Abstract
This manuscript seeks to provide a framework for teaching reading skills in the various content areas, specifically mathematics and most importantly to pinpoint specific strategies and resources teachers can use to help their students succeed in reading to learn.

Using Reading Strategies to Enhance Content Learning in Mathematics

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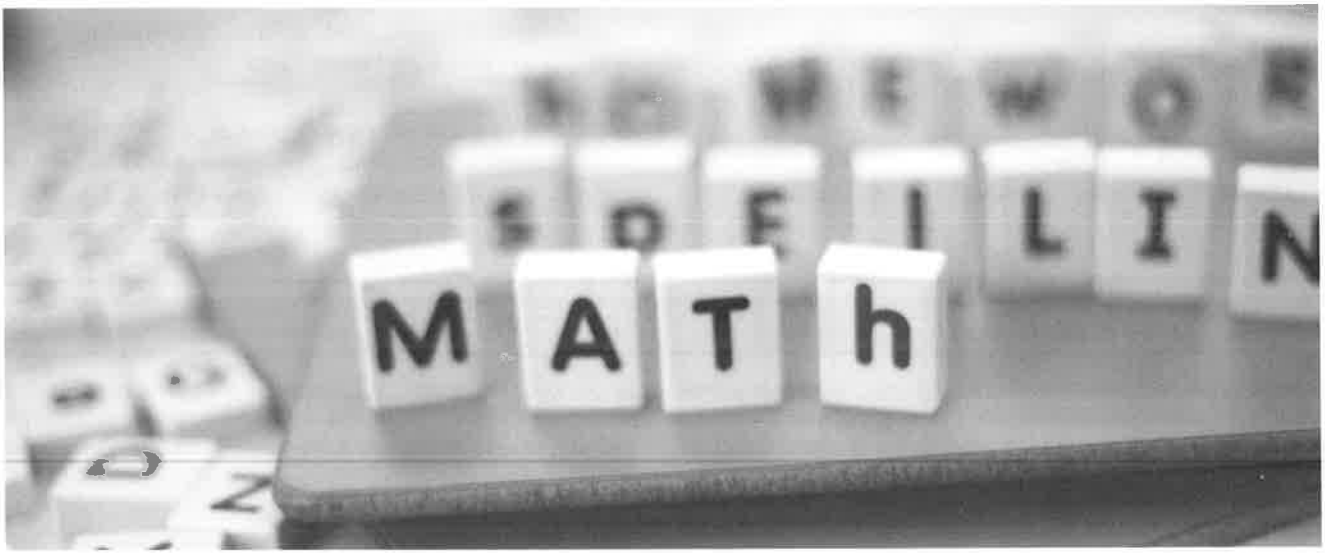

It is frequently said that from kindergarten to third grade students are learning to read, and starting at about fourth grade, they are reading to learn. Because reading is the foundation for future academic success, much of the time and energy in school in the early grades is directed toward the cultivation of reading skills. However, the expectation that students have mastered the basics of reading by the end of third grade should not result in an abrupt end to formal reading instruction at this time. Rather, the type of reading instruction offered should change. Shanahan and Shanahan (2008) found that the literacy curriculum should better meet the needs of students in reading and writing in the content areas. Thus, reading instruction must continue within content areas if students are to be truly successful across the curriculum.

As students transition from learning to read to reading to learn, teachers need to model how to most effectively read with these new goals in mind. Greenleaf, Schoenbach, Cziko, and Mueller (2001) state that students who learn to read early do not always perform at higher levels of literacy. Adept readers are skilled at adapting their reading strategies according to the content, but for struggling readers, this transition presents challenges. Teachers in all content areas can help students by teaching reading strategies directly. This kind of direct instruction is useful for proficient readers, but even more so for students who are not strong readers or those for whom English is not the primary language. Having a cache of reading strategies available to students can be beneficial to both struggling and proficient readers in all content areas. Learning how to use these reading strategies and knowing when to use the appropriate strategy is important to the success of all students. It is essential for teachers to provide students with ample practice time in order for them to become comfortable using the strategies (Antonacci & O'Callaghan, 2011).

