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Collaborating to Cross the Mathematics–Literacy Divide: An Annotated Bibliography of Literacy Strategies for Mathematics Classrooms

Literacy educators for preservice middle/secondary content area teachers frequently hear the following words: "But I'm not a reading teacher!" This statement reflects the long-standing concerns that content area teachers have about integrating literacy strategies into their instruction, and it is particularly evident for preservice and inservice mathematics teachers.

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A range of groups representing various constituencies is promoting adolescent literacy instruction across the curriculum, including the International Reading Association (IRA; Moore, Bean, Birdyshaw, & Rycik, 1999) and the National Council for Teachers of Mathematics (NCTM, 2000). A recent U.S. Department of Education report (Kamil et al., 2008) supports these organizations by making the following recommendations to help middle and secondary content area teachers facilitate their students' learning: (a) Provide explicit vocabulary instruction; (b) provide direct and explicit comprehension strategy instruction; (c) provide opportunities for extended discussion of text meaning and interpretation; and (d) increase motivation and engagement in literacy learning. Moreover, additional support for literacy integration is found in the recently released common core standards for mathematics, which suggest that mathematics teachers should include a focus on reading and writing within their content area to ensure their students' ability to read and write in mathematics (Common Core State Standards Initiative, 2010).

Rather than providing a meta-analysis of secondary school literacy research as a whole (e.g., Moje, Overby, Tysvaer, & Morris, 2008), our overarching goal in this article is to support literacy leaders as they collaborate with mathematics leaders to guide middle and secondary mathematics teachers in implementing the recommendations of the U.S. Department of Education (Kamil et al., 2008) to develop student understanding of mathematics language and processes. Mathematics language presents a particular challenge for students because the language of mathematics is typically used only in a school setting. Moreover, some mathematics terms, such as *power* or *radical*, have a different meaning in everyday English. Furthermore, with the resulting assessments of No Child Left Behind (NCLB), students are faced with a new kind of problem that requires the ability to read and write while demonstrating knowledge of mathematics concepts and skills. Instead of "naked computations," students are presented with words and context packed around numbers.

To respond to the challenge brought on by these new goals and assessments, greater communication between literacy and mathematics leaders is needed. Research suggests that students' ability to communicate mathematics requires integration of the language arts by teachers (Carter & Dean, 2006; Pugalee, 1999, 2001; Wallace & Clark, 2005); however, data from a recent study (Friedland, McMillen, & del Prado Hill, 2010–11) indicated that mathematics teachers do not see the literacy specialist as a source of support for more effective instruction, even when teachers see the value of integrating literacy into their classrooms.

Moreover, mathematics teachers may know of a particular strategy but are unclear about why, when, and how to use the strategy. Ongoing guidance, support, and professional development with literacy educators may narrow this apparent mathematics–literacy divide (Draper & Siebert, 2004; Phillips, Bardsley, Bach, & Gibb-Brown, 2009). Thibodeau's (2008) study, in which high school content area teachers worked together with a literacy specialist to learn how to integrate literacy strategies into their teaching, suggested the positive impact of long-term collaboration. Thibodeau found that the collaboration led to

> increased knowledge about literacy, increased capacity for the integration of new instructional techniques, increased feeling of self-efficacy, increased motivation for the changes required by the instructional innovation, and the ability to sustain the effort the changes required over the long-term (p. 59).

To facilitate student learning, mathematics and literacy professionals must collaborate to help mathematics teachers develop an awareness that "mathematics learning and literacy are inseparably intertwined...and that every mathematics learning event is also a literacy event" (Draper & Siebert, 2004, p. 953).

To aid in this communication, we seek to provide resources for literacy and mathematics leaders working together as they translate literacy strategies to help support mathematics teachers through modeling and providing examples for specific mathematics content and grade levels. Our goal is to suggest articles that explain both the process and the product of using effective instructional strategies to foster learning in the mathematics classroom. We also use this article to note the limited number of resources available for this kind of support and call for more research in this area.

