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Moving Beyond the Word Wall: How Middle School Mathematics Teachers Use Literacy Strategies[1]

Ellen S. Friedland, Susan E. McMillen, and Pixita del Prado Hill
Buffalo State College, Buffalo, New York

Middle school mathematics teachers were asked the following question during a post-lesson interview: "What role does literacy play in your math instruction?"

> *Justine[2]: "I guess it kind of guides my instruction; it is my instruction. Because that's how I'm instructing [students] — using those tools."*
>
> *Linda: "I think it needs to play a bigger role. I think I need to be more aware of the strategies, and I would definitely use more of them because it [seems] to help [students]."*
>
> *Kelly: "I think it should be integrated especially with the state testing having a lot of reading and word problems and [students] struggle with that so I think that it should be in my everyday lessons, but I feel I struggle as a teacher to integrate it."*

The National Council of Teachers of Mathematics' *Principles and Standards for School Mathematics* (NCTM, 2000) and the *Curriculum Focal Points* (NCTM, 2006) documents espouse a view of mathematics instruction as reasoning and sense making as a means to strengthening one's mathematics proficiency. This, importantly, includes problem solving, reasoning and proof, making connections, building and using representations, as well as communicating:

> Mathematical communication is a way of sharing ideas and clarifying understanding. Through communication, ideas become objects of reflection, refinement, discussion, and amendment. When students are challenged to communicate the results of their thinking to others orally or in writing, they learn to be clear, convincing, and precise in their use of mathematical language. Explanations should include mathematical arguments and rationales, not just procedural descriptions or summaries. Listening to others' explanations gives students opportunities to develop their own understandings. Conversations in which mathematical ideas are explored from multiple perspectives help the participants sharpen their thinking and make connections. (NCTM, 2000, p. 60)

In addition, talking, reading, and writing about mathematics broadens one's view of the subject and its connections to other subjects and real life. For all of these reasons, it is increasingly the case that teachers are being encouraged to explore the role of literacy strategies in their mathematics instruction. However, the comments by these three teachers point to the challenges associated with doing so on an ongoing basis.

Proponents of mathematics reform believe that mathematics teachers should be aware of their responsibility to incorporate literacy components into their teaching to facilitate their students' mathematical understanding (Borgioli, 2008; Carter & Dean, 2006; Zollman, 2009). After all, "…language is the primary medium through which any discipline is negotiated, constructed, and

[1] We wish to thank the teachers who participated in this study toward the goal of improving mathematics instruction for all students.

[2] All names used are pseudonyms.

learned" (Borgioli, 2008, p. 189). However, despite NCTM's stance and the International Reading Association's (IRA) efforts in support of adolescent literacy instruction across the curriculum (Moore, Bean, Birdyshaw, & Rycik, 1999), convincing middle and high school mathematics teachers of the learning possibilities associated with literacy strategies has been challenging (Frykholm, 2004; Siebert & Draper, 2008). Mathematics teachers may feel it is someone else's job to teach literacy strategies. Mathematics teachers may be unfamiliar with the literacy strategies that might be useful. Finally, even mathematics teachers who are familiar with literacy strategies may feel that focusing explicitly on them during their mathematics instruction might take important time away from a focus on the mathematics content itself (Darvin, 2007; Draper, Smith, Hall, & Siebert, 2005).

Because Departments of Education across the United States acknowledge the importance of literacy in content area teaching, most middle and high school teacher certification programs require literacy courses (Come Romine, McKenna, & Robinson, 1996). In these courses, a generally accepted definition of content area literacy is "The ability to use reading and writing for the acquisition of new content in a given discipline" (McKenna and Robinson, 1990; p. 184). These courses are designed to provide teachers with strategies that can facilitate their students' comprehension of and communication about specific content. Even so, many preservice and practicing mathematics teachers do not always find these courses useful or relevant to their content (Darvin, 2007; Muth, 1993). Furthermore, many practicing teachers who are familiar with literacy strategies and believe they are effective may not necessarily employ them (Barry, 2002; Siebert & Draper, 2008; Silver, 1999; Spor & Schneider, 2001; Sturtevant, 1996; Wedman & Robinson, 1988).

If mathematics teachers are going to successfully engage all students in mathematical reasoning and sense making, and if all of the NCTM process standards are to be taken seriously, it is important for mathematics teachers to be better prepared to use a wide range literacy strategies in their mathematics instruction beyond a few add-on strategies such as the "word wall," which is often where mathematics teachers begin in their efforts to address the literacy needs of their content area. In this article, we discuss a study designed to examine and support the use of literacy strategies among a small group of middle school mathematics teachers.

