

A Literature Review on Disciplinary Literacy

HOW DO SECONDARY TEACHERS APPRENTICE STUDENTS INTO MATHEMATICAL LITERACY?

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With so much attention placed on disciplinary literacy in the Common Core State Standards, what are some aspects of mathematical literacy?

The Common Core State Standards (CCSS) draw attention to disciplinary literacy for improving adolescent literacy. Disciplinary literacy has been described as “advanced literacy instruction embedded within content-area classes such as math, science, and social studies” (Shanahan & Shanahan, 2008, p. 40). Policy supports disciplinary literacy in secondary classrooms (e.g., American College Testing, 2006; Biancarosa & Snow, 2006; International Reading Association, 2006), notably in the CCSS for reading, science, and mathematics (National Governors Association Center for Best Practices [NGA Center] & Council of Chief State School Officers [CCSSO], 2010). Educators need to understand how disciplinary literacy affects instruction, curriculum, and assessment in order to follow the spirit of the CCSS (Zygouris-Coe, 2012). Yet it remains unclear exactly what disciplinary literacy means



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for instruction in specific subjects, including mathematics (Wolsey & Faust, 2013).

Disciplinary literacy represents a different approach from that of traditional content area literacy, which offers cognitive strategies for any subject area, such as questioning, visualizing, and summarizing (Shanahan & Shanahan, 2012). In exploring why disciplinary literacy may improve achievement, Moje (2008) suggests that secondary literacy has been approached from literacy theory rather than disciplinary learning theories. Instead, we should determine the thinking used by experts as they perform as scientists, mathematicians, historians, etc. We also need to link experts’ advanced skills to the beginning skills of students as apprentices in the discipline (Collins, Brown, & Newman, 1989; Schoenbach, Greenleaf, & Murphy, 2012). The apprenticeship phase implies the need to examine how teachers scaffold novice skills.

Research on disciplinary literacy is emerging, but much remains to be done. Researchers have examined how disciplinary experts use literacy professionally (Johnson and Watson, 2011; Shanahan & Shanahan, 2008) and preservice teachers’ perceptions of expert literacy (Conley, 2012). Conceptual pieces

state the importance of disciplinary literacy (Fang, 2012; Lee & Spratley, 2010; Shanahan & Shanahan, 2012). Researchers have analyzed how subjects differ by grammar (Fang & Schleppegrell, 2010) and conceptions of text (Wilson, 2011). Some study disciplinary literacy in secondary classrooms (Damico, Baidon, Exter, & Guo, 2009; Kukral & Spector, 2012; McConachie & Petrosky, 2010; Monte-Sano, 2010). These offer a promising beginning, but focus is needed on how teachers recognize literacy practices in their subjects (Learned, Stockdill, & Moje, 2011).

Mathematics teachers are included in the push for disciplinary literacy. But we are missing analyses of mathematical literacy in the CCSS. The purpose of this literature review is to explore mathematical literacy in the math standards and to offer suggestions for supporting student communication about math. I begin with research questions, methodology, and discourse theory as it operates in disciplinary literacy. Next, I present mathematical practices standards and connect them to mathematical literacy, followed by educational implications. I hope this work will benefit both mathematics teachers and literacy specialists by building a shared knowledge base about literacy valued by math educators and instructional practices that support it.

I organized this review by the following research questions:

- How does disciplinary literacy apprentice students to a subject?
- How do the CCSS represent mathematical literacy?
- How is mathematical literacy embedded in classroom instruction?

Methodology

Literature reviews are a form of original scholarship that shares existing research and builds a case for what remains to be done (Kilbourn, 2006). This review examines a theory of communication and features of mathematical literacy. It is not intended to be exhaustive, given the scope of mathematics. I

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searched for studies through Education Research Complete, ERIC, and PsycINFO. When database materials were unavailable, I traced articles through electronic and print collections. Additional searches were conducted through bibliographies, professional organizations, and educational texts. Search terms included “secondary education,” “disciplinary literacy,” “discourse,” “literacy,” “mathematical literacy,” “mathematic*,” “discurs*,” and names of researchers recommended by reviewers. Classroom studies were limited to those published after 2000.