We define literacy strategy to mean an instructional tool that employs any of the language arts—reading, writing, listening, or speaking—to facilitate, reinforce, or formatively assess students' comprehension of discipline-specific material. Our own collaboration, as well as comments from practicing mathematics teachers and reviewer comments from both mathematics and literacy journals, have indicated that mathematics teachers may view literacy strategies (as defined in this paragraph) as teaching strategies or simply as good pedagogy and may be unaware that some of their teaching strategies have specific names in the field of literacy. That is, they may be using such strategies effectively to teach mathematics content, but not purposefully using them to promote literacy in mathematics.

Procedures

We are one mathematics teacher and two literary educators who have collaborated on numerous projects to cross the mathematics–literacy divide at the college level. To help guide mathematics teachers toward literacy integration, literacy and mathematics leaders need to be aware of effective literacy strategies and why, how, and when the strategies can be used.

To provide literacy and mathematics leaders with strategies that have been documented as effective, we constructed an annotated bibliography of articles supporting NCTM's and IRA's standards (see Table 1). We conducted a database search (ERIC and Education Research Complete) for peer-reviewed journal articles published from 1980 through 2009 that focus on the use of literacy strategies in middle and secondary mathematics classrooms. The following subject terms were used in the search: *mathematics*, *literacy*, *reading*, *writing*, *secondary education* (and related terms), and *middle school teaching* (and related terms). Our search yielded 63 possible articles for inclusion in the annotated bibliography. It should be noted that only 6 of the 63 articles reviewed were empirical studies.

Qualitative data analysis was ongoing throughout the study. We read and reread the articles and discussed patterns, themes, and issues as they emerged (Bogdan & Biklen, 1992). Ongoing analysis throughout the project followed a pattern of independent

Table 1 An Annotated Bibliography of Resources for Using Literacy Strategies in Mathematics