As teacher educators in literacy and mathematics, we were interested in learning how we might provide preservice and inservice mathematics teachers with experiences that would lead them to attain a perspective consistent with reforms in mathematics education and beliefs about content area literacy instruction. In order to do this, we realized we needed to be more aware of which literacy strategies mathematics teachers find effective and the factors that impact their decisions to integrate them into mathematics instruction. Therefore, our study addressed the following questions:

1. Which literacy strategies do mathematics teachers use (and not use)?
2. How do mathematics teachers explain their use (and non-use) of literacy strategies?
3. What resources do mathematics teachers use for finding strategies and incorporating them into their mathematics instruction?
4. How do content area literacy courses affect mathematics teachers' attitudes toward and use of literacy strategies?
5. What factors within the school environment (school culture, program demands, assessment, district requirements, students) affect mathematics teachers' use of literacy strategies?

We were particularly interested in learning if and how mathematics teachers who had completed literacy course requirements as part of their certification programs were integrating literacy strategies into their mathematics instruction once they had begun teaching in their own classrooms.

Our Study of Literacy Strategies Used During Mathematics Instruction

Our study focused on six full-time middle school mathematics teachers (one male, five female) who had completed teacher education programs that included two content area literacy courses as required by law in New York State although only two of these teachers had participated in a field experience component associated with any of these literacy courses. The mathematics teaching experience of this group, at the onset of the study, ranged from 8 months to 3 years. Half were teaching in urban school districts and the other half were teaching in suburban districts. Three of the teachers taught from *Connected Mathematics Program* (CMP), a reform-oriented curriculum, while the other

Table 1

PARTICIPANT INFORMATION					
Participant	**Male/female**	**Urban/suburban**	**Teaching**	**Curriculum experience**	**Field experience as part of content area literacy course**
Allen	Male	Urban	1 year	Traditional	no
Jane	Female	Urban	1 year	Reform	yes
Justine	Female	Suburban	2 years	Reform	no
Kelly	Female	Suburban	3 years	Traditional	no
Linda	Female	Urban	1 year	Reform	no
Rebecca	Female	Suburban	2 years	Traditional	yes

three taught from more traditional curricula. Table 1 summarizes this information about our participating teachers.

We described the study to the participating teachers and told them we would like to observe two different mathematics lessons in which they used literacy strategies. The teachers then invited us to observe lessons in which they *believed* they were using literacy strategies as part of their mathematics instruction. There was no initial discussion as to what we meant by "literacy strategy" or any exploration of how they defined "literacy strategy."

However, in order to obtain information about teachers' prior knowledge of specific literacy strategies before we observed these lessons, we asked teachers to respond to a *Literacy Strategy Awareness Checklist*. This was a checklist we had created that included 37 literacy strategies commonly found in middle and high school content area literacy textbooks addressing vocabulary, comprehension, study skills, or writing.[3] We asked teachers to check one of the following for each strategy: "I have heard of this strategy," "I know how to apply this strategy in math instruction," "I would use this strategy," "I have used this strategy and would use it again," "I have used this strategy and would not use it again," "I would never use this strategy." We also provided additional space for teachers to list any additional strategies not included on the checklist or for us to name any additional strategies we observed in their mathematics lessons or were mentioned in the post-lesson interviews with teachers. The *Literacy Strategy Awareness Checklist* and teacher responses to it are summarized in Table 2.

Three of us observed each teacher during two different math lessons either through a visit to the classroom when the lesson was being taught or by viewing a videotape of the lesson. We each took detailed notes on any literacy strategies used, when it was used, how students responded, and any other details relevant to the use of literacy strategies during mathematics instruction. Each of us then wrote a summary of our observations.

Following each lesson, we interviewed and audiotaped each teacher to obtain their reflections on their use of literacy strategies during their lesson. The interview questions were designed to explore the teacher's working definitions of "literacy strategy," why the teacher selected specific literacy strategies, what the teacher thought about the effectiveness of the literacy strategies used during the lesson, where the literacy strategies were learned, and what resources were used to find literacy strategies more generally.

Our data analysis of both the lessons observed and the interviews involved an iterative process of comparative analysis (Glaser & Strauss, 1967) in which we each wrote, exchanged, and discussed theoretical memos that highlighted emerging themes including similarities, contrasts, divergent findings, and questions from each data set.

How Did These Middle School Mathematics Teachers Define "Literacy Strategy"?

