstract mathematical topics. Algebra is fundamental to more complex math, and described as a widely accepted gatekeeper course for students employment opportunities (Richardson, et al., 2014, para. 1). Support for this is also found in 7th grade ELA standards which focus predominately on determining figurative and connotative meaning, interpreting and analyzing how elements in literature interact to create meaning, writing arguments and supporting with evidence, engaging in collaborative discussions, comparing and contrasting points of view, and clarifying meaning of multiple-meaning words (MADOE, 2011a, 48-67). The grade 7 mathematics curriculum frameworks specifically call for students to do much of the same with standards that focus on applying operations, understanding problems rewritten in various forms, assessing reasonableness of solutions, using variables to represent quantities in real world contexts, constructing equations to solve problems, and comparing and contrasting algebraic solutions to arithmetic solutions. Students are furthermore asked to identify sequences and patterns, graph and interpret findings, and extend analysis of patterns using tables, graphs, words, and expressions (MADOE, 2011b, p. 60-64). Digisi and Flemming (2005) deduce that these skills are based heavily on reading, writing, and analytical topics taught for years in ELA, and therefore must be transferrable to a mathematical setting as concepts become more abstract.
A mathematics classroom reliant only upon lectures, teacher led examples, and independent practice assigned in textbooks is arbitrary for use outside of the classroom. Hillman (2013) exemplifies the importance for students to read, write, and speak about mathematics through connections drawn among the CCSS standards, disciplinary literacy, and mathematical discourses, expanded on Table 2.
<table>
<thead>
<tr>
<th>CCSS Mathematical Practices</th>
<th>Disciplinary Literacy Discourses</th>
<th>Mathematical Discourses</th>
</tr>
</thead>
<tbody>
<tr>
<td>Make sense of problems and persevere in solving them</td>
<td>Expert problem solving</td>
<td>Multiple, creative approaches</td>
</tr>
<tr>
<td></td>
<td>Writing/speaking as scaffolding</td>
<td>Verifying one’s own work</td>
</tr>
<tr>
<td>Reason abstractly and quantitatively</td>
<td>Expert style of communication</td>
<td>Mathematical language</td>
</tr>
<tr>
<td></td>
<td>Text features</td>
<td>Symbolic notation</td>
</tr>
<tr>
<td></td>
<td>Questions posed by experts</td>
<td>Quantitative approach</td>
</tr>
<tr>
<td>Construct viable arguments and critique the reasoning of others</td>
<td>Communication in the Discourse community</td>
<td>Properties of mathematical language</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Logical connectives</td>
</tr>
<tr>
<td>Model with mathematics</td>
<td>Interdisciplinary links</td>
<td>Narratives</td>
</tr>
<tr>
<td></td>
<td>Real world applications</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Visual and digital literacy</td>
<td></td>
</tr>
<tr>
<td>Use appropriate tools strategically</td>
<td>Transition from prose to visual mediators</td>
<td>Proficient with mathematical tools</td>
</tr>
<tr>
<td></td>
<td>Visual and digital literacy</td>
<td></td>
</tr>
<tr>
<td>Attend to precision</td>
<td>Style of communication</td>
<td>Properties of mathematical language</td>
</tr>
<tr>
<td></td>
<td>Norms of quality</td>
<td>Symbolic notation</td>
</tr>
<tr>
<td>Look for and make use of structure</td>
<td>Content area knowledge</td>
<td>Understanding the nature of numbers as a rule-based system</td>
</tr>
<tr>
<td></td>
<td>Discourse routines</td>
<td></td>
</tr>
<tr>
<td>Look for and express regularity in repeated reasoning</td>
<td>Content area knowledge</td>
<td>Understanding recurring patterns in numbers</td>
</tr>
<tr>
<td></td>
<td>Discourse routines</td>
<td></td>
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</tbody>
</table>

(Table 2: Hillman, 2013, 400)
Hillman suggests, “any learning strategies should reinforce that getting the answer is only one step in understanding math” (p. 403). This sentiment is directly reflected in the structure of PARCC, straying away from the factual recall typical of multiple choice questions, and moving towards critical and analytical multi-part open response questions. For these type of questions, students must be able to reason, solve, and justify their responses through writing in a way traditional instruction does not call upon. While traditional instruction serves as necessary introductions and assessments for the application of strategies, reliance on only this limits students’ “ability to put mathematical knowledge and skills to functional use rather than just mastering them within a school curriculum” (1, as cited in Kaiser & Willander, 2005, p. 22). By instructing students in a way that strictly promotes numeracy but basing progress on standardized tests that heavily incorporate literacy, students only become frustrated, self-conscious, and intimidated by mathematics. Incorporating familiar reading and writing strategies, typical of an ELA setting, empowers students to “express their confusions, beliefs, and feelings with others” and teachers to gain a clearer picture of students’ difficulties (Bicer et al., 2013, p. 364).

INTEGRATING MATHEMATICAL LITERACY

Mathematics teachers are responsible for teaching mathematical operations, and further transforming the vocabulary, syntax, and visual representations unique to this content area in a way that is relatable and meaningful to students’ everyday lives. Unlike the topics and tasks typical of ELA, it is highly unlikely that students will see mathematical topics outside of school in the same way they are presented in a textbook. Most secondary mathematics teachers are especially hesitant to bridge this gap through literary means because most are trained in only one
or the other subject and are not experts in content. They often lack experience in the “higher level languages and literacy skills” that Richardson, Morgan and Fleener believe are necessary to adequately breakdown these structures (as cited in Bach, Philips, Bardsely, & Gibb-Brown, 2009, p. 469). Despite extensive literature on examples of successful, practice-based strategies for mathematical literacy in the elementary grades, Lynch and Star (2014) note that there has been relatively little discussion of this in the middle levels. DiGisi and Fleming (2005) claim that progress towards this goal can be achieved if instruction incorporates tools, rather than strict instruction, to recognize math vocabulary, procedural vocabulary, and descriptive vocabulary, as well as strategies to aid in the interpretation and response to complex, multi-step questions.

VOCABULARY

Language and communication are fundamental to the learning process because of their prevalence in our everyday lives. Thus, a focus on instruction in these two areas can provide an opportunity to draw commonalities among mathematics and ELA. In mathematics, the bulk of a student’s exposure to vocabulary is found in textbooks, which relies on language and sequencing that are in stark contrast to what is used in common conversation. Sammons (2013) describes the study of mathematics as based on structures, and is therefore a unique genre that presents information in a language foreign to their pragmatic knowledge. For middle school students, these texts are distinctly different compared to the narrative texts elementary students typically recognize in their textbooks. Unlike elementary school where mathematical concepts can be hidden within picture books and other children’s literature, it is very rare to find both an appropriate and engaging literary text that adequately incorporates and provides meanings for these uniquely abstract mathematical topics. The primary text students rely on for understanding, therefore, is a classroom mathematical textbook.
Terms that are frequent in everyday life suddenly have dual and unexpected meanings within this level of mathematics. Vocabulary grows in complexity during introductory algebra, introducing terms such as plane, slope, and rate, which have never been encountered alongside mathematical concepts prior to this class. To add to the confusion symbols are used heavily in introductory algebra. Sammons (2013) suggests that this is the perfect setting for students to employ a decoding process similar to using sight words. The combination of words and letters creates mathematical sentences, in which the order, or syntax, codes the appropriate way in which to read and solve. Students must recognize that unlike narrative and familiar texts, these technical texts are not always comprehended from left-to-right. Factoring in these components, it is critical that students recognize mathematics as its own language with a specific set of rules and basic vocabulary, and that strategies in which were originally used to decode and understand the basics of ELA are transferrable methods for mathematics. These strategies include word such as color coding, modeling problems, and creating graphics to make sense of mathematical situations.

**VISUAL AIDS**

College and career mathematics rely heavily on a variety of visuals as a way to quickly and adequately represent data, such graphs, tables, geometrics, and charts. Students are often overwhelmed by multiple ways in which the same set of data can be defined among these visuals and given little explanation as to why one is more preferred in certain instances over another. The CCSS requires students to both sketch and interpret these data representations, which is unlike visuals used in most other academic classes. Furthermore, Darling (2013) recognizes an opportunity to introduce various components of these visuals individually as a means of scaffolding prior to analyzing. By breaking components of these visuals into separate pieces
and using similar strategies, such as color coding, providing a key, using models, and creating graphics, students can become comfortable with symbols and syntax targeted in isolation before being brought together as a final mathematical computation.

Graphic literacy, or visual literacy, is described by Rakes, Rakes, and Smith (1995) as the ability to interpret and create visual messages that are found in an abundance of content area texts. This is an area students especially struggle with because they typically do not recognize embedded relationships among concepts and understand how to link ideas. Most importantly, visuals direct learner’s attention to and prioritizing critical information, building personal connections among ideas in the text, and building connections between the text and prior knowledge (Pang, 2013).

Where students tend to ignore illustrations and models because they believe these representations lack enough information to rely on, teachers can incorporate visuals through multiple strategies to justify their importance. Though most people have a tendency to think in words rather than pictures, visualization skills can be promoted through practice and better prepare students to embrace these representations as adequate. Kleiman states that using color graphics promotes achievement, and that simple visuals to engage students and provide a recognizable image to connect to a skill is effective (as cited in Stokes, 2001). Moreover, having text presented in a concise form elevates the tendency of mathematical texts to be overwhelming for students. Venn diagrams, maps and visual organizers, in text notation, and the use of highlighters allow students to create their own interpretation of a given concept. Furthermore, providing mathematical concepts in a visually appealing way allows students to compare and contrast solutions and note potential roadblocks in the problem during the brainstorming and pre-solving process (Stokes, 2001).
GRAPHIC ORGANIZERS

Darling (2013) notes one of the most important aspects of teaching and learning mathematics is to incorporate strategies that specifically target improvement in problem solving skills. When faced with a problem that is a combination of mathematical operations, vocabulary, and visual representations, students are likely to let such overload of information deter them from attempting the problem; students simply remain stuck until guided in first step to take. Manzo, Manzo, and Thomas suggest that in this instance, it is appropriate to return students to the context of the problem by considering the three major phases of reading that occur when faced with an equally daunting text in any other subject area: pre reading, through reading, and post reading (as cited in Darling, 2013, p. 179).

