The Impact of Incorporating Specific Literacy Strategies in a Mathematics Classroom

Katherine Rudnicki
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Abstract

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Dedication

The work I have done this year would not have been possible if it were not for the support of my family, specifically my husband Stephen and my two little girls, Eliana & Marykate. While Eliana and Marykate are too young to realize the amount of work (on both their parents' part) that went into writing this paper, it is my hope that someday they will look back on this and be proud of what was accomplished. Thank you Steve for being such a wonderful person, and for your constant flexibility working around my schedule!
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The Impact of Incorporating Specific Literacy Strategies in a Mathematics Classroom

There has been much discussion about student performance in mathematics in the middle grades, including reasons why achievement is not as high as it could be. One of the reasons often given for poor performance in the middle grades, across all subject areas, is literacy. Many education professionals would agree that poor literacy directly impacts learning in all content areas. While content area literacy is important, many students plateau in their reading abilities in middle school (Greenwood, 2004). The research done for this paper has explored how applying specific literacy strategies in a mathematics classroom impacted student learning.

Literacy is everywhere. It is embedded in everything we do, including mathematics. Typically when the topic of literacy and math are discussed the first thing that comes to mind is word problems. Students are faced with much more than word problems in today’s math classroom. Literacy in math involves anything from basic mathematics vocabulary and computation, and reading and interpreting graphs and data, to working with and deciphering complicated textbooks. The list could go on and on. Reading in the math classroom includes shifting back and forth between words, symbols, numbers, letters and graphics, all of which have their own complexities. All of these things make literacy instruction extremely important in the middle school math classroom.

Many secondary educators entered the field of teaching because of a love for their specific subject (Daniels & Zemelman, 2004), not necessarily because they wanted to integrate reading instruction into their teaching. Pre-service teachers are now being required to take courses in literacy that present a multitude of literacy strategies for use in
a variety of content areas. While these courses are required, many of the strategies are not being used by emerging teachers in the middle school classroom. Reading instruction is no longer solely dependent on the reading or English teacher: all content area teachers must support literacy instruction in their respected areas, because they are best equipped to teach texts that are unique to their fields (Fordham, 2006a). Until teachers see the importance and benefits of incorporating literacy strategies into their content area, they will go on teaching without using them.

By incorporating literacy strategies in a middle school math classroom this researcher hopes to gain a better understanding of the strategies that have been identified as being helpful but have not typically used in the math classroom. Not only that, but also to see if in fact these strategies will make a difference in the math classroom. The population of students used in this study struggle not only with math but also with reading, and many are in remedial math as well as remedial reading. Introducing them to literacy strategies in the math classroom could help them make connections and see the usefulness of the literacy strategies across content areas.

This study also looked at the use of mathematics vocabulary in the classroom with the hope for improvement. Currently it appears students have an awareness of what something means (addition, for example), but are not familiar with the mathematical word for it (sum). They also have difficulty in explaining themselves when they know how to solve a problem or when they have questions about solving a problem. In math, written explanations are about what is being done and why it works (Tuttle, 2005). Being able to explain the problem solving process is an important skill, not only in math, but in many content areas. The hope is that this study will lead to further discoveries about how
students learn and encourage others to incorporate literacy strategies into their content areas for the benefit of all.
Literacy is an issue of importance to all educators, therefore it is no surprise that in recent years there has been a focus on literacy across the content areas. Mathematics, in particular, is one content area that seems to be getting a lot of attention these days. Many believe that all teachers, regardless of their subject area, are teachers of literacy (Devlin, 1999). In the mathematics classroom, even though educators have taken coursework on content-area literacy, few are incorporating what they have learned into their teaching (Draper, 2002). There are others who feel that while literacy is getting a lot of attention, consideration needs to be paid to numeracy as well, and teachers of all subject areas need to be including numeracy into their teaching (Jaye & Posamentier, 2007).

This literature review will explore many different methods and strategies available to educators to help integrate literacy into the mathematics classroom, from using picture books (Miller, 1998), to using the library (Fleming, 2004), to questioning techniques, to using graphic organizers such as K-W-L charts (Fisher, Frey & Williams, 2002). Any and all of these methods could be used in the secondary mathematics classroom to enhance the teaching of both mathematics content and literacy.

Literacy Teaching for All

Most educators today would agree that literacy is a fundamental basis for students' education. The ways in which literacy is defined can be very broad and has evolved to include many different things (Draper, 2002). "The traditional literacies – reading, writing, 'rithmetic – are still fundamental" (Ames, 2003, p. 35), but the concept of literacy encompasses much more today than ever before. Ames (2003) went so far as
to break it down into "five essential literacies", which are necessary to be considered
"truly educated": Fundamental, Scientific, Civic Literacy, Aesthetic Literacy, and
Personal Literacy (p. 35). Mathematical literacy falls under the umbrella of fundamental,
and involves being able to communicate "ideas and results effectively, both orally and in
integrated curriculum, including technology, the arts, and by incorporating "learning-by-
doing instruction" (p. 38). This concept is not new to mathematics teachers; real-world
problems and hands-on learning have always had a place in the math classroom.
However, specific literacy strategies and their connection to the math content might be a
struggle for the mathematics teacher.