Resource	Description
Adams, T.L. (2003). Reading mathematics: More than words can say. *The Reading Teacher, 56*(8), 786–795.	Shares vocabulary strategies to help students at all levels comprehend mathematical language. Discusses how to use informal language and nonmathematical word meanings to help students make connections to mathematical vocabulary. An open-ended game that asks students to create a mathematical sentence using selected math symbols allows for student responses at varying levels of sophistication. (VC)
Albert, L.R., & Anots, J. (2000). Daily journals connect mathematics to real life. *Mathematics Teaching in the Middle School, 5*(8), 526–531.	Presents fifth-grade math journals that feature solutions to student-created real-life math problems. The process of creating a problem, checking answers for real-life reasonableness, and reviewing solutions helped students make mathematical connections, find flaws in their own thinking, and deepen their understanding of mathematical content. Includes student work. (CW)
Barton, M.L., Heidema, C., & Jordan, D. (2002). Teaching reading in mathematics and science. *Educational Leadership, 60*(3), 24–28.	Describes literacy strategies (concept-definition web, extended anticipation guide) that are especially useful for confronting and identifying mathematical misconceptions as students activate prior knowledge. Vocabulary strategies (semantic feature analysis, creating personal verbal–visual associations) emphasize understanding common characteristics and hierarchical relationships and building personal associations. SQRQCQ (survey, question, reread, question, compute, question) and other comprehension/study strategies help students meaningfully read mathematics textbooks with their unique structure and text features. (VCS)
Baxter, J.A., Woodward, J., Olson, D., & Robyns, J. (2002). Blueprint for writing in middle school mathematics. *Mathematics Teaching in the Middle School, 8*(1), 52–56.	Offers practical suggestions, instructional strategies, and writing prompts for journals in the middle school mathematics classroom. Prompts for writing about prior mathematics content are useful for identifying lingering misconceptions and connected content knowledge. Prompts related to current mathematics content encourage identifying and generalizing patterns, posing and evaluating conjectures, and creating and evaluating mathematical arguments. (CW)
Borasi, R., Siegel, M., Fonzi, J., & Smith, C. (1998). Using transactional reading strategies to support sense-making and discussion in mathematics classrooms: An exploratory study. *Journal for Research in Mathematics Education, 29*(3), 275–305.	Supports the use of four comprehension strategies (Say Something, Cloning an Author, Sketch-to Sketch, and Enacting) to help students to construct mathematical meaning from reading. The high school students applied the strategies while reading alternative texts (texts about mathematics), rather than mathematics textbooks. (EC)
Bosse, M.J., & Faulconer, J. (2008). Learning and assessing mathematics through reading and writing. *School Science and Mathematics, 108*(1), 8–19.	Shares strategies for reading and writing **in** mathematics instead of just reading and writing **about** mathematics. The strategies emphasize moving fluently among multiple representations, analyzing mathematical texts, and explaining mathematical reasoning. Strategies such as student discussions of the implications of changing words in a theorem or definition support deep conceptual learning. Includes examples of instructional tasks. (VCW)
Braselton, S., & Decker, B. (1994). Using graphic organizers to improve the reading of mathematics. *The Reading Teacher, 48*(3), 276–281.	Provides a graphic organizer that guides students through a modified version of Polya's problem-solving process but still allows them to solve a problem in their own way. Its layout requires students to think, plan, and break the solution process into steps of their own choosing before computing. The graphic organizer can be used for any type of problem with no more than a three-step solution. Discusses how to introduce the graphic organizer by using a think aloud, multiple student answers, and analysis of incorrect answers. Includes student work. (C)
Davis, S.J., & Gerber, R. (1994). Open to suggestion: Content area strategies in secondary mathematics classrooms. *Journal of Reading, 38*(1), 55–57.	Describes how to apply several reading strategies to mathematics instruction. A knowledge rating chart indicates prior knowledge of vocabulary and whether or not the student can apply it in mathematics. "Word Problem Roulette" is a cooperative problem-solving strategy in which students solve a problem verbally and then write the solution in a round-robin style. A sample three-level math problem guide helps with problem analysis, but restricts students to solution methods using the computations or formulas provided in level three. "Possible Problems" requires higher level thinking as students create a math problem using all of the words, symbols, or numerals in a list. Applicable to any math content and to any level. (VCSW)

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Table 1 An Annotated Bibliography of Resources for Using Literacy Strategies in Mathematics *(continued)*

