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## Using mathematics as a gateway to literacy for English language learners

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USING MATHEMATICS AS A GATEWAY TO LITERACY  
FOR ENGLISH LANGUAGE LEARNERS

A Thesis  
Submitted  
in Partial Fulfillment  
of the Requirements for the Designation  
University Honors with Distinction

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University of Northern Iowa  
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has been approved as meeting the thesis requirement for the Designation University Honors with Distinction.

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## Introduction

English language learners (ELLs) constitute a population of students in United States schools that continues to rapidly grow in size. This group of students includes all students who “speak a language other than English at home and whose proficiency in English is limited” (Harper & de Jong, 2004, p. 152). According to Altieri (2010), the U.S. Census Bureau found more than four million ELLs present in K-12 classrooms in 2000. Furthermore, ELLs’ enrollment in U.S. schools increased eight times as much as total student enrollment increased from 1992-2002 (Peregoy & Boyle, 2005). As a result of their limited experience with the English language, ELLs often face a daunting challenge in school because they must learn academic content, which is typically taught in their nonnative language, as well as quickly gain English proficiency. To meet the needs of this large group of students, teachers should implement teaching practices that make subject matter comprehensible despite ELLs’ language difficulties. However, teachers frequently present verbal and written information in lessons without utilizing visual aids, social interaction among students, or other techniques to support ELLs as they attempt to comprehend content material. Consequently, ELLs gradually fall further and further behind in their academic achievement. This is particularly noticeable in the area of literacy, which includes the six aspects of reading, writing, listening, talking, viewing, and visually representing (Altieri, 2010; Tompkins, 2009). ELLs struggle in literacy because literacy tasks rely heavily on using and making sense of language. Consequently, educators need to incorporate methods in their teaching that effectively ease language problems, so they can help ELLs develop and succeed in the area of literacy.

One teaching approach that alleviates language barriers involves teachers using what students know and can do to develop students’ understanding of and ability in another area. Thus,

teachers can promote ELLs' literacy development by integrating knowledge and skills ELLs have from another subject area into their literacy instruction. Specifically, teachers can integrate mathematics into literacy instruction because research suggests that ELLs often understand and successfully carry out mathematical tasks. For example, Gunning (2003) points out that ELLs tend to perform well on mathematical computations. The universality of mathematical symbols seems to promote ELLs' understanding of mathematics instruction although lessons may incorporate unfamiliar English that the students would not typically understand. Also, Secada (1991) asserts that ELLs perform well on mathematics problem solving tasks because their problem solving abilities expand in conjunction with their development of dual language competence. This proficiency in problem solving is crucial to ELLs' mathematical achievement because problem solving is the essence of "*doing* mathematics...[and] building understanding of mathematical concepts" (Hyde, 2006, p. 8). Through the completion of problem solving tasks, ELLs engage in visual representation of problems, hands-on manipulation of materials, and group interaction. These visual, kinesthetic, and social learning experiences provide ELLs with additional information about mathematical concepts and problems, which allows them to make sense of the mathematical language encountered in lessons. Thus, mathematical instruction adds context and meaning to the language ELLs come across in mathematics, so ELLs effectively learn mathematics concepts and problem solving behaviors. Overall, the symbolic and contextualized nature of mathematics appears to act as a mechanism for enabling ELLs to move past language barriers, increasing ELLs' likelihood to experience success in the area of mathematics.

Yet, even with the identification of ELLs' strong achievement in mathematics, it remains unclear if any connections exist between mathematics and literacy that would make integrating

mathematics into literacy possible. Few people pay attention to how mathematics skills and concepts relate to literacy because “Many teachers, like their students, still think of math as a totally separate subject from language arts” (Fogelberg et al., 2008, p. 1). However, a large body of research exists that explains the possibilities for and benefits of integrating literacy into mathematics. Looking into the connections between mathematics and reading, one aspect of literacy, shows that specific properties are embedded in both. Minton (2007) describes how both areas involve thinking as people’s minds make sense of information to determine words or solutions and to then create meaning. Therefore, both mathematics and literacy involve comprehension, which Tompkins (2009) defines as a complex process of constructing meaning in order to create understanding. Also, teachers can help students gain deeper understandings in mathematics through teaching mathematical vocabulary, demonstrating how to read word problems to gather the correct meaning, encouraging discussion and writing of justifications for mathematics problem solving strategies and solutions, and more (Gunning, 2003). These numerous examples of literacy-mathematics connections illustrate how teachers can utilize what they know about teaching literacy to enhance their teaching of mathematics by helping students transfer their learning from literacy to mathematics. When students transfer learning, they exhibit “the ability to appropriately apply information and skills learned in one setting to a similar or different setting” (Thomas, 2007, p. 5). As the aforementioned research shows, students can apply their literacy skills and strategies to read, write, and talk about mathematics, so transfer appears to take place in this direction.

However, the application of mathematics skills to literacy in the opposite direction of transfer is desired for working with ELLs. This population of students tends to understand mathematics better than they understand the targeted new language. Therefore, ELLs would benefit from

using mathematics to improve their literacy ability. Thus, this thesis seeks to answer the following question: Can teachers utilize the power of mathematics to help students transfer mathematics understandings and skills to the area of literacy in order to teach ELLs important concepts and strategies for reading and writing?

## Methodology

In order to complete the thorough literature review required to answer my research question about the possibility of using mathematics to teach literacy to ELLs, I acquired and analyzed literature revolving around the themes of mathematics and literacy connections, transfer, and ELLs. I used the Rod Library, Internet databases, such as Wilson Web, Google Scholar, JSTOR, and AMS Journals, and my advisor's recommendations to gather appropriate books, articles, and reports. In my searches for literature, I included combinations of the words *mathematics*, *numeracy*, *literacy*, *reading*, *connections*, *integration*, *similarities*, *reading process*, *problem solving*, *transfer*, *ELLs*, *achievement*, and more. I also specifically searched to find articles and books cited in research I had already obtained that appeared pertinent to my research efforts as well as articles and books by authors my advisor suggested. Altogether I gathered and examined twenty-four books and forty-one articles, which provided me with a plethora of information on others' knowledge and beliefs about topics related to my thesis.

As I completed this comprehensive search for relevant literature, my thesis continually evolved as a result of my analysis and synthesis of obtained research. In my reading of the literature I obtained, I first skimmed each piece of literature to get the gist of the text, which guided my focus during the first full reading of the text. I completed the first read through of the entire text immediately after skimming, and I then read the piece a second time in order to make markings and begin analyzing and synthesizing the information. Since the research I completed provided qualitative information about literacy, mathematics, transfer, ELLs, and more, I engaged in constant comparative analysis (Glaser & Strauss, 1967) as I read in order to develop categories that emerged across the literature and to organize the information I found. In this way, I found the similarities and differences in ideas presented in the literature within each



category, which enabled me to then analyze the different perspectives and critique the literature. As a literacy education minor, I viewed and critiqued the information I gathered through the lens of literacy. Furthermore, I used this literacy perspective to draw my own conclusions about how the ideas from the analysis of the literature related and applied to literacy and literacy learning. In this way, I was then able to take the information from my research to generate my own recommendations and suggestions for elementary teachers wanting to implement mathematics-literacy integration in their classrooms. Thus, I utilized my literacy background to guide the connections I found between the literature on mathematics, literacy, and instruction of ELLs in order to generate a thesis that offers a new perspective for literacy teaching.