Improving Reading to Improve Mathematics
A literacy strategy is defined as an instructional tool that facilitates, reinforces, or assesses students' comprehension of discipline-specific material through the use of reading, writing, listening, or speaking (Friedland, McMillen, and Hill, 2011). Some mathematics teachers are actually unaware that they are using literacy strategies to teach mathematics content; they are simply making instructional decisions based on good pedagogy and best practices. According to Draper and Siebert (2004), "mathematics learning and literacy are inseparably intertwined and that every mathematics learning event is also a literacy event". When students are taught to use reading

strategies to learn mathematics their comprehension of mathematical problems improves (Franz, 2009; Donahue, 2003; Ostler, 1997). To illustrate the importance of applying reading skills to mathematics, Fuentes (1998) compared the process of reading and comprehending a math text with that of interpreting a poem. Poetry, like mathematics, requires the reader to figure out a concept or relationship in the words read. In both the reading of a math text and a poem, the reader is actively engaged in comprehending the material. To fully comprehend mathematical concepts in the classroom, a reader must be able to effectively choose from a wide variety of reading strategies. Utilizing these strategies, the student may achieve the desired result of understanding. Franz (2009) points out that the use of a graphic organizer that charts the word, definition, and associated equations helps students understand mathematical concepts because students are able to organize material that is similar and students are required to use specific approaches when finding solutions. Further support for integrating literacy strategies into the mathematics curriculum was revealed when the common core standards for mathematics were released. Suggesting that in order for mathematics teachers to ensure their students are able to read and write in mathematics, they should focus attention on reading and writing within their content area (Common Core State Standards Initiative, 2010).

Naturally, a student must comprehend what has been read. Yet students are presented with a distinct challenge when it comes to the language of mathematics since it is generally used only in a school setting. For example, some mathematics terms, such a power or radical, have a different meaning in everyday English. (Friedland, McMillen, Prado Hill, 2011) Since mathematics uses this specialized vocabulary, the effective use of reading vocabulary strategies can help students develop a better understand of mathematical concepts. Possessing such reading skills is especially critical in upper elementary and secondary school when students must read and comprehend more complex materials. Burton (1992) indicates that words with mathematical meanings that differ from their meanings in everyday life present unique challenges to students in mathematics classes. Students must understand that math, perhaps more than any other subject, has a language of its own. Assisting students in the discovery of strategies that can be used with the specialized mathematics terms is very important.

Teachers can help students internalize the terminology of mathematics through a process of using informal definitions to introduce formal definitions. Adams (2003) provides an example of the transition from an informal definition to a formal one. A student first learns that a shape with four equal sides is a square. This definition changes once polygons are introduced, and the student learns that regular polygons include many other shapes, such as pentagons, hexagons, and nonagons. The student's definition of a square is now: "a square is a four-sided shape with all equal sides". With the introduction of the rhombus, the informal definition is again transformed. "A rhombus is a four-sided shape with all equal sides, but not all rhombi are squares." The formal definition of "a square is a quadrilateral with all ninety-degree angles and all equal sides", yet the student has come to understand the meaning of a square through the transformation of the informal definition of a square (p. 787).

Challenges when Reading Mathematics

When a student's prior understanding of a word with multiple meanings does not include knowledge of the mathematical meaning, it may confuse his or her understanding of the mathematics involved. A few examples of such multiple-meaning terms include volume, product, net, face, cube, yard, and base. In other subjects, students' prior knowledge of a word can actually be used to their advantage. The idea is to make a connection between prior knowledge of a word and the mathematical meaning of the word, and encourage the student to develop a definition taken from his or her own experience (Berenson, 1997). For example, one meaning of the word base is "the place where a baseball (or kickball) player runs to or walks to when the player has hit (or kicked) the ball." Another meaning of the word base refers to the bottom of a lamp (Adams, 2003). The mathematical meaning of base is a side or face of a geometrical figure from which an altitude can be constructed. Yet in mathematics, base can also refer to a number equal to the number of units in a given digit's place (Cambridge Dictionaries Online, 2008).

Many words have more than one meaning. When a multiple-meaning word is encountered, teachers should discuss both the everyday and the mathematical meanings. For example, a leader is known as a ruler, yet a ruler in mathematical terminology means a measuring device. Once the differences are discussed, a real-life connection can be made between a measuring device and a leader by saying, just as a ruler measures length, a ruler's position is a measure of his/her importance, power, or influence (Adams, 2003). The goal of making this connection is to strengthen students' understanding of mathematics terminology and concepts and widen their range of information.

Words that sound the same but are spelled differently, like homophones, can be confusing when students encounter these words in their textbooks.