Resource	Description
Dougherty, B.J. (1996). The write way: A look at journal writing in first-year algebra. *The Mathematics Teacher*, *89*(7), 556–560.	Discusses three types of journal prompts for first-year algebra students: content, process, and affective. The content prompts push students to articulate mathematical relationships and to create personal yet precise definitions. One powerful prompt asks students to write about how their understanding about a mathematical concept has developed or changed. While some suggested process prompts focus on study habits, others have students reflect on their own problem-solving approaches, thus developing their metacognitive abilities. Includes student work. (VCW)
Ehlinger, J., & Pritchard, R. (1994). Using think alongs in secondary content areas. *Reading Research & Instruction, 33*(3), 187–206.	Describes how teachers can model metacognitive behavior by using think alongs to illustrate the problem-solving strategies of questioning oneself, providing evidence, and rereading. An example of addressing a scientific misconception models additional metacognitive strategies that transfer well to mathematics. (C)
Gay, A.S., & White, S.H. (2002). Teaching vocabulary to communicate mathematically. *Middle School Journal*, *34*(2), 33–38.	Presents variations of a verbal–visual word association strategy diagram useful for developing mathematical vocabulary and associated properties. The student-created diagrams promote higher order thinking as students generalize or classify mathematical terms and promote the creation of a personal frame of reference. Teacher-created concept circles (i.e., a circle containing four mathematical expressions or equations) are suggested as a vocabulary tool. Students identify and articulate common attributes or a connecting relationship among the four expressions of the concept circle, or, in a useful variation, explain why one section does not belong with the other three. Beyond vocabulary development, this strategy builds conceptual understanding and typically allows for several different answers. Includes student work and examples. (VC)
Halpern, C.M., & Halpern, P.A. (2006). Using creative writing and literature in mathematics classes. *Mathematics Teaching in the Middle School*, *11*(5), 226–230.	Ninth-grade students modify or create a story or fairy tale to include geometry content and drawings. A rubric assesses students on creativity and on the mathematical accuracy of both language and drawings. This is a motivating project that effectively reveals students' mathematical misconceptions. Project directions and rubric would need to be modified for content other than geometry. Includes student work. (W)
Herbel-Eisenmann, B.A. (2002). Using student contributions and multiple representations to develop mathematical language. *Mathematics Teaching in the Middle School*, *8*(2), 100–105.	Provides a useful framework for analyzing discourse patterns as students move from less formal to more precise mathematical language through the use of "bridging languages." Includes transcripts of classroom discussions in a standards-based algebra curriculum and explains how using these different ways of talking about mathematics-enhanced student learning. (C)
Kembitz, K. (2009). The mathematical word wall. *Ohio Journal of School Mathematics*, *59*, 45–46.	Suggests mathematical word walls consisting of student-created definitions and mathematics "graffiti" as an opportunity for students to take ownership of developing an understanding of the vocabulary words. (V)
Kirsch, I.S., & Mosenthal, P.B. (1993). Strategies for solving math document problems (Document strategies). *Journal of Reading*, *36*(6), 498–501.	Describes a strategy for locating the appropriate numbers and formulating a solution process for mathematical document problems. While the strategy is useful for problems based on tables, charts, graphs, manuals, or forms, it does not apply to typical narrative word problems. Includes an example and instructional suggestions. (C)
Kresse, E.C. (1984). Using reading as a thinking process to solve math story problems. *Journal of Reading*, *27*(7), 598–601.	Describes a widely applicable strategy for solving word problems that uses visualization prompts to improve understanding of the problem. It then uses a modified SQ3R [survey, question, read, recite (work), reasoning (check)] resembling Polya's process to support solving the problem. (C)
McIntosh, M.E., & Bear, D.R. (1993). Directed reading-thinking activities to promote learning through reading in mathematics. *The Clearing House*, *67*(1), 40–44.	Discusses how to use DR-TA (predict, read, confirm, resolution) to help students understand the purpose and organization of reading a math text and to locate, understand, and generalize the mathematical information. Three variations of the DR-TA are shared: no book, table of contents, and whole book. While the strategy is likely to improve comprehension when reading math texts, the article describes the strategies in a generic way and lacks mathematical specificity. Two figures supply the connections to mathematical content. (C)

(continued)

Table 1 An Annotated Bibliography of Resources for Using Literacy Strategies in Mathematics *(continued)*