Draper (2002) contended that while infusing literacy instruction with content
instruction would promote the development of literacy, many educators are not doing it.
Textbooks used to teach pre-service teachers secondary methods courses do not include
enough subject matter on literacy instruction across the content areas. Draper (2002)
found that while these textbooks "explain that teachers have a responsibility to support
reading instruction, they provide limited methods for how content-area teacher might
provide that support" (p. 377). Hollingsworth and Teel (1991) studied the effect a
secondary reading course had on two preservice teachers' literacy beliefs in the
classroom. While both teachers understood the importance of literacy in the content areas
and took a course about it, neither was readily applying it to their classroom teaching. It
was found that "the assumption that requiring certain course work in teacher education
programs will lead to changes in classroom practices is one worth challenging"
(Hollingsworth & Teel, 1991, p.194).
Fordham (2006a) stated that “because reading is integral to all subjects, every teacher bears some responsibility for helping students develop the literacy skills that enable them to acquire content knowledge” (pp. 33-34). The content area teacher is expected to be an expert in that field; therefore it is assumed that they would be best prepared to handle the teaching of literacy for their subject area. It is up to these content area teachers to seek out the information needed to develop and improve their students’ literacy and comprehension skills. Fisher and Frey (2006) assisted in developing a school wide literacy plan at Hoover High School in San Diego, California. The plan maintained that “all teachers needed to implement content literacy strategies in their classrooms” (Fisher & Frey, 2006, p.17). The main idea was to focus on a few key strategies that were to be consistently implemented across the content areas.

Incorporating literacy strategies into a content area class is something that is difficult for many teachers to figure out, specifically in mathematics. There are many sources available to connect literacy to social studies and science; however math appears to be more challenging. Fleming (2004) suggested teaching math in the library, using the librarians to aid in strengthening math skills. He provided ideas for using the library and linked it to the state standards. For example, for the mathematical strand Patterns, Relations, and Algebra, he suggested using reference books and other library resources to create real-world problems with actual data (Fleming, 2004). By linking mathematics to a real world scenario, students are motivated and more apt to see the meaning behind the mathematical concept, and better retain what is being taught.

Alvermann (2002) asserted that “effective literacy instruction for adolescents must take into account a host of factors, including students’ perceptions of their
competencies as readers and writers, their level of motivation and background knowledge, and their interests” (p. 203). The concept of student-centered instruction is important in order to keep the interest of adolescent students at the secondary level. Interdisciplinary units that involve many of the content areas are one way to reach students on a number of levels. Bintz, Hayhurst, Jones, Moore and Tuttle (2006) found that by working as an interdisciplinary team and creating units designed to help students think like scientist and mathematicians, students were engaged and given a context to make it easier to understand concepts being taught.

Carey, King-Jackson, Paugh, and Russell (2007) suggested “new literacies for a new world demand that students develop social knowledge” (p. 31). The teachers involved in this study worked as co-teachers for a part of a literacy block, which invited student ownership and innovation (Carey et al., 2007). The culture of our society today demands “active participation in collaborative literacy events” (Carey et al., 2007, p. 31). Student participation was important in the literacy tasks, as well as input from the teachers.

Mathematical Literacy

Mathematical literacy or numeracy as it is sometimes referred to, can vary in its definition. Martin (2007) stated, “Mathematical literacy implies that a person is able to reason, analyze, formulate, and solve problems in a real-world setting.” (p. 29). McCarthy and Zawojewski (2007) found that numeracy consists of a “creative and flexible use of mathematics to solve substantive, realistic problems” (p. 33). This is not how problems are typically encountered in the secondary mathematics classroom. Many secondary mathematics curriculums involve lecture, practice and application of
procedures taught. McCarthy and Zawojewski (2007) gave an example problem, a “Fitness Field Day Investigation” that could be presented to a secondary mathematics teacher for use in problem-based mathematics teaching (p. 32). Students are placed on problem solving teams to design a method for coming up with teams of students from fitness field day data. McCarthy and Zawojewski (2007) contended that this activity allowed students to “apply, practice, and adapt the conventional literacy skills they have learned in their classrooms” (p. 34). While this study involved only teachers of mathematics, not all teachers were on board from the start, and it took three years for the integration of this type of investigation into the regular mathematics curriculum.