## Literature Review

### *Similarities Between Mathematics and Literacy*

Although many people view mathematics and literacy as highly contrastive domains with little overlap in skills and concepts (Altieri, 2010; Fogelberg et al., 2008), closer inspection reveals that numerous connections exist between the two areas. These connections fit into five main categories: structures of the disciplines, thinking processes, comprehension efforts, problem solving properties, and strategic behaviors.

*Discipline structures.* In regards to their fundamental structures, both literacy and mathematics utilize forms of language. Letters and punctuation marks make up the symbols used in reading and writing alphabetic languages, while the language of mathematics also involves numerals and other ideographs (Goodman, 1996; Russell & Dunlap, 1977). Using their respective writing systems, mathematics and everyday language communicate messages that Devlin (2000) refers to as gossip. Whereas the gossip of everyday language focuses on the lives and relationships of real and fictional people, the gossip of mathematics language looks at properties and relationships of objects, numbers, and real or abstract entities. Thus, “mathematicians think about mathematical objects and the mathematical relationships between them using the same mental faculties that the majority of people use to think about other people” (Devlin, 2000, p. 262). Since mathematics language specifically focuses on the abstract world of numbers and space, it utilizes a different vocabulary and syntax than ordinary English (Austin & Howson, 1979; Bullock, 1994; Dale & Cuevas, 1987; Fogelberg et al., 2008; Russell & Dunlap, 1977). For example, mathematics uses technical terms, such as polynomial and secant, as well as repurposes everyday words, such as mean and rational. Also, Dale and Cuevas (1987) point out that one key syntactical difference between mathematics and everyday language “is the lack

of one-to-one correspondence between mathematical symbols and the words they represent” (p. 15). However, these variations in language properties have much less significance than the fact that the languages of both mathematics and literacy communicate messages that people must view and interpret.

In order for people to learn to comprehend and speak mathematics and literacy language correctly, they also must learn concepts related to these subject areas. Looking into the basic layouts of mathematics and reading concepts again reveals their similar structures. Minton (2007) outlines the interrelations of the surface structures of reading and mathematics in her comparison of letter and sound awareness to digit, value, and name awareness, decoding to taking numbers apart by digits, visual word recognition to visual number fact recognition, and syntactic rules. On the simplest level, readers can identify letters and their corresponding sounds. Mathematics also breaks down to these component parts because people can identify numerals, their names, and their concrete representations. When faced with combinations of letters, people can then isolate letters and their sounds to decode words, just as people can consider the value of individual digits in a number to determine the value of the entire number. Building upon these concepts, children learn to identify words on sight and to automatically combine values of numbers to solve basic arithmetic facts. Furthermore, students study word families, or collections of words containing the same rime but different onsets, for reading, and they study fact families, or sets of basic facts involving the same numbers in different orders with inverse operations, for mathematics (Peregoy & Boyle, 2005). Moving to the syntactic level, people learn rules and patterns in the language structure of words, sentences, and entire texts. Similarly, people discover patterns and connections between mathematical facts and operations. Thus, both reading and mathematics involve hierarchical development of skills and

concepts as students progress through advancing levels of understanding (Russell & Dunlap, 1977).

*Thinking processes.* A key element in expanding comprehension of these concepts involves people growing in their ability to acknowledge and utilize the thinking patterns prevalent in mathematics and literacy. Thus, people need to grasp abstract and symbolic thinking. Abstract thinking requires the brain to register and process information about a topic without directly encountering physical stimuli. Devlin (2000) suggests that the capability for this type of thinking came about in humans about 75,000 to 200,000 years ago, prompting the original creation of both mathematics and literacy language. With the ability to think symbolically, people could “let symbols represent experiences and ideas” (Goodman, 1996, p. 12). As a result, they created literacy and mathematics languages where letters, sentences, equations, and numbers represented spoken sounds, notions, quantities, shapes, and other real life and imagined phenomena. Understanding the connection between written mathematics and literacy language and the actual meaning of the symbols helps people perceive the purpose of mathematics, reading, and writing. Therefore, people today must use abstract thinking to make sense of and possess motivation to learn mathematics and literacy.

In addition to abstract thinking, reading and mathematics also require people to use metacognitive thinking. Hartman (2001) defines metacognition as the knowledge and regulation of cognition, so it includes knowing information about topics and strategies, knowing how to implement strategies, and knowing why and when to utilize different thinking strategies. When reading, people use metacognition when they ask questions about the meaning of terms and themes of a text, make predictions about upcoming events or conclusions in a text, evaluate their understanding of sentences or sections of a text, and use strategies, such as rereading, to fix

errors or confusions that have arisen (Minton, 2007). Garofalo and Lester (1985) claim that these “metacognitive skills involved in the intelligent control of one’s activities while engaged in a reading or memory task are not different from those involved in successfully performing other cognitive tasks. In particular, such metacognitive skills are deemed crucial in mathematical performance, particularly problem solving” (p. 166). Therefore, a strong similarity and connection exists between literacy and mathematics in regards to metacognition (Dale & Cuevas, 1987; Fogelberg et al., 2008; Hartman, 2001; Minton, 2007). As with reading, people carrying out mathematical tasks ask questions about the meaning of the problem, make predictions about appropriate actions to take and solutions to find, check the accuracy of their chosen problem solving strategy, and go back to identify and alter any mistakes (Minton, 2007; Pape, 2004). Thus, people engage in many of the same behaviors as they contemplate and monitor their thinking during the reading and mathematics problem solving processes.

*Comprehension.* Since mathematicians and readers utilize parallel thinking patterns, the main processes for engaging in mathematics and in reading also correspond closely. First, both domains require attention to the whole idea and message of a text or mathematical problem as well as to the individual components and procedures. Thus, readers engage in “cognitive processing of letters and words, word meaning, syntax, sentence-level meaning assignment, and linking of sentences at the paragraph level” (Brown, 1998, p. 191). While drawing from background knowledge as they strive to comprehend the overall message of a text, readers recognize and decode individual letters and words. Similarly, students working on mathematics aim to comprehend and solve a problem by considering how it relates to the mathematical knowledge they have and comparing the problem to others they have encountered, but they also identify operational signs or words and algorithmic procedures present in the problem (Wall &

Posamentier, 2007). Since readers and mathematicians both rely on existing knowledge to construct meaning from texts and numbers, Minton (2007) claims that the two domains correspond in their deep structure schematic systems. In the reading world, Rumelhart termed this concurrent comprehension of literature on the whole and part levels as the interactive reading model (Brown, 1998). This perspective of the reading process explains the bottom up processing where readers focus on the individual, simple components of a text to decode words as well as the top down processing where readers bring their personal experience and prior knowledge into the comprehension of texts (Avalos, Plasena, Chavez, Rascón, 2007; Brown, 1998). Yet, as discussed, this same type of bottom up and top down processing occurs during the mathematics problem solving process, so it seems an interactive mathematics model could be created to describe the analogous comprehension process that takes place as people complete mathematics problems.