Beginning with pre-reading, teachers are able to discuss the key words that may arise in a problem and provide translation or direction to context clues that will help students gain understanding as to what mathematical operations may be encountered. Learners struggling with basic decoding skills and recognition of the key operational words will become less frustrated by what Darling (2013) describes as initial “roadblocks” of the problem, and gain confidence to continue (p. 3). Textbooks often follow this approach by providing definitions to vocabulary to be encountered in a section of the chapter, followed by models of mathematical operations from multiple approaches, and culminated by practice through word problems. But if this structure is created within in a graphic organizer as a strategy, a diagram typically associated with brainstorming and prewriting techniques, students have an opportunity to categorize and prioritize steps before putting them into practice. Students are essentially provided with a familiar structure to explore multiple approaches and the connections to vocabulary and mathematical operations in the same space. Thus, mathematics follows a brainstorming and
editing process that encourages the incorporation of visuals and vocabulary, and allows all aspects of solving a problem to form visible connections in one central space. Essentially, “visual representation diagrams can successfully assist students struggling with the organization of information,” among one of the many new struggles that adolescent students face (Darling, 2013, p. 3).

**METHODOLOGY**

This study of seventh grade English and math learning took place at a suburban junior high school in southeastern Massachusetts from April 2014- put the concluding date here. This school was chosen because of its participation in the PARCC testing in the spring of 2014. In addition, it is among few school districts to introduce the departmentalization of subject areas in seventh, rather than sixth grade. Thus, students are confronted with the structure and additional responsibility of departmentalized instruction simultaneously with an introductory algebra course and higher standardized testing expectations.

In order to gather evidence to develop a research question during the Adrian Tinsley Summer Grant program, surveys about mathematics and English perception and anxieties were distributed to more than 200 seventh grade students in April 2014. These surveys were coded and analyzed using comparative charts and tables through SPSS. Classroom observation notes collected over eight observations in all 7th grade ELA and mathematics courses offered at the school were analyzed alongside this data using a cross comparative method over the summer of 2014. A total of ten weeks were spent reviewing scholarly journals and literature on mathematical literacy, which was then compiled and synthesized into an initial literature review.
Further participatory observations of this mathematics and ELA class took place in the first weeks of September 2014. A review of the study by Philips, Bardsley, Bach, and Gibb-Brown entitled “But I teach math!” The journey of middle school mathematics teachers and literacy coaches learning to integrate literacy strategies into the math instruction” became the foundation for the continuation of this research during the fall 2014 semester. The continuation of this study employed the use of various qualitative research methods in one class of 15 students. This portion of the study specifically aimed to determine whether the integration of three observed ELA strategies of graphic organizers, visual aids, and vocabulary instruction improve student performance when faced with specific mathematics topics. The incorporation of close reading techniques typical of an ELA classroom, such as highlighting, boxing vocabulary words, and utilizing context clues to make meaning of a text, tested the universal value of comprehension strategies when faced with new and complex math topics, rather than only following specific problem solving steps. In doing so, students will have greater confidence and subsequent success when faced with a problem that is worded or written differently than those which they have practiced in class because they will understand the concepts and reasoning behind solving rather than relying solely on step-by-step guidelines.

The researcher spent the weeks from September 9th, 2015 to October 5th, 2015 as a participant observer twice a week in the ELA classroom and mathematics classroom for one team of 7th grade students. Upon reviewing the classroom textbook, the 7th grade mathematics curriculum map, and participating in team planning time with mathematics teachers, it was determined that the main focus of these lessons would revolve around chapter three of the textbook, the introduction of equations. Furthermore, the researcher narrowed focus of this study to a class of 15 students, chosen on the following criteria: class size, homogeneity in current
mathematical and comprehension skill as noted during observations, and adequately balanced in
gender.

Following these observations, a pre-test (Appendix A) was created from both MCAS and PARCC questions. A total of twelve sample MCAS and PARCC questions were used. These questions were specifically filtered to target the number system and expressions and equations portion of the MA curriculum frameworks. However, multiple choice questions were edited to allow for open response and explanation in an effort to gather more evidence for students’ strengths and weaknesses. The pre-test was administered to students on October 15, 2014 for one class period (timed at 45 minutes of testing and 5 minutes of test distribution and directions). Calculators were not permitted for this test.

Results of the pre-test, taken into consideration alongside field notes, informed the creation of six supplemental lessons designed to target observed areas of difficulty. Lessons were focused primarily on topics to be covered in chapter 3 of the textbook rather than focused explicitly on pre-test questions in order to realistically represent normal classroom instruction. Lessons were created in collaboration with the classroom teacher, but the researcher provided lead instruction of each. Student work was filmed, photographed, and collected to document student progress. Parents were notified of the details of the research project and were required to sign a letter to confirm their approval of their child’s participation in the study (Appendix B).

A post-test (Appendix C) was administered in December 2014 following these lessons. Results were analyzed using cross comparative methods to show student growth over the course of these two months. Both sets of tests were graded for accuracy according to the solutions provided on the Massachusetts Department of Education and PARCC websites. In addition, both
sets of tests were tracked for students’ attempts to answer the question, as a number of students left questions blank. The results of these grades and attempts were compiled separately per question, and then synthesized into percentages in an excel document. Finally, these percentages were compared through two bar graphs: one graph represented students’ attempts to answer each question during the pre-test compared to those attempts during the post-test, and the second represented the accuracy of each response on the pre-test to the accuracy of each response on the post-test.

Mathematics Lesson Plans with ELA Strategic Elements

The first lesson (Appendix D) “An Addition Number Line,” was derived primarily from the strategies used in the ELA classroom by focusing on vocabulary, such as rational number, which was highlighted in chapter 2 of the Big Ideas Mathbook by Larson and Boswell that students had just completed. This lesson lasted 52 minutes, and included a warm up and summary. Warm up questions were completed as soon students entered the room, which focused on previous conventions of the last chapter: adding, subtracting, multiplying, and dividing positive and negative integers. The researcher focused on the categories that numbers can fall into and the definitions of each, such as whole number, integer, and/or rational number. After discussing the warm up and asking three student volunteers to demonstrate their answers and work on the board the lesson began. Each student was given an index card with a value on it. These values were written as fractions, decimals, or mixed numbers. Students were then asked to add their designated value with ten other students in the class, and given a worksheet (Appendix D1) comprised of a chart to keep track of these sums. After moving around the room and adding these numbers with other classmates, students asked questions such as “I am adding a fraction to a decimal, how should I write my answer?” Students were encouraged to provide the
answer in whatever format they wanted, unknowingly beginning to form the connection that this vocabulary can be synonymous with another depending on the number value given. After 20 minutes, students then went back to their original seats. The researcher drew a bulls-eye diagram on the board, with 6 values written within each ring, but no further explanation. As a class, students were asked to determine the similarities and differences among numbers in each ring of the bulls-eye. Within the next ten minutes, students recognized that in the innermost ring, only positive, whole numbers were listed. In the next ring, both positive and negative numbers were listed. In the next ring, both positive and negative whole numbers, as well as fractions and decimals, were listed. The researcher then discussed the definition of each number category, asking students to place one of the numbers on their list within the circle on the board. Finally, a series of five different colored sticky notes were laid out on a desk in the front of the room: a different color for fractions, for decimals, for integers, for rational numbers, and for whole numbers. Students were asked to choose three values from their list of sums, writing each value on every color sticky note that defined which categories the value could fit into. For example, if a student chose to list the sum “5”, their number could fit within each category, as 5 could also be written as a decimal (5.0) and a fraction 5/1. A negative fraction, however, would only be listed appropriately if the student placed it on the sticky notes dedicated to rational numbers look at definition for integer - whole numbers and their opposite and fractions. Finally, students determined where on a number line these sums would be listed, placing each of their sticky notes in a line at the appropriate place. The result was a color-coded number line, with a series of values properly placed that students could visually recognize that numbers may be represented in multiple ways and defined by more than one math term. This combination of graphic organizers, visuals, and vocabulary mimicked much of their previous work in the ELA classroom, and
provided an opportunity for brainstorming and student investigation that would not traditionally have been achieved.

Lesson 2 (Appendix E), “Algebruno”, included an activity on terms prior to teaching section 3.2 of the chapter. Referencing the popular card game, Uno, the researcher designed two sets of cards that represented terms rather than values. A series of six different terms were written in four different colors within each stack of cards, along with cards typical of the original game, such as reverse and wild. A worksheet was given to each student listing the rules of the game in case any student was unfamiliar with the traditional rules. Then, students were split into two groups and desks were arranged so that students were sitting in a rectangle. Students in each group (7 or 8 per group) were given seven cards to begin the game, and the remaining deck was placed in the center desk. One student began the game by picking the card on the top of the deck and flipping it over. The student to his or her immediate left was then responsible for matching this card, either by color, or by term, which was initially explained to students as having the exact same letter next to the number. Students kept track of the card that was chosen from the deck, and the card they placed to match it, on the worksheet that listed directions. The conversations during this game reflected students’ understanding of game rules, which thus reflected the rules they would be expected to remember as we embarked on solving equations. By providing vocabulary instruction at the end of the lesson, students realized that they had uncovered the importance of these vocabulary words in a mathematical context prior to being told the definition, and could use evidence from the game to support why certain expressions could be simplified and others not; this strategy is a direct reflection of context clue strategies employed in their ELA classes.
After three rounds of this game, the researcher then turned students’ attention to the front of the room. Using the chart on the worksheet, students were asked to add together any examples on their list they believed that they could according to the rules of the game. By choosing to add together only the terms that had the same letters, such as “3xy” and “5xy,” students began making the connection that only like terms could be combined. The researcher then discussed this discovery with students, providing multiple supplementary examples of this on the board during the last ten minutes of class, including three complex examples that students determined should be combined or not combined with members of their group. By allowing students to make these inferences as a larger group, discussions were truly student led. Furthermore, the additional discussion and practice at the end of class allowed students to draw connections from the purpose of the game to how this content was relatable to future mathematical concepts.

