Math Literacy Q & A

1. I do not teach English, and students in my classroom already know how to read and write (or they should). Why should I focus on these things when it is not my content area?

Literacy skills are not isolated to reading literature and not limited to reading alone. In fact, most educated adults use literacy skills to learn new information e.g. doing their work, researching the answers to questions, following directions for assembling furniture, etc. These activities all usually involve informational texts configured in multiple rhetorical structures and often involving unfamiliar vocabulary. It is generally agreed that text is the primary source of new information soon after we learn to read, even in math. As a content area teacher, it is critical that we do more than just teach concepts, principles, and procedures related to our disciplines. We must teach students how to learn beyond our classrooms; this will undoubtedly include reading, writing, and representing information in text. Additionally, beyond learning, literacy skills provide students an opportunity to be a source of information i.e., to teach others about what they learn through representing and writing.

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If all teachers in a school teach reading strategies, you can capitalize on what your students have already learned in their other classes. In particular, the comprehension strategies of developing gist statements, clarification, question generation and focused retellings can be used in reading and studying mathematics texts.

Mathematics teachers can align think alouds, classroom discussion, and peer interactions with textbook vocabulary, word problem formats, and situations. Such alignment allows students to connect multiple forms of literacy as they acquire a mathematical concept.

In mathematics, in particular, beyond preparing students for the word problem format on statewide exams, it is important to prepare students for mathematics as it is presented in our daily lives. From loan options and applications to tax forms and directions, most of the mathematics problems we face after schooling are in context. Learning mathematical literacy skills helps students continue to succeed after graduation.

2. How do I fit literacy instruction and the use of literacy strategies into my daily instruction when I do not have enough time, as it is, to cover my content?

As math teachers, we do not want to make literacy instruction itself the focus of our mathematics content instruction but rather to *encourage teachers to infuse literacy into mathematics, as this is required for students to advance mathematically*. With each unit of instruction, consider what text or texts would be critical for students to read in order to inform, incite, excite, or instruct them. Sometimes this will be a textbook, however, it should also be websites, newspaper articles, charts, graphs, etc. In other words, it may include any text materials that will expand your lesson. Multiple genres of mathematics literature may help students see the universal principles and need for mathematics. Mathematics cannot be viewed merely as something that a teacher will test students on in high school but rather as part of their future success and financial security. As you increase students' responsibility to use texts, you will also simultaneously have to visualize yourself as not always being the source of information. Additionally, teaching students to gain independence in their literacy development will allow them to interact more freely with multiple genres of mathematical literature.

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Of course, there are often times when you need to be the source of new information (e.g., introducing a core mathematical concept), but you can supplement that with other people's thinking when you include literacy activities in your instructional routines.

Comprehension strategy instruction builds students' ability to think aloud about mathematical concepts and mathematics reasoning. This can be a critical lifelong skill in terms of explaining one's reasoning to colleagues, training new employees, and other job-related tasks. Similarly, the ability to generate a succinct retell or a gist statement, to paraphrase, to know that it is okay to seek clarification from another person are goals of strategy instruction, but also critical for success. All of these can be taught and applied in mathematics class.

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3. In regards to reading, writing, and word learning in math, what kinds of texts should students read in my class?

Texts to Read

It depends on the content area, but in addition to textbooks, you should consider adding other sources from the Internet, local media, reference tools, etc. Envision yourself as providing students with the skills to utilize these tools to go beyond your classroom. For example, in mathematics, if you are teaching linear equations, you may want to start by looking at some sort of linear relationship represented in a newspaper article about the cost of *i-tunes* or fuel. You are likely then to use a textbook to help formalize students' understanding of linear relationships (e.g., formulae, vocabulary such as coefficients, constants, etc. and procedures such as finding the slope). Once students show understanding of the concepts of linear functions, they must learn stepwise procedures in order to transform equations to match specified formulae. Teach students the most efficient procedures effective across multiple mathematical skills. In addition to having students learn how to use their knowledge of linear equations, you may want to encourage them to find other sources of information that describe lines that can be interpreted mathematically that relate to their current and potential future.

Texts to Write

Too often, in efforts to increase writing skills, content area teachers are encouraged to provide students opportunities to write in ways that are described as authentic but really aren't. For example, it isn't particularly common to write lengthy prose about mathematical ideas. It is important that students be expected to engage in writing activities that are consistent with the discipline in which they are working. For example, in science, it is most important to write scientific reports that describe scientific phenomena in a way that instructs others. In social studies, it might be most useful to compare and contrast historical events or to develop a timeline. In mathematics, writing should be used to articulate mathematical proofs, compare and contrast ideas, or explain concepts and procedures that allow for student assessment.

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Students can engage in writing in newsprint and online as well. Many situational texts are available that allow students to learn how graphical displays or scientific formula relate to their present lives. From bacteria counts to sales figures, students should be allowed to learn and interact with mathematics as it relates to their lives.