*Problem solving.* Noticing the problem solving aspect of reading helps explain why this close relationship between the reading and mathematics problem solving processes exists. As people read, they use “operations or strategic activities...to problem-solve the puzzle of getting the messages from a text, or putting messages into texts” (Clay, 2005, p. 34). Goodman (1996) writes that people obtain information for solving this puzzle of meaning from three sources. The letters and words in the text provide graphophonic cues, word order and grammar offer syntactic cues, and the context of words combine with readers’ background knowledge to provide semantic cues. With this information, readers then partake in a psycholinguistic guessing game to “‘guess’ what’s coming, [make] predictions and inferences...[and] monitor their ‘guesses’ for contradictory cues” (Goodman, 1996, pp. 7-8). This means readers combine what they know with available clues from the text to solve the problem of determining what they will read next.

Whether this prediction occurs as readers eliminate possibilities for the next letter in a word or the next word in a sentence, it minimizes the necessary amount of processing in the brain (Smith, 1997). For example, Smith (1997) explains that readers can identify and comprehend around 100,000 words, but, at any specific location in a text, the grammar and semantics of the sentence and overall text to that point leave an average of only 250 viable word options. A parallel type of process occurs on the meaning level of the text as readers use their prior knowledge and experience to narrow the potential interpretations of the message the text communicates.

Although much of this problem solving behavior of considering and eliminating possibilities for words and meaning appearing in texts occurs automatically, readers must attend to this behavior more consciously when faced with greater perplexity. Smith (2004) refers to the amount of information that the reader gathers before making a decision about the next letter, word, or meaning of a text as the criterion level. Thus, when readers have high criterion levels, they consider several elements that influence the literature at the textual level that presents the problem. Consequently, readers employ more decoding or comprehension strategies, such as chunking or rereading, to seek solutions to the problems they encounter at the letter, word, or overall meaning levels (Olshavsky, 1976-1977). This mental process of recognizing a problem, predicting an answer, and using problem solving strategies to develop an accurate solution mimics the problem solving that occurs among mathematicians.

Indeed, a direct comparison can be made between the problem solving process and the reading process. Polya's four-step mathematics problem solving process directs students to read and understand the problem, decide how to solve the problem, execute their solving plan, and review their solution (Garofalo & Lester, 1985; Hyde, 2006; Hyde & Hyde, 1991). Lester (2003) identifies the first two steps as happening during the before phase of problem solving.

During the before phase of reading, Tompkins (2009) says teachers should teach students to preview the text, activate their prior knowledge, make predictions about the text, and set a purpose for reading. Through these actions, readers lay a foundation that can help them when they experience decoding or comprehension problems as they begin reading. In addition, an analysis of the text format while previewing the texts compels students to begin thinking about types of comprehension strategies that will most benefit them as they read the text. Thus, readers begin understanding and deciding how to solve reading problems presented by the text during the before reading stage. Moving into the during phases of mathematics and reading activates people's implementation of problem solving strategies. Lastly, the after phase of mathematics deals with reviewing the solution, the final step in Polya's problem solving process, in order for people to check the reasonableness of their answer and to integrate new information learned from solving the problem into their existing mathematical knowledge (Hyde, 2006). Readers also evaluate the success of the decoding and comprehension strategies they utilized, but this occurs mainly during reading since people meet and solve numerous problems while reading one text. However, a large scale reflection on reading material, implemented strategies, and overall comprehension of information also takes place after a person reads a complete text (Tompkins, 2009). Thus, throughout the entire process of comprehending and problem solving literary and mathematical problems, readers and mathematicians exhibit similar behaviors.

*Strategy use.* Consequently, the specific strategies people implement when reading or carrying out mathematics relate to each other as well. Fogelberg et al. (2008) and Hyde (2006) state that literacy and mathematics both involve making connections, making predictions, asking questions, self-regulating, inferring, visualizing, summarizing, and determining importance. Adding to this list, Minton (2007) discusses how people improve their numeracy and literacy



comprehension by expanding their vocabulary and synthesizing ideas. Ordering items and categorizing ideas also aid problem solving and reading comprehension (Burton, 1984). Clearly, people can apply a variety of the exact same comprehension strategies when completing literacy or mathematics tasks. One specific graphic organizer students can use in reading and mathematics that involves asking questions, self-regulating, and summarizing is the KWL or KWC chart (Hyde, 2006). With the KWL chart for reading, students write what they know about a topic, what they want to know about the topic, and what they learned about the topic from reading a book. Similarly, using the KWC chart for mathematics, students write what they know about a mathematics problem, what they want to know or figure out about the problem, and what mathematical conditions they watched for or learned about as they solved the problem. Thus, KWL and KWC charts illustrate how people perform comparable thinking strategies in literacy and mathematics even when the exact execution of the strategies varies slightly.

Looking past the surface variations in their implementation, several other common reading and mathematics strategies also relate to each other. For example, Greenwood (1993) describes how students can use the strategy of solving a simpler problem by using knowledge of seven times seven to then solve the original problem of eight times seven. In the same way, students can solve a simpler problem in reading by chunking a word. If a child does not know the word “winner”, the child can chunk the word to use knowledge of the simpler word “win” to then figure out the pronunciation and meaning of the word “winner.” Also, employing a decomposition strategy helps people to determine the pronunciation of a word or the value of a number (Minton, 2007). With mathematics, this involves breaking a number apart, such as finding the value of the number twelve by recognizing that it contains one ten and two ones. In reading, decomposition refers to reading “cat” after separating the word into the individual

phonemes of /k/, /a/, and /t/. In addition, children often take advantage of the strategy of inventing nonstandard representation to comprehend and communicate literacy and mathematics ideas. When children do not have familiarity with standard mathematical notation or algorithms, they create their own symbols and heuristics to represent and solve problems (Lester, 2003; Wall & Posamentier, 2007). This technique allows students to use the known to move past the barriers created by what they do not know about a mathematics problem to still solve and learn about the embedded mathematical concept. The same type of invented system appears in children's writing when they spell words based on their current understanding of phonics and orthography (Goodman, 1996). By using their own spelling system, children deepen their understanding of phonics while enabling themselves to shift their focus away from the conventional spelling of words to learning about the structure and content of written pieces. While all of the mentioned strategies differ to an extent based on whether they are applied to letters and words or numbers and symbols, they maintain underlying equivalencies.

The abundance of similarities in the core elements of reading and mathematics structure, thinking, and execution makes it possible to improve students' comprehension of literacy through the application of mathematical thinking and problem solving strategies. Thus, teachers can utilize what they know about teaching mathematics to enhance their teaching of literacy. Yet, as seen in the books of Altieri (2010), Fogelberg et al. (2008), Hyde (2006), and Minton (2007), people tend to take advantage of mathematics-literacy connections for the opposite purpose. In other words, educators generally focus on how relationships between mathematics and literacy make reading, writing, and communicating tools for strengthening students' mathematics understanding. While students can certainly benefit from this type of instruction, the identification of connections between fundamental elements of mathematics and literacy

suggests that teachers can just as easily capitalize on the potential of these connections to use mathematics in order to teach literacy. Applying the mathematics-literacy connection in this direction could hold particular value for students who struggle in literacy but possess a strong understanding of mathematics.