In order for this type of teaching and support of numeracy in general to be successful, the school culture must be one that is open to facilitating student development through teacher input and administrative leadership. A study done by Heron (2003) suggested that “classroom culture and the relationship the teachers form with the students inspire student participation and pride in learning” (p. 568). In this study, inquiry-based teaching was found to be beneficial to student learning, and student involvement was critical to motivation and success (Heron, 2003).

As discussed previously, real world scenarios help to motivate students to want to learn. Jaye and Posamentier (2007) suggested that all teachers, not just teachers of mathematics, get excited about teaching and using math, by showing them some of the “nifty relationships that exist in mathematics” (p. 47). Teachers of other content areas can begin to see math as a motivator rather than a subject that is feared. They contended that while it may seem like a digression, it is important for teachers to see how math can enhance the other topics being taught. Again, bringing real-world experiences into the
classroom, whether it is a mathematics classroom or a science or social studies classroom, enhances motivation while developing critical literacy skills. In order for learning to last, students must see the mathematics “as both meaningful and useful” (Steen, 2007, p. 17). Steen contended that if English teachers focus only on writing, students do not have the incentive to clearly express themselves in other subjects. Going further, the same is true with “numeracy: if it is only in mathematics classes that numerical arguments and logical deductions are emphasized, the widespread culture of ‘mathophobia’ is reinforced by the very educational system that is supposed to overcome it” (Steen, 2007, p. 20).

Specific Literacy Strategies to Incorporate into the Content Areas

Much information was available concerning specific literacy strategies across the content areas. Many of these strategies are meant to be applied to a wide variety of subject areas, not just mathematics. The understanding is that if students see similar strategies being used in social studies class and again in math, the comfort level with the strategy increases and students are more apt to use it again. While the strategies are meant to be used across a multitude of content areas, there were few studies that focused directly on literacy strategies and math. The strategies that did have the best connection to math content were picture books, questioning strategies, and the use of graphic organizers. Using specific literacy strategies such as picture books to introduce a topic, and graphic organizers to filter information, allowed for a more extensive range of mathematics material to be covered (Bintz et al., 2006).
Picture Books

There was no shortage of material when it came to studies regarding the use of literature in the mathematics classroom. Many of the studies found were geared towards elementary classrooms (Gary & Whitin, 1994), and incorporated picture books into the mathematics classroom (Lewis, Long & Mackay, 1993). Picture books are useful because they are appealing to children and adults. Most students have been exposed to the magic of reading and telling stories, which contribute to their perceptions of the world. Using picture books in a math classroom give students a context through which to develop mathematical ideas.

The study done by Gary and Whitin (1994) explored the concept of length using a picture book, *The Line-up Book* (Russo, 1986), with their first-grade students on one occasion. Students went on to investigate other mathematical relationships as a result of the discussions brought out through the picture book. On another occasion students explored division using another picture book, *The Doorbell Rang* (Hutchins, 1986). After having the story read to them several times, students then volunteered to act out the story. Through these picture books, students were able to make sense out of a real-life situation and were given the opportunity “to represent their ideas in different ways” (Gary & Whitin, 1994, p. 398). This same picture book, along with a many others, can be used to explore fractional concepts. Bostick Midkiff and Conaway (1994) explain that “although this book does not directly discuss fractional concepts, the story provides a real-life problem-solving situation using fractional portions of 12” (431).

As Gary and Whitin (1994) stated, “Stories can also serve as open invitations for students to connect their own interests and background experiences to various
mathematical concepts”, which is important to the retention of what is being taught (p. 399). Actively engaging students in their learning, and presenting the material in a variety of methods, as was done in these studies, makes the math more meaningful for the students. Gailey (1993) expressed the idea of teachers creating “a mathematics book corner where students can read” books on their own (p. 259). Both language and mathematics skills can develop as students “listen, read, write, and talk about mathematical ideas” (Gailey, 1993, p. 258).

Whitin (1994) also used stories to see the functional use of estimation. Three classroom scenarios were presented to show the connection between mathematical estimation and children’s literature in first, second and fifth grade. Of interest was the fifth grade classroom because it is closest to the secondary level. Many pieces of literature were shared with this group in order to discuss estimation and rules of thumb, and students eventually wrote their own version of an estimate (Whitin, 1994). The main goal was to “highlight the idea that estimates are always context dependent” (Whitin, 1994, p. 440). Students at this age level easily made connections to their own lives, which aids in developing their understanding of the mathematics content.

Children’s literature is full of ideas for mathematical connections. Even books not written by mathematicians could convey mathematical ideas metaphorically (Lewis, Long & Mackay, 1993). Introducing literature allows students to communicate mathematical concepts in a different way. Lewis, Long and Mackay (1994) suggested, “creating structured opportunities for students to write ‘copycat’ or parallel stories of children’s books that contain mathematical concepts” (p. 472). This was a successful way
for them to incorporate mathematical writing into the classroom, and allowed students to use their skills in language to benefit them in math.

