Using Literacy Strategies to Promote Content Area Literacy in Mathematics

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Using Literacy Strategies to Promote Content Area Literacy in Mathematics

Abstract
Integrating literacy within content specific classrooms has emerged as a key element for educators since secondary readers are falling behind. There exist strategies that can be used before, during, and after reading that can be applied to all content area courses. The purpose of this research was to determine if implementation of literacy strategies in two seventh grade mathematics classrooms in a rural public school could enhance achievement/understanding in a geometry unit. Data from assessments were compared to a control class that was taught the same material using traditional instruction. It was found that the implementation of literacy strategies in experimental mathematics classrooms alleviated three major misconceptions on the topic of geometry including, (a) whether a square was a rectangle or a rectangle was a square, (b) whether the radius is the distance across the circle, and (c) what properties make a polygon.

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Using Literacy Strategies to Promote Content Area Literacy in Mathematics

Educators at every grade level encounter students who have difficulties in reading. The nation is concerned with the problem of illiteracy and has focused most of its attention on beginning readers. In the United States the media bombards the nation with public service announcements promoting struggling readers of all ages to make an effort to learn how to read, and they stress the importance of reading to children. With all the focus on beginning readers, secondary readers are falling behind.

Farber, (1999) found that only six percent of graduating high school students were able to read at an advanced level. As students move from primary to secondary grades, the format of education shifts from learning how to read to reading to learn. Most content area teachers are not trained to teach reading, but according to the literature (Barton, Heidema, & Jordan, 2002; Clinard, 2000), emphasis on integrating literacy within content specific classrooms has emerged as a key element for secondary educators. Efforts have been made to promote literacy in content area classrooms by requiring secondary school teachers to take a course in reading. There exist strategies that can be used before, during, and after reading, but can these strategies be applied to all content area courses? The purpose of this research is to determine if the use of literacy strategies can enhance achievement/understanding in the mathematics classroom.
Review of Literature

The nation has focused much attention on beginning readers, but efforts to assist readers at the secondary level are lagging. According to Farber, 1999, only six percent of seventeen year old Americans read at an advanced level. This means that few high school students at the graduating level can synthesize and learn from specialized material. Fewer high schools have reading support staff than elementary schools, which leaves the responsibility of training students in reading to secondary content area teachers. This makes content area teachers responsible for teaching reading skills at the same time as teaching their content. The following text will describe different literacy strategies that can be used before, during, and after reading that can be implemented into content area classrooms to possibly increase student understanding in content area courses.

Struggles in Reading

According to the literature (Farber, 1999), high school students struggle with reading for different reasons. Some students have failed to learn the fundamentals of reading in the primary grades and some students never progressed in fluency. Many secondary school students are able to read the words on the page, but they may not have the skills that allow them to synthesize or summarize information, draw conclusions, make generalizations, or connect information drawn from texts to their knowledge.

In secondary school, teaching shifts from the process of learning to the content students should learn, leaving teachers with little time to address reading. According to the literature (Dieker & Little, 2005; Research, 2002; Way, 2001), as students move from
primary to secondary grades, the format of education shifts from learning how to read to reading to learn. Students at the secondary level are expected to read and understand increasingly more difficult materials in an array of content areas. Literacy skills must become increasingly sophisticated to meet more challenging expectations, and reading to learn from content area materials can be a struggle. At the secondary level, teachers expect students to apply reading skills to learn. The inability to use reading skills impacts students across all disciplines.

Secondary school students are expected to learn independently from print, but no one shows them how, according to the literature (Farber, 1999). According to the literature (Barton, Heidema, & Jordan, 2002; Clinard, 2000), emphasis on integrating the language process of listening, speaking, thinking, reading, and writing within content specific classrooms has emerged as a key element for secondary educators, but most content area teachers are not trained to teach reading. Thirty seven states require secondary school teachers to take at least one course in reading, yet the literature (Farber, 1999; Spor, 2005) shows that only a small percent of teachers use the strategies they learned. Secondary school teachers who neglect to address literacy may be adding to the problem, sending the wrong message about how mature reading works. As students continue to progress through the school system, they often fall farther and farther behind relative to their abilities to read to learn.

**Narrative vs. Expository Texts**

According to the literature (Research, 2002; Spor, 2005) most children are brought up with narrative texts, but by third grade their text books are mainly informational or
expository. Expository and narrative text structures place different demands on the reader's comprehension. Narrative texts focus on story grammar, characteristics, setting, theme, conflicts, plot, and conflict resolution. Expository texts vary greatly, and can focus on problem solutions, descriptions, cause and effect relationships, categorizing, sequencing, or comparing. Expository materials use special organizational features such as text headings and subheadings, chapters and sections, and table of contents and glossaries. Many expository texts use extensive graphics such as tables, charts, diagrams, figures, photos, and illustrations which are often accompanied by explanatory captions. In addition to a change in text structure, students encounter sentence structures that have changed from simple to complex as more complicated concepts are conveyed.

Students tend to be more familiar with narrative text structures than with expository text structures. The movement from narrative to informational texts poses problems for most students because reading for content knowledge requires the use of different strategies compared to strategies used for reading a narrative text. Students have little experience reading expository writing, text structure found in text books, and other content area texts. Content area text books contain facts and information that are conveyed as main ideas and details, rather than in story form, and students often become frustrated with content specific vocabulary and concepts. Students lack comprehension strategies necessary for gaining meaning from texts, and without the understanding of text structure, students have difficulty getting meaning from their content area reading material.
Reading Mathematics

According to the literature (Adams, 2003), we often pass up opportunities to get children to see mathematics as a language and not just something we do. The basic notion of reading mathematics as a language is often excluded or given little attention to in the classroom. The literature (Beliveau, 2001) also states that the language of math is comparable to a foreign language. Mathematics is a combination of symbols, numbers, and words that are sometimes interrelated and interdependent, and at other times are disjointed and autonomous, which makes reading mathematics a multifaceted task. Adams (2003), claims that the reader needs to acquire comprehension and mathematical understanding with fluency and proficiency through reading numerals and symbols, in addition to words.

Mathematics texts.

According to the literature (Barton et al., 2002; Beliveau, 2001; Douville & Pugalee, 2003), mathematics texts are the most difficult of all the content area texts to read, even for students who do not experience reading problems in other areas of the curriculum. Mathematics texts are characterized by multiple abstractions, specialized symbolism, and technical vocabulary. Mathematics texts can contain more concepts per line, sentence, and paragraph than other kinds of texts. Students detest reading math textbooks and often skip right to the problems, sometimes without the necessary background to complete the problems.

According to the literature (Barton et al., 2002) authors of math texts often imply rather than explicitly state the importance and relationships among ideas. Cue words
such as first, another, and for example appear much less in mathematics texts than in other texts. Without signal words, students must infer which sentences contain new ideas and how one set of facts is related to another. Authors of mathematics texts are usually experts of the content, and know the subject so well that they skip steps and do not provide the relevant background information or details in their explanations.

Reading mathematics texts requires skills in reading that students may not have used in other content areas. Decoding and comprehending mathematical signs, symbols, and graphics, and interpreting information while also comprehending text passages is difficult for students. In reading mathematics texts it is required to read left to right, right to left, and diagonally. Students need to be able to read numerals and symbols in context. In order to be equipped to read numerals and symbols in mathematics texts, students must first know basic number words and understand place value, and they must also decipher the meaning of the symbols. For students across grade levels, a weakness in mathematical ability is due to obstacles focusing on symbols as they attempt to read the language of mathematics.

Strategies for reading mathematics texts.

According to the literature (Draper, 2002) mathematics teachers often regard methods advocated by literacy instructors to be incongruent with the nature of their discipline. Many mathematics teachers view literacy instruction in the classroom as simply helping students read their text book. Literacy and literacy instruction are necessary parts of teaching mathematics, but many teachers limit reading in the content area to activities involving reading biographies of mathematicians, and reading about the
history of mathematics. It is more important to teach students how to read, write, listen, speak, and think while reading math texts.

Assisting students with mathematics texts is not the same as teaching students how to read, it is more like helping students make sense and learn from the text. According to the literature (Douville & Pugalee, 2003) the difficulty of reading mathematics texts coupled with the complex tasks necessary for students to construct problem solutions means that students need to have ownership over specific strategies designed to support them through the problem solving process.

The literature (Research, 2002; Spor, 2005) suggests that the ability to identify and take advantage of text-structure can contribute to student comprehension. Strategic reading involves strategies that students use before, during, and after reading to better comprehend and remember what they read. Teachers must introduce, model, and require student use of reading strategies that will enhance comprehension. Reading instruction can teach students skills and strategies required for reading content area materials successfully. Reading instruction can also give students ample opportunities to apply these skills and strategies in real reading situations.

According to the literature (Research, 2002) most students benefit from explicit instruction that helps them to understand and use text structure as they encounter them in their reading materials. Barton et al. (2002) suggests that if teachers read the students' text through the eyes of a novice reader instead of an expert, they can better help their students detect whether the author is communicating or implying necessary information. Before having students read a text, teachers can provide students with graphic organizers, chapter outlines, and structured overviews to help students navigate texts.
The literature suggests (Daniels & Zemelman, 2004; Research, 2002) instructional practices for teaching students about expository texts. Teaching students how to analyze the features of a textbook can help them get a better understanding of what to expect when reading their texts. Teachers can help students identify and use special text features such as headings and subheadings, previews, summaries, photographs and illustrations, and captions that accompany them. Teachers can also help students interpret text graphics such as charts, indices, and glossaries. Using the textbook feature analysis strategy can help students better understand how their textbook works and how it is organized.