### *Mathematics and Literacy for ELLs*

ELLs comprise one such group of students that tends to display success in the area of mathematics. A study by Lesaux and Siegel (2003) shows that second grade ELLs in one Canadian school district scored an average of seven points higher on an arithmetic test than native English speakers. Gunning (2003) also comments that ELLs typically perform well on computational mathematics tasks. Even people who speak languages containing only a few specific number words can accurately solve approximation and comparison computations that involve large quantities (Pica, Lemer, Izard, & Dehaene, 2004). Furthermore, ELLs' mathematical achievement remains when carrying out tasks that not only involve numbers, symbols, and pictures, but text as well. Secada (1991) found that ELLs and English speakers in first grade solve addition and subtraction word problems with equal success. Therefore, although people often conclude that a lack of reading or English language proficiency produces difficulty with mathematics, research does not support the existence of a causal link between these two elements (Bourke & Keeves, 1977; Bulcock & Beebe, 1981; Secada, 1991). In fact, a study by Bourke and Keeves (1977) reveals that large percentages of students considered to have non-mastery in reading achieved mastery level scores in numeration. While Bulcock and Beebe (1981) point out "there is a high correlation between reading and numeration, such that children in the early grades of schooling who perform well in reading also tend to perform well in arithmetic" (pp. 19-20), they note that many factors related to graphic input, comprehension

strategies, and more impact both reading and mathematics. These outside variables affecting reading and mathematics abilities in similar ways could explain the correlation between the two areas. However, as ELLs' ability to understand mathematics exhibits, the correlation between mathematics and reading ability does not mean reading proficiency precedes mathematical competence.

It appears that certain elements of mathematics make it an accessible subject for ELLs despite the large role language can play in mathematical instruction and tasks. First, the universality of mathematical symbols seems to increase the comprehensible input ELLs receive during mathematics instruction (Goodman, 1996; Gunning, 2003). Freeman and Freeman (1994) define comprehensible input as oral or written messages presented in a context that people can understand. Thus, content learning and language acquisition depend on ELLs receiving comprehensible input (Ariza, 2006; Dale & Cuevas, 1987; Freeman & Freeman, 1994; Freeman & Freeman, 2000; Manyak, 2008; Peregoy & Boyle, 2000; Peregoy & Boyle, 2005; Virginia Department of Education, 2004). The common use of manipulatives, visual representations, and hands-on activities to teach mathematical concepts and solve mathematics problems also adds to the comprehensible input ELLs receive from mathematics (Virginia Department of Education, 2004). Although students may struggle to grasp the meaning of the verbal explanations teachers provide on various mathematics concepts, concretely seeing the concepts in action through visual representations can clarify confusions caused by the language barrier. Consequently, while specific sentence structure and vocabulary within mathematics problems and reasoning may trouble ELLs at first, the embedded context of the mathematics content can increase students' ability to grasp the meaning of the information and problem, helping ELLs learn English and mathematics at the same time (Virginia Department of Education, 2004). Thus, mathematics

promotes understanding for many ELLs because its symbolic structure seems to serve as a tool for moving past language complications within the domain of mathematics.

While teachers can also take strides to alleviate language issues in literacy, the pervasive presence of language makes literacy a challenging area for ELLs. However, just as ELLs can study and learn mathematics before attaining a solid foundation in listening to and speaking English, they can also learn to read and write with limited language proficiency (Anderson & Roit, 1996). Focusing specifically on reading, ELLs and native speakers follow similar processes for learning and engaging in reading (Avalos et al., 2007; Coleman & Goldenberg, 2010; Harper & de Jong, 2004; Lesaux & Siegel, 2005; Manyak, 2008; Peregoy & Boyle, 2000). However, ELLs differ greatly from native English speakers in their English language proficiency, background knowledge, and first language literacy experiences (Peregoy & Boyle, 2000). Peregoy and Boyle (2000) and Lesaux and Siegel (2005) point out that previous experience with reading can potentially cultivate ELLs' reading skills, such as understanding the purpose of print, following the directionality of texts, and decoding words based on letter and sound correspondences. Yet, ELLs' lack of language proficiency and background knowledge cause them to face particular difficulty with reading comprehension (Anderson & Roit, 1996; Hickman, Pollard-Durodola, Vaughn, 2004; Peregoy & Boyle, 2000). Providing ELLs with text topics and structures with which they have familiarity enhances their understanding of concepts and vocabulary within texts (Coleman & Goldenberg, 2010; Hickman et al., 2004; Peregoy & Boyle, 2000). Therefore, ELLs receive more comprehensible input when reading texts on which they have background knowledge and experience, thereby enabling them to effectively comprehend the texts. Yet, in the absence of background knowledge or nonverbal cues that suggest meaning of texts, ELLs struggle to comprehend what they read and may attempt to

directly translate what they read in English into their first language. Unfortunately, direct translation hinders comprehension further by slowing the reading rate and attracting students' attention to what they know instead of to making sense of the unknown elements in the text (Brown, 1998; MacKay & Bowman, 1969). Thus, the reading habits and capabilities of ELLs suggest they most benefit from learning comprehension strategies that facilitate their comprehension of texts even in the presence of unfamiliar and difficult language.

#### *Connections Between Instruction of ELLs and Instruction in Mathematics and Literacy*

An emphasis on comprehensibility led to the identification of the main instructional practices teachers should adopt in all subject areas to contribute to increased learning among ELLs. Referred to as sheltered instruction, these teaching practices “foster second language development and academic learning by using the second language for instruction in special ways to make it comprehensible to second language learners” (Peregoy & Boyle, 2005, p. 78). Sheltered instruction requires teachers to use simplified language, facial expressions, and repetition and to emphasize and explain main points and key vocabulary during lessons (Ariza, 2006; Hickman et al., 2004; Peregoy & Boyle, 2005; Virginia Department of Education, 2004). Another strategy involves using nonverbal cues, such as pictures, real objects, demonstrations, and gestures, to supplement the comprehension ELLs obtain from verbal and written instruction (Altieri, 2010; Ariza, 2006; Bauer & Manyak, 2008; Canney, Kennedy, Schroeder, & Miles, 1999; Coleman & Goldenberg, 2010; Dale & Cuevas, 1987; Freeman & Freeman, 2000; Peregoy & Boyle, 2000; Peregoy & Boyle, 2005; Virginia Department of Education, 2004). Similarly, using visual and kinesthetic teaching techniques, including graphic organizers, dramatic play, and hands-on activities, facilitates ELLs' understanding (Altieri, 2010; Ariza, 2006; Bauer & Manyak, 2008; Canney et al., 1999; Dale & Cuevas, 1987; Fogelberg et al., 2008; Freeman &

Freeman, 2000; Harper & de Jong, 2004; Peregoy & Boyle, 2005; Virginia Department of Education, 2004). Lastly, prior knowledge about the topic or familiarity with aspects of the instruction further improves ELLs' ability to learn academic and language content in their nonnative language (Altieri, 2010; Avalos et al., 2007; Bauer & Manyak, 2008; Coleman & Goldenberg, 2010; Dale & Cuevas, 1987; Freeman & Freeman, 2000; Harper & de Jong, 2004; Hickman et al., 2004; Peregoy & Boyle, 2000). All of these sheltering techniques work because they provide a context for the language involved in the instruction, thereby increasing the transmission of "comprehensible input [which] activates the parts of the brain that lead to language development" (Freeman & Freeman, 2000, p. 22). Furthermore, several of these strategies, including nonverbal cues, visual and kinesthetic teaching techniques, and use of prior knowledge and familiarity, correspond with a mathematics-literacy integration teaching standpoint (Altieri, 2010).