Picture books could also be brought into a secondary mathematics classroom to reinforce literacy concepts as well as mathematical ideas. “Children’s literature presents a natural way to connect language and mathematics” (Bostick Midkiff & McCart Cramer, 1993, p. 303). Understanding math vocabulary is a critical piece of comprehending key mathematical ideas. Clements and Sarama (2006) stated that, “talking about mathematics builds language skills” (p. 17). Reading picture books to middle and even high school students would be beneficial to the students because even though the text is short, the vocabulary can be quite advanced (Miller, 1998). Miller (1998) provided a number of excellent reasons for incorporating picture books into the secondary classroom, such as creating independent reading options for students, introducing abstract topics, and integrating multicultural content. Picture books use many visual examples and many students can relate their own experiences to those they see in the book.

**Graphic Organizers**

In a mathematics classroom, one strategy that lends itself very well to the content is that of the graphic organizer. Graphic organizers provide students with a visual connection to vocabulary or concepts in any content area classroom. It is critical when using a graphic organizer that students are actively involved in creating the visual, and not just given a handout with the organizer already filled out (Greenwood, 2004).

“Common graphic organizers include semantic webs, cause and effect charts, Venn diagrams, matrices and flow charts” (Fisher & Frey, 2006, p. 19). Graphic organizers
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encompass a wide range of strategies, and can be basic and simple or increasingly complex.

Braselton and Decker (1994) introduced a diamond-shaped graphic organizer as a strategy for deciphering word problems to a fifth grade classroom. Their organizer involved five steps: restate the problem, decide what information is needed to solve the problem, plan the mathematical calculation, perform the calculation, and then finally determine if the answer is reasonable. Explicit instruction was necessary to ensure students knew how to best utilize the graphic organizer as a tool for problem solving. As Braselton and Decker (1994) found, once students become comfortable with the graphic organizer, they “moved from teacher-guided problem solving to working in small groups” (p. 278).

Greenwood (2004) introduced six specific vocabulary strategies based on some form of graphic organizer. Word maps were used to help students “develop a general concept of definition” (Greenwood, 2004, p. 29). Word analogies were also used by Greenwood (2004) that required “students to infer a relationship between two often disparate terms and to then apply that relationship to another pair” (p. 30). Semantic feature analysis, which focused student attention on categorizing words, and a vocabulary self-collection strategy, was also discussed. The Frayer model (Frayer, Frederick & Klausmeier, 1969) was introduced to a group of eighth grade science students. This graphic organizer, like many of the others mentioned in this study, was modeled by the teacher on the overhead projector and by talking out loud before the students was given a chance to try it. Word sorts were also discussed, which did not necessarily involve the use of a graphic organizer but did involve classifying vocabulary words into distinct
predetermined categories. This strategy was identified as being hands on, and actively engaging student attention (Greenwood, 2004).

Incorporating the Frayer model, or concept map as it is sometimes referred to as (Hancewicz, Heuer, Kenney, Metsisto & Tuttle, 2005), provided opportunities for rich classroom discourse. Students in this study shared their models with their classmates after they created them. This enabled them to expand their thinking instead of simply recording their own ideas on paper. There is a need for content area teachers to move away from direct vocabulary instruction to allowing students to take control over their own learning of these words through the use of graphic organizers.

Another graphic organizer discussed with useful applications in a math classroom was that of the KWC chart (Hyde, 2006). It was described as a “transformation of the KWL into a mathematical tool” (p. 20). The big ideas fall under the three headings: K for what do students know for sure, W for what do students want to figure out, and C for are there any special conditions, constraints, rules or tricks to watch out for (Hyde, 2006). This type of organizer worked well with story problems, and again promoted the use of discourse within the mathematics classroom.

**Summarizing**

Summarizing is a literacy strategy that has various meanings, depending on the content area being referred to. In reading a novel, summarizing has a lot to do with the story’s plot; in math it could be used when trying to decipher a word problem, but that is not always the case. Summarizing in a math class could be as simple as restating a question, in words that make sense to the reader. Regardless of the meaning, Friend (2000) asserted that summarizing is a strategy that needs to be specifically taught to
students in order for them to see success using it. While this study focused specifically on writing a summary, giving guidelines for doing so, the idea that students need to be shown how to summarize is an important one.

Summarizing in a math classroom could be done in a number of different ways, and involves making inferences and determining what is important. This needs to be done on “several different levels: the text as a whole, each sentence, and even each word” (Hyde, 2006, 126). The idea of summarizing what is important, especially in a mathematics story problem, has a lot to do with the use of graphic organizers, which were discussed previously.