The third lesson (Appendix F) of this research study was “Building Equations through Expressions”. This lesson continued to incorporate vocabulary and visual aids. This lesson was also lecture based for more than half of its duration. Understanding the definition of a one-step equation is a critical standard in the 7th grade Massachusetts Curriculum frameworks, and ideal for discussing through the use of diagrams and visuals that are typical of brainstorming activities in an ELA classroom. This is primarily due to the fact that fundamentals of algebra and the writing process, where graphic organizers are typically utilized, have a brainstorming process that looks strikingly similar: determining and giving detailed explanations of the who, what, where, when, how, and why is a model that Sammons (2013) argues ELA and mathematics teachers can both rely on (31). The introduction to equations through graphic organizers was based from the six-step process for learning new words according to Marzano and Pickerings...
(2005) in figure 1, and adapted into a Frayer Diagram introduced by Sammons (2014) in figure 2.

The diagram of equations allows students to break down the parts of an equation in the same way they are used to breaking down parts of a word with roots and prefixes in ELA, noting how the smaller components combine to make meaning for the mathematical sentence. The introduction of graphic organizers intentionally implies that solving a math problem is a process, similar to writing, where brainstorming, drafting, revision, and editing are required. Students were reminded of this throughout the lesson as teacher-led examples were displayed on the board. Finally, students volunteered to personify the equation themselves, holding up a piece of an equation as other students in class rearranged them and directed them to divide, add, subtract, combine, etc., in order to solve the problem. When a mistake was made, students were prompted to rearrange to their original place in the line so students could visualize everything in the problem from the beginning. Next students were given an equation broken down into a diagram (Appendix F1). Students worked individually to determine where the vocabulary words to
describe this equation were most appropriate. After completing this independently, the researcher began to deliver traditional instruction in front of the class. The researcher asked for one student volunteer per line to demonstrate where the vocabulary term fit the best, prefaced with a question regarding previous knowledge of the term in question, or where else in their everyday life a student may have heard this term. For example, prior to calling on a student to demonstrate where a vocabulary word belonged on the diagram, the researcher inquired “Who can prove they are the best ELA student of all time by using your previous knowledge of roots and prefixes to determine what equal means? We know it means something equals something else, but what does that mean if we have determined that this entire diagram represents an equation? How does this differ from an expression?” By prompting students to think of the vocabulary as something broken down using previous knowledge, students could easily recognize that expression is “an expression that contains numbers, operations, and one or more symbols” whereas an equation is, “A mathematical sentence that uses an equal sign to show that two expressions are equal” (Glossary flashcards, n.d.). These graphic organizers could be adapted for any mathematical concept, and show the relationship between the basic vocabulary and high order thinking skills and processes of one mathematical topic in one central location.

After the diagram was completed and discussion had ended, the researcher then distributed a graphic organizer with the steps of solving equations (Appendix F1). Students followed along as she delivered guided notes, listing the steps to solving an equation in the designated boxes of the graphic organizer. Students listed the steps and solved the example as a class, and then worked in partners to complete two more equations. Finally, with ten minutes left in class, students volunteered to be part of a physical demonstration of solving an equation. Seven students participated in holding a piece of an equation in the front of the room for the
Running head: EXPLORING SIMILARITIES BETWEEN INSTRUCTION

class. Without any teacher assistance, students in the audience worked collaboratively to direct students on each side of the equation to find the solution. Students were asked to sit down, or pick up another card if they had been subtracted from or added to the equation respectively. Finally, only the students holding the variable, the equal sign, and the solution were left standing. By allowing for movement during this lesson, students realized the importance of physically moving terms from one side of an equation to another, witnessing students being combined or subtracted from their position and ultimately understanding that only three values should be left standing for an equation to truly be considered solved.

The fourth lesson (Appendix G) was the most student-driven of all six lessons. This lesson was “Equation Application”, and inspired by websites geared toward lesson planning and sharing. A series of three color by number pictures were coded with equations rather than only whole numbers. Students worked individually to solve equations with designated colors, and the solutions to each corresponded to numbers on the picture. For example, if one equation was listed with the color purple and the solution was three, all of the areas labeled with a three on picture would be colored purple. This lesson was adapted later in the semester for another activity that utilized the structure of a maze rather than color-by-number, placing a series of equations at different points along the route with the correct solution inside the arrow that pointed to the direction in which to continue. Both of these activities encouraged independent work, the utilization of notes and collaboration with other students, and the importance of double checking and showing all work when completing equations. Most importantly, this lesson heavily incorporated visual strategies. For example, if a student had made an error on an equation that coded for the apple in the cornucopia, students would recognize that an error was made if the color was not red. This encouraged students check his or her work to ensure their
picture would not be colored incorrectly. A subsequent lesson of this, and equation-coded maze, proved much more of a challenge. Students did not have as obvious of a signal that their work was incorrect if they were to take the wrong path in the maze, encouraging them to double check work before continuing on. But most importantly, both of these lessons used visuals to reinforce the reasoning behind solving an equation: to use mathematics to find a valid and solution to a problem. Therefore, if a student found the solution to an equation that was coded for coloring an apple of the cornucopia called for the color purple, they were able to immediately recognize that this did not make sense, and were encouraged to plug their solution into the equation to ensure that the number made sense in the equation itself. By doing so in a low-stakes situation, students were also able to see the value in problem solving as a process that involves editing and revision just as writing in an ELA classroom, and utilize their notes from previous lessons that included graphic organizers as a guide to reaching their solutions.

The lesson that immediately followed, lesson 5 (Appendix H) also included student collaboration, and the process of providing, reviewing and editing work. Students were divided into groups of two or three and participated in a gallery walk. The mathematics teacher and the researcher collaborated on this lesson, deciding upon six questions that adequately spanned material within the chapter, and placing each on a piece of construction paper at different points in the room. Students traveled with partners and white-lined paper to each separate “gallery,” where they were required to note mathematical vocabulary, solve the problem at hand, and also note any instances where mistakes could be made that would result in the wrong answer. The researcher and mathematics teacher rotated about the room to ensure students were on task and understood what the question was asking. By requiring students to explain where mistakes could be made, rather than just the steps they took to solve the problem, students practiced the type of
technical writing mathematics requires. Students used mathematical and procedural vocabulary to discuss their conclusions, and were required to reflect on the proper steps to take when solving a problem to be able to decide which steps are incorrect.

Lesson 6 (Appendix I), a two-part lesson, required students to apply the skills they learned and used in the previous five lessons. With a partner, students were given an index card with a value listed on it. On the first day of this lesson, the researcher used the overhead projector to work through an example using the number fifty-four. She prompted students to work backwards to create an equation that would result in a solution of this value, meaning that the variable in the equation would have to represent fifty-four. First, the researcher asked students to decide on a value to be placed after the equal sign in the problem. In this instance, students chose one hundred-sixty. Next, she projected the equation “x ___ = 160”, as a visual guide to the following steps. After this, the researcher asked students to decide on two computations they would like to incorporate in their equation, listing the options of addition, subtracting, multiplication, and division. As a class, students chose addition and division. The researcher then posed the question, “54 divided by what, added to what, will give you 160?” Working as a class and using their calculators, students chose to divide fifty-four by 6, and then were prompted to find out how much more it would take to get to 160. Students utilized turn to talk during this portion of the lesson, but the bulk of ELA strategies was utilized once students compiled a list of procedural words that could be found in a word problem rather than “divided by” and “plus” as to make a word problem more interesting. Some examples of suggestions were “put into groups of 6” and “found an extra 151.” Students were required to list their procedural vocabulary in a graphic organizer as they begin creating their word problem, and were also given a detailed list of vocabulary to choose from.
From here, the researcher chose seven apples to apples cards, a popular card game that involves nouns and adjectives, to design a creative word problem to develop this mathematical scenario. After this demonstration, students were asked to begin working in pairs to work backwards from the solution they received using a guided graphic organizer (Appendix I2). The final result was a solvable 3 or more sentence word problem consisting of procedural vocabulary, proper mathematical conventions, and nonsensical information.

Designing creative word problems took students an entire 52 minute class. During the next class, students were asked to present their word problem to other groups of students in the class to be solved. Using a graphic organizer designed the same way, but flipped upside-down as to promote students working “forwards” instead of “backwards”, (Appendix I2) students were asked to highlight procedural vocabulary, box in important values, and underline any valuable information listed in the problem, just as the techniques used for close reading and understanding new vocabulary in the ELA classroom. Since these word problems were meant to include nonsensical and silly information to throw the reader off, students truly understood the value of incorporating close reading techniques, such as highlighting, boxing words, and underlining context clues to sift through the word problem and focus on the most important details. Furthermore, by working backwards, students understood the process of creating a word problem and were able to develop a better understanding of the purpose of the end result.
Results

The results of the pre and post assessment, as well as the multiple instances for collaborative group work and in-depth instruction of vocabulary, real world content, and mathematical skills provide evidence for the success of cross-curriculum instruction of ELA strategies with mathematical concepts within an introductory algebra course.

After excluding pre-test data from two students who had been moved from class and one student who was absent for the post-test and unable to make it up under the same circumstances, 12 samples of pre and post test data were analyzed. The pre and post-tests were graded for accuracy and completeness in separate categories. The researcher and mathematics teacher took the test individually and discussed solutions, then compared these results once more to the solutions available on Massachusetts Comprehensive Assessment System Question Search located on the Massachusetts Department of Education website.