The literature (Daniels & Zemelman, 2004) suggests another strategy, SQ3R, which can be implemented to help students use their textbooks more effectively. SQ3R asks students to (a) survey the text by identifying text structure and previewing illustrations, (b) question what might be answered in the text, (c) read, reflect on the reading, and then review or summarize what has been read. SQ3R assumes that students can comfortably use a wide range of comprehension skills such as selecting main ideas, important details, using textbook features, identifying expository text structure, self-questioning, and summarizing. The SQ3R strategy does not require lengthy preparation of physical materials, but does require that teachers thoroughly prepare students to utilize each of its individual skill components.

*Problem solving.*

According to the literature (Beliveau, 2001), strong reading skills are essential for problem solving. Mathematical problems presented in the context of a story or real life
scenarios require decoding skills that are needed to solve the problem. According to the literature (Douville & Pugalee, 2003), in order for students to solve a math problem, they must first be able to process the related verbal information. Students must be able to analyze the relationships among the facts stated in the problem and determine which facts express relationships to what is and what is not known.

Adams, (2003) suggests teaching students how to use a four step problem solving strategy. The four steps included in the strategy are (a) read the problem without focus on key words and questions, (b) understand the problem by attending to vocabulary, context and setting, questions, needed information, and extraneous information so to understand and know that the problem is asking, (c) solve the problem by choosing and using an appropriate strategy, look for patterns, make a model, eliminate possibilities, use easier numbers, work backwards, and estimate, and (d) look back and check for validity by engaging in discussions to justify the answer. Adams, (2003) states that it is imperative to model the four step problem solving process to students and to show them how to return to the previous steps when stuck to truly complete the process.

A similar problem solving strategy, SQRQCQ, was included in the literature (Barton et al., 2002). SQRQCQ stands for survey, question, read, question, compute, and question. The survey step asks students to read the problem quickly for a general understanding so that the student can then question what information the problem requires. Students are then asked to reread the problem to identify relevant information and details that are needed to solve the problem. Students then question what procedure needs to be done to complete the problem and then computes or constructs the solution to
the problem. After completing computations the student questions if the solution process seems correct.

The Importance of Prior Knowledge

According to the literature (Maria, 1989), reading is a holistic, constructive process that is affected by many factors, particularly the background knowledge which the reader brings to the text. Prior knowledge is arguably the most important resource when learning with texts. Reading and learning are constructive processes. According to the literature (Barton et al., 2002; Draper, 2002; Maria, 1989; Martinez, 2003; Research, 2002), students draw from prior knowledge and experience to make sense of new information. Background knowledge is made up of the reader’s experiences both with the world and with the text, including their experiences in identifying words and word meanings, and understanding how text is organized. Meaning created from reading depends on prior knowledge, content knowledge, and ability.

Students often lack mathematical content knowledge, and the lack understanding of how to use and manipulate math signs and symbols. Research-Based Content Area Reading Instruction, (2002) states:

Research has established that students’ background knowledge plays a critical role in their understanding of the higher level concepts contained in most content area materials. Students bring to content area reading a range of experiences and knowledge about many topics. The extent of this knowledge and the case with which they can activate it and apply it to content area topics directly affects how well they understand what they read. (p. 6)
Reading comprehension is hindered greatly by the lack of background knowledge of students and by their inability to use comprehension strategies to integrate information from the text with their background knowledge.

Since background knowledge is such an important factor in reading, a problem arises when the background knowledge of the reader differs from that of the author. According to the literature (Maria, 1989), a student may have the necessary background knowledge, but may fail to call it up and use it as an aid to comprehend a text. Students may also have misconceptions about one aspect of the topic that may also interfere with comprehension. The literature suggests (Barton et al., 2002) that teachers can guide students to confront misconceptions and acquire prerequisite knowledge through pre-reading activities.

*Pre-reading strategies.*

The literature suggests (Research, 2002) teaching comprehension strategies to use before reading to provide several opportunities for students. Students need the opportunity to activate their prior knowledge about the content area topic to be studied by having them tell what they know about the topic or by inviting them to discuss what they want to learn about. Students need to participate in activities that enable them to see relationships among their ideas about the topic. Students should be provided with opportunities to participate in activities that develop prerequisite background knowledge and vocabulary about content area topics, and they should be able to preview and make predictions about the text to establish goals and purpose for reading. Pre-reading
activities that give students these opportunities include using brainstorming, anticipation
guides, KWLs, and graphic organizers.

According to the literature (Daniels & Zemelman, 2004), brainstorming can help
students realize what they know about a topic, revealing both their conceptions and their
misconceptions. During brainstorming activities students identify ideas and issues that
they know about a topic so that they can be addressed and returned back to later. The
literature (Barton et al., 2002; Daniels & Zemelman, 2004; Spor, 2005) suggests that
anticipation guides can be used to help students identify what they know and may not
understand about a topic. An anticipation guide is composed of a set of true/false
statements which students respond to individually, in pairs, or in small groups before
reading a text. Anticipation guides engage students in important issues so that they can
either support or challenge their positions through writing or through discussion. After
reading students may go back to their responses to see if any have changed. This helps
student focus on big ideas and to make predictions.

The KWL activity asks students to write down what they know, what they want to
know, and what they have learned about a specific topic. The literature (Daniels &
Zemelman, 2004) suggests that a KWL can help access prior knowledge, make
connections, and help students develop a purpose for reading. Graphic organizers can
introduce main concepts and show how related concepts are connected to the main topic
according to the literature (Barton et al., 2002; Daniels & Zemelman, 2004; Maria, 1989;
Spor, 2005). There are many different variations of graphic organizers. Most graphic
organizers centralize around a main topic, and show connections between ideas
graphically. Graphic organizers help students discover what they know, make connections and group ideas, and arrange information in a logical and concise diagram.

The literature suggests (Barton et al., 2002; Martinez, 2003) that activating prior knowledge prepares students to make connections, draw conclusions, and get new ideas. Students will learn and remember more from what they read if they bring more knowledge and skills to a text. Making explicit connections between what students already know and what they will be learning makes it much easier for students to assimilate new knowledge. It is the responsibility of the teacher to build student background knowledge. Prior knowledge provides a framework for comprehending new information. When new information is combined with prior knowledge, students can access memory to construct meaning.

Strategies for Learning Vocabulary

According to the literature (Adams, 2003; Research, 2002), each discipline has its own code of communication. Terminology that is used to communicate ideas within a discipline may or may not carry meanings that make sense outside of the discipline. The literature suggests (Beliveau, 2001; Research, 2002; Richel, 2005) that before students can be expected to read in the content areas, they must first understand the vocabulary of that content in order to comprehend the reading. In other words, in order for students to comprehend texts, they must know the meanings of the words they read. If students do not know the meaning or become frustrated and skip important words, comprehending text can be difficult. The more actively and deeply students process words, the better they learn them. Because knowledge of vocabulary and reading comprehension are so
highly related, effective content area vocabulary instruction must provide students with explicit instruction in specific content related words and concepts and with strategies that help them to learn words independently.

According to the literature (Adams, 2003; Beliveau, 2001; Research, 2002), when students encounter vocabulary with multiple meanings, it causes issues with reading comprehension. In mathematics, words can often have dual meanings. Familiar words can pose problems if students are unaware that they can have different meanings or connotations that are determined by the context on which they appear. Students are confused with mathematical terminology when they see a familiar word, such as factor, product, mean, or origin, with an unfamiliar definition in the math classroom.

Students need to be comfortable moving between meanings, and they need to know which meaning is used to make connections and strengthen understanding of terminology and concepts. Teaching meanings of key words prior to introducing a topic or selection in which the words will appear helps students link new words to words they know. The literature (Adams, 2003) suggests that using informal and formal definitions enables students to appropriately apply mathematics vocabulary they encounter when reading mathematics. It is important for students to create informal definitions before learning formal definitions so that they can understand and build meanings of the words.

The literature (Martinez, 2003) states “In mathematics, vocabulary definitions often need examples and also should be used in context. Connections to attributes, uses, and situations help in solidifying thinking. An understanding of definitions and mathematical terms must be developed with connections to the conceptual basis” (p. 3). The literature (Beliveau, 2001) suggests creating vocabulary lists with mathematical definitions and the
general definition of terms with different meanings. Doing this helps illustrate to
students that a word can have multiple meanings, depending greatly on content and
shows how the mathematical definition can relate to the general definition. Another
suggestion is to create a memory match game with words and symbols that match
mathematical definitions with standard definitions.

Other vocabulary strategies include a variety of graphic organizers suggested in the
literature (Adams, 2003; Barton et al., 2002; Beliveau, 2001; Daniels & Zemelman, 2004;
Research, 2002). Using a graphic organizer to provide students with examples and non-
examples of terms or concepts helps students to develop definitions in their own words so
that it can be synthesized and internalized instead of memorized. Graphic organizers help
students create mental or visual images associated with technical vocabulary to help
facilitate recall and meaning. Graphic organizers can also help students link new
vocabulary with background knowledge, focus on semantic relationships of new and
familiar words and concepts, and map and categorize terms.