**Questioning**

The idea of questioning in a middle school classroom, or any classroom for that matter, seems instinctive. Most educators ask questions of their students on a daily basis for many reasons, one of them being to assess student comprehension of the topic being taught. By using a variety of questioning techniques, educators can address different levels of thinking in their students. Not only is it important for teachers to be asking the right questions, but it is equally important for students to be taught how to develop their metacognitive awareness by asking the right questions.

As Fordham (2006a) stated, “not all questions are equal” (p. 35). Particularly in math, questions can do much more than encourage students to recall facts. Lilburn and Sullivan (2002) have devoted an entire book to the art of questioning as it relates to math, and generally categorize questions as either open or closed. They go on to discuss the main features of good questions and their usefulness in the math classroom. While Lilburn and Sullivan (2002) contended that “closed questions are much more common”
than open, it is the open ended question that will provoke higher level thinking in the mathematics classroom (p. 1). There are many specific examples provided for use in math lessons, ranging from number sense to measurement and geometry.

One study on questioning looked at how using embedded questions could provoke students to become more aware of what they were thinking when they read (Weir, 1998). While this study focused on students in a remedial reading setting, the strategies utilized were universal. In order to get students to think during reading, reading passages were changed so that questions could be inserted at points identified as being critical for understanding (Weir, 1998). This enabled the teacher to “simulate the metacognitive strategies that skillful readers employ” (Weir, 1998, p. 460). Guidelines were provided for when and how to skillfully embed questions within a text. By employing this strategy, students began to see their role in understanding what they were reading.

Content area teachers can improve classroom instruction not only by asking the right questions but also by training students in question generation (Ciardiello, 1998). Ciardiello (1998) contended that “student questioning training offers an appropriate strategy for teaching cognitive and metacognitive skills because it is a form of language instruction that serves the expansive range of thinking processes” (p. 217). Essentially, by making students cognitively aware of the questions they ask, educators are teaching students to think.

Hyde (2006) asserted that educators can encourage students to ask questions in math class by ensuring it is a comfortable place to learn. Mistakes are inevitable in a math class and students need to know it is okay. Hyde (2006) described a method of questioning that also involves the use of a graphic organizer, the KWC chart, which was
more groups, seven and four students each, were seen in the math lab every other day ninth period, which met from 2:00-2:40 PM. This was the last period of the regular school day. These students had their regular math class every day during fourth period. The last group had five students and met every other day during tenth period, which was an after school math lab that met from 2:45-3:25 PM. These students had regular math class every day during fourth period, and attended the after school math lab because of other constraints in their schedule that did not allow them to participate in math lab during the regular school day.

The math lab environment was a small classroom setting with students seated around the outside of two tables that form an L-shape, with the math lab teacher on the inside of the L. The room was equipped with a whiteboard used for problem solving, as well as two computers for use by both students and teacher, and a wide variety of student supplies. Student work done in the math lab was kept in individual student folders located in a crate in the math lab classroom. Students almost always had regular math class homework, and additional homework was typically not given in the math lab.

*Procedures & Materials*

This research study looked at how applying specific literacy strategies influenced learning in the math classroom. Students met with the math lab teacher every other day for forty minutes, and it was in this time frame that the research was conducted. The research was carried out through a process of planning, acting, observing and reflecting. As math lab lessons were planned, careful consideration was given to what the students were doing in the regular math classroom. The purpose of the math lab was to support the regular math teacher while strengthening students’ math skills. Once it was determined
what they would be working on in the regular math class, a literacy strategy was introduced to the students that would enhance the math unit they were working on.

Through a variety of assessment methods described further below, student reaction to the literacy strategies introduced was observed.

The literacy strategies incorporated in the math lab included the use of graphic organizers for vocabulary or concepts, the use of picture books to make connections, thinking aloud, summarizing and journaling. Specifically, if a picture book was read to the students to engage them in the lesson, it was followed by questions to be answered either individually or as a group. Answers to these questions were recorded in student journals, which were kept in the math lab.

Students began class as usual with a problem of the day, and this was typically when the literacy strategy was introduced. After the problem of the day, students had time to get help with their homework, if necessary. Students from the third period groups generally did not have questions or need help with their homework, because their regular math teacher would collect it first thing in the morning. Students from the seventh, ninth and tenth period groups almost always had math homework that they received in their regular math class and wanted time to work on it, ask questions and get help if necessary. Typically in this portion of the math lab class, the literacy strategies were not incorporated or utilized.

Once students’ questions on homework were addressed, there was often time to delve further into extra practice on whatever unit students were working on. This time was typically used to give students the opportunity to practice problems they would be faced with on tests or quizzes. This practice time provided the opportunity to informally
assess student progress by checking their work on the mathematics problems given to them by me. Clipboard notes were kept on students' progress (see Appendix A), and was added to throughout the class period. Student work was also kept in the individual students' folders in the crate in the classroom, to be used as a reference or to do a more formal assessment of their progress. Lessons were also often taught during this time; either a preview of what they would be doing in math class that day (as was the case with the third period groups), or a review of what they had already seen in math class that day (as was the case with the seventh, ninth and tenth period groups). During this lesson time reference would be made to the literacy strategies used, making connections for students from one math content area to another. A journal of progress was kept and added to during planning periods, after students moved on to their next class.