I narrowed the results to include peer-reviewed articles, education books, and policy reports concerning secondary mathematics instruction. Limiting results to secondary classrooms eliminated studies about service learning, tutoring, after-school programs, and elementary classrooms. To maintain a broad picture of literacy, I excluded exceptional cases such as special education support, English learners, or gifted and talented interventions.

Theoretical Perspective: Discourse Theory

Disciplinary literacy as communication among experts is grounded in discourse theory. Origins of discourse theory as formal study of spoken or written language to learn about one’s thinking may be traced to Harris’s (1952) thesis “Discourse analysis.” Over the past sixty years, discourse theory has been adopted and refined by several academic fields: linguistics, social linguistics, cognitive linguistics, anthropology, philosophy, literary studies, interdisciplinary cultural studies, and social theories (Yang & Sun, 2010). Social linguist James Gee (2011) proposed his own theory, describing his term *Discourse* as drawing from a dozen theorists, including Foucault’s discourses, Lave and Wenger’s communities of practice, and Wittgenstein’s forms of life. Gee’s theory represents his 20-year evolution from focusing on isolated language to studying language in use shaped by the values of society and cultural context, including occupations (Gee, 2012).

Gee’s Discourse theory supports teaching students to think like mathematicians, scientists, or historians (Moje, Luke, Davies, & Street, 2009; Shanahan & Shanahan, 2008). Identity is shaped by communities whose languages we share. Gee (2012) described Discourses as the entirety of human communication in a situation that helps us identify who we are by what we say and do:

Discourses are ways of behaving, interacting, valuing, thinking, believing, speaking, and often reading and writing, that are accepted as instantiations of particular identities by specific groups....They are socially situated identities. They are, thus, always and everywhere social products of social histories. (p. 3)

Gee used Discourse to describe the broad view of human interaction described above. He defined *literacy* as “mastery of a secondary Discourse,” in which secondary Discourses are those learned outside the home (p. 173). Literacy as mastery implies a long journey from novice to expert, similar to an apprenticeship.

Learning as an apprenticeship introduces students to the reading, thinking, speaking, and writing of a field (Collins, Brown, & Newman, 1989; Gee, 2012; Schoenbach, Greenleaf, & Murphy, 2012). An apprenticeship model deemphasizes didactic approaches in favor of observation, coaching, successive approximation of mature practices, and student reflection on problem-solving approaches (Collins, Brown, & Newman, 1989). Apprenticeship invites students to learn *actively*. For students to comfortably express learning, teachers guide them through intermediate stages of mastery, when students misapply new knowledge and can learn from mistakes.

In education, we can recognize Discourse theory in policy statements about how educators should use CCSS. Literacy is presented as an overall method of learning a discipline. According to the website of the Wisconsin Department of Public Instruction (2012b):

Each discipline has its own specific vocabulary, text types, and ways of communicating.... Students who are literate in a particular discipline are able to successfully read, write, and speak about that discipline and can listen to and think critically as others communicate in that community.

The CCSS direct K–12 teachers to examine implicit literacy traditions in English language arts, social studies/history, science and mathematics (NGA Center & CCSSO, 2010, p. 3).

Disciplinary literacy addresses cognitive complexity by identifying that each subject presents diverse challenges: “Most students need explicit teaching of sophisticated genres, specialized language conventions, disciplinary norms of precision and accuracy, and high-level interpretative processes” (Shanahan & Shanahan, 2008, p. 43). If we accept Gee’s definition of literacy as mastering a Discourse, we can envision

the learning required from examining educational standards, including the mathematical practices standards.