According to the literature (Richek, 2005), vocabulary instruction is often too tedious
and ineffective. Having students write out or state definitions in a dictionary is not
effective because students often cannot understand the definitions that dictionaries
present. Direct instruction in word meaning can make a significant difference in a
student's overall vocabulary. Incorporating activities using words creatively results in
excellent student learning.
During Reading Strategies

The literature suggests (Research, 2002) that the ability to read fluently reflects student comprehension of words and understanding of text structure. Fluent readers possess automatic word identification skills and are aware of grammatical features of sentence construction. Fluent readers have the flexibility to adjust their rate to both difficulty level and purpose for reading. Skilled readers monitor their understanding continually, can realize when they do not understand the reading, and can apply strategies to compensate for their lack of understanding.

It is important to teach students strategies for comprehending during reading. These strategies can help students construct mental images of the content they are reading, reflect on and monitor their understanding of text as they read, and help summarize the information to gain knowledge. According to the literature (Barton et al., 2002; Daniels & Zemelman, 2004; Draper, 2002; Florida, 2005), it is important to show students how smart readers think. A think-aloud is a strategy that can help students explore meaning as they read. During a think-aloud activity, the teacher reads aloud from a sample passage and models the thinking process involved in making sense of confusing sections of text. With this strategy students are able to see the strategy that effective readers use to deal with ambiguous passages, identify main ideas, and make logical inferences. Students can either write their thinking directly on a copy of the passage, or they could also use post it notes. The think-aloud strategy helps students learn to consciously think about, monitor, and reflect on their strategy used to help with interpreting a difficult passage.

Another during reading strategy suggested in the literature (Florida, 2005; Hashey & Connors, 2003; Research, 2002) is reciprocal teaching. Reciprocal teaching is an
instructional procedure designed to enhance student reading comprehension using the four strategies of predicting, questioning, clarifying, and summarizing. Students are given one of the specific tasks and work together to deepen comprehension through social interaction. Teachers first model the strategy to students, and then the students try out this strategy in a supportive environment. Teacher scaffolding helps students move to work independently using this strategy. Researchers (Florida, 2005; Hashey & Connors, 2003; Research, 2002) have found that activating prior knowledge, generating and asking questions, making inferences, predicting, summarizing, and visualizing are all helpful comprehension strategies that lend themselves well to instruction. The strategy of using reciprocal teaching fits perfectly into what researchers have identified as useful and easily implemented comprehensive strategies.

*The importance of mental imaging.*

The literature (Hibbing & Rankin-Anderson, 2003) suggests there is a connection between the verbal and non-verbal coding systems in our brain that allow us to create images when we hear words, and that generate names or descriptions of things we see in pictures. Successful readers automatically make verbal and nonverbal connections quickly and efficiently. Creating a mental image of what is read is a natural process for more proficient readers, and when proficient readers do not get a mental image easily, they see this as a warning that they lack comprehension. Many students depend on images because they provide a concrete representation of actions, ideas, time, and space. School classrooms, media centers, and computer labs are filled with visual images. Students are also confronted regularly with continuous images on television or videos.
that create the visual image for them. Unfortunately, this bombardment of visual images does not necessarily transfer to the students’ ability to create mental images that support reading comprehension. Students gaining meaning from action sequences seen on television or videos is different than students using their own external experiences to create internal visual images that support comprehension.

Some students read words fluently but still lack the ability to create mental images that relate to a text. Connections between words and images may not be made, putting comprehension at risk. Students who lack the ability to create visual images when reading often experience difficulties with comprehension. Many reluctant and low ability readers with comprehension difficulties are not able to describe the pictures in their minds when they read. Struggling readers are too busy reading the words to understand the meaning of a text.

A study done by Douville and Pugalee, 2003 found that there were more students who used mental imagery as a strategy than those who did not. Students who were able to create visual images while reading a text were even able to explain how imagery contributed to understanding a text. The literature (Douville & Pugalee, 2003; Hibbing & Rankin-Anderson, 2003) suggests that prompting students to use imagery has a powerful effect on learning and remembering. When students are taught to generate mental images as they read, they experience greater recall and enhanced abilities to draw inferences and make predictions. Comprehension of text is enhanced when students are prompted or taught to use mental imagery.

The literature (Hibbing & Rankin-Anderson, 2003) suggests that illustrations in books and texts can make reading more enjoyable and provide students knowledge that
they might be missing. This strategy is especially helpful for struggling readers since they often move their eyes between picture and text to get greater comprehension. If the text and illustrations mismatch, the illustrations can interfere with comprehension and reduce learning. However purposeful illustration mismatches can be used to engage students more deeply with the text. Teachers can help students understand and retain knowledge by creating drawings or quick sketches along with the instruction. Drawings can also be created by students to help them visualize, and get a different perspective. The use of sketches, illustrations, picture books, and movies provide students with information on which to build visual imagery. Students may need to be prompted repeatedly to focus on their mental images as a way to monitor their comprehension.

Since it has been shown that mental imagery supports conceptual engagement in literacy learning, the literature suggests (Douville & Pugalee, 2003) that mental imagery can also support students’ conceptual engagement in problem solving tasks. Little inquiry has been conducted in the effects of mental imagery on mathematics problem solving. Mental imagery holds promise for facilitating mathematics achievement because mathematical problem solving requires reading and computational abilities. Mental imagery can aid in the dual coding of both verbal and nonverbal representations of mathematical concepts. This suggests that internal representations through mental imagery play an important role in problem solving.

The Importance of Communication

In order for students to learn and communicate clearly in and out of school they need to be able to read, write, speak, listen, and think effectively. According to the literature
(Way, 2001), adolescents need to have strong literacy skills so they can understand academic content and communicate in a credible way. The literature (Martinez, 2003) suggests that students cannot learn without communicating their thoughts, testing their ideas, and using feedback and discovery to gain a sense of what is reasonable and expected. In mathematics, students must communicate their mathematical ideas as part of understanding them. Without communication, students are not able to reason, defend, or understand the conceptual basis of mathematics.

Principles and Standards for School Mathematics (NCTM, 2000) calls for more student-centered mathematics classrooms that de-emphasize rote memorization of isolated skills and facts, and emphasizes problem solving and communication. NCTM emphasizes the important role that communication plays in helping students construct mathematical knowledge, create links between their understandings of abstract symbols, and create links between their understandings of mathematical ideas.

According to the literature (Moyer, 2000), mathematics is learned through the use of language. Making daily connections is vital for students to learn, speak, and write in the language of mathematics. Moyer states: “Teachers who promote mathematical discussion throughout the curriculum are developing key abilities in students that will serve them well in communicating mathematically throughout their lives” (p. 246). The use of language in oral and written forms, and the use of numbers to count and compute provide information that allows us to make decisions daily.

The literature suggests (Pugalee, 2001) that communicating about mathematics engages students in thinking skills and processes that aid in developing mathematical literacy. Communication provides opportunities for students to analyze and evaluate
their mathematical thinking and strategies of others. Giving students opportunities to
develop skills in communicating mathematically will allow them to become comfortable
expressing their results of their thinking in written and oral forms to others.

According to the literature (Moyer, 2000) students have difficulty communicating
mathematically. Teachers can help students activate prior content knowledge, master
vocabulary, and make sense of unfamiliar text styles by incorporating reading and
learning strategies. Students need strategies to use after reading to help them review,
paraphrase, summarize, and interpret text. According to the literature (Daniels &
Zemelman, 2004; Research, 2002), students should be provided with opportunities to
participate in discussions on texts and be able to present important information from the
text through oral reports or visual representations.

RAFT writing assignments are projects that give students focus on particular
vocabulary to allow them to internalize information in different styles. In a RAFT,
students are asked to write as if playing a role to a specific audience in a format that
demonstrates meaning of vocabulary and main ideas on a topic. Using extended projects
and RAFT writing assignments can help students dig deeply, reflect on, and apply
learning to new situations. According to the literature (Crumbaugh & Schram, n.d.)
writing in mathematics classes can help students make sense of mathematics by clarifying
their thinking, constructing arguments, posing questions, reflecting about their work, and
developing new approaches for problem solving. The literature suggests (Beliveau,
2001) that students' mathematical literacy will increase if they practice writing about
concepts and processes. Students must have ownership of multiple strategies to deal with
multiple literacy tasks, and students must also take ownership of effective problem solving strategies.

Combining the Strategies

Engagement and exploration activities prepare students to comprehend future reading assignments. According to the literature (Guthrie, Van Meter, McCann, Bennett, Poundstone, Rice, Faibisch, Hunt, & Mitchell, 1996) students who have high self-efficiency for summarizing, outlining, and note-taking strategies are more likely to set higher academic goals than students with low self-efficiency for these strategies. Engaged readers choose to read for a variety of purposes and comprehend the materials within the context of the situation. Engaging classroom contexts are observational, conceptual, self-directing, metacognitive, collaborative, expressive, and coherent.