The results of this data collection are shown in Figure 3 and Figure 4 below. The percentages that these graphs represent are displayed in Figure 5 and Figure 6. Figure 3 compares the number of questions students answered correctly on the pre-test to the number of questions students answered correctly on the post-test, organized according to question number on using an excel spreadsheet. Figure 4 compares the attempts students made to answer questions on the pre-test to the attempts students made to answer questions on the post-test in a similar arrangement. As both Figures show, students made improvements on almost all questions by the post-test, most evident in the category of question attempts. This data coincides with the literature that claims student willingness to attempt questions, and therefore their
confident in mathematical ability, if mathematical literacy is incorporated into the introductory algebra curriculum.

(Figure 3: Solution Accuracy)  (Figure 4: Attempted Solutions)

(Figure 5: Pre-Test Data)  (Figure 6: Post-Test Data)

Of the 14 questions scored (question 10 broken into parts A and B), five questions failed to show improvement during the post-test. However, this can be reasoned by the content of the lessons, which did not integrate opposite quantities, and negative integers as heavily as the chapters to follow. While all lessons, and most specifically lesson 1 (Appendix D), lesson 4 (Appendix G), and lesson 5 (Appendix H) introduced the rules of negative integers and
reciprocals when adding, subtracting, multiplying and dividing, the lesson was not focused on manipulating these integers in a way that explicitly focused on crafting rules for data sets or justifying a reciprocal representation of data. For example, question 1, which was altered during the post-test to ensure answers that specifically addressed the vocabulary of lesson 1, was marked correct only if the student circled all three categories that the value .375 could be represented by. Most students were able to identify two of the three, which when compared to the pre-test results, showed marked improvement in student’s vocabulary recognition. However, when asked to manipulate the given expression in question 5 (Appendix A), students struggled to comprehend the alternative representation of a fraction as the definition and explanation of the term reciprocal was not focused during any of the six lessons; this term was introduced with unit rates in a chapter taught after this study, as outlined by the textbook. Furthermore, Question 3, which addressed positive and negative integers in a word problem showed improvement by one student. While the term “opposite” was used heavily during lesson 3 (Appendix F) in regards to balancing an equation, this student grasped the concept that in this process, the term being moved is left as a zero value on one side and the opposite of its value on the other to ensure that values are never truly lost. By utilizing the vocabulary of this lesson and applying the mathematical concept behind it, the student deduced that depositing money and withdrawing the same amount of money is similar to recognizing a term to be separated on one side of an equation and moving it to the other side, resulting in a balance of values. The remaining sample responses tended to lean toward response D, where the scenario outlined not attempting 4 questions on a test in which each question was worth 4 points. Question 4, which allowed students to illustrate a scenario that would also represent opposite quantities, showed improvement among all students in their visual representations of positive and negative integers.
Question 5 required students to use a visual to continue a pattern in another 4 steps. This question was successful, as there were an equal amount of attempts from the pre and post-test and this question showed a 33% improvement in accuracy during the post-test. Question 7, 8, and 9 all showed similar improvement, as it also involved the manipulation of visuals to find greatest common factors and graph data. Question 6 and also question 10a, which required students to find a unit rate to then use for question 10b, showed improvement by only one student, as these topics had not been included in the six outlined lessons; concept of a unit rate was heavily focused in both, which was discussed in chapter 4 after this study was completed. Finally, question 11, which required students to find the input-output rule of a chart of values, focused on negative integers. Decline in accuracy from pre-test to post-test was simply due to mistakes in sign changes with the integration of negative integers.

When considering the material focused in all six lessons the post-test results show marked improvement in the questions that truly targeted expressions, equation, vocabulary, and visuals aids. Figure 4, which depicts the number of students who attempted each question of the total 12 samples, provides evidence for improvement in every question. This category defined correctness as the display of any work, answer, and/or valid attempts at answering the question provided. A question left totally blank was counted as a failed attempt. Question 2, which involved the input and output rule of positive integers, held the same number of attempts during the pre and post-test.
Discussion

While this data only represents a small sample of the 7th grade class, the results displayed in both figures provide evidence that the integration of these strategies would be helpful to a larger sample. Though mathematical literacy and the research involving cross-curriculum instruction is increasing, there is still much work to be done on these topics in the field of secondary education. The discussion of cross-curriculum instruction tends to focus solely on an elementary, self-contained classroom structure, where content is more easily transferrable across subject areas because only one teacher is responsible for providing the instruction in all subject areas.

As I continue to teach mathematics in a 7th grade classroom, the impact of cross-disciplinary connections is evident in student participation and willingness to take risks on new topics, thus granting students the opportunity to form their perception of mathematics on more than fundamental number sense gained in an elementary setting. Bridging the gap among subject areas can impact student confidence and performance, help students draw real world connections that will serve them in their high school, college and careers in years to come, and allow students to retain an open mind towards technical fields.

Designing a mathematics curriculum that ensures this cross-curricular instruction through mathematical literacy is a crucial task. The support of a team of teachers in both ELA and mathematics would be invaluable to collaborating on a curriculum that would incorporate foundational elements of mathematical concepts and comprehension strategies. The result would support a perspective of mathematics for teachers and students that more adequately meets the expectations of mathematical understanding in preparation for college and careers. Vocabulary,
visual, and comprehension strategies in mathematics are the most common and necessary tools for building the comprehension skills necessary to help students develop a deeper conceptual understanding of mathematics, particularly algebra, and therefore, must find a way into our mathematical curriculum if we are to ensure student success outside of the secondary classroom setting.
1. A bottle contains 0.375 liters of juice. What is another way to express 0.375?

2. Blake organized a checkers tournament. Every player will play each of the other players once. Blake made the table shown below to calculate the number of games to be played based on the number of players.

<table>
<thead>
<tr>
<th>Number of Players</th>
<th>Number of Games to Be Played</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>4</td>
<td>6</td>
</tr>
<tr>
<td>5</td>
<td>10</td>
</tr>
<tr>
<td>6</td>
<td>15</td>
</tr>
<tr>
<td>7</td>
<td>21</td>
</tr>
</tbody>
</table>

What is the number of games to be played with 10 players? Explain how you found your answer.

3. Which statement best describes a situation in which opposite quantities combine to make zero?

A. Shawna made 8 cups of soup and divided the soup into 8 containers.
B. Melanie deposited $10 in her savings account and then withdrew $10 from the account.

C. Peter scored 2 goals in the first period of a hockey game and 2 goals in the second period.

D. Marcos missed 4 questions on a test in which each question was worth 4 points.

Draw a representation of the correct situation to support your answer below:

4. Caleb made an arithmetic pattern using cards with the letter $\times$ on them. The first four steps of his pattern are shown below.

\[ \begin{array}{cccc}
\text{Step 1} & \text{Step 2} & \text{Step 3} & \text{Step 4} \\
\times & \times & \times & \times \\
\times & \times & \times & \times \\
\times & \times & \times & \times \\
\times & \times & \times & \times \\
\end{array} \]

Caleb continued his pattern. What is the total number of cards in Step 8?

A. 2
B. 2
C. 2
D. 3

A. 1
B. 4
C. 5
D. 2
5. Which of the following is equivalent to the expression below? Using specific math vocabulary, explain in writing how you know.
\[ \frac{1}{5} \cdot 62 \]
A. \( 62 \div 5 \)
B. \( 62 \div \frac{1}{5} \)
C. \( 5 \div 62 \)
D. \( \frac{1}{5} \div 62 \)

6. Alice made 24 cupcakes.

- She frosted \( \frac{1}{2} \) of the cupcakes.
- She put sprinkles on \( \frac{1}{3} \) of the frosted cupcakes.
- She ate \( \frac{1}{4} \) of the frosted cupcakes that had sprinkles.

What is the total number of cupcakes that Alice ate? Show your work and explain how you found your answer.
The diagram above represents a relationship between 2 numbers. What numbers does this diagram represent? What does the overlap between them mean?

8.
Carolyn recorded the temperature, in degrees Fahrenheit, at noon on each day last week. The temperatures are shown in the box below.

\[77, 72, 81, 82, 77, 75, 69\]

Name one type of graph that Carolyn can use to represent this data, and then create it below.
9.

Mr. Ruiz is starting a marching band at his school. He first does research and finds the following data about other local marching bands:

<table>
<thead>
<tr>
<th></th>
<th>Band 1</th>
<th>Band 2</th>
<th>Band 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of brass</td>
<td>123</td>
<td>42</td>
<td>150</td>
</tr>
<tr>
<td>instrument players</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Number of percussion</td>
<td>41</td>
<td>14</td>
<td>50</td>
</tr>
<tr>
<td>instrument players</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

A. Mr. Ruiz realizes that there are _____ brass instrument player(s) per percussion player in bands 1, 2, and 3.

B. Mr. Ruiz has 210 students who are interested in joining the marching band. He decides to have 80% of the band be made up of percussion and brass instruments. Use the unit rate you found in Part A to determine how many students should play brass instruments. Show or explain all your steps.

10. An input-output table is below.

<table>
<thead>
<tr>
<th>Input</th>
<th>Output</th>
</tr>
</thead>
<tbody>
<tr>
<td>-2</td>
<td>-6</td>
</tr>
<tr>
<td>-4</td>
<td>-8</td>
</tr>
<tr>
<td>-8</td>
<td>-12</td>
</tr>
<tr>
<td>-16</td>
<td>-20</td>
</tr>
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What is the rule for the relationship between the input number and the output number?
11. Valerie and Grace have part-time jobs. Valerie earns $2 less per hour than Grace earns. Let $g$ represent Grace's hourly wage in dollars. Which of the following expressions represent Valerie's hourly wage?

A. $2g$
B. $2 - g$
C. $g - 2$
D. $g / 2$

12. Mary's chores include taking out the trash every third day and washing the dishes every fourth day. She took out the trash and washed the dishes on February 7. Based on Mary's schedule for doing chores, what is the next date that she will do both chores on the same day?