Resource	Description
McIntosh, M.E., & Draper, R.J. (1995). Applying the Question–Answer Relationship strategy in mathematics. *Journal of Adolescent & Adult Literacy*, *39*(2), 120–131.	Presents four categories of Question–Answer-Relationships (QARs) that have been modified to guide students in reading and comprehending mathematics texts. Includes instructional suggestions, nonmathematical examples, and student work in mathematics. Applicable to a variety of mathematical content at all levels. (C)
Meaney, T., & Flett, K. (2006). Learning to read in mathematics classrooms. *Australian Mathematics Teacher*, *62*(2), 10–16.	Describes Read-Think-Do(x2), a cyclical comprehension strategy that provides opportunities for students to question what they read and to connect it both to other mathematical knowledge and to real-life experiences. Supports the development of metacognitive skills and note-taking skills as students are required to review their notes and use them as a resource for themselves and for others. (CS)
Norton, A., Rutledge, Z., Hall, K., & Norton, R. (2009). Mathematical letter writing. *Mathematics Teacher, 103*(5), 341–346.	Preservice teachers created individualized mathematical letter-writing prompts for Algebra 2 students. By writing letters, the students improved their ability to explain their mathematical reasoning, revealed mathematical misconceptions, and showed a slight improvement in their ability to write proofs. Includes student work. (ECW)
Rothstein, A., & Rothstein, E. (2007). Writing and mathematics: An exponential combination. *Principal Leadership*, *7*(5), 21–25.	Lists 10 strategies for guiding students in the writing process in mathematics. Only the "Personification and Interactions" strategy is explained and has an example. While the strategies are applicable to any mathematical content and may have the potential to deepen students' mathematical understanding, mathematics leaders and teachers are likely to need explanations and examples of some of the other strategies. (VW)
Siegel, M., & Borasi, R. (1992). Toward a new integration of reading in mathematics instruction. *Focus on Learning Problems in Mathematics*, *14*(2), 18–36.	Presents the need for a rich variety of mathematical texts employing different textual formats for presenting mathematical thinking. Shares several transactional reading strategies that encourage students to predict, analyze, verify, and explore consequences of the mathematical material being read. Includes an instructional example of teaching students to factor through reading and discussing mathematics rather than traditional teacher-directed instruction. (C)
Thompson, D.R., & Rubinstein, R.N. (2000). Learning mathematics vocabulary: Potential pitfalls and instructional strategies. *The Mathematics Teacher, 93*(7), 568–573.	Describes oral, writing, visual, and kinesthetic strategies to promote mathematical vocabulary development and mathematical understanding simultaneously. High school examples from five content strands address advanced mathematical vocabulary. Writing prompts are all mathematics content prompts, rather than affective prompts. Contains a useful one-page categorization of potential pitfalls with mathematical vocabulary, including some pitfalls that are unique to mathematics. (VCW)
Varcaretu, A.S.P. (2008). Reading texts and writing problems to improve problem solving. *Mathematics Teacher*, *101*(6), 451–455.	Presents instructional strategies for introducing the structure of a mathematics problem and the problem-writing task. Ninth-grade students wrote their own problems after reading both historic and current mathematical primary sources. As students created, peer-reviewed, and revised problems, they developed an understanding of insufficient, sufficient, and superfluous information and an appreciation for the complexity of real-life mathematical problems. Includes student work. (CW)

Note. E = Empirical Study; V = Vocabulary; C = Comprehension; S = Study; W = Writing

reading of the articles, independent writing of analytic memos, group discussion to reach consensus on emerging themes, and rereading the articles to confirm, refute, or elaborate initial conclusions.

First, each of us read the articles to determine if the article (a) included a description of a literacy strategy and (b) targeted the strategy specifically toward middle or secondary school students, featured examples of middle and secondary content, or was included in a journal targeting classrooms at that level. During this first review, we also wrote a theoretical memo indicating the focus of the strategy (e.g., vocabulary, comprehension, study, or writing) and the targeted grade level(s) or content. Those articles that did not meet the two criteria were excluded from the next round of reading.

During the second round of reading, we individually reviewed the articles and responded to the following questions in a compare–contrast matrix to elucidate possible trends or themes:

1. Who is the author's intended audience?
2. Is the strategy explicitly connected with current educational guidelines as documented by NCTM, IRA, or other professional organizations?
3. What reasons are offered for implementing the strategy?
4. Were specific mathematics examples included? Was the application of the literacy strategy in a mathematics context made clear?
5. Was the primary focus of the article on instructional strategy (pedagogy) as used in the discipline of mathematics?
6. Was the description of the strategy clear enough that it could be applied to multiple mathematical topics or grade levels?
7. To what extent does the author explain how to use the strategy? Could literacy and mathematics leaders glean enough information to integrate the strategy into mathematics instruction?