A study by Fisher, Frey, & Williams, (2002) was conducted to see if using before, during, and after literacy strategies across the content areas would increase student learning. The seven specific literacy strategies were utilized in this study were: (a) think-aloud, (b) KWL charts, (c) graphic organizers, (d) vocabulary instruction, (e) writing to learn, (f) structured note taking, and (g) reciprocal teaching, most of which have been discussed previously. Posters that listed the strategies were hung in the classrooms so that students could refer to and become familiar with the names of the strategies they used. Teachers in the study attended monthly preparatory meetings, read research reviews of strategies, discussed successes and challenges of implementing the strategies, and used video tapes to model for peers.
At the conclusion of this study, the Gates-MacGinitie Scores used to measure reading achievement of the school increased over a three year period from an average of a 5.9 grade level reading ability to an average of an 8.2 grade level reading ability. Also, the vocabulary sub tests increased by sixteen percent, and the academic accountability targets were met for the first time. This study showed that there is a link between strategic teaching and student learning.

A study by Guthrie et al., (1996) incorporated a program called Concept Oriented Reading Instruction, or CORI. In this program students were taught how to retrieve, comprehend, integrate, and communicate to others. Through teacher modeling, peer modeling, teacher scaffolding, guided practice, teamwork, CORI emphasized book organization, relevance of information, appropriateness of detail, and differences between facts, explanations, and opinions. This taught students how to form goals, categorize, extract, and abstract. Teachers provided instruction that enabled students to present their understanding in many forms including written reports, class-authored books, dioramas, charts, and informational stories. The results of this study found that incorporating the program increased literacy engagement, and that literacy engagement was positively correlated to motivation, frequency, and breadth of reading.

Emphasis on metacognitive strategies including searching for information, representing ideas graphically, planning, evaluating, and integrating enhance the development of literacy engagement. Students with more extrinsic motivation, such as working to just complete and assignment or to gain recognition, are likely to engage in rote learning and obtain verbatim knowledge rather than a fully integrated conceptual understanding. Students who have a commitment to understand the content of an
instructional unit are likely to get a deeper understanding of the content than students who have different kinds of commitments.

**Implementing the Strategies**

According to the literature (Daniels & Zemelman, 2004) reading is more than decoding; it is an active and constructive process. Good readers have a repertoire of thinking strategies they use to comprehend texts. Good readers visualize, question, infer, evaluate, analyze, recall, and self-monitor. Prior knowledge is the main determinate of comprehension, and reading is a staged and recursive process.

The literature (Florida, 2005) suggests that teachers must show students how to think metacognitively while they read, and they must show students how to apply real world knowledge. Teachers must help students become knowledgeable about strategies and why it is important for them to use these strategies. Teachers must provide their students with a variety of strategic learning tools designed to support achievement across the curriculum.

According to the literature (Brandenburg, 2002; Farber, 1999), students have difficulty combining or applying techniques, especially in unfamiliar situations. When adolescent students are shown how to monitor their own thinking, they are able to get more from their texts and perform more complicated operations. Listening, speaking, and writing are important facets of subject area learning. All teachers across the curriculum and grade levels can play a role in teaching students to use literacy strategies in the content areas that can help them become independent readers and thinkers.
Methodology

Two teachers enrolled in a university graduate course collected data from three seventh grade mathematics classrooms in a rural western New York predominately white public middle school. All three classes covered the same material in an entire seventh grade geometry unit. Two classes were taught the unit using before, during, and after reading literacy strategies. The other class was taught the unit using traditional instruction.

Both teachers created and implemented before, during, and after reading literacy strategies in lessons throughout the unit for the experimental classes. Data was collected in all participating classes on performance on assessments, which included graded homework assignments, quizzes, tests, and tickets to leave. All participating classes were given the same assessments throughout the unit. Data was also collected on the students’ level of engagement throughout specified lesson. Data from each class was compared.

During each lesson one teacher taught the lesson while the other teacher made observations and collected data. Anticipation guides, graphic organizers, guided think-alouds, a read-aloud, a game, and a RAFT writing component were the literacy strategies implemented into the instruction of the experimental classes.
Results

Students in the first and second experimental groups were presented with before, during, and after reading literacy strategies in lessons throughout the unit on geometry. These strategies included an anticipation guides, graphic organizers, guided think-alouds, a read-aloud, a game, and a RAFT writing component. The first literacy strategy implemented into the experimental classes was an anticipation guide.

Anticipation Guide

Prior to starting and after completing the unit on geometry, students completed the geometry anticipation guide found in Appendix A. Questions 1, 3, 5, and 7 were considered critical questions because a significant increase or decrease in understanding was demonstrated. The average score for the first experimental class increased from 50.0% to 87.5% on critical questions. The average score for the second experimental class increased from 75.0% to 90.7% on critical questions. The average score for the control class increased from 75.3% to 86.6% on critical questions.

Tickets out the Door

On day two, students were asked to explain which statement was true, (a) all rectangles are squares, or (b) all squares are rectangles. In the first experimental class, 73.0% answered the question correctly, and 47.4% explained with quality answers. In the second experimental class, 64.7% answered the question correctly, and 35.3% explained with quality answers. In the control class, 77.8% answered the question
correctly, and only 22.2% explained with quality answers. Responses were considered to be quality answers if the students named at least two properties of quadrilaterals that would differentiate the two statements.

On day three, students were asked to find the area and the perimeter of a triangle, and the perimeter of a quadrilateral, shown in Appendix B on the daily tracking sheet. In the first experimental class 84.2% were able to find the perimeter of the triangle, 26.3% were able to find the area of the triangle, and 47.4% were able to find the perimeter of the quadrilateral. In the second experimental class 88.9% were able to find the perimeter of the triangle, 61.1% were able to find the area of the triangle, and 22.2% were able to find the perimeter of the quadrilateral. In the control class, 52.6% were able to find the perimeter of the triangle, 57.9% were able to find the area of the triangle, and 73.3% were able to find the perimeter of the quadrilateral.

On day four students were asked to list all the names of a figure, and were provided with a drawing of a square. In the first experimental class, 31.5% of students were able to list two or three classifications, and 68.5% were able to list four or five classifications. In the second experimental class 11.1% were able to list zero or one classification, 38.9% were able to list two or three classifications, 44.4% were able to list four or five classifications, and 5.6% were able to list all classifications. In the control class, 71.4% were able to list two or three classifications, and 28.6% were able to list four or five classifications.

On day five students were asked to find the circumference of a circle shown in Appendix B on the research tracking sheet. In the first experimental class 89.9% answered correctly, in the second experimental class 60.0% answered correctly, and in
the control class 77.7% answered correctly. On day six the students were asked to find the area of a circle. In the first experimental class 94.4% answered correctly, in the second experimental class 68.4% answered correctly, and in the control class, 52.9% answered correctly.

On day ten, students were asked to find the surface area of a cylinder shown on the research tracking sheet in Appendix B. In the first experimental class 38.9% answered correctly, in the second experimental class 21.4% answered correctly, and in the control class, 68.3% answered correctly. On day 13 students were given a volume worksheet shown in Appendix C and were asked to find the volume of each figure. The first experimental class average was 65.8%, the second experimental class average was 75.1%, and the control class average was 85.0%.

**RAFT**

On day fourteen students were given a graded RAFT writing component to complete to sum up the geometry unit. The class average for the first experimental class was 60.0%, the class average for the second experimental class was 44.0%, and the class average for the control group was 60%. 40.9% of the first experimental class, 15.0% of the second experimental class, and 29.4% of the control class did not turn in the assignment.
Quiz and Unit Test

On the take home quiz the class average for experimental class one was 78.1%, the class average for experimental class two was 76.0%, and the class average for the control class was 64.4%. The take home quiz can be found in Appendix C. On the unit test the class average for experimental class one was 85.5%, the class average for experimental class two was 71.0%, and the class average for the control class was 83.8%. The unit test can also be found in Appendix C.
Discussion

Students in the experimental groups and in the control group performed almost equally on assessments. Even though most of the assessment showed similar results, the responses in the experimental groups showed a higher level thinking. This was found to be most significantly evident after looking at before and after responses to the critical questions on the anticipation guide. In general, students in the experimental groups were more attentive and actively engaged. Students in the experimental groups asked more questions and participated more regularly than students in the control group.

Anticipation Guide

Cooperating teachers first had students complete an anticipation guide prior to beginning a unit on geometry. According to the literature (Maria, 1989), prior knowledge is the most important resource when learning because students draw from prior knowledge and experience to makes sense of new information. The literature suggests (Barton et al., 2002; Maria, 1989) that students often have misconceptions that may interfere with comprehension, and that teachers can guide students to confront these misconceptions and acquire prerequisite knowledge through pre-reading activities such as an anticipation guide. The anticipation guide, shown in Appendix A, was used to first gauge the students’ level of understanding of various concepts in geometry. This allowed the cooperating teachers to get a better idea of where the students stood in their understanding of geometry, and helped expose any misconceptions they had.
At the end of the unit the anticipation guide was revisited. The literature (Barton et al., 2002; Daniels & Zemelman, 2004; Spor, 2005) suggested that anticipation guides engaged students and helped them to focus on big ideas, so it was important to go back and revisit the anticipation guide to help students see how their understanding had changed. The literature (Barton, et al., 2002; Martinez, 2003) also suggested that making connections between what students already know and what they will be learning makes it easier for students to assimilate new knowledge. In order to determine if the students’ misconceptions had been eliminated, the anticipation guide was used as part one of the unit test. The significant results from the second implementation of the anticipation guide were compared to the original implementation.