Words to Learn

Mathematics relies on very precise meanings of technical vocabulary. Like science vocabulary, some of the words have both general and mathematical meanings, and in such cases, it is important that students understand the difference. More unique to mathematics than science, however, is the necessity for precision even with seemingly

insignificant words. For example, "a," and "the" have very different meanings when applied to mathematics. Such precision has to be the focus of instruction.

We can't possibly teach students all words in math directly, so rather than ask which words should be taught; we should ask how we teach students to learn words. In content area learning, students should be taught concepts that anchor their learning. These words usually are not simply vocabulary that easily fit into typical discourse. Rather they are unknown concepts that define an area of study and require thoughtful instructional attention (e.g., definitions, models, representations, examples, counterexamples). Because of the tremendous effort that is required to teach conceptual vocabulary, content area teachers have to judiciously select concepts that will not overwhelm students. There are over 620,000 words in the English language.

4. What literacy skills (or learning strategies related to literacy) are essential for students to learn in math classrooms?

- Asking questions before, during, and after reading
- Researching questions and documenting findings
- Modeling examples of critical concepts
- Paraphrasing ideas
- Interpreting vocabulary and word problems in order to solve the problem
- Dissecting word problems for relevant and irrelevant points
- Translating word problems to mathematical expressions and vice versa

5. Many of my students lack sufficient literacy skills to adequately complete the content area work in my content area; other students have very advanced skills. How do I differentiate instruction in my classroom when students have such a disparate range of literacy skills?

Differentiating instruction in literacy during content area learning is very difficult but necessary to support all students. The first step in effective differentiation is preliminary and on-going assessment of students' knowledge and learning what is necessary for each student to acquire concepts and skills.

In the process of differentiating instruction, it is important that you ensure you are not compromising the sophistication of the content you are teaching due to students' different literacy skills. The first step in effective differentiation is defining precisely how much reading and writing is necessary to effectively learn the content to be mastered. Often we require more reading and writing than is necessary and overwhelm students rather than use literacy as a tool for teaching our content. If the reading level is beyond that of the students,

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choose alternate sources such as early grade textbooks or specially designed ancillary guides for directions or background knowledge. Next, it is important to ensure that students have skills and strategies that good readers have. In mathematics, this is primarily knowing how to use the tools of a textbook or unit (heading, bolds, mapping examples to problem types, dissecting problems, translating words to mathematical expressions/equations and mathematical expressions/equations to words). This makes mathematics somewhat easier as it doesn't require lots of reading or writing.

In addition to providing struggling readers with skills and strategies for reading informational texts, it is also important to consider grouping strategies that can support struggling readers. For example, using partner work or problem solving teams is a way to scaffold reading and problem solving for students simultaneously. For heterogeneous grouping, assign students of different performance in teams of 3 or 4 students. Present the team with a problem that includes some vocabulary or word problem analysis or explanation. The higher level readers should be assigned the analysis and the lower level readers should be assigned the group liaison. By assigning the lower level reader as the liaison, he or she must explain the group's work. Thus, the group works to help this student understand the information well enough to explain to the class or the teacher.

It is also important to consider procedural facilitators to assist in reading and writing. These can be easily differentiated, and students can choose whether they need the support. In mathematics, these are likely to take a format such as a concept map, graphic organizer, or compare-contrast sheet. Again, students can be taught to use these and to use them selectively as you and they feel they are necessary.

6. I know word learning and vocabulary instruction are important in math. What words should I focus on to teach and support? What strategies work the best?

Vocabulary understanding and reading comprehension is critical in mathematics. However, it plays out very differently in mathematics. For one thing, knowing exactly what words to focus on can be tricky (Kouba, 1989; Schell, 1982). And most texts are not very helpful in terms of helping teachers know a) which words should be pretaught (e.g. adjacent in a geometry lesson since it is an adjective as opposed to a formal mathematics term) and b) which words serve as the core of a lesson, or the core of a unit, and thus should **not** be pretaught. As a general rule, a word that is the core of a lesson (e.g. parallel, oblique, commutative) is not appropriate for the normal preteaching of vocabulary.

Contemporary textbooks have often made solid efforts to provide teachers with words that are worth stressing for English learners. Be aware that there may be some native speakers who also need help with these words. Peer activities, preferably structured 2-3 times a week on vocabulary seem a good idea, and research for elementary students suggests they do enhance outcomes.

Most of the techniques for vocabulary instruction described in this material are based on research of Beck and McKeown, Graves, Biemiller and others are appropriate for mathematics with minor adjustments. One key principle is that if a word is worth teaching, it should be taught over multiple days using a variety of modalities - both oral and written, used in a sentence or a written solution to a mathematics problem, used as a means to provide oral feedback to a peer on adequacy of her or his strategy for solving a problem.

We believe the amount of review needed for mathematics vocabulary is likely to be longer than many of the terms used in English class or history class, because they are technical and complex and often removed from common usage.

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In terms of understanding the key words to teach, remember that students need to understand the terminology associated with each concept in order to read textbook directions and refer back to sections later. In mathematics, texts often provide (terse) definitions, instructions for students and either worked out solutions to problems or derivations or proofs.