Data Collection

Data was gathered through a variety of methods as part of the usual classroom activities. As mentioned previously, teacher clipboard notes were kept daily on each specific group of students. Student journal reflections also provided information as to the effectiveness of the strategies introduced. Communication with the participants' regular sixth grade math class teacher was done on a weekly basis. This communication was in the form of a weekly update (see Appendix B), where students' scores on unit tests, quizzes, and sometimes homework was documented. It also provided information on upcoming unit topics, tests and any other information that might help better support the students.

At the end of each mathematics unit the regular math teacher had a unit test, and sometimes a quiz or quest in the middle. In some cases the grades for these formal
assessments were provided to me through the weekly report. In the math lab, student progress was documented as well not only through the use of my clipboard notes and journal, but also through student journal entries. At the end of each math lab session, students were often asked to write in their math journal, sometimes with specific questions and sometimes with simple prompts to help frame their thinking. These journal entries were used to assess their progress and often related to the literacy strategy introduced in the math lab.

Through the variety of methods described above, data was collected for the research on literacy strategies and their effectiveness in the mathematics classroom. Because the students used for this study came from different mathematics classrooms, the math lab lessons often times varied from one class to another. The regular math teachers were not always working on the same math topic at the same time in class, which forced me to be flexible when it came to planning my lessons. Plans had to be changed at times and lessons adjusted to better match what the regular math teacher was doing in class. The literacy strategies used with the students could be applied to a variety of topics, so students were still receiving similar content from the math lab.
Results

Once all the assessments, journal entries, and observations were completed, the responses were categorized according to the experiences of the participants. The information was then analyzed for patterns, themes, and trends and then compared for relationships and differences. The majority of the data collected for this study was qualitative because of the nature of the math lab setting at this particular school. As previously discussed, students did not receive numerical grades in the math lab, and while information was passed along from the participants’ regular sixth grade math teacher to the math lab teacher, it was not always done consistently. Furthermore, the regular math class assessments did not always line up in terms of material covered with the time frame used for this research study.

Students in the math lab were for the most part very receptive to the strategies that were introduced. Each strategy that was introduced led to a discussion about where it might be used outside of the math class. At first, student response to this question was not connected to other content areas. They would respond by saying they would use it in the real world, or in their job. They may have said this because they thought that was what the teacher wanted to hear. However, after further discussions for each strategy, students began to see the usefulness across other content areas, and their responses in their journals indicated so.

Frayer Model

One of the first strategies introduced to the students was using a graphic organizer to sort through information. There are a wide variety of organizers that could be applied to a mathematics classroom. For this study, students were shown the Frayer model
(Frayer, Frederick & Klausmeier, 1969) and how it can be used to develop the learning of vocabulary words. A Frayer model has four rectangles with a circle in the middle (see Appendix C). The vocabulary word or concept is placed in the center, and the rectangular boxes surrounding it are filled with important information about that word or concept. The Frayer model lends itself nicely to math vocabulary because it provides spaces for a definition, important characteristics, examples and non-examples. The spaces for examples and non-examples are convenient because they can include pictures that are helpful in conveying many mathematical concepts, especially graphs.

Almost all of the students had not seen this graphic organizer before. Students were, however, familiar with the term graphic organizer. Modeling how to fill out the organizer was essential to student success if they were to use this on their own. Once the teacher modeled how to fill out the graphic organizer, students quickly picked up on what to do, but were not entirely thorough in filling out the organizer. The first time students used the Frayer model, many had a difficult time coming up with characteristics, which are the most important facts about the word that is being defined. They also had a hard time with the non-example piece of the model. Many were confused as to what would go in this section of the model. After it was explained to the students that a non-example should be something that may easily be confused with the word being defined, students began to see the point to that category.

This strategy took a considerable amount of time, especially because students were not at all familiar with the word they were researching and the technique of filling out the organizer. The first time through was awkward for them, and many were rushing through trying to move on to their next word. The first few groups to use the Frayer
model needed more time than had been originally planned, and therefore the plan was
adjusted and the later groups had the time needed to really delve into this task properly.

Students were given an opportunity to use the Frayer model again during the
course of this research. The second time around went much differently than the first.
Prior to giving students words to use for their model, the teacher presented the class with
examples, both good and bad, from the last time they were used. A classroom discussion
was held to discuss the qualities of the good example as well as the bad. Students
appeared much more comfortable with the strategy because they had seen it before. The
graphic organizer was much more complete for the majority of students than the first
time. It also did not take as much time to utilize this technique the second time around.
Students began to see the connection to graphic organizers and other content areas in
general because of discussions held throughout the course of the class. This improvement
in classroom discourse was extremely encouraging, especially since students were
beginning to use more formal mathematical language than they had in the past.