Since these middle school mathematics teachers were asked to incorporate literacy strategies into the lessons we observed, we believed it was essential to determine how these teachers defined a literacy strategy. In response to

[3] This paper describes only the strategies used by the middle school mathematics teachers participating in the study. For further explanations and more examples of these and other strategies, see Alvermann, Phelps, & Ridgeway Gillis, 2010; Barton & Heidema, 2002; Buehl, 2008; and Readence, Bean, & Baldwin, 2008.

Table 2

FEATURES OF "PROVIDE RESOURCES" ROUTINE		
Literacy Strategy	**Focus of the Literacy Strategy: Vocabulary (V), Comprehension (C), Study (S), Writing(W)**	**Number of participants self-reporting that they have used this strategy and would use it again**
Analogical Study Guide	VCS	0
Anticipation Guide	C	1
B-D-A (Before-During After Reading)	C	0
Concept Definition Mapping	V	2
Cloze	VC	1
Cornell Method (Split-Page Notetaking)	S	2
Cubing	W	0
DRTA (Directed Reading-Thinking Activity)	C	0
Elaborative Interrogation	C	1
Embedded Questions	C, S	1
Fact Pyramids	C	1
Semantic Feature Analysis	V	0
Frayer Model	V	4
Graphic Organizers	VCS	6
Guided Listening Procedure	C	0
Guided Writing Procedure	W	0
Inquiry Charts (I -Chart)	CSW	0
Interactive Reading Guides	C	1
Journal Writing	W	3
Knowledge Rating	V	0
KWL (Know- Want to Know- Learned)	C	2
Learning Logs	W	2
Math Reading Keys	VC	0
Mind Mapping	VC	0
Possible Sentences	V	0
QARs (Question-Answer-Relationships)	C	0
Quick Writes	W	1
RAFT (Role, Audience, Format, Topic)	W	2
Reciprocal Teaching	C	1
Semantic Map	V	0
SQRQCQ (Survey-Question-Read-Question-Compute-Question)	S	1
Three Level Study Guide	CS	0
Verbal and Visual Word Association	V	1
Vocabulary Overview Guide	V	1
Vocabulary Self Collection Strategy	V	1
Word Family Trees	V	1
Word Sorts	V	1

our questions about the role of literacy strategies in mathematics instruction during our interviews, they said the following:

Allen: " I think it means ways to help students understand what they are reading and being able to retain the information more efficiently."

Jane: "…tool or method I can use to help my students read and write better than they otherwise would. Something to improve reading and writing skills at the same time as using whatever content we are using that day."

Justine: "Any type of like organizational tool for the kids along with reading and writing."

Kelly: "I think it means anything with reading, writing, getting the kids to write their thoughts down, vocabulary, comprehension, anything."

Linda: "A way to get students to understand, retain, and then recall and use information."

Rebecca: "…Anything to help the kids to understand…."

These data suggest these mathematics teachers perceived literacy strategies as vehicles to help students comprehend, explain, and learn information. It is interesting to note that none mentioned using literacy strategies to uncover what students were thinking or monitor their progress in learning important mathematics content.

Which Literacy Strategies Did These Mathematics Teachers Use During Mathematics Instruction and How Did They Use Them?

As indicated earlier in Table 2, a total of 22 literacy strategies were in use by at least one of these mathematics teachers. All six mathematics teachers indicated that they use graphic organizers during mathematics instruction. The other strategies used by more than one teacher included:

- Frayer model, which is a graphic organizer focusing on a vocabulary word, and the template for which can be see in Figure 1;
- Journal writing;
- Concept definition mapping, which is a graphic organizer focusing on ways to describe a concept including what is it, what is it like, and some examples;
- Split-page methods of notetaking, using a divided page, with students writing key terms on the left side of the page and explanations of the terms on the right side of the page;
- K-W-L, which is a comprehension strategy asking students what they know, what they want to know, and what they learned about a topic;
- Learning logs; and
- RAFT (Role, Audience, Format, Topic), which is a strategy that includes writing about a topic from a perspective other than their own, and can be seen applied to an exploration of prime and composite numbers in Figure 2.

During the interviews, some of these middle school mathematics teachers mentioned using other strategies they had not listed on the Literacy Strategy Awareness Checklist such as highlighting important information and using "exit tickets" to check for understanding of key ideas.

FIGURE 1: Template of Frayer Model.