Two major misconceptions were found after collecting the initial anticipation guide. First, students were not sure if a square was a rectangle, or if a rectangle was a square. In the first experimental class, 11.1% of students believed that all squares were rectangles, and 50.0% believed that all rectangles were squares. In the second experimental class, 57.9% of students believed that all squares were rectangles, and 26.3% believed that all rectangles were squares. In the control class, 70.6% of students believed that all squares were rectangles, and 35.3% believed that all rectangles were squares.

Quadrilateral graphic organizer.

Graphic organizers can introduce main concepts and show how related concepts are connected to the main topic according to the literature (Barton et al., 2002; Daniels & Zemelman, 2004; Spor, 2005). Students in the experimental groups were provided with a graphic organizer that mapped out the relations of the different classifications of
quadrilaterals. Students worked together with the teacher to name and fill out the properties of each quadrilateral on the graphic organizer, shown in Appendix D. During the lesson, students in the experimental class voiced connections between the anticipation guide and the graphic organizer. In the control group students were taught the properties of each quadrilateral without the graphic organizer, and were less eager to offer answers.

On day two students were presented with a ticket out the door that asked them to explain if all rectangles were squares, or if all squares were rectangles. In the first experimental class 73.0% answered correctly, in the second experimental class 64.7% answered correctly, and in the control class 77.8% answered correctly. Initially compared to the experimental classes, the control class seemed to have a slightly better prior understanding of the properties of quadrilaterals, so then the quality of responses was also considered. Responses were considered to be quality answers if the students named at least two properties of quadrilaterals that would differentiate the two statements.

In the first experimental class 47.4% explained with quality answers, in the second experimental class 35.3% explained with quality answers, and in the control class only 22.2% explained with quality answers. It was found that some students in the experimental classes were able to clearly explain the properties that differentiated a square from a rectangle so that it would conclude that a square was a rectangle, but some of the students then answered that a rectangle was a square. Both teachers believed that the use of a graphic organizer helped the students in the experimental classes get a better understanding of the hierarchy and properties of quadrilaterals by mapping out the relationships between the different quadrilaterals along with their written properties.
Classification game.

On day four students in the experimental classes played a classification game with the teacher. According to the literature (Richok, 2005), vocabulary instruction is often too tedious and ineffective, but incorporating activities using words creatively results in excellent student learning. As soon as it was announced that a game would be played students were excited and ready to participate. Each student was given index cards to draw different types of quadrilaterals specified by the teacher. The teacher shouted out the names or properties of the different quadrilaterals, and the students then held up the index card with the picture that matched that description. At the end of day four students were asked to list all the names of a figure, and were provided with a drawing of a square. Students were not told how many classifications there could be. Table 1 demonstrates that the experimental classes were able to name more classifications than the control class.

Table 1
Class Average for the Ability to Name a Square Using All Six Classifications

<table>
<thead>
<tr>
<th></th>
<th>0-1</th>
<th>2-3</th>
<th>4-5</th>
<th>6</th>
</tr>
</thead>
<tbody>
<tr>
<td>E1</td>
<td>6/(31.5)</td>
<td>13/(68.5)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>E2</td>
<td>2/(11.1)</td>
<td>7/(38.9)</td>
<td>8/(44.4)</td>
<td>1/(5.6)</td>
</tr>
<tr>
<td>C</td>
<td>10/(71.4)</td>
<td>4/(28.6)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Note: E1 = experimental class 1; E2 = experimental class 2; C = control class. N/(%), where N=number of students with correct answers, and (%) is the percentages of students answered correctly.

Table 2 shows the difference in achievement between the experimental and control classes before and after the geometry unit for understanding that all squares are rectangles. The experimental classes showed a vast improvement compared to the
control class. It is believed that this significant improvement was due to the use of the graphic organizer and the game.

Table 2
Class Percentage for Correct Answers on Geometry Anticipation Guide

<table>
<thead>
<tr>
<th>Question 1</th>
<th>Before</th>
<th>After</th>
</tr>
</thead>
<tbody>
<tr>
<td>E1</td>
<td>2/(11.1)</td>
<td>16/(80.0)</td>
</tr>
<tr>
<td>E2</td>
<td>11/(57.9)</td>
<td>13/(81.3)</td>
</tr>
<tr>
<td>C</td>
<td>12/(70.6)</td>
<td>9/(76.9)</td>
</tr>
</tbody>
</table>

Note. E1 = experimental class 1; E2 = experimental class 2; C = control class. N/(), where N=number of students with correct answers, and (%) is the percentages of students answered correctly.

Read-aloud/Guided Think-aloud

The second major misconception found was that students believed that the radius was the distance across the circle. 50.0% of students in the first experimental class, 63.2% of students in the second experimental class, and 53.9% of the students in the control class believed that the radius was the distance across the circle. When looking at this data it was thought that students were familiar with the term radius being associated with a circle, but were not sure of its relation.

According to the literature (Research, 2002), it is important to teach students strategies that will help them monitor their understanding, and that will help them summarize the information to gain knowledge. On day five, students in the experimental classes participated in a read-aloud and a guided think-aloud, found in Appendix D. The short story read aloud was Sir Cumference and the Dragon of Pi, written by Cindy
Neuschwander. The read-aloud was extremely successful. The literature (Hibbing & Rankin-Anderson, 2003) suggested that illustrations in books and texts can make reading more enjoyable and can provide students with knowledge that they might be missing. While reading, the teacher held up the book and pointed out the different pictures that described the action of the story. The students were actively listening and taking notes while the teacher was reading.

During the think-aloud students were able to translate words into symbols and numerals in context, and were able to decipher the meaning of the symbols. Students were also able to relate what they saw in the pictures to the concepts they were learning about circles. Students in the experimental groups were actively participating, giving answers to questions, and even voicing connections between the story and the properties of circles. The control group learned about circle through traditional instruction, and they did not show the same enthusiasm or interest. However, Table 3 showed evidence that reviewing the definition of a radius through traditional instruction and through instruction involving literacy strategies yielded positive results.

**Table 3**

Class Percentage for Correct Answers on Geometry Anticipation Guide

<table>
<thead>
<tr>
<th>Question 3</th>
<th>Before</th>
<th>After</th>
</tr>
</thead>
<tbody>
<tr>
<td>E1</td>
<td>9/(50.0)</td>
<td>19/(95.0)</td>
</tr>
<tr>
<td>E2</td>
<td>12/(63.2)</td>
<td>14/(87.5)</td>
</tr>
<tr>
<td>C</td>
<td>9/(53.9)</td>
<td>13/(100)</td>
</tr>
</tbody>
</table>

Note. E1 = experimental class 1; E2 = experimental class 2; C = control class. N/(%), where N=number of students with correct answers, and (%) is the percentages of students answered correctly.
At the end of day five students were asked to find the circumference of a circle as a ticket to leave. In the first experimental class 89.9% answered correctly, in the second experimental class 60.0% answered correctly, and in the control class 77.7% answered correctly. The second experimental group was the most actively engaged during the read-aloud, though it was interesting to find that this group had the lowest number of correct responses on the assessment.

3-D graphic organizer.

On day eight, students in all classes were shown models of solids. Students in the experimental class were provided with a graphic organizer to learn the different three dimensional shapes. The graphic organizer, shown in Appendix D, separates the shapes into prisms, pyramids, and cylinders. The experimental groups were able use the graphic organizer to connect the model to the drawing of the solid. One student in the second experimental class was very disruptive during the lesson and was eventually removed. Other students in the class were actively participating and answering questions. Table 4 shows that all classes improved on their knowledge of the difference between prisms and pyramids. The most significant increase was demonstrated by the first experimental class. Since all classes increased their knowledge significantly, it was difficult to determine if the graphic organizer really had any true effect on the results.
Table 4

Class Percentage for Correct Answers on Geometry Anticipation Guide

<table>
<thead>
<tr>
<th>Question 5</th>
<th>Before</th>
<th>After</th>
</tr>
</thead>
<tbody>
<tr>
<td>E1</td>
<td>10/(55.6)</td>
<td>18/(90.0)</td>
</tr>
<tr>
<td>E2</td>
<td>17/(89.5)</td>
<td>16/(100)</td>
</tr>
<tr>
<td>C</td>
<td>14/(82.4)</td>
<td>13/(100)</td>
</tr>
</tbody>
</table>

Note: E1 = experimental class 1; E2 = experimental class 2; C = control class. N/(%), where N=number of students with correct answers, and (%) is the percentages of students answered correctly.

Frayer model.

On the first day of the unit, students in the experimental group were provided with a Frayer model, shown in Appendix D, which described a polygon by essential characteristic, non-essential characteristics, examples, and non-examples. According to the literature, (Adams, 2003; Barton et al., 2002; Beliveau, 2001; Daniels & Zemelman, 2004; Research, 2002), using a graphic organizer to provide students with examples and non-examples of terms or concepts helps students to develop definitions in their own words so that it can be synthesized and internalized instead of memorized. Students in the experimental classes were able to complete the Frayer model using their own prior knowledge with minimal guidance from the teacher.

Table 5 shows that both experimental groups gained a bit more understanding about polygons, and that the control group actually decreased in their understanding. It was thought that the control group might have been able to guess better on the first trial, and that it was possible that the Frayer model helped the experimental classes enhance their
prior knowledge. This is consistent with the research which also stated that graphic organizers help students link new and familiar words and concepts, and helps them to map and categorize terms.