Mathematical Standards of Practice

In 2000, the National Council of Teachers of Mathematics (NCTM) updated the Principles and Standards for School Mathematics, intended to improve K–12 mathematics (NCTM, 2000). The math standards are divided into two sections: content standards and process standards. The process standards describe ways of learning content knowledge recognizable as the conventions and norms of disciplinary literacy. The five process standards are problem solving that includes grappling with complex problems; expressing reasoning and proof; clear, convincing, and precise communication of concepts and procedures; connections and integration among mathematical ideas, topics, and ideas from other subjects; and multiple representations of ideas, such as pictures, manipulatives, tables, graphs, and symbols (NCTM, 2000).

When the CCSS Mathematical Practices were written, the authors drew from the NCTM process standards and a National Research Council (2001) report to arrive at eight practices representing long-standing traditions of the mathematical community (NGA Center & CCSSO, 2010). The CCSS mathematical practices state that students will be able to do the following eight tasks:

1. Make sense of problems and persevere in solving them.
2. Reason abstractly and quantitatively.
3. Construct viable arguments and critique the reasoning of others.
4. Model with mathematics.
5. Use appropriate tools strategically.
6. Attend to precision.
7. Look for and make use of structure.
8. Look for and express regularity in repeated reasoning.

From these, one can infer values that are important for how students read, write, and speak about mathematics. Table 1 proposes connections among the CCSS standards, disciplinary literacy, and mathematical discourses. In the first standard, we see that

TABLE 1 Connections Between Standards, Disciplinary Literacy Discourses, and Mathematical Discourses

CCSS Mathematical Practices	Disciplinary Literacy Discourses	Mathematical Discourses
Make sense of problems and persevere in solving them	Expert problem solving Writing/speaking as scaffolding	Multiple, creative approaches Verifying one's own work
Reason abstractly and quantitatively	Expert style of communication Text features Questions posed by experts	Mathematical language Symbolic notation Quantitative approach
Construct viable arguments and critique the reasoning of others	Communication in the Discourse community	Properties of mathematical language Logical connectives Narratives
Model with mathematics	Interdisciplinary links Real-world applications Visual and digital literacy	Connections between subjects and ideas Data representation in many forms, including visual mediators
Use appropriate tools strategically	Transition from prose to visual mediators Visual and digital literacy	Proficiency with mathematical tools Diverse data representation
Attend to precision	Style of communication Norms of quality	Properties of mathematical language Symbolic notation
Look for and make use of structure	Content area knowledge Discourse routines	Understanding the nature of numbers as a rule-based system
Look for and express regularity in repeated reasoning	Content area knowledge Discourse routines	Understanding recurring patterns in numbers

problem solving is much more than getting the right answer. It involves creativity and determination to allow oneself to make mistakes, adopt alternatives, and keep trying. This viewpoint has a long history in the mathematical community. One of the paragons of problem solving, George Polya argued for 40 years for teachers to assign engaging problems that encourage students to guess at answers and then to creatively formulate multiple solutions and evaluate the accuracy of their answers (Passmore, 2007).

In the second, third, and sixth standards, we see a view of the language valued in math classes. These standards state that mathematical language should be abstract, quantitative, logical, defensible, and precise. The ability to describe and defend one's reasoning is powerful in mathematical learning, as seen in the review. Students will be able to understand the concepts underlying a problem, both contextualized in real life and decontextualized to apply to similar problems (NGA Center & CCSSO, 2010). This implies that students must grapple with different levels of detachment among reader, subject matter, and author (Gee, 2012) and then apply the right detachment at the right time. The focus on quantitative thought indicates the types of problems that experts are interested in: "Quantitative approaches are used to

describe current conditions, investigate relationships, and study cause-effect phenomena" (Gay, Mills, & Airasian, 2011, p.11). Working with quantitative units requires the ability to consider the meaning of units and concepts, not just to focus on computation (NGA Center & CCSSO, 2010). Lastly, the language of mathematicians is precise, one in which every word is included deliberately and slight changes will alter the meaning of an entire proposition (Shanahan & Shanahan, 2008). Much of math's precision comes from the use of symbolic notation to express quantities, functions, and operations in the fewest possible terms, a form of text uncommon in other disciplines.