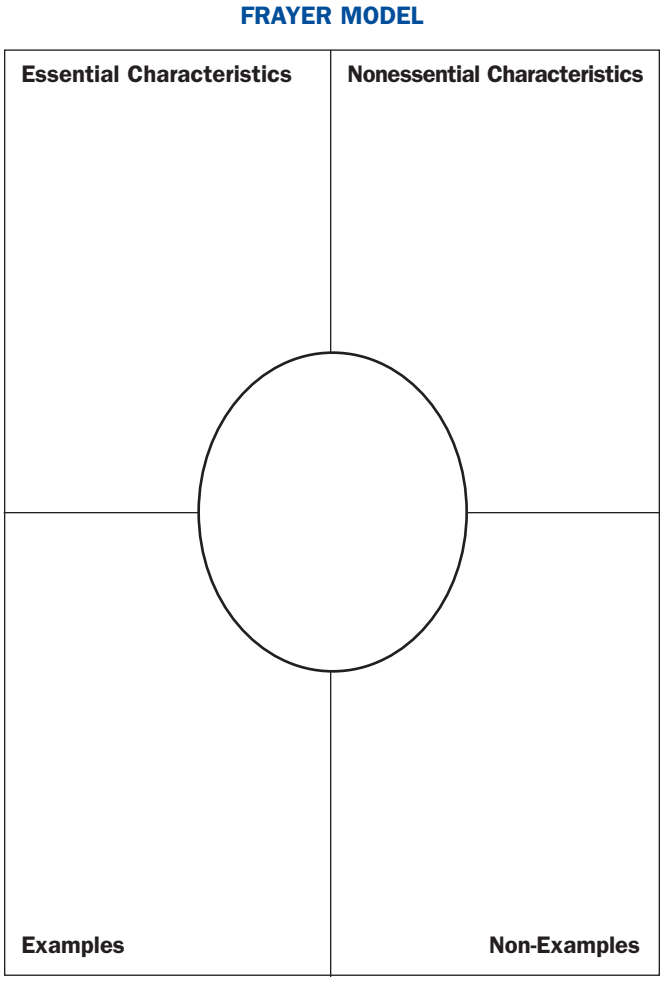


FIGURE 2: RAFT writing assignment on prime and composite numbers.

Name:

Primes/Composites

Directions: Choose ONLY 1 assignment. Please keep in mind the role that your are taking on and the audience that you are talking to. Discuss the topic given in the correct format. The final assignment should be typed. All assignments will be graded based on the given rubric.

Role	Audience	Format	Topic
Composite Number	Prime Number	Conversation	Discuss why you are better
Prime Number	Composite Number	E-mail or Text Messaging	Compare/Contrast yourself to the composite number
Prime Number	All other numbers	Diary Entry	Discuss why you are special
Manager	All numbers	Job Ad (Help Wanted)	How can you be as hired as a factor

For many of the literacy strategies, teachers frequently indicated they did not know how to apply the strategy in mathematics even if they had heard of it. At the same time, it was only through discussion during the interview that some teachers even became aware that their mathematics instruction included literacy strategies. For example, during the interview Allen described a graphic organizer vocabulary strategy he uses when introducing new concepts which includes definition, characteristics, examples, and nonexamples but he was unaware that it was named the Frayer model and had not indicated knowledge of the strategy on the *Literacy Strategy Awareness Checklist*.

In our observations of mathematics lessons, we found that each teacher used multiple literacy strategies during their mathematics instruction, all of which are identified in Table 3.

However, we found a striking range in how teachers used literacy strategies during their mathematics instruction, ranging from a high degree of literacy strategy integration to a limited degree of literacy strategy integration. The teachers who developed lessons with a high degree of literacy integration seemed to be more at ease with both the mathematics content of the lesson and with the literacy strategies themselves, and effectively used these literacy strategies to introduce new material, reinforce previous learning, and monitor comprehension. In contrast, the teachers who developed lessons at the limited integration end of the spectrum seemed to add a literacy strategy because they were expected to use one, appeared to be uncomfortable with the lesson, and used activities often did not seem to relate to each other. Furthermore, there were differences in the way the students responded to the lessons; the students were consistently engaged in the highly integrated lessons, while students who participated in lessons that were at the limited integration end of the spectrum were not on task as often. This finding was apparent in both urban and suburban settings using both reform and traditional curriculum materials and was not dependent on level of teaching experience.

Vignettes of Literacy Strategy Integration Based on Observations of Lessons and Interviews

The following vignettes, based on observations of mathematics lessons and interviews, are intended to capture the range of literacy strategy integration across the classrooms we observed, starting with full integration and ending with limit integration.