A. February 10
B. February 12
C. February 14
D. February 19

(Adapted from sample items from Pearson Education, Inc., 2015; Massachusetts Department of Elementary & Secondary Education, 2011)
Dear Parent/Guardian of [name removed] Mod 5 student,

My name is Danielle Caron and I am currently a student at Bridgewater State University majoring in secondary education and English. I am working on my honor’s thesis and am looking to integrate specific comprehension tools more typical of an English classroom, such as graphic organizers, an emphasis on vocabulary, and visual aids, into a math classroom.

I will be developing some lesson plans from the techniques observed in Ms. Sullivan’s classroom, and will be introducing them to [name removed] mod 5 students. Your child will be asked to complete a short pre and post assessment, based from sample 7th grade MCAS and PARCC questions found on the Massachusetts Department of Education website. They will participate in some lessons taught by me using graphic organizers, an emphasis on vocabulary, and visual aids to help them develop problem solving strategies in math.

Every contribution to this project made by your child, such as their pre and post assessments, class work, critiques of these strategies, etc. will remain completely anonymous to anyone other than myself, [mathematics, ELA, and principal names removed], and my mentor from BSU., Dr. Patricia Emmons.

Working with the staff and students of [school name removed] provides an amazing opportunity for me to develop effective skills and teaching methods prior to beginning my student teaching requirement this spring, which pending official placement, will hopefully continue to be in this wonderful district. I am looking forward to working with mod 5 math students under the guidance of [mathematics and ELA teacher names removed] and hope this research will be beneficial to everyone involved!

Thank you for your time,

Danielle Caron

Parent

Signature: _____________________________________________________________
1. A bottle contains 0.375 liters of juice. Circle all of the number categories in which 0.375 can be represented.

   Rational Number  Whole Number  Integer  Fraction  Decimal

2. Blake organized a checkers tournament. Every player will play each of the other players once. Blake made the table shown below to calculate the number of games to be played based on the number of players.

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What is the number of games to be played with 10 players? Explain how you found your answer.
3. Which statement best describes a situation in which opposite quantities combine to make zero?

A. Shawna made 8 cups of soup and divided the soup into 8 containers.

B. Melanie deposited $10 in her savings account and then withdrew $10 from the account.

C. Peter scored 2 goals in the first period of a hockey game and 2 goals in the second period.

D. Marcos missed 4 questions on a test in which each question was worth 4 points.

4. Draw another situation where opposite quantities combine to make zero.

4. Caleb made an arithmetic pattern using cards with the letter \( \times \) on them. The first four steps of his pattern are shown below.

\[
\begin{align*}
\text{Step 1} & : x & & x \\
\text{Step 2} & : x & & x & & x \\
\text{Step 3} & : x & & x & & x & & x \\
\text{Step 4} & : x & & x & & x & & x & & x & & x
\end{align*}
\]

Caleb continued his pattern. What is the total number of cards in Step 8?

A. 2

B. 4

C. 5

D. 2
5. Which of the following is equivalent to the expression below? Using specific math vocabulary, explain in writing how you know.
\[
\frac{1}{5} \cdot 62
\]
A. \(62 \div 5\)
B. \(62 \div \frac{1}{5}\)
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What is the total number of cupcakes that Alice ate? Show your work and explain how you found your answer.
7. 

What does the diagram above represent about the relationship between these two numbers? What mathematical term can be used to name the numbers in the middle circle?

8. 

Carolyn recorded the temperature, in degrees Fahrenheit, at noon on each day last week. The temperatures are shown in the box below.

77, 72, 81, 82, 77, 75, 69

Name one type of graph that Carolyn can use to represent this data, and then sketch it below.
9. Mr. Ruiz is starting a marching band at his school. He first does research and finds the following data about other local marching bands

<table>
<thead>
<tr>
<th></th>
<th>Band 1</th>
<th>Band 2</th>
<th>Band 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of brass instrument players</td>
<td>123</td>
<td>42</td>
<td>150</td>
</tr>
<tr>
<td>Number of percussion instrument players</td>
<td>41</td>
<td>14</td>
<td>50</td>
</tr>
</tbody>
</table>

A. Mr. Ruiz realizes that there are ____ brass instrument player(s) per percussion player in bands 1, 2, and 3

B. Mr. Ruiz has 210 students who are interested in joining the marching band. He decides to have 80% of the band be made up of percussion and brass instruments. Use the unit rate you found in Part A to determine how many students should play brass instruments. Show or explain all your steps.

10. An input-output table is below.

<table>
<thead>
<tr>
<th>Input</th>
<th>Output</th>
</tr>
</thead>
<tbody>
<tr>
<td>-2</td>
<td>-6</td>
</tr>
<tr>
<td>-4</td>
<td>-8</td>
</tr>
<tr>
<td>-8</td>
<td>-12</td>
</tr>
<tr>
<td>-16</td>
<td>-20</td>
</tr>
</tbody>
</table>

What is the rule for the relationship between the input number and the output number?
11. Valerie and Grace have part-time jobs. Valerie earns $2 less per hour than Grace earns. Let $g$ represent Grace's hourly wage in dollars. Write an expression to represent Valerie’s hourly wage.

12. Mary’s chores include taking out the trash every fifth day and washing the dishes every second day. She took out the trash and washed the dishes on February 7. Based on Mary's schedule for doing chores, what is the next date that she will do both chores on the same day?

A. February 10

B. February 17

C. February 14

D. February 19
13. Use the triangle below to solve the following problem:

“The cooking club made some pies to sell at a basketball game to raise money for the team. The cafeteria contributed four pies to the sale. Each pie was then cut into five pieces and sold. There were a total of 60 pieces to sell. How many pies did the club make?

What is the word problem asking you to find?
What are the numbers given?
What key words tell you what to do with these numbers?
Write your equation
Solve for X

14. The most useful lesson/activity that Ms. Caron brought in was ________________________ because ________________________

(Massachusetts Department of Elementary and Secondary Education. (2011a, March 5).)
Lesson 1: An Addition Number Line

MA CURRICULUM STANDARDS

- Apply and extend previous understandings of addition and subtraction to add, subtract, multiply, and divide rational numbers; represent addition and subtraction on a horizontal or vertical number line diagram
  - Apply properties of operations as strategies to add and subtract rational numbers

GRADE 7 MATH PRIORITY STANDARDS FOR TEACHERS

The Number System

- Perform operations with rational numbers and extend them to real life applications (integers, fractions, decimals) (7.NS.1 - 2)
- Know and apply the rules for integers, fractions, and decimals. (7.NS.1 - 2)

STANDARDS FOR LITERACY IN SCIENCE AND TECHNICAL SUBJECTS

- Determine the meaning of symbols, key terms, and other domain-specific words and phrases as they are used in a specific scientific or technical context relevant to grades 6–8 texts and topics.
- Integrate quantitative or technical information expressed in words in a text with a version of that information expressed visually (e.g., in a flowchart, diagram, model, graph, or table)

2. Write informative/explanatory texts, including the narration of historical events, scientific procedures/experiments, or technical processes.
  - Use precise language and domain-specific vocabulary to inform about or explain the
### Key Content Vocabulary:
- **Rational number**
- Integer
- Whole number
- Decimal
- Fraction

### ELA strategies:
When introducing this vocabulary, students first rely on context clues. Questions such as, “what do these separate rings have in common,” and “why do you think this example is not placed in this other ring” are used to initiate students thinking. Turn and talk is used to allow students to brainstorm with classmates rather than rely on lecture. Finally, words are defined in their familiar context. Once the conventional mathematical definition of this vocabulary is given, students are asked to place these definitions in their own words, forming a meaningful sentence to promote its meaning from an individual perspective.

### Materials/Equipment:
- Construction paper
- Guided worksheet
- Index cards with numerical value
- Sticky notes

### Real World Connection
Students will encounter this vocabulary as it is embedded into word problems. When asked to suggest an appropriate integer, or to translate a number into a rational number (ratio, fraction, etc), students will be unable to complete the problem without knowing these definitions. Furthermore, as students begin to encounter positive and negative numbers, fractions and decimals, and the concept of absolute value, it is important for students to recognize the characteristics and representations of which numerical values can take form. Conversions among different representations of numbers may be necessary when measuring ingredients, converting measurements, or even calculating sale prices quickly and efficiently.

### Instructional Procedure

<table>
<thead>
<tr>
<th>Duration</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>5 Min</td>
<td>Connection to prior learning or background building activity:</td>
</tr>
<tr>
<td></td>
<td>1. Warm up questions</td>
</tr>
<tr>
<td></td>
<td>This lesson draws connections to the previous two chapters by utilizing the vocabulary students have already encountered (whole number, rational number, etc.). These vocabulary terms will be used heavily during this chapter, but will be integrated into expressions and equations rather than held in isolation. It is crucial that students have a handle of these definitions before moving forward to the first section of chapter 3.</td>
</tr>
</tbody>
</table>
### 10 Min
1. **Discuss math vocabulary:** What kind of words do you hear in everyday life that remind you of math? What kind of words only seem to stay in this class?
   - **a. introduction to algebra:** Sometimes questions are going to be written with words that seem to be from a foreign language. If we can remember the words, we have a head start in knowing what the first step should be.

### 10 Min
**Activities, resources, and materials to present new content area knowledge and skill:**
1. **Pick a card:** Students pick a card from the deck that has a numerical value written in one of five ways: as a fraction, decimal, or word form to write their own.
2. **Add to a neighbor:** Use worksheet (Resources L1) to add your value to a classmate’s. It is up to you to keep these values as decimals, fractions, or write them in words.

### 20 Min
**Activities, resources, and materials to present new content area knowledge and skill:**
1. **Use traditional diagram:** Draw bulls-eye diagram on the board, omitting the name of each category and only placing appropriate examples of numerical values in each ring. Discuss as a class what students notice is similar and different about each of these numbers.
2. **Define:** After class discussion, ask students to define, in their own words, what each category of numbers represents.
3. **Categorize:** Students pick 5 of the solutions they have found on their worksheet. Using color coded sticky notes, place these values on every sticky note that this value can be categorized as.
4. **Number line:** Add each of these sticky notes to the number line. Some values should be represented on multiple colored sticky notes to visually represent the various ways in which these numerical values can be defined.