Yet another teaching practice that aligns with sheltered instruction guidelines as well as research on learning in reading and mathematics is social learning. Freeman and Freeman (1994) argue that interaction with peers during lessons increases ELLs' overall learning because students gain comprehensible input as peers communicate with them at their level of competence, students have the opportunity to practice utilizing their second language, and students hear each others' ideas and explanations on academic concepts. This contribution to each others' learning through group collaboration displays itself in Manyak's (2008) daily news literacy instruction where students share information from their own lives in Spanish before discussing the news in English. As example dialogues from this type of instruction illustrate, ELLs can build on one another's academic and language understandings as they translate and clarify the meaning of information, supplement each others' vocabulary, and rephrase statements

to fix grammatical errors. ELLs acquire additional information about standard English use from conversing with native English speakers (Fillmore & Snow, 2000). Also, this type of interaction allows for the use of gestures and repetition as native speakers try to ensure ELLs understand their intended message (Peregoy & Boyle, 2005). Consequently, social learning can enable ELLs to receive more individualized attention that effectively aids them in comprehending lesson material. Just as receiving other students' perspectives and explanations promotes ELLs' content and language learning, it also deepens all students' reading comprehension because students can pick up on details and interpretations of texts that they did not initially consider (Freeman & Freeman, 2000). Furthermore, talking about the use of specific writing or reading strategies among peers prompts students to "assume greater responsibility for their own use of comprehension strategies and receive feedback about their strategic use from others" (Fisher & Frey, 2008, p. 19). Similarly, conversations and collaboration between students during mathematics tasks cause all students to recognize multiple problem solving strategies and evaluate their efficiency and accuracy as they compare ideas (Altieri, 2010; Lester, 2003; Wall & Posamentier, 2007). In addition, hearing explanations of mathematical strategies and solutions and defending their own problem solving corrects students' mathematical misconceptions and reinforces their understandings of mathematical concepts (Altieri, 2010; Barwell, 2005; Hyde & Hyde, 1991; Lester, 2003; Virginia Department of Education, 2004; Wall & Posamentier, 2007). By heightening the meaningfulness and clarity of concepts, social interaction facilitates the learning of literacy and mathematics material, especially for ELLs.

People markedly extend their literacy and mathematics learning through social construction of meaning due to the interactive nature of the thinking processes associated with these two areas. As mentioned earlier, both literacy and mathematics involve attention to provided visual input



through bottom up processing and attention to implicit information through top down processing (Avalos et al., 2007; Brown, 1998). People utilize distinct prior knowledge, experiences, and connections during top down processing because no two people share the exact same experiences and perspectives. Thus, even when reading the same text, “there is a range of meanings that any individual can develop” (Freeman & Freeman, 2000, p. 24). When given the same mathematics problem to solve, students automatically make different inferences and decisions about strategies to apply to the problem (Hyde, 2006). Therefore, within the top down processing, speaking to other people broadens the knowledge and experience a person can draw upon in comprehending a text or mathematics problem. As a result, social interaction and social construction of meaning is a driving force in mathematics and literacy learning. As Wall and Posamentier (2007) repeatedly demonstrate, engaging students in the mathematics process standards created by the National Council of Teachers of Mathematics, which include problem solving, reasoning and proof, communication, connections, and representation, obligates teachers to utilize social learning in their classrooms. Through group work and mathematical talk, students jointly construct meaning and create representations of mathematical concepts (Hyde, 2006; Hyde & Hyde, 1991; Lester, 2003; Wall & Posamentier, 2007). The same act of combining various ideas to jointly construct meaning occurs in literature groups and discussions. Conversations about information and events in texts encourage students to continually modify their interpretations of texts as they gain additional and different insight from other students (Avalos et al., 2007; Freeman & Freeman, 2000; Tompkins, 2009). Therefore, social interaction helps students create and take away similar understandings of a text’s meaning. This involvement of social learning to make sense of mathematics and literacy language benefits all populations of learners, including ELLs, because every individual can offer a unique perspective that contributes to the group’s

construction of meaning and each individual's personal comprehension of the material.

### *Significance of Mathematics and Literacy Integration*

Overall, the educational practices for instructing ELLs and for teaching mathematics content and strategies and literacy content and strategies overlap in numerous aspects. As a result, it seems that integrating mathematics with literacy for ELLs should be a simple and natural teaching process. Even more importantly than being easy to implement, mathematics and literacy have logical connections that make it a valuable teaching tool to utilize mathematics to develop ELLs' literacy abilities. First of all, ELLs experience success in mathematics because the universality of mathematical symbols and concrete visual properties of mathematics concepts and instruction alleviate language complications. In contrast, ELLs encounter particular difficulty in literacy, especially with reading comprehension. Knowing this, educators should seek methods for using ELLs' strength in mathematics as an avenue to advance their weaker area of literacy. Fortunately, mathematics and literacy possess several relationships in their structure, thinking, and execution. In particular, the reading component of literacy ties together most closely with mathematics in the thinking and strategies involved in comprehending mathematics and reading. Therefore, it does seem possible to improve ELLs' comprehension of literacy by teaching students to apply mathematical thinking and problem solving strategies to the problem solving involved in the reading process.

In addition, teaching ELLs to see connections between mathematics and literacy and to use the same types of strategies in both adds familiarity to the content and skills they learn. Thus, students have background knowledge in mathematics to which they can connect literacy learning, which allows ELLs to better understand literacy instruction. Table 1 lists the parallels between mathematics and literacy found and synthesized from the current literature.

Table 1

*Parallels Between Mathematics and Literacy Concepts and Strategies*

Author(s)	Mathematics	Literacy
Hyde, 2006; Russell & Dunlap, 1977	Use and understand symbols	
Minton, 2007	Digit, value, and name awareness (1 is one and represents one object)	Letter and sound awareness (A is a and sounds like /a/)
Russell & Dunlap, 1977	Relationship between <i>digits</i> and numerals (ex. 1: 5 ¼)	Relationship between letters and words (ex. a : clap)
Minton, 2007	Decomposing numbers (ex. 12=3+3+3+3 or 6+6)	Decoding (ex. cat= /k/+/a/+/t/)
Minton, 2007	Automatic retrieval of basic facts	Automatic retrieval of sight words
Peregoy & Boyle, 2005	Fact families	Word families
Minton, 2007	Number context awareness (knowing how numbers and mathematical signs fit into a problem)	Word context awareness (knowing how words fit into sentences and overall texts)
Dale & Cuevas, 1987	Variable referent	Pronoun referent
Greenwood, 1993	Using knowledge of a simpler problem to solve a problem (ex. I can solve 7x7 to figure out 8x7.)	<i>Using chunking to decode a word (ex. I can read “win” to figure out “winner.”)</i>
Greenwood, 1993	Using counting and other inefficient strategies for computation problems	<i>Sounding out words and using other inefficient strategies for decoding words</i>
Minton, 2007	Learning algorithms or procedures for solving mathematics problems	Learning standard sentence structure <i>for solving decoding problems with syntactic cues</i>

*(table continues)*

Table 1 (*continued*)