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Since most textbooks appear to be sequentially built, it is important to keep up with the vocabulary as some words (e.g., monomial to polynomial or pentagon and hexagon) have the same root. For instruction in solving word problems, knowledge of operational terminology can be helpful to students who are reluctant to attempt word problem solving. However, contextual clues and extraneous information may confuse students so help students understand the problem first and the terminology second. It is fine to tell students that using a dictionary (e.g. one on their computer), glossary in a text etc. is a desirable technique if you are unsure of what a word means in a problem.

7. How often should I use literacy strategies? In other words, should I use a before, during, and after reading strategy in every single math lesson?

Literacy strategies can be used frequently within mathematics. Word problems may take literature and relate it to mathematical sentences. Directions in textbooks are often difficult to read and need to be taught to students. However, literacy instruction in mathematics plays out very differently. Before reading strategies should include a) preteaching and use of any technical words that are essential for understanding the days' lessons, and b) review of key terms and concepts covered over the past week (not every word every day but review is critical). One literacy strategy that is essential is linkage to **relevant** prior knowledge. For this to succeed

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teachers must make sure that relevant material is the focus. Too often, this can become a fishing expedition. Some of the key comprehension strategies such as generating questions, gist statements, are excellent "after reading" activities. However, remember that in mathematics students may only actually read 12 sentences or so during the whole period.

8. What kinds of questions should I ask students when I teach math concepts?

Ask frequent clarifying questions on assignments, directions, and word problems. Teachers may want to experiment with asking students to work with a partner and generate gist statements at strategic times during a lesson and/or use some of the Questioning the Author queries: e.g. what is the author trying to tell us? Why did the authors put in this piece of information?

9. Do I need to use different strategies for boys and girls?

While some argue that there are inherent differences between boys and girls learning mathematics (see Gallagher & Kauffman, 2005), the debate is not conclusive. Encourage attempts to succeed in mathematics even when students find a concept difficult. Everyone will struggle with mathematics at some point, we need to help students work to achieve and continue taking mathematics courses.

10. How does the use of literacy strategies relate to learning styles? In other words, what strategies lend themselves well to different styles of learning?

There are differences between learning preferences and learning styles. A learning style is the type of instruction that helps a student learn most efficiently or most effectively. A learning preference is what type of instruction a child appreciates the most. In some cases, a students learning style is different from her learning preference.

That being noted, mathematics has very important visual and auditory components. Teachers should incorporate visual and auditory stimuli to coordinate with well-designed tactile and kinesthetic instruction. The advice we always give teachers is to make sure to attend to all learning styles to ensure that students with all types of preferences have access to the material. Make sure there is a good deal of discourse (i.e. both teachers and students talk about mathematics), write about mathematics, and that there are clear outlines/graphics etc. about important concepts and terms and procedures.

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11. On average, how much time should students spend in the act of reading and writing in a typical class in my math classroom?

Students may spend a large amount of time writing in mathematics courses. Mathematical sentences are present and required in computation, geometric and statistical formulas, as well as deciphering word problems. There are many controversies as part of the mathematics wars as to whether students are asked to do too much writing or too little writing. Mathematics classes do need to focus on mathematics and writing out the steps to solving a problem should be considered a type of writing. Certainly, reading texts with understanding (including the graphics, symbols, equations etc.) is an important type of reading that shares a good deal with the reading the students do in geography and math classes.

12. Many strategies appear to support the needs of struggling readers and writers; what strategies work best for advanced students in math?

Advanced students, with superior memory skills, may not need the same number of practice repetitions for problem solving to acquire a mathematics skill. Instead, set up situations where the student chooses the most appropriate problem solving strategy instead of assimilating one approach into multiple problem types. Also, it is possible to distribute practice across class sessions. Such distributed practice may have long-term retention effects (Rohrer & Taylor, 2006). There are great controversies in the field about the relative role of enrichment vs. acceleration for gifted and advanced students. Teachers should encourage finding sophisticated problems (often on web sites), and even some reading of mathematics texts or articles on topics being considered.

13. What strategies or practices work best to motivate and engage students in reading and writing in math?

Students are asked to find the relevance to what they study. Finding literature that is both socially and academically relevant may help students make the connections between classroom learning and everyday living. Introduce books where mathematics is the focus or at least contributes to the overall understanding. Newspaper articles on stocks, sports statistics, debt, and school test scores may be something that relates to the students.

14. What are the best and easiest strategies for assessing literacy skills in math?

Assessing students' ability to set up a word problem, and paraphrase a word problem before solving it, allows us to see if the student understands the problem. Likewise, students may be asked to paraphrase directions within the textbook before working from those directions. It important to reduce the number of failed attempts at learning and find means to improve success.

15. What are the best strategies for helping students comprehend visual texts (e.g. charts, maps, graphs, etc.) in math?

Make the visual text come alive. Talk about a situation (e.g., family trip) while showing a map. Show a video of a rocket's trajectory while mirroring the curve on a parabolic graph. Explain the comparison of numbers of soldiers in the Civil War while showing a histogram. Lastly, mathematics should not be isolated to 50 minutes per day.

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