**Assessment:** What specific, tangible evidence will show that each student has met the two types of objectives?
1. Student understanding will be evident as a through the formative assessment of a number line. Values placed on more than one sticky note will prove student understanding of the vocabulary definition.
2. Individual understanding will be evident through the answers provided on worksheet. Mathematical operations can be graded, but the main objective will be achieved through the student’s definition in their own words of each of these mathematical terms.
An Addition Number Line

Each of you has a card with a number on it. Now, go around the room and **ADD** your number to 10 others. Keep track of your work and answers in the space below.

<table>
<thead>
<tr>
<th>+</th>
<th>Answer</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td></td>
</tr>
<tr>
<td>2.</td>
<td></td>
</tr>
<tr>
<td>3.</td>
<td></td>
</tr>
<tr>
<td>4.</td>
<td></td>
</tr>
<tr>
<td>5.</td>
<td></td>
</tr>
</tbody>
</table>

Your number: ________

In your own words, write a definition for each of the categories of numbers below:

**INTEGER**

**WHOLE NUMBER**

**RATIONAL NUMBER**

**FRACTION**
Finally, just as you did on the number line, place your number and each of your ten answers in as many circles as they can fit into below.

*inspired by Sample circles of Connections Chart, adapted from McGregor 2007 as cited in Sammons, 2013, 111
MA CURRICULUM STANDARDS
Expressions and Equations
• Use properties of operations to generate equivalent expressions.
  1. Apply properties of operations as strategies to add, subtract, factor, and expand linear expressions with rational coefficients.
  2. Understand that rewriting an expression in different forms in a problem context can shed light on the problem and how the quantities in it are related.

GRADE 7 MATH PRIORITY STANDARDS FOR TEACHERS
Equations and Expressions
  3. Writing and solving linear equations (7.EE.1, 4)

STANDARDS FOR LITERACY IN SCIENCE AND TECHNICAL SUBJECTS
Reading
• Determine the meaning of symbols, key terms, and other domain-specific words and phrases as they are used in a specific scientific or technical context
• Compare and contrast the information gained from experiments with that gained from reading a text on the same topic

Lesson 2: Algebruno
### Key Content Vocabulary:
- Variables
- Terms
- Like terms

### ELA Strategies
Just as in constructing a sentence or paragraph, components of mathematical sentences can be combined and simplified according to a specific set of rules. Students are introduced to variables and guided to consider what the word variable means in their science class. Reinforcement of other vocabulary, such as like and simplify, allows students to use prior knowledge to solve an unfamiliar problem.

### Materials/Equipment:
- Index cards written with terms in 4 colors
- Worksheet explaining game rules
- Worksheet to keep track of score

### Real World Connections
Mistakes when combining terms and simplifying values, especially integers, is the root of multiple mathematical errors in algebra. Students will utilize variables as representations for missing information in mathematics and science often throughout their secondary education in problem sets that represent real world conflicts, such as representations of time, volume, distance, etc.

## Instructional Procedure

<table>
<thead>
<tr>
<th>Duration</th>
<th>Description</th>
</tr>
</thead>
</table>
| **5 Min** | Connection to prior learning or background building activity:  
1. **Warm up questions:**  
This lesson serves as an introductory lesson for expressions and equations. Today focuses only on equations, and we start with subtraction and addition of rational numbers as a continuation of the last chapter. After solving 3 problems on the board, the teacher then adds letters. The teacher ask students if he/she has made any other changes, and then ask them to predict how the class will solve this at the end of class. |
| **10 Min** | 1. **Discuss math vocabulary:** Define term by using the mathematical definition and other dictionary definitions. Which fits the best?  
- **Introduction to algebra:** Once defined, ask students to think of what like terms would mean and their role in a mathematical sentence |
### 15 Min

**Activities, resources, and materials to present new content area knowledge and skill:**

1. **Split into groups of 5-6:** Students separate into small groups and are given a deck of cards. Directions are explained to whole class, and students are directed to read them over once more with their groups.

2. **Play game:** Students play against each other following traditional uno rules: cards can be matched either by number (with the addition of letters so that cards are now matched as like terms) or by color (which are mixed so that expressions are varied). Students keep track of the cards they used and cards they are against according to worksheet (Appendix C).

<table>
<thead>
<tr>
<th>15 Min</th>
<th>Activities, resources, and materials to present new content area knowledge and skill:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td><strong>1. Post-game:</strong> after playing two-three rounds of algebruno, students are asked to remain in their groups and turn attention to their worksheets. The question is asked “What does simplify mean?”</td>
</tr>
<tr>
<td></td>
<td><strong>2. Discuss:</strong> Students volunteer their ideas on what simplify means. Then, the teacher ask students to refer to their worksheet and find an example of something that can be simplified. At this point, the teacher reinforces that simplifying means to combine things of the same sort so that it is easier to manage. The teacher then reminds students that the letters on the cards are to represent a label for a group of things, ie: 5a could mean 5 apples, or 5 ants. Students are likely to recognize that numbers that are followed by the same letter may be added or subtracted it</td>
</tr>
<tr>
<td></td>
<td><strong>3. Discuss:</strong> Why expressions that have multiple letters cannot be combined or “simplified.” If 5a represents five apples, and 6b represents six bananas, one cannot simplify any further without still referring to apples and bananas. Like terms, then, are terms that have the label in common.</td>
</tr>
<tr>
<td></td>
<td><strong>4. Practice:</strong> Students practice their understanding by referring back to their worksheet, and attempting to simplify the expressions they decide fit this description.</td>
</tr>
</tbody>
</table>

### Assessment:

**What specific, tangible evidence will show that each student has met the two types of objectives?**

1. Student understanding will be proven through their ability to participate in the game as a group. Students will be able to discuss ideas and challenges among one another in a small group setting.

2. Individual understanding will be evident by keeping track of scores on the worksheet. After two rounds of the game are played, students will be asked to “simplify” their answers. Because of the way the cards are organized and able to be matched by color and also terms, students will have a variety of expressions to note differences.
Appendix E1

Name: _____________________________________________

ALGEBRUNO

How to play:
Each player is dealt 7 cards, the remaining cards are left as a deck in the middle of the group.

The first player flips a card from the deck, and matches it either by putting down a card with a like term, or written in the same color. If player does not have a card to match, they must pick one from the deck.

A player may also put down a:
- **Reverse:** changes the game from going clockwise around circle to counterclockwise until another reverse card is played
- **Skip:** player is allowed to skip turn without having to pick up another card
- **Wild:** player must come up with a LIKE TERM that would match the card
- **+2:** the next player must pick up two cards from the deck

<table>
<thead>
<tr>
<th></th>
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</tr>
</thead>
<tbody>
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<td>9.</td>
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</tr>
<tr>
<td>10.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
CHALLENGE ROUND

Now, circle the answers in column 3 that only have **one term** in them. Turn these into equations by setting them equal to any number in the box below. Then solve. Each number can be used ONCE.

| 1 | 8 | 9 | 5 | -2 | 3 | 7 | 4 | 10 | 15 | 12 | 18 | 25 |

1. ______________________________________________________________________

2. ______________________________________________________________________

3. ______________________________________________________________________
Appendix E2

(Game adapted from Maynard, T.. (2013).)
Lesson 3: Building Equations through Expressions

MA CURRICULUM STANDARDS

- Apply and extend previous understandings of addition and subtraction to add and subtract rational numbers; represent addition and subtraction on a horizontal or vertical number line diagram.

GRADE 7 MATH PRIORITY STANDARDS FOR TEACHERS

Equations and Expressions
3. Writing and solving linear equations (7.EE.1,4)

STANDARDS FOR LITERACY IN SCIENCE AND TECHNICAL SUBJECTS

- Use precise language and domain-specific vocabulary to inform about or explain the topic.
- Determine the meaning of symbols, key terms, and other domain-specific words and phrases as they are used in a specific scientific or technical context relevant to grades 6–8 texts and topics.

<table>
<thead>
<tr>
<th>Key Content Vocabulary: Rational number</th>
<th>ELA Strategies</th>
</tr>
</thead>
<tbody>
<tr>
<td>Expression</td>
<td>This lesson focuses primarily on the use of graphic organizers and multiple representations of concepts to encourage students to break said concepts into fundamental principles, similar to breaking down a larger word or sentence into its smaller components to better understand the connections among all aspects of the word/phrase. The use of visual aids, and especially organizational structures, allows students to process this new topic through pictures, words, step-by-step instructions, and a clear diagram of the mathematical concepts defined with mathematical vocabulary.</td>
</tr>
</tbody>
</table>
### Materials/Equipment:
- Graphic organizer
- Equation diagram
- Camera
- Equations examples/rules

### Real World Connections
The representation of unknown values as variables is a concept that will be used heavily in the higher level mathematics and technology based classes, such as physics and chemistry, which students will encounter in their secondary education. These concepts will represent real-life situations that students must be able to comprehend. In the case of the introduction to algebra classes, students will use equations and the variables within them to represent real-world concepts of percentage of increase and decrease, the ratio for proportional relationships of time and distance, and also as a means of solving unknown values for a variety of scenarios.

### Instructional Procedure

<table>
<thead>
<tr>
<th>Duration</th>
<th>Description</th>
</tr>
</thead>
</table>
| 5 Min    | **Connection to prior learning or background building activity:**  
1. **Warm up questions:**  

This lesson continues lesson 2 and adds in equation. Students are given expressions to simplify to recall the previous lesson. 3 students are called to the board to solve. |
15 Min

1. **Handout:** Give students a diagram of an equation with a word bank. Ask them to label the parts of it according to what they recall from yesterday’s lesson.

2. **Discuss math vocabulary:** Discuss the meaning of equation by breaking down the prefix “equa.” Then, ask students what it means to express something. Students will recognize this method of breaking down words into roots and prefixes from their ELA class.