Table 5

Class Percentage for Correct Answers on Geometry Anticipation Guide

<table>
<thead>
<tr>
<th>Question 7</th>
<th>Before</th>
<th>After</th>
</tr>
</thead>
<tbody>
<tr>
<td>E1</td>
<td>15/83.3</td>
<td>17/85.0</td>
</tr>
<tr>
<td>E2</td>
<td>17/89.5</td>
<td>15/93.8</td>
</tr>
<tr>
<td>C</td>
<td>16/94.1</td>
<td>9/69.9</td>
</tr>
</tbody>
</table>

Note. E1= experimental class 1; E2 = experimental class 2; C = control class. N/(%), where N=number of students with correct answers, and (%) is the percentages of students answered correctly.

Overall, the experimental groups had the most significant increase in understanding from the beginning to the end of the unit when basing the results on the critical questions from the anticipation guide. Table 6 shows the class percentages for correct answers on the anticipation guide prior to and after the geometry unit. It is believed that the use of literacy strategies had a definite impact on alleviating misconceptions when comparing the responses on the anticipation guide.
Table 6
Class Percentage for Correct Answers on Geometry Anticipation Guide

<table>
<thead>
<tr>
<th>Class Average</th>
<th>Before</th>
<th>After</th>
</tr>
</thead>
<tbody>
<tr>
<td>E1</td>
<td>18/(50.0)</td>
<td>20/(87.5)</td>
</tr>
<tr>
<td>E2</td>
<td>19/(75.0)</td>
<td>16/(90.7)</td>
</tr>
<tr>
<td>C</td>
<td>17/(75.3)</td>
<td>13/(86.6)</td>
</tr>
</tbody>
</table>

Note. E1 = experimental class 1; E2 = experimental class 2; C = control class. N/(%), where N = number of students, and (%) is the percentages of students answered correctly. Average is based on answers to critical questions only.

RAFT

The literature (Martinez, 2003) suggested that students must communicate their mathematical ideas as part of understanding them. The literature (Pugalee, 2001) also suggested that communicating about mathematics engages students in thinking skills and processes that aid in developing mathematical literacy. RAFT writing assignments can help students dig deeply, reflect on, and apply learning to new situations according to the literature (Daniels & Zemelman, 2004; Research, 2002).

On day fourteen students were given a RAFT writing assignment that allowed them to choose three different roles. The first role the students could choose was to be a square and create a family tree for a math class and give characteristics of each member of the family. The second role the students could choose was to be a circle and write a love letter to Pi explaining their relationship. The third role students could choose was to be a cartoonist and create a cartoon for a math class that showed how the teacher taught his or her students about the different types of three dimensional figures.
In the first experimental class, nine out of twenty two students did not turn in the assignment. Five students in this class chose to be a square, five chose to be a circle, and three chose to be a cartoonist. The class average for the first experimental class was 44.0%. In the second experimental class three out of twenty students did not turn in the assignment. Eight students in this class chose to be a square, six chose to be a circle, and two chose to be a cartoonist. The class average for the second experimental class was 60.0%, and this class had the most quality responses. In the control class the class average was 60%, and five out of seventeen students did not turn in the assignment. Five students in this class chose to be a square, six chose to be a circle, and one chose to be a cartoonist. Average scores included zeros for those students who did not turn in the assignment.

According to the literature (Crumbaugh & Schram, n.d.) writing in mathematics classes can help students make sense of mathematics by clarifying their thinking, constructing arguments, posing questions, reflecting about their work, and developing new approaches. When it came to assessing the RAFT assignments, it was surprising to find that what was most lacking was creativity. Usually on these types of assignments the creativity is high, but the content is lacking. Students in the experimental classes had better descriptions than the control class, but were still lacking the creativity. It was interesting to find that the most quality and creative responses came from students who chose the love letter, and the least amount of creativity came from the cartoon. Quality responses were more apparent in the experimental classes. Students in the experimental class seemed to have the process and content mastered more than the control class. This
is consistent with the literature (Beliveau, 2001) which suggests that students’ mathematical literacy will increase if they practice writing about concepts and processes.

*Geometry Quiz*

On day 7, the students were given a take home quiz where they had to name, find the perimeter, and find the area of different figures. A copy of the take home quiz is in Appendix C. On the take home quiz the class average for experimental class one was 78.1%, the class average for experimental class two was 76.0%, and the class average for the control class was 64.4%. The percent of students found in each grade range is shown in Table 7. Students who scored in the 0%-64% range mostly included students who refused to turn in the quiz, and students who refused to finish the quiz. The scores in this range on average were in the forties or lower. Each class seemed to have the same amount of students fail. All three classes on average were close, but the experimental classes were the only classes that had students score in the 95% or higher range, and the also they had a higher class average.

**Table 7**

<table>
<thead>
<tr>
<th></th>
<th>0-64</th>
<th>65-69</th>
<th>70-74</th>
<th>75-79</th>
<th>80-84</th>
<th>85-89</th>
<th>90-94</th>
<th>95+</th>
</tr>
</thead>
<tbody>
<tr>
<td>E1</td>
<td>4/(21.1)</td>
<td>1/(5.3)</td>
<td>1/(5.3)</td>
<td>2/(10.4)</td>
<td>2/(10.4)</td>
<td>4/(21.1)</td>
<td>4/(21.1)</td>
<td>1/(5.3)</td>
</tr>
<tr>
<td>E2</td>
<td>5/(27.7)</td>
<td>1/(5.6)</td>
<td>1/(5.6)</td>
<td>1/(5.6)</td>
<td>5/(27.7)</td>
<td>3/(16.7)</td>
<td>2/(11.1)</td>
<td></td>
</tr>
<tr>
<td>C</td>
<td>4/(25.0)</td>
<td>1/(6.3)</td>
<td>1/(6.3)</td>
<td>2/(12.4)</td>
<td>4/(25.0)</td>
<td>4/(25.0)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Note. E1* - experimental class 1; *E2* - experimental class 2; *C* - control class. N(%) , where N=number of students with correct answers, and (%) is the percentages of students answered correctly.
The biggest difference found between the experimental classes and the control class was on questions nine and ten which both dealt with finding the area and perimeter of circles. In all three classes, a majority of students were able to name the figures as circles. In the experimental classes about half the students were able to find the area and perimeter of the circles, but in the control class few were able to find the area, and about half were able to find the perimeter successfully. Earlier it was discussed when analyzing the anticipation guide that the control class had trouble understanding the radius was not the total distance across the circle. Interestingly enough, on questions nine and ten, only the diameter of the circle was given. Students in the control class were confusing the radius and the diameter, thus hindering their ability to calculate the area and perimeter of the circles successfully. This shows promise that using literacy strategies could increase understanding.

**Geometry Unit Test**

The unit test consisted of five parts. The first part of the unit test was a revisit of the anticipation guide, the second part was a matching section on classification, the third part was finding area and perimeter, the fourth part was finding volume, and the last part was finding surface area. A formulas sheet was included in the back of the test for students to use as reference. This was done because students are allowed to use this form while taking standardized tests.

On the unit test the class average for experimental class one was 85.5%, the class average for experimental class two was 71.0%, and the class average for the control class was 83.8%. Table 8 shows the average grade range per class for the unit test. The first
experimental class had a large number of students in the 95% or higher range, and the second experimental class also had a majority of the students in the 90% and higher range. The second experimental class average was hindered by a few students who refused to take more than the first page of the test. It is believed that the class average would have been much higher if the tests of those students who refused to participate were not counted.

Table 8

Class Average Range for Geometry Unit Test

<table>
<thead>
<tr>
<th></th>
<th>0-64</th>
<th>65-69</th>
<th>70-74</th>
<th>75-79</th>
<th>80-84</th>
<th>85-89</th>
<th>90-94</th>
<th>95+</th>
</tr>
</thead>
<tbody>
<tr>
<td>E1</td>
<td>1/(5.0)</td>
<td>1/(5.0)</td>
<td>1/(5.0)</td>
<td>3/(15.0)</td>
<td>5/(25.0)</td>
<td>1/(5.0)</td>
<td>8/(40.0)</td>
<td></td>
</tr>
<tr>
<td>E2</td>
<td>3/(18.8)</td>
<td>1/(6.25)</td>
<td>1/(6.3)</td>
<td>3/(18.75)</td>
<td>1/(6.25)</td>
<td>6/(37.5)</td>
<td>1/(6.25)</td>
<td></td>
</tr>
<tr>
<td>C</td>
<td>2/(15.4)</td>
<td>1/(7.7)</td>
<td>1/(7.7)</td>
<td>3/(23.1)</td>
<td>4/(30.8)</td>
<td>2/(15.4)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Note: E1 = experimental class 1; E2 = experimental class 2; C = control class. N/%, where N=number of students with correct answers, and (%) is the percentages of students answered correctly.*

**Graphic organizers.**

On days nine, ten, and eleven, students in the experimental group were provided with a graphic organizer for finding surface area of three dimensional shapes. All classes were taught how to use the formulas for finding surface area. On day ten, students were asked to find the surface area of a cylinder shown on the research tracking sheet in Appendix B. In the first experimental class 38.9% answered correctly, in the second experimental class 21.4% answered correctly, and in the control class, 68.3% answered correctly.

The day after the first day of learning about surface area all the students took a field trip, missing their classes for the day. This one day absence, coupled with the difficulty
level of finding the surface area hindered the success of the experimental classes. Since the students in all the classes seemed to have difficulty, both teachers decided that one more day was required to review surface area.