Picture Books

Students in the math lab were genuinely excited to have a picture book read to
them. The book chosen was *Sir Cumference and the Dragon of Pi* by Cindy
Neuschwander, a fictional story that introduces the mathematical concept of pi. Radius
has to save his father, Sir Cumference, from staying a dragon forever by figuring out that
pi is the secret to the potion needed to save him. The students who came to math lab on
day one were just told to listen to the story and think about what key math words they
could hear. A classroom discussion was held at the end of the story to talk about what
students remembered about circles, radius, diameter and pi. While the discussions held on
day one were appropriate, many students were not actively involved in their learning. It was decided that for day two students, in order to help direct students' focus to the key math ideas being talked about, a graphic organizer would be used while the story was being read.

While students were listening to the story, they had a graphic organizer in front of them (see Appendix D). This organizer was meant to keep students focused while listening to the teacher read the story. It was explained to them that they were to look for key math words for the first column, important facts in the story for the second, and any personal connections for the fourth column. Students were instructed to leave the third column empty, so that it could be filled in together with the class after the story was read. Even with the graphic organizer to prompt them, many students only filled out the first column and left all the others blank while listening to the story. Three students did not write anything at all in their organizer, and when asked why they all responded that it was difficult for them to listen and write at the same time.

All of the students were excited about having a picture book read to them during math class. It was something new and different, and they were attentive and focused for the entire story. Many were not happy about having to fill out the organizer, and as stated previously a few did not fill it out because of their attention issues. While students on both days left class excited about the book, the students on day two who used the graphic organizer to focus their thinking were able to delve into the math content more deeply than the students who did not use the organizer. By using the organizer, they became metacognizant of their learning and took ownership of their work in filling it out.
Summarizing & Thinking Aloud

Students were exposed to a summarizing strategy using a supplement to the local newspaper. The supplement provided passages pertaining to a number of real life mathematics problems including sports, recreation, money and geography. After each passage were questions pertaining to the content. Most of the questions were computational in nature. The first passage was read out loud to the students by the teacher, where the thinking aloud strategy was used to demonstrate what students should be thinking about as they read. The importance of using this strategy was stressed and students were able to observe the teacher in action. Information that was thought to be important was either circled if it had to do with numbers or underlined if it was an important fact. Students then attempted to answer the questions following the passage with the teacher, referring back to the information that was highlighted in the passage during the think aloud session.

Students were then asked to try the strategy on their own with the next passage, using the circling and underlining technique to summarize and highlight the important information in the text. Once they were done they shared their findings with the other students in the class, including what they were thinking about when they read the passage. Many students underlined the same things, but some students had circled or underlined too much. This prompted a discussion on what was enough and what was too much information and emphasis was placed on the idea of summarizing what is in the text to highlight the most important information. When students looked at the questions that were asked at the end of the passage, some of them could easily see from what they underlined or circled what the important numbers were in the text. Some students though
still had difficulty with the computations involved in the questions, which was a result of not being familiar with vocabulary words being used.

It was interesting to see students respond to the use of the newspaper in the math classroom. They were excited and wanted to flip through the pages, so time was spent looking at the different parts of the paper and discussions were had about the usefulness of math in the real world. The importance of using authentic content reading materials became very clear with this exercise. Students were definitely most comfortable with this literacy strategy because it is one that many of them have used before in other content areas. All of the students who attend remedial reading, which is the majority of the math lab students, had seen this strategy used before and therefore were very comfortable with trying it themselves in the math class.

*Journal Entries*

Students were asked to write in a math journal throughout the course of this research study. Many students had experienced writing in a journal in other content areas, but not typically in a math setting. Although journaling was not directly discussed in the literature found for this study, the idea of promoting discourse and metacognition among students was a common thread. The thought was that getting students to think about what they are doing and reflect on why they are doing something would be beneficial to becoming better learners. For this study, getting students to become aware of why we used these specific literacy strategies and how they might carry over into another content area was a main goal.

At first, to make the students more comfortable with the journal writing process, they were given specific questions to address in their writing. The journal writing
progressed over the course of the study to a point where students were given ideas in which to frame their thinking when writing in their journals, rather then specific questions to respond to. To find out how students felt about using the Frayer model for the first time, they were asked to write specifically about why they thought the model would be helpful in math class, and where else they might possibly use it. The responses to these prompts were typically that they could use it to study vocabulary words in math. When asked where else they might use it, many students responded that they could use it in the real world, without any further clarification. This indicated that they did not make any connection to the usefulness of the model in other content areas.