The fourth CCSS practice, modeling with mathematics, combines the NCTM standards of connection to other math ideas and subjects with representation of ideas in multiple forms, such as graphs, tables, flowcharts, and equations (NGA Center & CCSSO, 2010). Modeling connects math classes to authentic problems and demonstrates the utility of mathematical thought. Making connections requires students to use previously learned concepts to construct new knowledge about situations outside school. Some teachers consider modeling to be a major challenge of the CCSS, because it affects students' abilities to understand word problems, which are found in

all the content standards, and requires transfer across concepts (Bostic & Matney, 2013).

The remaining three CCSS practices describe work with numbers and their nature. The fifth standard describes tools that are used to produce knowledge, such as pencil and paper, calculators, and software for statistics or dynamic geometry (NGA Center & CCSSO, 2010). The use of tools relates to the NCTM standard of representation, because students must understand different ways of presenting data to use various tools effectively. The last two standards describe the nature of numbers. Students learn how to use the structure of numbers as part of rule-based systems that create knowledge clusters and make abstract reasoning possible (National Research Council, 2001). They learn numerical properties, such as commutative, associative, and distributive, that explain methods of calculation. Students also learn to recognize and use recurring patterns that create shortcuts and enable one to devote attention to complex mathematics. Knowledge of patterns may lead mathematically proficient students to abstract formulas from equations and allow students to check the reasonableness of their answers (NGA Center & CCSSO, 2010). With these mathematical practices in mind, we can identify important values and norms in studies of mathematical literacy.

Mathematical Literacy

Mathematical literacy as Discourse provides a broad view of how mathematicians communicate. Communication has been the goal of many mathematics reforms since the late 1990s, including the NCTM standards (for a review, see Yore, Pimm & Tuan, 2007). Many challenges of mathematical literacy center on how students reason while problem solving, as described in the first CCSS standard. We see communication in the third CCSS standard, which states that students should learn to construct arguments and critique those of others. We also see this idea at the state level: “Mathematically literate students are able to analyze, reason, and communicate ideas effectively as they pose, formulate, solve and interpret mathematical problems in a variety of situations” (Wisconsin Department of Public Instruction, 2012a). With this emphasis on communication, discourse has long been at the heart of mathematics education.

According to Sfard (2007), mathematical discourse is characterized by four text features:

mathematical words, narratives, visual mediators, and routines. By studying transformations in these features, researchers hypothesize about the discursive development of students (e.g., Hull & Greeno, 2006; Sfard, 2007). Mathematical words relate to quantities, shapes, and operations. Mathematical literacy involves close reading and rereading of terms that carry precise meanings (Gritter, 2010; Shanahan & Shanahan, 2008). This is one type of precision described in the sixth CCSS standard. Although there are fewer words per page in math than in other disciplines, each word carries meaning that must be unpacked carefully to enable understanding.

For example, an often confusing word-level feature is the logical connective: “a group of words and phrases which serve to link propositions in reasoned argument” (Dawe, 1983, p. 331). Logical connectives make the abstract, quantitative reasoning of the second CCSS standard possible. They include *and*, *or*, *because*, *so*, *if*, *if...then*, and *if and only if* (Meaney, 2007). Confusion about which connectives to use can interfere with the interpretive steps of algebra (Tsamir & Almog, 2001). Pimm & Sinclair (2009) reported that, even in college, students omit formal connectives in conversation, relying on such informal connectives as *so*, *because*, and *which means* as well as the tone of one’s voice, gestures, or hedging statements, including *That’s right, isn’t it?*

Sfard’s second discursive feature—narratives—are strings of words that describe an object or relation and may be judged as true or false. Common narratives include definitions, proofs, theorems, and theories. Mathematicians use narratives to construct networks among resources to understand unfamiliar concepts (Wilkerson-Jerde & Wilensky, 2011). Although producing texts is important, mathematical literacy includes understanding texts produced by others (Johnson & Watson, 2011; Yore, Pimm, & Tuan, 2007). These networks of narratives allow mathematicians to connect their ideas to those of others, as described in the third CCSS standard.