3. **Discuss diagram:** Ask students to volunteer one piece that they have labeled until the entire worksheet has been discussed.

3. After this, the class verbally lists the potential differences between an expression and an equation by placing an example of each on the board and asking one volunteer to circle the difference. Students are likely to underline the equation once discussing that “equa” represents means equals. Referring back to the diagram, students will also notice that an equation is really an expression or a term with an equal sign connecting another expression or term.

10 Min

**Activities, resources, and materials to present new content area knowledge and skill:**

1. **Guided notes:** Ask students to follow along as lesson is given using graphic organizer. Students will place the given definition in box one, facts and characteristics to remember, an example in how to solve, and a picture that will help them remember what is unique about this example.

15 Min

**Activities, resources, and materials to present new content area knowledge and skill:**

1. **Practice:** Ask students to try a few on their own as the teacher walks around the room and answer questions or direct instruction.

2. **Trade:** Trade work with a partner and have them check off all of the steps you did.

3. **Act:** Students end class by representing an equation in front of the class. Volunteers each take a piece of construction paper that has a term listed on it. The rest of the class organizes them into forming an equation. Then, students direct the volunteers to move around, combine, eliminate, etc., within the equation in order to solve so that only an x and a solution are left standing.
Assessment: What specific, tangible evidence will show that each student has met the two types of objectives?

1. Student understanding will be proven through class participation and turn and talk discussions. Asking students to direct the students who volunteered to be a piece of the equation demonstration is considered a formative assessment, as students are allowed to agree or disagree with where the pieces of the equation should move to be solved.

2. Individual understanding will be evident through participation in class, as well as the diagram and graphic organizer worksheet where crucial notes will be taken. By giving students time to practice, I can walk around and ensure notes are properly taken. These will then be placed in student binders for reference whenever needed.
Constant: A number in an equation that does have a variable next to it

Term: a number, variable, or number and variable. Terms are separated by operation signs (+, -, *).

Variable: the letter used to represent what you are trying to find; it represents a value that is able to change

Coefficient: any number that is directly next to a variable. This represents multiplication of the variable and number

Expression: a math sentence that does not include the equal sign, and cannot be solved unless you are told what to plug in for the variable

Equation: a math sentence that has an equal sign so that you are able to solve for a variable

(Image cited by Nag, A.. (2012).)

Lesson 4: Equation Applications

MA CURRICULUM STANDARDS
- MA.4.c. Extend analysis of patterns to include analyzing, extending, and determining an expression for simple arithmetic and geometric sequences (e.g., compounding, increasing area), using tables, graphs, words, and expressions.

GRADE 7 MATH PRIORITY STANDARDS FOR TEACHERS
Equations and Expressions
- 3. Writing and solving linear equations (7.EE.1,4)

STANDARDS FOR LITERACY IN SCIENCE AND TECHNICAL SUBJECTS
Reading
- Follow precisely a multistep procedure when carrying out experiments, taking measurements, or performing technical tasks.
- 4. Determine the meaning of symbols, key terms, and other domain-specific words and phrases as they are used in a specific scientific or technical context relevant to grades 6–8 texts and topics.

Key Content Vocabulary:
- Rational number
- equation
- terms
- like terms
- expression

ELA Strategies
Students will be required to use the equations as a code for the color or path to take according to the directions on the worksheet. Though less explicit than lessons given with additional vocabulary instruction, this lesson requires students to think independently, and use revision and editing strategies to ensure work is complete and correct before moving to the next step.
### Materials/Equipment:
- Graphic organizer
- Equation diagram
- Camera
- Equations examples/rules

### Real World Connections
Though this lesson is enjoyable and mainly focused on independent work, the process of following the appropriate steps and referring to notes when a mistake has been made is a critical habit to promote in a fundamental algebra course, and the use of colors or a mistaken turn in a maze will remind students immediately the importance of accuracy and neat, detailed work when attempting these difficult mathematical concepts. Students are likely to rush through problems once they feel comfortable with the concepts; this lesson reminds students that mathematics is about reading through the question, brainstorming, attempting, and reviewing, much like a piece of writing.

### Instructional Procedure

<table>
<thead>
<tr>
<th>Duration</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>5 Min</td>
<td>Connection to prior learning or background building activity: 1. Warm up questions:</td>
</tr>
</tbody>
</table>

This lesson is a combination of two separate activities focused on practicing the steps for solving one and two step equations. We begin with 3 practice problems on the board and ask students to solve. At this point in the unit, any mistakes made can either be fixed by the student who originally solved the problem, or they can ask another classmate to go and fix the problem. This allows the warm up to be more student-directed.
### 10 Min

**1. Handout:** Students are given the choice of 3 color-by-number worksheets.

**2. Discuss math vocabulary:** Emphasize vocabulary through steps: remind students that because this is an equation, you must solve to find the color that these sections will correspond with. We do this by combining like terms first, and solving for the missing value, or variable. This makes sense, because of the definition of variable, meaning able to change, which is represented through the multiple different colors that could be chosen for each section. Only one would make the sentence true.

**3. Discuss diagram:** Ask students to refer to graphic organizer that was used in previous class if any questions arise.

### 35 Min

**Activities, resources, and materials to present new content area knowledge and skill:**

**1. Independent work:** Students work independently on each worksheet. Because the equations are scrambled within each worksheet, students would not be able to simply copy the color codes.

**2. Students are encouraged to check work with students and to complete more than one worksheet**

### Assessment: What specific, tangible evidence will show that each student has met the two types of objectives?

1. Individual understanding will be proven through their ability to complete worksheets accurately. Mistakes will be evident if wrong colors are used/wrong path is taken.

2. Class understanding will be determined through conversations held by partners throughout the activity and questions that arise in class
Appendix G1

(adapted from Teaching High School Math. (2015).)
Lesson 5: Gallery Walk

MA CURRICULUM STANDARDS
- 7.4aEE: Solve multi-step real-life and mathematical problems posed with positive and negative rational numbers in any form (whole numbers, fractions, and decimals), using tools strategically. Apply properties of operations to calculate with numbers in any form; convert between forms as appropriate; and assess the reasonableness of answers using mental computation and estimation strategies.

GRADE 7 MATH PRIORITY STANDARDS FOR TEACHERS

Equations and Expressions
- Writing and solving linear equations (7.EE.1,4)

STANDARDS FOR LITERACY IN SCIENCE AND TECHNICAL SUBJECTS

Reading
- 7.5RST Analyze the author’s purpose in providing an explanation, describing a procedure, or discussing an experiment in a text.
- 7.3RST Follow precisely a multistep procedure when carrying out experiments, taking measurements, or performing technical tasks.

Writing:
- 7.1bWHST. Support claim(s) with logical reasoning and relevant, accurate data and evidence that demonstrate an understanding of the topic or text, using credible sources.
- 7.2d WHST: Use precise language and domain-specific vocabulary to inform about or explain the topic.
### Key Content Vocabulary:
**Rational number**
Terms  
Like terms  
Expression  
Equation  
Distribute

### ELA Strategies
Gallery walks are a resource seen often in ELA classrooms as a means of getting students to move about the room, note similarities and differences among concepts, and demonstrate their understanding through writing. This gallery walk involved multiple mathematical problems, including vocabulary, which must be responded to using proper mathematical vocabulary. In addition, students are asked to write technically, and determine where potential mistakes could be made when solving these problems. Students are therefore giving directions in how to solve the problem, but alerting readings of what not to do. Though this is technical writing, it requires the use of specific vocabulary, and the ability to defend one’s method through the proper explanation of the mathematical process.

### Materials/Equipment:
**Questions written on construction paper and hung around room**  
**Pen/pencil and paper for computations**  
**Guideline for students of rules of gallery walk**  
**Cards with student names to assign partner**

### Real World Connections
Though the gallery walk is used as a formative assessment for student understanding prior to taking a chapter test, students are asked to defend their work, much as they defend arguments in ELA, by referencing their mathematical process as evidence. Students must learn to write technically, and sufficiently guide readers through their problem-solving process, regardless of the college or career field they plan to enter. Students must also work collaboratively, weighing other perspectives and ultimately coming to a cohesive conclusion in how to solve any problem at hand.
### Instructional Procedure

<table>
<thead>
<tr>
<th>Duration</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>5 Min</td>
<td>Connection to prior learning or background building activity:</td>
</tr>
<tr>
<td></td>
<td>1. Warm up questions</td>
</tr>
<tr>
<td></td>
<td>This lesson serves as a review for students as they prepare for a chapter test. By ensuring that students are listing potential mistakes, rather than the steps that students are now familiar with when solving a one and two step equations, students are required to think outside the box and ensure that they understand the comprehension and reasoning behind each step that they are completing. In addition, students must sharpen their writing skills in this process, utilizing procedural vocabulary and ensuring that their responses are clear.</td>
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<tr>
<td>10 Min</td>
<td>1. Discuss math vocabulary: Remind students what term, like term, equation, expression, and variables mean in order to solve the problems during the gallery walk</td>
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<td>a. introduction to algebra: Students will see algebraic concepts in multiple formats around the room, and have to utilize the different strategies discussed in previous lessons to determine the proper steps in order to solve the problems</td>
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<tr>
<td>35 Min</td>
<td>Activities, resources, and materials to present new content area knowledge and skill:</td>
</tr>
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<td></td>
<td>1. Directions: Students separate into assigned pairs. Each group begins at a different gallery in the room and rotates clockwise as each problem is completed. Students must work collaboratively to determine what the question is asking, what vocabulary is being used, to solve the problem at hand, and to explain any potential problems a student may encounter when solving this (i.e.: be aware of negative signs, remember to distribute, etc).</td>
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<td>2. Activity: Students complete 6 problems around the room on a white-lined paper to be turned in. Students are required to double check the work with their partner before submitting, rewriting work on another piece of paper to promote editing and double checking when solving problems.</td>
</tr>
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</table>
| 5 Min | Activities, resources, and materials to present new content area knowledge and skill:  
1. **Discussion:** Review thoughts on gallery walk: Which problems were the most challenging? Which were the easiest? What do we need to work on? Students then use these problems as a study guide for a chapter test later in the week. |

| Assessment: **What specific, tangible evidence will show that each student has met the two types of objectives?**  
1. Individual understanding will be proven through their participation with their partner, and ability to complete these problems within the class period. Students will also be able to utilize prior notes and resources in the classroom, other than the classroom teacher, to promote student-directed problem solving techniques. Student understanding will also be evident through the pace at which students are able to solve problems.  
2. Whole-class understanding will be evident by the completion and detail of work, and through conversations overheard as I walk around the room and check in with groups during activity. |
Appendix H1

Simplify Expression

3(x-9) - (6x+3)
Lesson 6: Create a word problem (2 day lesson)

MA MATHEMATICS CURRICULUM STANDARDS

- Apply properties of operations as strategies to add, subtract, factor, and expand linear expressions with rational coefficients.
- Use variables to represent quantities in a real-world or mathematical problem, and construct simple equations and inequalities to solve problems by reasoning about the quantities.
  a. Solve word problems leading to equations of the form px + q = r and p(x + q) = r, where p, q, and r are specific rational numbers. Solve equations of these forms fluently. Compare an algebraic solution to an arithmetic solution, identifying the sequence of the operations used in each approach.