Author(s)	Mathematics	Literacy
Wall & Posamentier, 2007	Mathematics skills and knowledge (facts, concepts, procedures) serve as tools for mathematical problem solving	<i>Literacy skills and knowledge (phonemic awareness, phonics, prior knowledge, decoding strategies) serve as tools for reading and comprehending</i>
Wall & Posamentier, 2007	Nonstandard representation of problem	<i>Invented spelling</i>
Seo, 2009	Solving an algebraic equation	Writing a standard paragraph
Pape, 2004; Smith, 2002 (mathematics) and Brown, 1998; MacKay & Bowman, 1969 (literacy)	Look for overall meaning of word problems rather than directly translating words into mathematical symbols	Look for overall meaning of texts rather than directly translating into native language
Greenwood, 1993 (mathematics); Fogelberg et al., 2008 (mathematics and literacy)	Thinking aloud and showing work to display mathematical thinking process and understanding	Thinking aloud to display reading thinking process and understanding
Lester, 2003; Wall & Posamentier, 2007	Relationship between answer to problem and solution method	<i>Relationship between miscue and cueing system(s) used</i>
Wall & Posamentier, 2007	Group problem solving	<i>Literature circles</i>
Wall & Posamentier, 2007	Using reasoning and proof for problem solving strategies and answers	<i>Using reasoning and textual support for comprehension strategies and interpretation of literature</i>
Lester, 2003; Wall & Posamentier, 2007	Exploring and using multiple mathematics problems to prove or disprove mathematical ideas and concepts	<i>Exploring and using multiple words, sentences, and texts to prove or disprove phonics and syntax rules</i>
Hyde, 2006	KWC	KWL
Russell & Dunlap, 1977	Maze technique/cloze procedure	

*(table continues)*

Table 1 (*continued*)

Author(s)	Mathematics	Literacy
Hyde, 2006	Question-Answer-Relationship	→
Anderson & Roit, 1996; Fogelberg et al., 2008	Estimation	Prediction
Fogelberg et al., 2008; Hyde, 2006; Minton, 2007	Mathematics-to-self, mathematics-to-mathematics, and mathematics-to-world connections	Text-to-self, text-to-text, and text-to-world connections
Fogelberg et al., 2008; Hyde, 2006; Minton, 2007; Seo, 2009	Drawing a picture or creating a mental image	→
Fogelberg et al., 2008; Hyde, 2006; Minton, 2007	Expanding vocabulary, asking questions, determining importance, inferring, synthesizing	→
Minton, 2007	Rereading and reading ahead	→
Fogelberg et al., 2008; Greenwood, 1993; Hyde, 2006; Minton, 2007	Self-monitoring and self- correction (using metacognition)	→
Fogelberg et al., 2008; Wall & Posamentier, 2007	Using different methods, approaches, and strategies to solve the same mathematics problem	Using different methods, approaches, and strategies to decode the same words or comprehend the same portions of texts
Garofalo & Lester, 1985; Hyde, 2006; Hyde & Hyde, 1991 (mathematics); Clay, 2005; Goodman, 1996; Olshavsky, 1976-1977; Smith, 2004; Smith, 1997 (literacy)	Problem solving process	Reading process

*Note.* Italics indicate items derived from my own personal connections and interpretations.

In addition to adding familiarity, many of the connections between strategies and thinking in mathematics and literacy address other sheltered instruction principles, such as involving visuals, graphic organizers, hands-on activities, and social interaction. Consequently, support for the advantages of teaching ELLs literacy through mathematics once again intensifies.

Research showing how the most successful readers and mathematicians display increased use and self-evaluation of mathematics and literacy strategies, including many of those mentioned in Table 1, provides yet another reason teachers should integrate mathematics and literacy.

Knowledge of more strategies activates students' ability to opt to use more sophisticated and efficient strategies to problem solve in mathematics, reading, and spelling (Farrington-Flint, Vanuxem-Cotterill, & Stiller, 2009). Furthermore, using more decoding and comprehension strategies helps readers engage in more mental processing and bring more relevant prior knowledge to texts as they attempt to decode and comprehend them (Peregoy & Boyle, 2000). Therefore, proficient readers tend to use more strategies when reading than lower achieving readers (Fisher & Frey, 2008; Olshavsky, 1976-1977; Peregoy & Boyle, 2000). Also, struggling readers make the largest improvements in comprehension abilities when they receive strategy instruction (Dole, Brown, & Trathen, 1996). As Minton (2007) discusses, strategy knowledge and use offers similar benefits in mathematics too because successful mathematicians demonstrate flexibility to use multiple strategies to solve mathematics problems, efficiency in selecting appropriate strategies, and accuracy in carrying out strategies to solve problems. In a comparison of the problem solving strategies of students and trained mathematicians, the trained mathematicians "tried many more approaches, constantly asking themselves if their strategy was working and changing it immediately if it was not" (Hartman, 2001, p. 18). In addition to showing better mathematicians use more strategies, the findings from this study also show that

skilled mathematicians rely on metacognition to monitor understanding and strategy use. Similarly, readers achieve higher rates of comprehension when they self-monitor their comprehension and implement fix-up strategies to repair comprehension problems (Hartman, 2001; Fogelberg et al., 2008; Goodman, 1996; Minton, 2007; Peregoy & Boyle, 2000; Smith, 2004). In general, it appears that knowing about, using, and monitoring the use of more problem solving and comprehension strategies enhances achievement in both literacy and mathematics. Thus, learning about and applying the same strategies in mathematics and reading through mathematics-literacy integration increases the likelihood that students will understand and feel comfortable using these strategies, thereby making them more successful in both mathematics and reading.

However, students tend not to recognize similarities between the two subjects when teachers fail to emphasize the mathematics-literacy relationship, so teachers must explicitly indicate the similarities in order for students to transfer mathematics strategies and thinking to literacy learning (Fogelberg et al., 2008). When teachers explicitly remind students that they can use the strategies and skills they learn in another situation or topic area, the chance of students successfully transferring the strategies and skills to new contexts increases (Billing, 2007; James, 2006; Thomas, 2007). Beyond telling students how and when learning can transfer to another context, other instructional factors also affect the probability of students transferring learning. While no exact conditions for engendering transfer exist, Barnett and Ceci (2002) discuss how near transfer, which involves transfer of learning between similar knowledge domains and contexts, occurs more frequently than far transfer, which requires transfer of skills between more unrelated knowledge domains and contexts. Within the knowledge domain, which refers to the typical subject area where knowledge and skills are applied, the type of transfer proposed by

mathematics-literacy integration falls into the far transfer classification because teachers rarely have students use mathematics knowledge and skills during reading or writing instruction. Consequently, transfer between mathematics and literacy poses a challenge, even when teachers explicitly point out mathematics-literacy connections to students.

Yet, Barnett and Ceci's (2002) taxonomy for far transfer indicates that teachers can increase the likeliness of far transfer in the knowledge domain dimension by minimizing the distance of transfer in the dimensions of physical context, temporal context, functional context, social context, and modality. The physical context involves the location where transfer instruction and application occurs. Thus, near transfer could involve teaching and having students utilize mathematics-literacy connections in the same room at school while far transfer might involve students receiving instruction at school and then applying transferrable mathematical strategies when they read books while on vacation in another state. To minimize the distance of transfer in the temporal context, teachers should have students practice using a mathematics strategy for reading as soon as possible after showing students how the strategy relates to reading. Since the functional context involves the purpose an individual sees for using knowledge and skills, near transfer naturally occurs in this context with the transfer of mathematics skills to literacy skills because students regard both as fulfilling academic purposes. In terms of the social context, teachers can decrease the distance of transfer by ensuring students work individually or in the same size of cooperative group when using a concept or strategy in mathematics as when using the concept or strategy in literacy. Lastly, teachers should have students use specific connected mathematics and literacy ideas in the same format, such as in a written graphic organizer or with the use of manipulative materials, in order to minimize the distance of transfer in the modality context. By taking these measures, such as teaching mathematics skills and



concepts in the same room, in the same student grouping, and on the same day as teaching students to relate and apply those mathematical skills and ways of thinking to their literacy learning, teachers can promote the ease with which students will see the connections and transfer strategies between mathematics and literacy.