Students who were provided with graphic organizers performed at a much lower level than the students taught traditionally, but on day eleven, some students in the experimental classes shared different methods they used to find the surface area of figures that did not involve using the exact printed formula. When these students shared their methods the other students seemed to have an enlightening moment, and many students voiced that they believed their classmates’ methods were much easier than the formula. At this point the teacher guided the students and showed them step by step how their individual methods matched the formula, and encouraged students to use the method they found easiest.

The results from the unit test showed that reviewing surface area for one more day paid off. The first experimental class performed much better on part five of the unit test. Most of the students in the first experimental class were able to find the surface area of three dimensional figures successfully. The second experimental class and the control class had only about half the students successfully find the surface area of three dimensional figures.

Guided think-aloud.

On day twelve, students in the experimental classes were provided with a guided think-aloud. The guided think aloud, shown in Appendix D, made the students responsible for their own learning. During this day of instruction, students in the
experimental groups asked more questions and participated more regularly than the control group. On day 13 students were given a volume worksheet and were asked to find the volume of each figure. The first experimental class average was 65.8%, the second experimental class average was 75.1%, and the control class average was 85.0%. Even though the students in the experimental class seemed to be more engaged in the lesson, they failed to show this knowledge on the assessment.
Conclusion

There were several factors that could have hindered the results of this research. At the beginning of the unit, the use of literacy strategies had seemed promising. Students in the experimental classes were demonstrating more breadth and depth of understanding about the properties of quadrilaterals, and they were getting excited about learning. Problems with understanding material seemed to arise after beginning the section on surface area. The day after the first day of learning about surface area all the students took a field trip. This one day absence, coupled with the difficulty level of finding the surface area seemed to have put a damper on the success of the experimental classes. Teachers were able to alleviate some of the issues with surface area by extending the lesson another day, and by addressing the issues that students had.

Another major issue was student lack of effort. Some students in each class refused to work during class, refused to turn in assignments, and even refused to finish their tests. It was interesting to find that these types of students in the experimental classes were some of the first to contribute to discussions and to show some understandings during activities of high interest, such as the read-aloud and guided think-aloud. It is almost impossible to get every student to want to learn in the classroom, but it was interesting to find that the most engaging activities drew in the most obstinate students.

Considering this research took place in a rural, predominately white public school, it would be difficult to say that the results would be applicable to a more populated or urban setting. Only three classes were involved in the study, and the research only lasted for one unit. For future research, it would be necessary to expand the research and apply the
strategies to more schools in a more diverse area to really determine if literacy strategies can increase the level of understanding of the students.

Another major issue was that teachers were implementing literacy strategies at every moment of opportunity. It was difficult to say which literacy strategy was increasing student achievement and understanding when most every lesson contained at least one literacy strategy implementation. For future research, it might be more beneficial to use one before, one during, and one after reading literacy strategy for a unit first, instead of trying to incorporate as many strategies as possible.

It was apparent that the use of literacy strategies engaged students more in learning the mathematical content. It seemed that the more engaged the students became during the lesson, the better they performed on assessments. The more engaging activities such as the quadrilateral game, and the *Sir Conference and the Dragon of Pi* read-aloud had a significant impact on student understanding. This was shown most when looking at the significant questions from the anticipation guide before and after results.

According to the literature (Barton, Heidema, & Jordan, 2002; Clinard, 2000), emphasis on integrating literacy within content specific classrooms has emerged as a key element for secondary educators. Efforts have been made to promote literacy in content area classrooms. As students continue to progress through the school system, they often fall farther and farther behind relative to their abilities to read to learn. All teachers across the curriculum and grade levels can play a role in teaching students to use literacy strategies in the content areas to help them become independent readers and thinkers. Teachers must help students become knowledgeable about strategies and why it is important for them to use these strategies. Teachers must provide their students with a
variety of strategic learning tools designed to support achievement across the curriculum.
References


Beliveau, J. (2001). *What strategies strengthen the connections between literacy and math concepts for higher math achievement with culturally diverse students?* Manuscript submitted for publication.


Draper, R. J. (2002). School mathematics reform, constructivism, and literacy: A case
for literacy instruction in the reform-oriented math classroom. *Journal of Adolescent & Adult Literacy, 45*(6), 520-529.


National Council of Teachers of Mathematics. (2000). *Principles and standards for*


Appendix A: Anticipation Guide

Name ___________________________  Period __________

**Geometry Anticipation Guide**

Use your prior knowledge of geometry to answer the questions below. Be sure to make an educated guess if you are not sure of the answer.

1. All squares are rectangles  
   True  False

2. All rectangles are squares  
   True  False

3. The radius is the distance across a circle  
   True  False

4. The perimeter of a circle is called the circumference  
   True  False

5. A rectangular prism is the same figure as a rectangular pyramid  
   True  False

6. A circle is a polygon  
   True  False

7. A rectangle is a polygon  
   True  False

8. All the sides of an isosceles triangle are equal  
   True  False

9. An acute triangle must be equilateral  
   True  False

10. A trapezoid is a type of triangle  
    True  False
## Appendix B: Daily Tracking Sheet

### Research on the Effectiveness of Using Literacy Strategies in the Mathematics Classroom

**Key:**  
E1 – Experimental Class 1  
E2 – Experimental Class 2  
C – Control

<table>
<thead>
<tr>
<th>Day</th>
<th>Topic</th>
<th>Assessments</th>
<th>Strategies</th>
<th>Class</th>
<th>Quantitative Results</th>
</tr>
</thead>
</table>
| 1   | Classification, Area, and Perimeter of Quadrilaterals | Anticipation Guide  
See Appendix A | Anticipation guide, Frayer model, & graphic organizer | E1  
E2  
C | See Tables 1-7 |
| 2   | Classification, Area, and Perimeter of Triangles | Ticket out the door  
"Explain which statement is true:  
1. All rectangles are squares, or  
2. All squares are rectangles" | Graphic organizer | E1  
E2 | Class Average:  
73.0% Correct  
47.4% Quality  
Class Average:  
64.7% Correct  
35.3% Quality |
| 3   | Area and Perimeter of Trapezoids | Ticket out the door  
"Find the area and the perimeter of the triangle" | Traditional instruction | E1  
E2 | Class Average:  
84.2%  
26.3%  
47.4%  
Class Average:  
88.9%  
61.1%  
22.2% |
<table>
<thead>
<tr>
<th></th>
<th>Title</th>
<th>Activity</th>
<th>Class Average:</th>
</tr>
</thead>
<tbody>
<tr>
<td>4</td>
<td>Review of Days 1-3</td>
<td>Ticket out the door “List all the names of this figure”</td>
<td>Triangle Perimeter: 52.6%</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Triangle Area: 57.9%</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Quadrilateral Perimeter: 73.7%</td>
</tr>
<tr>
<td>5</td>
<td>Circumference of Circles</td>
<td>Ticket out the door “Find the circumference of the circle”</td>
<td>Class Average: 88.9% Correct</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Read aloud &amp; Guided Think aloud</td>
<td>Class Average: 60.0% Correct</td>
</tr>
<tr>
<td>6</td>
<td>Area of Circles</td>
<td>Ticket out the door</td>
<td>Class Average: 77.7% Correct</td>
</tr>
<tr>
<td>7</td>
<td>Review of Days 1-7</td>
<td>Take home quiz See Appendix C</td>
<td>Class Average: 78.1%</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>See also Table 9</td>
</tr>
<tr>
<td>8</td>
<td>3-D Shapes</td>
<td>None</td>
<td>Class Average: 76.0%</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>See also Table 9</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Class Average: 64.4%</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>See also Table 9</td>
</tr>
</tbody>
</table>

<p>|   |                         | Graphic organizer                            | N/A                          |
|   |                         |                                               | E1                           |
|   |                         |                                               | E2                           |</p>
<table>
<thead>
<tr>
<th>Day</th>
<th>Task</th>
<th>Strategy</th>
<th>Traditional Instruction</th>
<th>Class Average</th>
</tr>
</thead>
<tbody>
<tr>
<td>9</td>
<td>Surface Area</td>
<td>None</td>
<td>C</td>
<td>N/A</td>
</tr>
<tr>
<td>10</td>
<td>Surface Area</td>
<td>Ticket out the door “Find the surface area of the cylinder”</td>
<td>E1 38.9%  E2 21.4%  C 68.8%</td>
<td></td>
</tr>
<tr>
<td>11</td>
<td>Surface Area</td>
<td>None</td>
<td>E1  E2  C</td>
<td>N/A</td>
</tr>
<tr>
<td>12</td>
<td>Volume</td>
<td>None</td>
<td>E1  E2  C</td>
<td>N/A</td>
</tr>
<tr>
<td>13</td>
<td>Volume</td>
<td>Ticket out the door Volume worksheet</td>
<td>E1 65.8%  E2 75.1%  C 85.0%</td>
<td></td>
</tr>
<tr>
<td>14</td>
<td>Geometry Unit Review</td>
<td>R.A.F.T. See Appendix D</td>
<td>E1 60.0%  E2 44.0%  C 60.0%</td>
<td></td>
</tr>
<tr>
<td>15</td>
<td>Geometry Unit</td>
<td>Test See Appendix C</td>
<td>N/A  E1 85.5%  E2 71.0%  C 83.8%</td>
<td></td>
</tr>
</tbody>
</table>

Qualitative Data
The anticipation guide really helped students activate their prior knowledge of geometry. Students were able to complete the Frayer model and graphic organizer using their own knowledge. Students voiced connections between the anticipation guide and the graphic organizer. In the control group students were less likely to offer answers.