Students were asked to journal many times over the course of this research. In their later journal entries, when prompted where they might use the literacy strategies other than in math, many students made connections to other classes such as science, reading and social studies. For one journal entry students were just given a framework to focus their thinking instead of a direct prompt. They were asked to do a free write in their journal, which is three minutes of quiet time to get their thoughts down. Students were asked to think about three things: their own learning process, graphic organizers and math. While they needed prompting from the teacher to maintain their focus, this writing time gave students the opportunity to reflect on the use of graphic organizers in the math classroom.
Discussion and Conclusion

Looking back at the research done on literacy and mathematics, there were many similarities in the findings of this study. There is no question that the students in this study benefited from seeing literacy strategies in the math classroom. Many students have difficulty in math for a variety of reasons. These literacy strategies reach many different students and engage them in meaningful mathematical discussions. By sharing strategies like graphic organizers with students to help them organize their thoughts and their work, teachers are providing them with strategies that they can take with them when they leave the math classroom.

Implementing specific literacy strategies in the math classroom was not as difficult as it seemed it would be. While this researcher had taken courses in literacy for teacher certification, the strategies had not truly been put into practice until this study. Hollingsworth and Teel (1991) pointed this out as typical for new teachers in their research. Many of the strategies were incorporated as the problem of the day, and typically did not take much of the class time to present. Once students became familiar with a strategy, like journaling for example, it became easier to include it in the everyday routine.

Much of the research (Gary & Whitin, 1994, Lewis, Long & Mackay, 1993) addressed the idea of literacy strategies being engaging and opening the door for students to make connections in their learning. In this research study students were actively engaged in the picture books, journal writing and use of the graphic organizer. They made connections between techniques used in other content areas. It was interesting to see the students respond so well to the strategies found in the literature. Students were
also very comfortable with some of the strategies because they had seen them in other classes, as was discussed in the literature.

One observation throughout the study was that different strategies lent themselves better to certain math units, and some were hard to adjust to fit the units students were working on. The picture book about circumference and pi, for example, was used with all of the groups in the study even though a few of the groups of students were already finished with the geometry unit. The book still worked because the students had finished the unit on geometry and they were therefore familiar with many of the vocabulary words being used. There are many picture books that could be used in a math classroom, and many of them are at the perfect reading level for middle school students. This is something that is relatively simple to incorporate, is a great precursor to a math unit, and really promotes terrific discourse in the math classroom.

Out of the forty students involved in this study, five of them were identified as English Language Learners with varying ability with the English language. These students receive at least one period a day of direct English as a second language instruction. It was observed with all of the strategies introduced that many of these students struggled with making connections to the math content.

Journaling was particularly difficult for these students. It took much more time for them than others to formulate their thoughts on their own and get them down in writing. The Frayer model was also difficult because it relied so heavily on students coming up with their own meaning and even using definitions from a math text proved difficult. Overall, these students struggle with math along with other content area subjects primarily because they are faced with a language barrier. Consistent literacy strategies
across content areas could be very beneficial to these students, and this would be a good area for future research.

Future research might also include focusing solely on vocabulary in the math classroom, and using specific strategies to see if a difference can be made. There are many different literacy strategies available for teachers to use, and many focus primarily on the development of vocabulary. It would be interesting to study the effect of teaching vocabulary rich strategies to students in a math classroom to see if their performance would improve over time. Math is such a complex language that the vocabulary involved varies and is challenging for many students. By focusing primarily on vocabulary students might become more insightful in their computational skills.

The idea of questioning was brought up numerous times in the research. Questioning by both teacher and student is important in the math classroom. Teachers need to be asking the right questions, and students need this skill to become more aware of their thinking. This is an area that would be interesting to look into further for remedial math students, because it might help to develop their language skills not only for the math classroom, but for other content areas as well.

Content area literacy is without a doubt an importance piece of the puzzle in providing the best education possible for students today. This research showed the importance of literacy teaching for all, the idea from the literature review that all content area teachers are responsible for creating opportunities to introduce literacy into their content. The students in this study were making connections between content areas quickly. The cross-curricular connections that were made are invaluable for students to see how one subject relates to the next. Teachers need to see the importance in these
connections and realize that the implementation of literacy strategies into content areas is not a difficult endeavor. With consistent use of common strategies early on in education, students are provided with something they can use for a lifetime of learning.
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Appendix A

Clipboard Notes

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**Summary of Lesson/Literacy Strategy Used:**

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**MISCELLANEOUS COMMENTS:**
Weekly Update

**Math Lab Update**

For the Week of: March 17 – March 21

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**Upcoming Test/Quizzes? UNIT:**

**DATE:**

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Appendix C

Frayer Model

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<td>Non-Examples:</td>
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Vocabulary Word
Appendix D

Graphic Organizer

What am I reading?

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Pages __________
Topic __________________

What did I already know? What sounds familiar?