Although these types of words sound alike, they may have different meanings, which can impede comprehension. As with multiple-meaning words, it is helpful to address the possible similarities and clear up any misunderstandings that students may have. Students might be asked to identify another name for a 90 degree angle. A student knows it is also called a right angle, but must decide if the correct spelling for the word is right or write. Creating a classroom word wall and maintaining individual notebooks of math terms and their meanings, possibly with illustrations, are two very useful strategies for helping students to learn the specialized vocabulary of mathematics. Both enable students to better decipher and effectively read mathematics.

Math-Specific Strategies

If students are to become successful in comprehending information in their textbooks, it is imperative that teachers provide them with appropriate mathematical content strategies. There are many reading strategies for the content areas available for students to use. Figure 1 provides a list of websites that will assist teachers and students in finding and implementing effective reading strategies to use in the content areas, specifically mathematics. Some of these reading strategies can be used before the student reads the text, during reading the text, and after reading the text that will make the comprehension process easier. Figure 2 suggests a few strategies that mathematics students can apply during each of these times. Prereading strategies, such as word

Websites for Reading Strategies for Mathematics
TEACHERS
http://www.justreadnow.com
http://www.readingquest.org
http://www.visualthesaurus.com/cm/teachersatwork/1305/
http://score.rims.k12.ca.us/score_lessons/content_area_literacy/
http://www.learner.org/jnorth/tm/ReadStrats_20Best.html
http://www.suite101.com/content/middle-school-content-area-reading-strategies-a95631
http://www.pgcps.pg.k12.md.us/~elc/readingacross1.html
Students
http://www.vtaide.com/png/assess.htm
http://www.homeschoolmath.net/online/problem_solving.php
http://www.mathstories.com
http://www.kidzone.ws/math/wordproblems.htm
Parents
http://www.literacyconnections.com/StrongReadingComprehensionSkills.php
http://hubpages.com/hub/Strategies-for-solving-math-story-problems_
http://www.homeschoolmath.net/online/problem_solving.php

FIGURE 1 *Websites for Reading Strategies for Mathematics*

Reading Strategies Suggestions for Mathematics			
PREREADING STRATEGIES			
Word Sort	Semantic Web	List/group/label	SQ3R
Admit Slip	Graphic Organizer		
DURING READING STRATEGIES			
QAR	Word wall	SQRQCQ	SQ3R
Journaling	Graphic Organizers	Reciprocal Teaching/Questioning	
AFTER READING STRATEGIES			
Journaling	SQ3R	Exit Slips	Graphic Organizers

FIGURE 2 *Reading Strategies Suggestions for Mathematics*

sort, semantic web, list/group label, and admit slips promote vocabulary understanding which is crucial to successful comprehension of the text. These particular vocabulary strategies help students sort and organize words from their textbooks with common similarities and link them to their prior knowledge for a deeper understanding of the text (Bear, Invernizzi, Templeton, & Johnston, 2008). When using admit slips before a mathematics lesson, questions or prompts are developed by the teacher that provide insight into possible student misunderstandings and understandings.

Reading strategies can also be used during reading to assist students in constructing meaning. One such strategy that is helpful to students when they read mathematics textbooks and concepts is QAR, Question Answer Relationship, designed by Raphael (1982). This strategy encourages students to analyze a question before trying to answer it. Sometimes the answer to a question is provided within the text, and sometimes students need to search the text to find an answer. Yet at other times, they must read the material and use prior knowledge to provide answers to the questions.

Reading mathematics textbooks and knowing how to proceed with computation of a mathematics problem presents additional challenges for some students. Equipping students with reading strategies that will improve their chance of success is useful when students read to learn. One such word problem solving strategy is Survey, Question, Read, Question, Calculate, Question (SQRQCQ) (Logsdon, 2009). This strategy is especially helpful to students when locating important and relevant information in a word problem. The procedure for implementing this strategy requires the student to:

Survey the math problem
Question what is required
Read the math problem
Question yourself about the operations involved
Calculate the problems
Question yourself about the steps you took

Reciprocal Teaching is another strategy to use while reading by both the student and the teacher. This strategy is best modeled first by the teacher using predicting, questioning, clarifying, and summarizing to figure out the meaning of the text (Palincsar & Brown, 1986). The students can then take turns assuming the role of the teacher. In the first step, the student reads a passage and then summarizes it. Step two is when the student clarifies confusing parts of the passage. The student may get assistance from other members of the class if needed. The student then moves to step three where he/she asks questions of the class to identify the important information. The final step is predicting. In this step, the student asks the other class members to make predictions about what will happen next in the text.