While Barnett and Ceci (2002) discuss the importance of maintaining the same social context, whether individual or group, when teaching for transfer, other research suggests that group learning in particular provides the best context for increasing the probability of the transfer of knowledge and skills to new situations. For example, Haskell (2001) claims a group culture that supports transfer “creates a universe of meaning for us that shapes our learning, transfer, and even our memory” (p. 137). Also, as De Corte (2003) argues, positive social interaction and collaboration among students in classrooms can motivate students to strive for transfer. Thus, conversations with peers help students understand mathematics-literacy connections and aspire to determine how to use mathematics strategies in the area of literacy. In order to facilitate students’ discovery of potential transfer situations, James (2006) suggests that teachers of ELLs encourage students to brainstorm different contexts to which they can transfer and apply newly learned skills. By having students perform this brainstorming activity in groups or as a whole class, they have the potential to generate numerous ideas and rationales for how mathematics strategies apply to parallel problem solving situations that exist in literacy. Billing (2007) argues that this type of social development of explanations of strategies and the conditions for their transfer increases the likelihood that students will successfully transfer strategies. Therefore, social learning impacts students’ recognition and comprehension of transferrable skills. In the next stage, when students begin attempting to transfer mathematical concepts and strategies to literacy, social interaction continues to play a significant role. Coaching and providing feedback

to peers on their application of transferrable skills as well as discussing the appropriateness and accuracy of their implementation of transferred skills strengthens students' understanding of the relationship between the different knowledge domains and increases their effectiveness in transferring learning between the two subjects (Billing, 2007; Fisher & Frey, 2008; Thomas, 2007). Thus, implementing social learning and the other research-based methods for promoting transfer allows teachers to take advantage of the mathematics-literacy teaching approach, thereby enabling them to reach out to mathematically inclined students who struggle in the area of literacy, such as ELLs. Furthermore, based on the inherent importance of social learning in mathematics and literacy (Avalos et al., 2007; Freeman & Freeman, 2000; Hyde, 2006; Hyde & Hyde, 1991; Lester, 2003; Tompkins, 2009; Wall & Posamentier, 2007), implementing the mathematics-literacy teaching approach supports the mathematics and literacy learning of all student populations.

### Classroom Implications and Recommendations

Since the social element of integrating mathematics into literacy fosters deeper understanding of mathematics and literacy concepts and strategies for all students, including ELLs, all elementary teachers should adopt the mathematics-literacy teaching technique in their classrooms. Encouraging students to explore the interrelationships between the two domains and explicitly instructing students on how to transfer skills between mathematics and literacy will bolster the foundation of students' understandings in both areas. Thus, while helping students that excel in mathematics, such as ELLs, learn about applying mathematics strategies to reading, mathematics-literacy integration also helps students that excel in reading to see the subjects' parallels, so they can then apply reading strategies and thinking to mathematics. Due to the abstract and metacognitive nature of many of the connections between literacy and mathematics concepts, teachers may find that integrating the two content areas functions best with upper elementary students. However, laying the foundation for recognizing similarities between mathematics and literacy can easily begin in the primary elementary grades. Furthermore, by explicitly teaching specific mathematics and literacy comparisons and using the nonverbal, visual and kinesthetic, prior knowledge-based, and social construction of meaning teaching techniques emphasized for the teaching of ELLs, mathematics, and reading, teachers can make mathematics-literacy connections more concrete and comprehensible to younger students. While teachers can effectively make use of any of the strategy and concept parallels between mathematics and literacy listed in Table 1, I will showcase three particular strategies to provide examples of how mathematics-literacy integration may look in the classroom.

### *Solve a Simpler Problem Strategy*

One problem solving strategy utilized for both mathematics and literacy is to solve a simpler problem to then solve the original problem. In mathematics, this involves solving a problem with smaller or more familiar numbers (Greenwood, 1993). This strategy has two main advantages for improving students' comprehension and solving of a problem. First, testing a strategy with smaller numbers allows students to more easily verify the accuracy of their strategy. For example, if a student felt uncertain about the proper procedure for regrouping in a subtraction problem, they could check the application of the procedure with  $13-9$ , make any corrections, and then use regrouping with an original problem of  $231-52$ . Secondly, solving a simpler problem can enable a person to consider the difference between the numbers used in the simpler problem and in the original problem in order to then manipulate the solution from the simpler problem to reach the solution to the original problem. For example, when given a mathematics problem involving  $8 \times 7$ , a student may not automatically know the answer. Yet, by solving  $7 \times 7$  before discussing with peers and using drawings or manipulatives to determine how to use that answer of 49 to figure out  $8 \times 7$ , students can reach the correct solution. Thus, students find a way to solve the original mathematics problem as well as deepen their understanding of the problem and its associated mathematical concepts.

In reading, solving a simpler problem fits closely with this second method of solving a simpler mathematics problem, and it manifests itself in the strategy of chunking. Chunking involves students breaking a word apart into smaller, recognizable chunks to decode the word. For example, if a student encounters the unknown word "winner", the child can chunk the word, using their solution of the simpler word "win" and the suffix "er" to then figure out the pronunciation of the word "winner." In this instance, chunking also aids the student in problem

solving the meaning of the word “winner” as the student uses knowledge of the meaning of the individual word parts to decide a winner is a person who wins. As with mathematics, the child can use manipulative letters to break apart the word “winner” and determine what letters and sounds to add to the initial chunk “win” to decode the whole word. Also, students can discuss what word chunks to use to decode “winner” since some students may recognize and use the simpler words “in” or “inner” as well. In addition, students can collaborate to define “winner” and explain how it contributes to the meaning of the sentence or overall story. Therefore, solving a simpler problem allows students to tackle original, difficult words and increases their comprehension of the text.

Teachers can facilitate students’ transfer of the mathematics strategy of solving a simpler problem to their reading by following the previously mentioned guidelines for promoting transfer. Thus, teachers would want students to talk about how the mathematics strategy may apply to reading strategies. Then, students and the teacher would coach each other and provide feedback on the implementation of the solving a simpler problem strategy in reading. To explicitly illustrate the parallels between the strategy’s use in mathematics and literacy, teachers could create handouts or a poster detailing this information, such as the handout in Figure 1.

# Solve a Simpler Problem

Mathematics

Problem


Reading

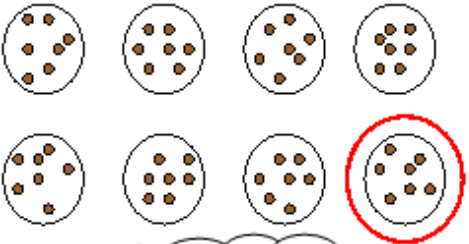
**Original problem:** You want to make 8 cookies, and you want each cookie to have 7 chocolate chips. How many chocolate chips do you need?