GRADE 7 MATH PRIORITY STANDARDS FOR TEACHERS

Equations and Expressions
- Writing and solving linear equations (7.EE.1,4)

STANDARDS FOR LITERACY IN SCIENCE AND TECHNICAL SUBJECTS

Reading
- Write informative/explanatory texts, including the narration of historical events, scientific procedures/ experiments, or technical processes.
  a. Introduce a topic clearly, previewing what is to follow; organize ideas, concepts, and information into broader categories as appropriate to achieving purpose; include formatting (e.g., headings), graphics (e.g., charts, tables), and multimedia when useful to aiding comprehension.
  b. Develop the topic with relevant, well-chosen facts, definitions, concrete details, quotations, or other information and examples.
  c. Use appropriate and varied transitions to create cohesion and clarify the relationships among ideas and concepts.
  d. Use precise language and domain-specific vocabulary to inform about or explain the topic.
  e. Establish and maintain a formal style and objective tone.
### Key Content Vocabulary:
List of operational signal words: *i.e.*: less than, more than, double, half of, etc.

### ELA Strategies
Students must design a creative word problem using only a handful of topics given to them, and the mathematical components that will ensure it can be solved. Using a combination of procedural vocabulary, mathematical vocabulary, graphic organizers, and mathematical skills, students will combine everything they have learned in the chapter to create an engaging word problem for another student to solve. Students must learn to work backwards using the information given to them to craft a problem that is both solvable, engaging, and provides readers with adequate information.

### Materials/Equipment:
- Index cards written with terms in 4 colors
- Worksheet explaining game rules
- Worksheet to keep track of score

### Real World Connections
Allowing students to create their own word problem gave students the opportunity to understand the process that anyone who is faced with a mathematics problem may encounter. The word problems were created using imaginary scenarios that the students created, inspiring them to use real world problems, such as losing money or doubling the amount of food a person could purchase. Students were able to be very creative in this process, but had to incorporate the procedural and mathematical vocabulary to ensure that their scenarios make sense. Students gained a deeper understanding of the mathematical processes that occur alongside the writing process to create a meaningful and engaging problem with enough information to be able to solve. By working backwards and developing their own, students have a better grasp of what key words to look for when solving a problem in later chapters.

### Instructional Procedure

<table>
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<th>Duration</th>
<th>Description</th>
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| **5 Min** | **Connection to prior learning or background building activity:**  
1. **Warm up questions:**  
   This lesson serves as a formative assessment for students understanding of steps for solving an equation. The warm up will be a whole-class dissection of a word problem on the board. Students are asked to point out key words, numbers, and omit unnecessary details in order to solve a basic word problem |
### 3. Discuss math vocabulary:
A list of operational words is displayed on the board. These are divided into categories: addition, subtraction, multiplication, division, and equals. Students are asked to look at this list and discuss alternative wording for the same operation with a partner. Any additional suggestions are then added to the board.

#### a. Introduction to algebra:
Students now use all prior knowledge to create their own meaningful instances of algebraic concepts. While these responses are likely to be humorous and outrageous, it allows students to see the though process that is required to create word problems, and the specific information necessary in order to complete one. Essentially, this lesson aims to make word problems much less intimidating by allowing students to participate in the process of creating one from scratch.

### 35 Min
**Activities, resources, and materials to present new content area knowledge and skill:**

1. **Independent work:** Students work independently to create their own word problems utilizing graphic organizers. The directions to complete each section of the graphic organizer is listed in R3.

### 35 Min
**FOLLOWING THIS LESSON THE NEXT DAY:**

1. **Trade:** After students have created their own word problem, they then trade with other students in the class. Students receive the same graphic organizer that is flipped to represent the process of solving. Following the directions for each section, students underline and omit information to get to the root of the mathematical process, and solve.

### Assessment:
What specific, tangible evidence will show that each student has met the two types of objectives?

1. Student understanding will be proven through conversations among classmates, references to worksheets and words listed on the board, and the amount of additional teacher-led direction students need to complete this assignment.

2. Individual understanding will be evident with the end result: a word problem of at least three sentences that uses procedural and mathematical vocabulary, with correct mathematical processes, and creative detail. Understanding will also be evident with the completion of graphic organizers that have step-by-step direction, and students’ ability to solve classmates created problems.
You and your team are in charge of creating the world’s best word problem.

You will be told what your variable has to equal, but the rest is up to you to figure out!

1. Write what your variable equals in Box 1

2. Make your equation.

Using what you know X has to equal, work backwards to fill in the rest of the problem.

**EXAMPLE:**

I am told that X = 5

My team decides that our equation will = 25,

**Ask yourself**, what do I have to do to X to get to 25?

I could.…

• multiply x by 25,

• I could multiply x by 15 and add 10

• Divide 125

• Add 5 to 4(5)

Write all of this in box 2.

3. Write your equation in box 3

4. Look at what operations you used to get that equation. **Pick one phrase** from **each operation** you used on the list of operations. Write these in the box 4.

Appendix I2
EXAMPLE:
I was going to multiply x by 25, I could say the product of …

5. Pick TWO green cards from your pile and THREE red cards from your pile. Using all of the numbers you came up with, the words from the list, and the names you have picked, write a story about it that someone could solve!

FINALLY, write your names on the blank side of the index card. Write your word problem on the side with the lines. Put it in the envelope when you are done!
1. Read your story *more than once*. Write down any information that might be important here.

2. Underline all of the key words that will tell you what to do, and what you are looking for. Use the CLUES checklist to help!

3. Translate these words into an equation. Change what you are looking for to X, find out what everything has to EQUAL, and use the other details to help you get there.

4. Now you have an equation. Get X alone, and ask yourself what do I have to do to X to get that answer?

5. You have solved the equation. Plug it back in to the story to make sure it makes sense!
**Use CLUES to help you solve the problem**

- **CIRCLE** the key numbers
- Put a **LINE** under the important words: operations
- Cross out **UNNECESSARY** details
- **EVALUATE**: Ask yourself what had to happen to X to get that answer
- **SOLVE** and check

**Look for key words and phrases to translate the sentences into math**

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<thead>
<tr>
<th><strong>ADDITION</strong></th>
<th><strong>SUBTRACTION</strong></th>
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<tbody>
<tr>
<td>Increased by</td>
<td>Decreased by</td>
</tr>
<tr>
<td>More than</td>
<td>Minus, less</td>
</tr>
<tr>
<td>Combined, together</td>
<td>The difference between/difference of</td>
</tr>
<tr>
<td>Total of</td>
<td>Less than</td>
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<tr>
<td>Sum, plus</td>
<td>Fewer than</td>
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<td>Added to</td>
<td>Between</td>
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<tr>
<th><strong>MULTIPLICATION</strong></th>
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<td>Times</td>
<td>Out of</td>
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<td>Multiplied by</td>
<td>Ratio</td>
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<tr>
<td>The product of</td>
<td>Quotient of</td>
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<tr>
<td>Increased by</td>
<td>Percent of (divide by 100 or move decimal)</td>
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<tr>
<td></td>
<td>average</td>
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<tr>
<th><strong>EQUALS</strong></th>
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<td>At the price of</td>
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<tr>
<td>Total</td>
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</table>

(adapted from Middle Grades Life Savers. (2015).)
During the 1920s, Romeo and Juliet took a trip to the famous Los Angeles. They had a memorable experience, but spent most of their time gambling at a casino. They gambled against the famous Orville Wintour. At first, Romeo and Juliet won but then that amount got tripled, giving them a larger total. On the other hand, Orville was having trouble playing his cards right and only won 3. Afterwards,

One day, Indiana Jones was delivering some foreign lollipops. There was a bunch of lollipop criminals that were trying to take the lollipops from the truck. Then a big tornado came along and blew all the criminals away. Indiana Jones couldn’t continue his trip. When he reached his destination, he had 9 boxes with 504 lollipops all together. How many lollipops are in each box?

In Las Vegas, Russia, Winnie the Pooh and his friends went to a buffet eating competition against a professional driver. Winnie ate 465 donuts in 14 hours. How many donuts did she eat per hour?

There were x amount of penguins and 1/3 of them got put inside the ocean by irritating construction work. How many penguins were originally on the berg?

There was a cabbage named Tony Stark he had in brilliant Hollywood inside a refrigerator with his salads and veggies. All the cabbages in the refrigerator was making out till a forest Godzilla opened up the refrigerator and pulled them up into stacks for a new cabbage set. How many cabbages did Godzilla eat in all?

(adapted from Stapel, Elizabeth, (2014).)
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