Students in the experimental groups were more attentive and actively engaged. The graphic organizer made students responsible for constructing their own knowledge. The experiment group 2 is usually very disruptive, yet when filling in the graphic organizer students were actively participating and asking questions.

As soon as I announced that we would be playing a game students were excited and ready to participate. Students in the control class were working, yet they were not as engaged or excited about learning.

The read aloud was extremely successful. The students were actively listening and taking notes while I was reading. The experiment 2 group was the most actively engaged during the read aloud. It was interesting though that that group had the lowest number of correct responses on the assessment.

Students in all classes were shown models of solids in all three classes. The experimental groups were able use the graphic organizer to connect the model to the drawing of the solid and the net. One student in the experiment two class was very disruptive and was eventually removed. Other students in the class were actively participating and answering questions.

Students in the control group performed better on the assessment, however the responses in the experimental groups showed higher level thinking. Students in the experimental groups were able to find the formula for surface area when guided by myself.

The guided think aloud made the students responsible for their own learning. Students in the experimental groups asked questions and participated more regularly than the control group.
Appendix C: Assessments

Directions: 1. Classify each figure.
2. Find the perimeter of each figure.
3. Be sure to show all your work.

1. Name ____________________________
   Area ____________________________
   Perimeter _________________________
   25 cm

2. Name ____________________________
   Area ____________________________
   Perimeter _________________________
   27 cm

3. Name ____________________________
   Area ____________________________
   Perimeter _________________________
   12 cm

4. Name ____________________________
   Area ____________________________
   Circumference ____________________
   10 cm

5. Name ____________________________
   Area ____________________________
   Circumference ____________________
   15 cm
Part 1: True or False: Circle the correct answer for each question. (1 pt each)

1. All squares are rectangles. True False
2. All rectangles are squares. True False
3. The radius is the distance across a circle. True False
4. The perimeter of a circle is called the circumference. True False
5. A rectangular prism is the same figure as a rectangular pyramid. True False
6. A circle is a polygon. True False
7. A rectangle is a polygon. True False
8. All the sides of an isosceles triangle are equal. True False
9. An acute triangle must be equilateral. True False
10. A trapezoid is a type of triangle. True False

Part 2: Area and Perimeter: Find the area and perimeter of each figure being sure to show all your work and circle your final answer. (5 points each)

21. 15 cm
   10 cm

22. 1.2 m
   1 m

23. 1.5 m
   10 cm
   1.1 cm
   2.5 cm

24. 5 cm

25. Find the diameter of a circle if the radius is 200 cm. (worth 2 points)
Part 5: Surface area: Find the surface area of each figure. (5 points each)

34.

35.

36.

Bonus: Find the volume of the following figure.

FORMULA SHEET

AREA OF A TRIANGLE:
\[ A = \frac{bh}{2} \]

AREA OF A PARALLELOGRAM:
\[ A = bh \]

AREA OF A TRAPEZOID:
\[ A = \frac{1}{2} \times (b_1 + b_2) \times h \]

AREA OF A CIRCLE:
\[ A = \pi r^2 \]

CIRCUMFERENCE OF A CIRCLE:
\[ C = 2\pi r \]

SURFACE AREA OF A RECTANGULAR PRISM:
\[ SA = 2lw + 2lh + 2wh \]

SURFACE AREA OF A CYLINDER:
\[ SA = 2\pi r^2 + 2\pi rh \]

VOLUME OF A RECTANGULAR PRISM:
\[ V = lwh \]

VOLUME OF A CYLINDER:
\[ V = \pi r^2h \]

PERIMETER OF A Rectangle:
\[ P = 2l + 2w \]
Appendix D: Literacy Strategies

Frayer Model

- Definition (in own words)
- Characteristics
- Examples (from own life)
- Non-examples (from own life)
Quadrilateral Graphic Organizer

What are the Properties of Special Quadrilaterals?
SIR CUMFERENCE AND THE DRAGON OF PII

As King Arthur was reading the story of Sir Cumference and his son, Radius, he asked questions to help them understand the story better.

**What was the circumference that the dragon needed to be divided by?**

**The answer is pi, used to represent any circle’s circumference.**

**What is the circumference of the dragon?**

**What was the diameter of the dragon?**

**What was the circumference divided by the diameter?**

"I heard that the circle edge of a circle, called the circumference, is three and one-ninth times as long as the diameter, which is the measure across the circle. It's true for any circle."

"I say, we’re no circle, said Sir Cumference. From now on, we will all be for saying, 3.14... without an end will be the name of this number for all things round."

Can you write an equation for relationship between the circumference and diameter?

The Circle’s Message

"Around the middle and clockwise, divide by a number we call pi. From three, great and small, the number is the same for all. It’s also the basis for a circle."

**What is the formula for the circumference of a circle?**

"Radius thought about Sir’s wheel. He arranged the strips on the pie like the circles. There were three strips left over. He divided them around the rim of the pie pan. Every strip got around the edge exactly the same. Lady Fogina turned her wheel. The strips are too long. Radius folded it in half, but half was longer than the strips. He folded it in quarters, but even a quarter of the pie was too long. He folded it in eighths, and then it was as short as right."

Radius found that the distance around the pie was about one-eighth more than three strips. Find the decimal equivalent to 3.14."

Each time he measured he found the distance around the circle divided by distance across the middle was 3.14. What is 3.14 written as a decimal?"
<table>
<thead>
<tr>
<th>Prisms</th>
<th>Pyramids</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="image1.png" alt="Prism 1" /></td>
<td><img src="image2.png" alt="Pyramid 1" /></td>
</tr>
<tr>
<td><img src="image3.png" alt="Prism 2" /></td>
<td><img src="image4.png" alt="Pyramid 2" /></td>
</tr>
<tr>
<td><img src="image5.png" alt="Prism 3" /></td>
<td><img src="image6.png" alt="Pyramid 3" /></td>
</tr>
<tr>
<td><img src="image7.png" alt="Prism 4" /></td>
<td><img src="image8.png" alt="Pyramid 4" /></td>
</tr>
<tr>
<td><img src="image9.png" alt="Prism 5" /></td>
<td><img src="image10.png" alt="Pyramid 5" /></td>
</tr>
</tbody>
</table>

3-D Shapes

- Prisms:
  - ![Prism 1](image1.png)
  - ![Prism 2](image3.png)
  - ![Prism 3](image5.png)
  - ![Prism 4](image7.png)
  - ![Prism 5](image9.png)

- Pyramids:
  - ![Pyramid 1](image2.png)
  - ![Pyramid 2](image4.png)
  - ![Pyramid 3](image6.png)
  - ![Pyramid 4](image8.png)
  - ![Pyramid 5](image10.png)

- Cylinder:
  - ![Cylinder](image11.png)
Volume of a 3-d Figure

What is the volume of solid?

Where have you used volume previously this year?

Finding the volume of a solid

1. Find the area of the base of the figure

Base

\[ A = \] \
\[ A = \] \
\[ A = \]

Base = 

\[ A = \] 
\[ A = \] 
\[ A = \]

Base = 

\[ A = \] 
\[ A = \] 
\[ A = \]
2. Multiply the area of the base with the height

Height of Figure 1 ____________

Height of Figure 2 ____________

Height of Figure 3 ____________

Figure 1  Figure 2  Figure 3
V= ________  V= ________  V= ________
V= ________  V= ________  V= ________

**Volume Formulas**

Rectangular Prism V= ____________  V= ____________

Cylinder V= ____________  V= ____________

Triangular Prism V= ____________  V= ____________

3. Label the volume in ________________ because ________________
Directions: Chose which RAFT you would like to complete. You may not mix roles, format, audience, or topic. Be creative, but also make sure that your completed RAFT completely covers the topic stated.

<table>
<thead>
<tr>
<th>Role</th>
<th>Audience</th>
<th>Format</th>
<th>Topic &amp; Strong Verb</th>
</tr>
</thead>
<tbody>
<tr>
<td>Square</td>
<td>Math Class</td>
<td>Family Tree</td>
<td>Create your own family tree and give characteristics of each family member.</td>
</tr>
<tr>
<td>Circle</td>
<td>$\pi$</td>
<td>Love Letter</td>
<td>Explain relationship</td>
</tr>
<tr>
<td>Cartoonist</td>
<td>Math Class</td>
<td>Cartoon</td>
<td>Show the interaction between instructor and students while a teacher teaches his/her students about the different types of 3 dimensional figures.</td>
</tr>
</tbody>
</table>

Choice 1: You are a square. You are to create a family tree for the quadrilateral family. Along with your family tree you should include a description of each member of the family. Make sure to include what you know about each figure we have studied and use proper names and terminology.

Choice 2: You are a circle. Write a love letter to $\pi$ explaining your relationship. Make sure to include the relationship between circles and $\pi$ clearly so that someone who knows nothing about the relationship can learn from your writing.

Choice 3: You are a cartoonist. You have been hired by a teacher to create a cartoon for their math class. This cartoon must show how a teacher teaches his/her class about the different types of 3 dimensional figures and their properties. Students reading this cartoon should learn the proper names and properties of different 3 dimensional figures.