Table 3

SUMMARY OF OBSERVATION AND INTERVIEW DATA

Teachers	Literacy Strategies Observed During Mathematics Lessons	Reasons Given for Using Literacy Strategies	Sources of Literacy Strategies	Curriculum Materials and District Context
Allen	Guided discussion/ questioning; summarizing; alternatives to text; activation of prior knowledge (vocabulary); vocabulary study guide; word-meaning-example; summary writing; post-reading comprehension questions; think-pair-share	• Help students retain information • Provide students with something to refer to when they study • Make math easier for struggling students and, consequently, help them enjoy math • Introduce new terms at the beginning of a lesson • Promote student discussion and understanding of content	• Promote student engagement • ELA teacher • Undergraduate and graduate mathematics education courses	Traditional; Urban
Jane	Guided discussion/ questioning; interactive word wall; word-meaning-example; vocabulary categorization; modified Frayer model; journal writing	• Help students learn to communicate math in their own words • Help students solve problems • Required by the school and the district • Facilitate students' understanding of mathematical concepts	• Content area literacy coursework • Textbooks from literacy courses	Reform; Urban
Justine	Guided discussion/ questioning; notetaking from multiple sources; modified Frayer model; graphic organizers; reciprocal teaching	• Help students learn to communicate math in their own words • Facilitate students' understanding of mathematical concepts • Help students organize information	• College coursework • Internet • Other teachers, e.g., the special education teacher • Professional development programs • Professional journals	Reform; Suburban
Kelly	Guided discussion/ questioning; vocabulary notebook; song writing; definition-picture-example; vocabulary categorization; graphic organizers; RAFT; exit tickets	• Help students organize their thoughts • Monitor students' understanding • Promote student engagement • Help prepare students for the state assessments • District focus on improving vocabulary • Help students learn to communicate math in their own words	• Cooperating teacher during student teaching • ELA teacher • Internet • Professional journals • School Math Department	Traditional; Suburban
Linda	Read aloud (trade book); prereading introduction to vocabulary (multiple choice activity); post-reading comprehension questions; split-page notetaking; exit ticket	• Monitor students' understanding • Facilitate students' understanding of mathematical concepts • Help students "do well" and make concepts easier to learn • Part of the math program (journal writing)	• ELA teacher • Noted that she hadn't been looking for literacy strategies until participating in this study	Reform; Urban
Rebecca	Guided discussion/ questioning; exit tickets; analogies; split-page notetaking; graphic organizers; modified cloze activity	• Does not want to teach to the test • Help students go beyond rote memorization of information • Motivate students to learn the content	• Content area literacy coursework • Internet • Other teachers • Professional development programs • Professional journals • Textbooks from content area literacy courses	Traditional; Suburban

Justine fully integrated literacy strategies into her mathematics teaching. For example, she felt comfortable using the Frayer model and modified it to suit her purpose (see Figure 3). She set up the organizer to include creating a definition in one's own words and providing example and non-examples. She then had her class complete it for prime numbers, using jigsaw grouping (expert groups learn information and then return to their original group to teach the group members what they learned) and with students consulting textbooks, trade books, and other resources to explore the meaning of prime number. As the lesson unfolded, she frequently related any specialized vocabulary to their more general meaning in an effort to help her students understand new terms. She noted that she had learned the Frayer model in a college course but had modified it for use in introducing new concepts to her students.

Jane also seamlessly integrated literacy into her mathematics teaching. She consistently asked the students higher-level thinking questions to monitor their comprehension of mathematical concepts. Her "think-pair-share" activities also engaged the students in using the language of mathematics. Jane was also observed using an interactive word wall, where students were asked to actively categorize words on a large chart, as well as using journals that involved reflective writing using this vocabulary. Jane explained that she decided to "combine" these two strategies—the word wall and journals—that she had learned in her literacy courses.

Rebecca also effectively integrated a variety of literacy strategies into her lessons. For example, she used graphic organizers in several ways and incorporated a non-mathematics analogy to help students understand how to set up a proportion, displaying the analogy

FIGURE 4: Example of an analogy graphic organizer.