Survey, Question, Read, Recite, Review (SQ3R) (Robinson, 1970) is an effective strategy when used during reading to aid in the construction of meaning. The first stage is survey, where the student scans the title, headings, illustrations, and reads the first and last paragraph to get a feel for the assignment. The next stage is where the student turns headings into questions or writes any other questions that come to mind. In the reading stage, the student is actively reading for answers to the questions. During the recite stage, the student recites the answers to the questions without looking at the book. The final stage, which is review, has the student summarize the important information either by writing or discussing it. This strategy is discussed as during reading strategy, but can also work equally well for before and after reading. The use of graphic organizers is another example of a strategy that can be successfully implemented before, during, and after reading.

Using Graphic Organizers to teach Mathematics

Graphic organizers are visual representations that help students organize information and concepts. When students use graphic organizers in the mathematics classroom, they are presented the opportunity to think about relationships between concepts as well as identify missing information or connections. Zollman (2009) points out that many teachers use graphic organizers to help students clarify their thoughts, communicate their thinking strategies, and infer solutions to problems. His Four corners and a diamond mathematics graphic organizer provides students a place to begin the process of problem-solving. Although the format of graphic organizers differs, the important ideas and relationships are still the main focus. There are software programs available (i.e. Kidspiration, Inspiration, Inc.) as well as websites that allow students to explore creative ways to show the concepts learned and their interrelatedness.

Journal Writing and Mathematics

Strategies used after reading are just as beneficial to the students for comprehension as the before and during strategies. Journal writing in mathematics has proven to be a beneficial after reading strategy that helps promote literacy across the curriculum. Incorporating journal writing activities into content areas where it has traditionally not been used enhances students' reading comprehension (Atwell, 1990). When journal writing is used in a specific subject area, such as mathematics, students extend their thinking about the content. Teachers acknowledge that some students use writing as the key to understanding

other disciplines, especially mathematics. Whitin and Whitin (2000 p. 15) contend that writing is a means for discovery in mathematics. They point out that when students regularly write about mathematics in open-ended ways, they begin to realize new ideas about the process. Results of Pugalee's (2004) ninth grade algebra study determined that journaling may enhance students' ability to problem solve, because they must arrange and explain their thoughts.

It is recommended that students should journal daily, although weekly journaling may be more useful for older students. Whether students write daily or weekly, the teacher should check and respond to journal entries. This feedback keeps students on track and motivated. Research indicates an increase in students' academic performance as well as a deeper comprehension of the content area through the addition of daily academic journal writing (Hutchinson, Schorzman, & Gauthier, 2003).

Journaling during a mathematics lesson helps students heighten their understanding of the information as well as document student thinking and learning (Urquhart, 2009). It is considered by many to be the most effective method of writing to teach mathematics (Vacca, Vacca, & Mraz, 2011). Writing in journals for the purpose of improving reading skills in mathematics can be carried out in a number of ways. Students may free-write, which provides students an opportunity to discover ideas independently, or respond to a prompt, which allows students to explore their attitudes and understanding about mathematics. It may also be helpful for students to complete a guided response sheet or exit slips.

Exit Slips are an effective way for students to let the teacher know what they have learned from the lesson. Students write responses to specific questions posed by the teacher. Exit slips require very little time at the end of a lesson, usually only about five minutes. Yet the information gleaned from the exit slip provides valuable information about what the students understand or areas that need clarification (Fisher & Frey, 2004).

Conclusion

For mathematics students to be able to make sense of their texts, they must have the tools needed to be successful. Using reading strategies before, during, and after reading will provide the support they need to become independent in their learning. Prereading strategies, or before reading strategies, are effective for stimulating prior knowledge and building vocabulary. Since vocabulary is essential to the acquisition of new mathematics concepts it results in a deeper level of understanding (Chard, 2011). During reading strategies help the students identify the big idea or important information in the text. After reading strategies, such as journaling, provide students with an opportunity to reflect, express, and clarify information from the text. Having a variety of strategies available that the students feel comfortable using will improve their chance of success. Not only is it important for the students to learn the strategies, but also to know the correct strategy to use in a given situation. Strategies should be modeled by the teacher and practiced by the students in order for this to be an effective tool for them to use, especially when the teacher is not present.