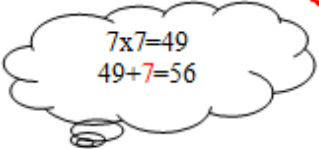
**Problem to solve:**  $8 \times 7$

**Simpler problem chosen:**  $7 \times 7$

**Getting from simpler problem to original problem:**

1. Talk with table group. 
2. Use objects or draw a picture to show  $7 \times 7$ , and see what must add to show  $8 \times 7$ .






**Answer:** 56

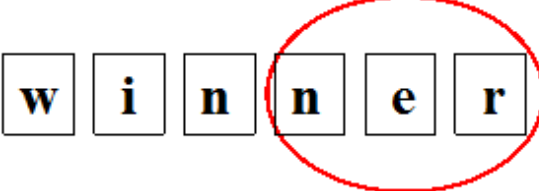
**Original sentence:** I was the **winner** of the race.

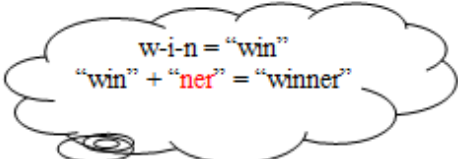
**Problem to solve:** winner

**Simpler problem chosen:** w-i-n

**Getting from simpler problem to original problem:**

1. Talk with table group. 
2. Use letter tiles to show w-i-n, and see what must add to get w-i-n-n-e-r.





**Answer:** "winner"

Figure 1. Handout on the solve a simpler problem strategy.

### *Reasoning and Proof Strategy*

Executing the same social and explicit transfer teaching methods, teachers could also prompt students to utilize the strategy of using reasoning and proof in both mathematics and literacy. With mathematics, teachers should require students to show their work and support their solutions by explaining their reasoning for following certain mathematical procedures. Visual representations in the form of drawings or manipulatives can contribute to students' explanations since they detail students' thinking as they solved the problem. Relying on both representational and verbal or written mathematical explanations generates comprehensible input for ELLs to understand peers' explanations as well as a mode of output for ELLs to explain their own rationales. Also, this reasoning and proof emphasis encourages students to think systematically and make sense of mathematical problems and ideas (Wall & Posamentier, 2007). Since the communication of rationale for problem solving strategies and solutions occurs among students, they can comment on and question each others' thinking in order to socially develop understanding of mathematics concepts. In the same way, students should defend the comprehension strategies they use and subsequent interpretations of texts they make when engaging in book discussions. As students share viewpoints they bring to the text, they too socially construct meaning from the combination of textual information and different students' ideas. Once again, a handout directly comparing uses of reasoning and proof in mathematics and in literacy would increase students' perception of the similarities between the strategy's use in the two areas. Figure 2 provides an example of correlations in the application of the strategy to a mathematics problem and a reading story question.

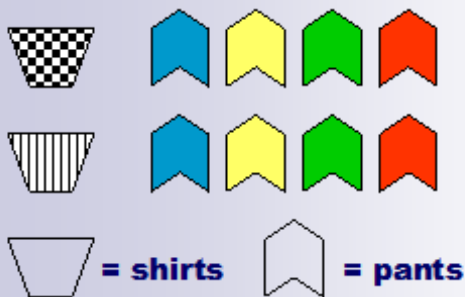
<h1>Reasoning and Proof</h1>	
<h2>Mathematics</h2>	<h2>Reading</h2>
<b>Problem:</b> How many different outfits can Shana wear if she has 2 shirts and 4 pairs of pants?	<b>Story Question:</b> Why did Riley go to bed in the middle of the day?
<b>Answer:</b> 8 outfits	<b>Answer:</b> Riley was having a bad day and thought going to bed would keep any other bad things from happening to her.
<b>Strategy:</b> Draw a picture	<b>Strategy:</b> Infer
<p><b>Explanation:</b></p>  <p><b>Shana can wear each shirt with each of the four pairs of pants. This means she has 8 outfits because <math>2 \times 4 = 8</math>.</b></p>	<p><b>Explanation:</b></p> <p>“Riley tripped over her fan on the way out her door.”</p> <p>“Her hair was such a tangled mess that the comb got stuck in it.”</p> <p>“The bus had already left.”</p> <p>“With a smile on her face, Riley fell back asleep.”</p> <p><b>The text and illustrations showed that Riley was mad about bad things happening but happy about going back to bed.</b></p>

Figure 2. Handout on the reasoning and proof strategy.



### *Making Connections Strategy*

A third strategy to teach students to transfer from mathematics to literacy is making connections (Fogelberg et al., 2008; Hyde, 2006; Minton, 2007). The three types of connections students can make include mathematics or text to self, mathematics or text to mathematics or text, and mathematics or text to world. Therefore, this comprehension strategy aids students in organizing conceptual knowledge and in activating prior knowledge to better understand mathematics problems or literary texts (Hyde, 2006). Since the making connections strategy shows students how problems or texts have familiarity with their preexisting knowledge and experiences, it naturally incorporates one of the sheltering techniques for teaching ELLs. Utilizing the sheltering method of drama to have students act out mathematics problems or story events as well as their corresponding situation in students' lives, other problems or stories, or the world, could also fortify ELLs' comprehension of the making connections strategy itself as well as of the mathematics problem or literary text involved. Furthermore, the making connections strategy lends itself to social learning because students can discuss or act out the connections they make in pairs, small groups, or as a whole class in order to make additional connections and better comprehend problems or texts. As with the other two strategies featured for classroom application, an explicit juxtaposition of the strategy's use in mathematics and in literacy may benefit students. An example handout appears in Figure 3.

# Making Connections

Mathematics	Reading
<b>Problem:</b> How many ways can you make change for \$1?	<b>Story Event:</b> The cows laughed at the horse who could not moo.
<b>To Self</b>	
My mom gave me 4 quarters for my \$1, so I could buy a pop from the vending machine.	My brother laughed at me when I could not ride a bike.
<b>To Mathematics or Text</b>	
This is like the problem we did yesterday where we found different ways to pay \$0.55 for a candy bar.	This is like a story we read last week where kids were mean to a boy who could not spell words correctly.
<b>To World</b>	
People use and keep track of money every day when they buy and sell things.	People everywhere laugh at and bully other people who cannot do things or are different from them.

Figure 3. Handout on the making connections strategy.

### *Conclusion*

It is always important to adapt instruction and find the teaching method and way of explaining material that helps each individual student learn. Having mathematics-literacy integration as an additional approach to teaching literacy, which can also have an impact on students' mathematics learning, will enable teachers to increase their effectiveness as they help more students in the classroom. While this thesis has displayed the viable connection between mathematics and literacy and examined points on teaching ELLs and teaching for transfer to explain how teachers can utilize mathematics-literacy integration, its effectiveness in the actual classroom still needs to be tested. Thus, this work should serve as a starting point for future research where others can further examine and study this connection when teachers implement such strategies as the three discussed in the classroom implications and recommendations section in order to determine the actual significance of the connection in improving students' literacy abilities in practice. Additional studies can also focus on how the teaching approach affects student populations besides ELLs as well as how it affects students' mathematics learning. Positive results from these types of studies can result in the dissemination of these ideas for a mathematics-literacy integration teaching technique in schools across the nation.

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