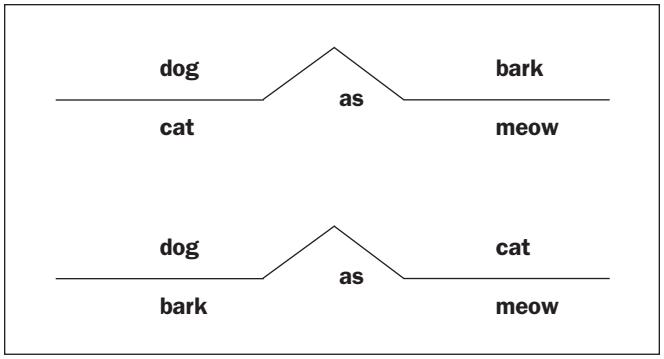
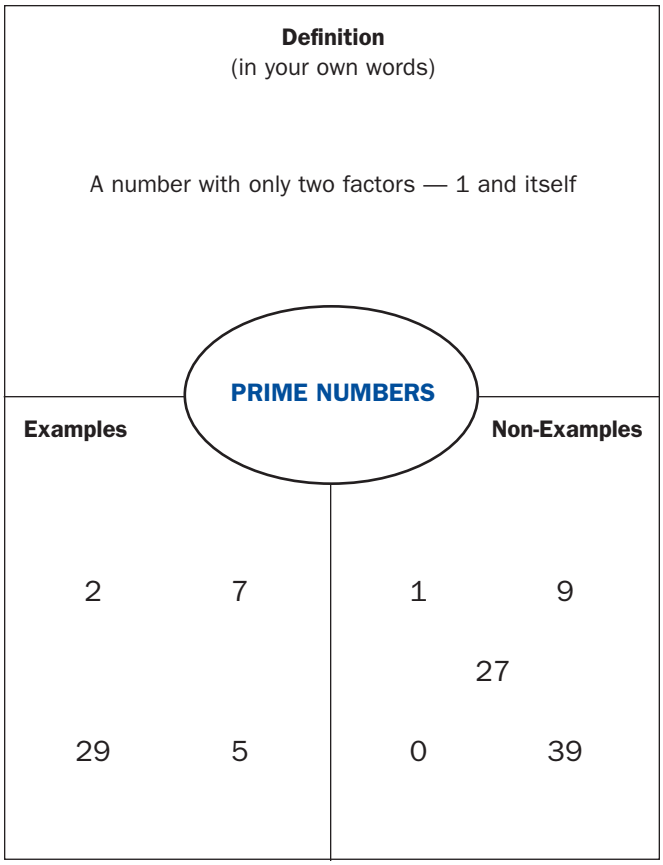


FIGURE 3: Example of a modified Frayer Model organizer.



"dog : bark" as "cat : meow" (see Figure 4), asking them for another way the analogy could be written, and then relating the example to a mathematics problem. During the interview, Rebecca noted that she believes that using words without numbers helps students understand mathematical concepts. She ended class with an exit ticket, a proportion word problem to see how the students could use the organizer to represent the proportion. Rebecca explained that she had learned this analogy strategy at a conference, and though it had not been applied to a mathematics context, she believed it could be an effective strategy for facilitating students' comprehension of mathematics content.

Allen's lesson fell more toward the middle of the literacy integration spectrum, using literacy strategies in his lesson, but not fully integrating them into his teaching. For example, at the beginning of a lesson focused on connecting mathematics with real life, Allen wrote on the board, "When do you use math in everyday life? Give an example of how you would." The students offered responses such as baking, banking, building,

and construction, and Allen reinforced these responses by eliciting comments about how each response connected to mathematics, asking questions to ensure comprehension and encourage discussion. Allen then passed out a mathematics magazine, asked students to read the article and then discuss the article with another students, and then distributed a sheet with instructions asking students to summarize the article—but students were not guided through the writing process nor did Allen model or explain what he meant by a summary. He allowed each student to discuss the article with another student. At the end of this lesson, one student presented her summary while Allen asked questions to check her comprehension, but never returned to the question of how the real-life scenario in the article related to mathematics. During the interview, Allen stated that when he began teaching at the school he began receiving the mathematics magazines and "didn't know what to do with them." This was the first time he had used the magazine in class and he stated that he did so because he was asked to use a literacy strategy for this study.

Kelly acknowledged that she was uncertain about how to integrate literacy into her mathematics teaching. She informed the interviewer that she had sought help from the language arts teacher who told her about RAFT (role, audience, format, topic) but this language arts teacher had been unable to help her apply it to mathematics content she was teaching. Because we requested that she use a literacy strategy during her mathematics instruction, Kelly decided to use RAFT as a guided practice activity, but she did not make time during the lesson to introduce the RAFT strategy to her students or explain how it could be used to address the mathematics content they were learning, nor did she provide adequate time for her students to use the RAFT strategy effectively even if it had been appropriately introduced. Kelly did not have the prior knowledge needed to fully integrate the RAFT strategy into her instruction.

Linda's lesson also fell toward the limited literacy integration end of the spectrum. The purpose of the mathematics lesson was to facilitate her students' understanding of different kinds of angles since they had not done well on a test that required students to classify and name angles based on particular attributes. Linda had planned a lesson that involved the use of a trade book hoping that this text "…make real-world connections for them to help them understand." (Linda acknowledged that this was the first time she had used a trade book in her mathematics instruction.) Students began by completing a multiple choice vocabulary activity containing isolated non-mathematical vocabulary words from the story (e.g., mounted, cautiously, abrupt). The book was then projected using a document camera so that the entire class could view the book while it was read aloud. No reference was made to the words on the pre-reading vocabulary list when they appeared in the book, no picture clues or references designed to help students understand key vocabulary were referenced, and no questions were asked to monitor the students' comprehension while the book was read. It was only after finishing the reading and completing a multiple-choice comprehension check that Linda closed the lesson by making explicit connections between different kinds of angles and the concepts discussed in the book.