References

Adams, T.L. (2003). Reading mathematics: More than words can say. *The Reading Teacher*, 56(8), 786-795.

Antonacci, P.A. and O'Callaghan, C.M. (2011). *Developing content area literacy.* Los Angeles: SAGE Publications, Inc.

Atwell, N. (1990). *Coming to know: Writing to learn in the intermediate grades.* Portsmouth, NH: Heinemann.

Base, (n.d.). In *Cambridge Dictionairies online.* Retrieved from http//dictionary.cambridge.org/dictionary/british/base

Bear, D.R., Invernizzi, M., Templeton, S., and Johnston, F. (2008). *Words their way: Word study for phonics, vocabulary, and spelling instruction (4th ed.).* Upper Saddle River, NJ: Merrill/Pearson.

Berenson, S.B. (1997). Language, diversity, and assessment in mathematics learning. *Focus on Learning Problems in Mathematics*, 19 (4), 1-9.

Burton, G., (1992). Using Language Arts to Promote Mathematics Learning. *The Mathematics Educator*, 3(2).

Chard, D. (2011). Vocabulary strategies for the mathematics classroom. Houghton Mifflin Math. Retrieved from http://www.eduplace.com/state/pdf/author/chard_hmm05.pdf

Common Core State Standards for Mathematics. Retrieved from www.corestandards.org

Draper, R.J., and Siebert, D. (2004). Different goals, similar practices: Making sense of the mathematics and literacy instruction in a standards-based mathematics classroom. *American Educational Research Journal*, 41(4), 927-962.

Fisher, D., and Frey, N. (2004). Improving Adolescent Literacy: Strategies at Work. New Jersey: Pearson Prentice Hall. Retrieved March 10, 2011, from http://www.adlit.org/strategies/19805

Franz, D. (2009) Supporting struggling readers in mathematics education. Apex Learning, Mississippi State University.

Friedland, E., McMillen, S., Hill, P. (2011). Collaborating to cross the mathematics-literacy divide: An annotated bibliography of literacy strategies for mathematics classroom. *Journal of Adolescent and Adult Literacy*, 55(1), 57-56.

Fuentes, P., (1998). Reading comprehension in mathematics. *The Clearing House*, 72, 81-88.

Greenleaf, C., Schoenbach, R., Cziko, C., and Mueller, F. (2001). Apprenticing adolescent readers to academic literacy. *Harvard Educational Review* 71: 1, 79-129.

Hutchinson, L.F., Schorzman, E., & Gauthier, L.R. (2003). Academic journals and small groups: Confluencing strategies for content area comprehension in middle schools. *New England Reading Association Journal* 39(2).

Logsdon, A. (2009). Solving Math Word Problems – Learn the SQRQCQ Strategy to Solve Math Problems. Retrieved November 7, 2008, from http://learningdisabilities.about.com/od/instructionalmaterials/ht/sqrqcq.htm.

Palinscar, A.S. and Brown, A. L., (1986). Interactive teaching to promote independent learning from text. *The Reading Teacher*, 39, 771-777.

Pugalee, K.K. (2004). A comparison of verbal and written descriptions of students' problem-solving processes. *Educational Studies in Mathematics*, 55, 27-47.

Raphael, T.E. (1982b). Question-answering strategies for children. *The Reading Teacher*, 36, 186-190.

Shanahan, T. and Shanahan, C. (2008). Teaching disciplinary literacy to adolescents: Rethinking content-area literacy. *Harvard Educational Review*, 78 (1), 40-59.

Urquhart, V. (2009). Using writing in mathematics to deepen student learning. Retrieved March 9, 2011. http://info@mcrel.org

Vacca, R.T., and Vacca, J. & Mraz, M. (2011). Content area reading: Literacy and learning across the curriculum. Boston MA: Pearson Education, Inc.

Whitin, P., and Whitin, D. (2000). Math is language too: Talking and writing in the mathematics classroom. Urbana, IL: National Council of Teachers of English.

Zollman, A. (2009). Students use graphic organizers to improve mathematical problem-solving communications. *Middle School Journal*, 41 (2), 4-12.

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- Empower members of the GRA and local councils to become effective leaders in the field of literacy.
- Provide quality reading education services to all Georgia educators.
- Recognize exemplary individuals, local, and state literacy efforts.
- Achieve maximum involvement of members at the local, state, and international levels to receive maximum benefits.
- Promote the goals and objectives of the International Reading Association of Georgia.