Discussion of the trends and themes emanating from this process appear later in this article.

A primary purpose of this review was to create an annotated bibliography of articles that could be used as a resource for literacy and mathematics leaders who wish to provide professional development opportunities for mathematics teachers focusing on standards-based teaching and literacy. We agree with Moje (2008), who suggested that content area teachers need to view "literacy practice as an integral aspect of subject area learning, rather than as a set of strategies for engaging with text" (p. 99). Therefore, we included the article in the annotated bibliography if (a) the process of implementing the strategy was described well enough so that literacy and mathematics leaders could provide mathematics teachers support for replicating the strategy in classrooms, (b) the instructional strategy was generalizable to mathematics topics or grade levels beyond those described, and (c) the instructional strategy would facilitate students' understanding of mathematics and reflect current standards in both literacy and mathematics instruction.

By using these criteria for selecting articles for this bibliography, we found explanations of instructional strategies that could provide both literacy and mathematics leaders with ways to help teachers to foster mathematical communication in their classrooms consistent with NCTM's Communication Standard. We found 24 articles that met our criteria for inclusion in the annotated bibliography. In addition to the citation, the annotations include the following information: (a) a brief description of the strategy and its name if included; (b) whether it was a vocabulary, comprehension, study skills or writing strategy; (c) whether the article was an empirical study; (d) whether the article included mathematics examples; and (e) a discussion of how the strategy may be used and why it is useful.

Discussion

One significant finding is the apparent paucity of articles that are based on empirical studies. Although there are articles describing literacy strategies and how to use them in mathematics, the findings regarding their effectiveness are anecdotal rather than evidence based. In fact, only 2 of the 24 articles (noted with the code "E" in the annotated bibliography) reported empirical research suggesting the effectiveness of the literacy strategy. This finding is similar to that emanating from Alvermann and Swafford's (1989) search for recommended research-based comprehension and vocabulary strategies appropriate for middle and secondary content area instruction. Only 4 out of the 82 studies they found focused on using literacy strategies in mathematics instruction. Three of those studies that revealed positive results investigated the use of structured overviews.

While there is an obvious need for more research-based evidence for integration of specific literacy strategies in mathematics instruction, we feel that because we restricted the articles in the bibliography to peer-reviewed journals, literacy and mathematics leaders will find the strategies described useful. Moreover, we hope that both literacy and mathematics leaders, teachers, and teacher educators/researchers will field test these strategies in empirical studies to build the knowledge of effective literacy practices.

An additional limitation is that there are numerous pertinent articles that we are aware of from our own reading or from other sources that did not surface in this database search. We purposefully chose to search online because this was the preferred means for finding strategies for 50% of the mathematics teachers in one study (Friedland, McMillen, & del Prado Hill, 2010). Perhaps this limitation of database searching is due to differences in terminology used by those in the field of literacy and those in the field of mathematics.

For example, Kirsch and Mosenthal's (1993) article described an activity that mathematics educators are likely to describe as using Polya's (1945) problem-solving strategy while literacy educators are likely to see this as Ogle's (1986) K-W-L comprehension strategy.

In Polya's (1945) four-step problem-solving plan, students (1) gather data and understand the problem, (2) devise a plan making connections to previously solved problems, (3) carry out the plan, and then (4) look back to determine the reasonableness of the result and to consider other solution methods. This process is similar to the K-W-L strategy in which the students first identify what they Know about a topic, then decide what they Want to find out or Wonder about it, and finally list what they have Learned.

Thus it may be reasonable to assume that mathematics educators writing or reviewing articles about Polya's problem-solving strategies would not include references to literacy strategies or to K-W-L when identifying keywords for such articles. Therefore, these articles would be unlikely to appear in a database search such as the one we used for this article, even though a literacy educator would consider them to be about using literacy strategies in mathematics instruction. This suggests the need for mathematics and literacy educators to develop a common understanding of terms and strategies.