All of these middle school mathematics teachers were concerned about teaching mathematics effectively to all their students. They all noted that their main objective was to use techniques that facilitated their students' understanding of the mathematics content of their lessons. In particular, they indicated that the use of literacy strategies during mathematics instruction was intended to help their students understand, organize, and retain the mathematics content of their lessons. Even more specifically and with regard to the observed mathematics lessons, teachers indicated they used literacy strategies to teach vocabulary (Jane, Kelly and Rebecca), to engage students (Allen), to reteach something that students struggled with (Linda), to organize a large quantity of information (Allen, Kelly and Rebecca) and to improve on a lesson as it is presented in the math book (Jane). However, our observations and interviews showed important differences in how efforts to integrate literacy strategies into their mathematics instruction actually played out in practice.

What Resources Did These Middle School Mathematics Teachers Use To Find Literacy Strategies?

Some of the middle school mathematics teachers in the study sought advice on literacy strategies from colleagues, including special educators and ELA teachers. However, according to these mathematics teachers, the ELA teachers knew some literacy strategies but not how to apply them in mathematics. Interestingly, we found that none of the mathematics teachers approached their school's literacy support specialist for support with the use of literacy

strategies during mathematics instruction. The teachers were either unaware of who that person was or stated that there was no literacy specialist in the building, yet further inquiry on the part of the authors found that there was a literacy support specialist in each participant's school. This finding could be due partially to a lack of clarity in the school regarding the role and responsibilities of the literacy support specialist. In the schools studied, the literacy specialist held different titles such as "Reading Specialist Coach," "Reading Teacher," "Reading Coach," and "AIS (Academic Intervention Skills) ELA Teacher." In addition, the literacy support specialist in several schools worked only with younger students, and therefore did not seem to be a resource for the middle school teachers in the building. As noted in Table 3, these middle school mathematics teachers also referred to other sources for information: professional journals, the Internet, professional development programs, textbooks, and coursework. Jane and Rebecca —the teachers who participated in a field experience associated with their content area literacy courses— were the only teachers who mentioned using materials from their content area literacy classes.

What Did We Learn About the Use of Literacy Strategies During Middle School Mathematics Instruction?

The middle school mathematics teachers in our study had all completed teacher education programs in which they were exposed to literacy strategies and how to apply them in mathematics. Graphic organizers, some form of the Frayer model, and journal writing were frequently used strategies. However, responses on the *Literacy Strategy Awareness Checklist* showed a lack of knowledge of many of the strategies that are commonly presented in content area literacy textbooks. Even if they were aware of the strategies, they did not necessarily use them in their mathematics teaching. Furthermore, some teachers were unaware when they did use literacy strategies in their mathematics teaching.

While all these middle school mathematics teachers believed that using literacy strategies engaged their students and helped them learn mathematics content, our study suggests that content area literacy courses may not provide enough background and support to promote the consistent integration of the strategies they learned. An associated literacy field experience during the teacher certification program suggests promise for greater literacy integration into mathematics instruction, as evidenced in Rebecca's and Jane's mathematics lessons, but the support of ongoing professional development and opportunities for partnerships with literacy specialists are also needed if mathematics teachers are to find effective ways to use literacy strategies to strengthen the mathematics learning of their students.

Implications: Crossing the Mathematics/Literacy Divide

For the teachers in our study, a wide gap appears to exist between their preservice preparation and their inservice practice. Two of the three teachers who were able to successfully integrate literacy strategies into their mathematics teaching had participated in field experiences as part of their content area literacy courses. During those field experiences they had developed mathematics lessons that integrated literacy strategies and then actually taught those lessons in middle mathematics classrooms. In fact, there is some evidence to suggest that teachers who initially were resistant to the idea of incorporating literacy strategies into mathematics instruction begin to reconsider their views, developing an appreciation of the role these strategies play in mathematical reasoning and sense making. Without this kind of literacy field experience, it appears to be more difficult for mathematics teachers to make a commitment to the use of literacy strategies during mathematics instruction and successfully plan for and enact the integration of these strategies into their mathematics teaching practice.