An important difference among the articles we read in our review process is the varying degree of specificity when explaining the strategy as well as varying degrees of clarity for applying the strategy. In addition, the purpose of the strategy was not always clear. Greater description of how the strategy works in a classroom setting, how the strategy might be applied for particular middle school or high school content, and the reasons for using the strategy may increase teachers' use of these strategies in their classrooms.

Braselton and Decker (1994), for example, described how to scaffold instruction using a graphic organizer for solving problems, providing a template and examples of students' work. Because they explained the application of the strategy and gave clear examples, we included this article in the bibliography. We also reviewed Bintz and Moore's (2002) article that described several excellent trade books teachers can use in geometry units and offered specific reasons for their use. However, although they discuss *when* the trade books could be used with specific topics, they do not describe *how* to do that.

Trade books associated with mathematics content do not facilitate or reinforce students' comprehension of content area material unless incorporated into instruction purposefully and appropriately.

Trade books associated with mathematics content do not facilitate or reinforce students' comprehension of content area material unless incorporated into instruction purposefully and appropriately, and mathematics teachers may be more willing to use trade books if that process is made clear to them (Palmer & Stewart, 1997). Therefore, without explicit suggestions regarding implementation from the author, a literacy leader unfamiliar with mathematical concepts may not be able to guide the mathematics teacher in how to integrate the literature effectively into instruction.

In our own experience, we have found that preservice and inservice mathematics teachers are more likely to use an instructional strategy that is generalizable across content or grade levels. Barton, Heidema, and Jordan (2002) offered several specific examples of strategies using mathematics content. In addition, their clear and detailed description of how to create and use anticipation guides with science content makes it generalizable to mathematics content. In contrast, Gibson and Thomas (2005) presented an engaging unit on the use of quilts for a geometry unit, but the strategy included is specific to one area of geometry content; therefore, we did not include it in our annotated bibliography.

Of the articles included in the annotated bibliography, 21 addressed comprehension, 10 addressed writing, 9 addressed vocabulary, and 3 addressed study skills. We believe these numbers reflect the efforts of NCTM and other professional organizations as well as assessment shifts caused by NCLB that emphasize comprehension, writing, and vocabulary skills. Interestingly, although the articles seem to be responding to current standards, only nine articles specifically refer to NCTM, three refer to NCTM in addition to a literacy-focused professional development organization, and 12 do not refer to any professional organization.

Another finding concerns the location of the articles: Only 7 of the 24 the articles were published in literacy journals, while 13 were published in mathematics education journals and 4 in other educational journals. Therefore, literacy leaders may not have encountered these strategies applied to mathematics in their own professional reading. Similarly, in some cases literacy and mathematics educators seem to have a different understanding of what constitutes a literacy strategy.

For example, in our collaboration in the development of this article, we found that the literacy educators considered the use of a trade book to present mathematics content to be a literacy strategy. However, the mathematics educator considered this strategy to be good pedagogy, but was not initially aware that it would be considered a literacy strategy. Ongoing discussion and collaboration between literacy and mathematics personnel and continuing professional development are essential for developing commonly understood terminology, sharing ideas and resources, and maintaining mathematics teachers' motivation to employ literacy strategies in their teaching.

Moving Forward

Literacy leaders should be aware that professional development is a powerful approach for challenging mathematics teachers to better integrate literacy into their mathematics instruction (Cady, Meier, & Lubinski, 2006). In fact, results from a recent survey indicated that mathematics teachers in New York state rely on professional development opportunities as the primary sources for learning new instructional strategies (McMillen, del Prado Hill, & Friedland, 2010). Therefore, collaboration between literacy and mathematics leaders in professional development efforts can help bridge the gap between knowledge of literacy strategies and implementation of the strategies in mathematics instruction.