In addition, mathematics methods courses are often taught through mathematics education departments and may not incorporate literacy strategies into the coursework, either through modeling the use of literacy strategies during instruction or in the assignments given during the course. Yet these mathematics methods courses are strong predictors of the strategies mathematics teachers use in their mathematics teaching practice (Gagnon & Maccini, 2007) and have been shown to be effective in changing preservice teachers' beliefs about what it means to teach mathematics (Wilkins & Brand, 2004). Our study points to the need for further research to explore the potential benefit of increased collaboration between literacy instructors and mathematics instructors to provide preservice teachers with additional opportunities to both use literacy strategies in their mathematics instruction and to deepen their understanding of the value of doing so.

We also know that building a strong collaboration between literacy instructors and mathematics instructors can be a complex undertaking. It may involve examining and

discussing the similarities and differences in instructional goals and practices that are represented by mathematics and literacy educators. It may require the creation of a common ground where literacy and mathematics educators can simultaneously consider literacy and mathematics issues that arise in mathematics classrooms. For an interesting discussion of the complexities of this kind of collaboration between two university educators—one a literacy educator and one a mathematics educator—and the potential for a shared perspective, see *Different Goals, Similar Practices: Making Sense of Mathematics and Literacy Instruction in a Standards-Based Mathematics Classroom* (Draper and Siebert, 2004). The creation of these kinds of shared perspectives are essential to the creation of collaborations that contribute to the integration of literacy strategies that strengthen both the practice of teaching mathematics and student learning of mathematics.

At the inservice level, we know that ongoing professional development is an important vehicle for strengthening mathematics teaching practice (Cady, Meier, & Lubinski, 2006; Heck, Banilower, Weiss, & Rosenberg, 2008). Our literature search provided a plethora of descriptive work that provides mathematics teachers with tools (ideas, examples, applications) for integrating literacy strategies into mathematics instruction but few research-based articles examine what the use of these strategies looks like in practice or how they impact mathematics learning. These are important questions to address as we consider that nature of the professional development that might be designed.

Our study points to the need for research to better understand what forms of support will help teachers learn and integrate literacy strategies described in the literature in their own classrooms and the impact of these strategies on student learning. If teachers are exposed to strategies that other mathematics teachers have used successfully, they may be more likely to try them. In addition, working together in professional learning communities with colleagues to explore what works and how it works can be an important source of support. Teachers need opportunities to see that "…mathematics learning and literacy are inseparably intertwined…and that every mathematics learning event is also a literacy event, and every literacy event in a mathematics classroom is a mathematic learning event" (Draper & Siebert, 2004, p. 953). Finally, we know that the support of administrators in their roles as instructional leaders in mathematics, also plays a key role in supporting teachers as they attempt to take on these new instructional practices (Burch & Spillane, 2003). Even while there is much that needs to be explored further, the results of our study suggest the following for mathematics leaders:

- Explore resources that identify literacy strategies that might be used to strengthen mathematics instruction and begin to establish shared visions of what this might look like in practice.
- Create opportunities for mathematics teachers and literacy specialists to work together with the mathematics leader serving as "translator" between mathematics and literacy concepts.
- Build on the work of classrooms teachers who are already integrating literacy strategies to strengthen the mathematics learning of their students by holding best practice professional development sessions where teachers can share ideas they have used effectively.
- Examine what it might mean to use literacy strategies to assess student understanding and monitor student progress in mathematics.
- Review school/district textbooks/curriculum packages for literacy strategies included and highlight these for teachers during professional development sessions.
- Examine the involvement of the school and district in innovative standards-based efforts such as literacy integration across the curriculum and how these might be used to strengthen mathematics instruction in a systemic way.
- Include interview questions about literacy integration to signal to new teachers that literacy integration is valued and expected.

But in order to move forward with these recommendations, we need a clearer understanding of the ways in which literacy and mathematics specialists might collaborate to develop effective professional development programs that support teacher learning and practice (Shanahan & Shanahan, 2008). It is important for literacy specialists to develop an understanding of mathematics as a discipline so that they can develop a shared perspective with mathematics educators on the teaching of mathematics content, just as it is important for mathematics specialists to learn how literacy strategies can serve to deepen the focus on mathematical reasoning and sense making and help students learn important mathematics content (Draper & Siebert, 2004). It is also important to achieve greater clarity about the role and responsibilities of literacy support specialists and mathematics support specialists so that collaboration

with each other can lead to the kind of professional development program that could help effect change at the school level. As a result of such partnerships, we hope that more mathematics teachers will move beyond using limited literacy strategies such as the word wall in order to take on the kinds of literacy strategies that result in a richer and deeper mathematics teaching practice and contribute to the mathematics learning of all students.

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