Using these articles can help these leaders begin the collaborative discussion about how best to provide mathematics teachers with the tools they need to facilitate student ability to learn and communicate mathematics. Although all of the articles in the annotated bibliography describe how to apply the strategy, and many of them appear in mathematics journals, they provide varying degrees of support for mathematics leaders who may not be as familiar with the strategy as a literacy specialist. Similarly, literacy leaders may not be familiar with the mathematics content described in some of the articles or know how to apply the strategy to other mathematics topics.

Working together to capitalize on each other's strengths can lead to the design of professional development sessions that provide mathematics teachers with a model for crossing the mathematics–literacy divide. For that reason, and based on what we have learned from our own collaboration and our work with both mathematics preservice and inservice teachers, we make the following recommendations for literacy and mathematics leaders as they guide mathematics teachers through professional development:

- Develop a common definition of *literacy strategy*.
- Increase awareness of the standards suggested by each other's professional organizations (e.g., IRA, NCTM).
- Increase familiarity with the journals of each other's discipline areas.
- Pair up to create completed examples of literacy strategies for mathematics content at all levels to help mathematics teachers develop a better understanding of how the strategies work.
- Cowrite articles sharing successful collaboration efforts that result in the increased use of literacy strategies in mathematics instruction.

Our recommendations for designing and implementing effective professional development are as follows:

- Codesign and present professional development for mathematics teachers at all levels.
- Explain how to implement a literacy strategy during instruction using specific mathematics examples and why the strategy is effective.
- Identify mathematics teachers who are effectively integrating literacy strategies into their instruction and ask them to share examples and the subsequent impact of the strategies on their students.
- Review adopted mathematics curricular materials for included literacy strategies and highlight these during professional development. Refer to examples in the adopted curriculum.
- Identify homework problems that lend themselves to the efficient use of a literacy strategy and share a list of such problems with teachers. Provide time during professional development for teachers to solve these problems using a literacy strategy.
- Support mathematics teachers in modifying literacy strategies to best meet their students' needs and to best suit specific content and grade levels.
- Show mathematics teachers how to scaffold instruction so that the students can become independent learners.
- Continue to support mathematics teachers as they begin to implement additional literacy strategies into their instruction.

Our own collaboration as literacy and mathematics teacher educators presents an example of how learning from each other can lead to change in practice; by working together, each of us has learned to view our area (literacy or mathematics) with the other's content in mind. If educators are going to support NCTM's and IRA's visions for facilitating all students' mathematical understanding through literacy strategy integration, collaboration among mathematics and literacy educators at all grade levels including college is critical. We believe that sharing the articles included in the annotated bibliography can be a starting point for collaboration and discussion among literacy and mathematics colleagues in any educational context to help develop a common understanding of how these strategies can work in mathematics instruction.

Take Action!

1. Evaluate: Determine which literacy strategy will best help your students to learn the concept(s) you are presenting or which strategy can help you to evaluate the students' learning.

2. Communicate: Talk to the literacy specialist or with other teachers to plan how to integrate the strategies.

3. Try it: Sometimes you have to modify the strategy to fit what you are teaching. Keep your purpose for using the strategy in mind. For example: You can use a graphic organizer to explain a concept (see Barton, Heidema, & Jordan, 2002). You can also use it to show students how to solve a problem (see Braselton & Decker, 1994).

4. Assess: Determine how well the strategy worked to facilitate student learning or how well it supported your students' learning. Obtain student feedback on the strategy, too.

5. Revise: Make changes to the strategy if necessary. Try the revised strategy again with different material. Flexibility is key!

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IRA Books

- *Literacy + Math = Creative Connections in the Elementary Classroom* by Jennifer L. Altieri

IRA Journal Articles

- "Multimodal Teaching and Learning: Creating Spaces for Content Teachers" by Mary Thompson, *Journal of Adolescent & Adult Literacy*, October 2008
- "Using Children's Literature to Inspire K–8 Preservice Teachers' Future Mathematics Pedagogy" by Robin A. Ward, *The Reading Teacher*, October 2005