Visual mediators, Sfard’s third feature, are usually images of abstract symbols created for the sake of discourse, including formulas, diagrams, graphs, and drawings. These are representations of data described in the fourth CCSS standard, modeling with mathematics. Students learn correct ways of reading each form, such as understanding that variables represent unknown quantities in formulas. Visual mediators are

an integral part of mathematical literacy, not “mere auxiliary means for conveying or giving expression to preexisting thought. Rather, one views them as a part and parcel of the act of communication and thus, in particular, of thinking processes” (Sfard, 2007, p. 572). To read math and create mathematical arguments, students must understand visual mediators.

Lastly, a mathematical Discourse includes routines: well-defined, shared patterns of communication and action. Some routines include categorizing, recognizing when problems require similar procedures, calculating based on operational properties, and deductive reasoning. Routines define reasoning and acceptable argumentation. In the CCSS, students learn these patterns in the seventh and eighth standards. Math teachers who are familiar with the NCTM process standards and the CCSS Mathematical Practices will recognize them in these four discursive features. Math teachers may use this knowledge to identify specific classroom strategies for examining each feature explicitly with students (see Table 2 for examples).

Inviting students to share their reasoning is a major component of math standards. Kaiser and Willander (2005) propose a system of five levels of reasoning in mathematical literacy. The first level, illiteracy, is ignorance of basic concepts and methods. Second is nominal literacy, in which students may understand a concept by name but are limited in its application because of naive theories and misconceptions. The third level is functional literacy, in which students use vocabulary and methods in specific circumstances but do not transfer them or make generalizations. Fourth is conceptual or procedural literacy, in which students make generalizations. Able to understand relationships among concepts and procedures, students use central ideas and methods to conduct inquiry that integrates different functions. The fifth level of the hierarchy is multidimensional literacy, which contextualizes mathematics within social, historical, and philosophical dimensions, including how mathematics applies to contemporary social issues and is an invention to describe patterns

in the world. Attaining the fifth level of this hierarchy may be recognized as mastery of math as a Discourse, in which students have internalized all the CCSS standards.

Some criticize this approach to evaluating levels of reasoning via students’ verbalization. Meaney (2007) challenged the hierarchical structure of Kaiser and Willander’s system, arguing that the context of the problem posed must be considered. Meaney examined videotapes in which students were given a task of ordering four boxes of unknown weight from lightest to heaviest. The middle two boxes were almost the same weight, too close to determine by hand weighing. Students were provided with balances but not instructed to use them.

Classroom teachers asked students to verbalize their reasoning through three stages of the weighing task: plans, descriptions, and instructions. In the first stage, students explained what they would do before starting. Second, they described their actions while weighing the boxes. In the third stage, students explained how they would instruct their classmates to complete the task. The author found that children’s level of explanation changed by stage. Most children offered nominal or functional explanations during the planning and describing stages. In fact, many students used only gestures while describing. But when the last stage required them to instruct classmates, more students demonstrated conceptual or procedural literacy. Meaney concluded that it was the children’s perception of the stages that guided the level of literacy displayed, not their development. Although Meaney cautioned that use of hierarchical literacy levels may misrepresent students’ capabilities, both articles demonstrate how teachers can encourage students to share their mathematical reasoning.

Gresalfi, Martin, Hand, and Greeno (2009) add an additional note of caution about determining if students display competence, an emphasis of standards-based educational reform. Although identifying who needs help is important, a label of incompetence can lead to negative consequences, especially if students

TABLE 2 Mathematical Features and Suggestions for Instruction

Features	Instructional Suggestions
Mathematical words	Word study of roots and affixes, close reading, writing definitions, study of logical connectives
Narratives	Close reading, practice verifying statements, creating narratives
Visual mediators	Instruction on reading specific representations, creating visual mediators to support reasoning
Routines	Practice different levels of mathematical reasoning

internalize an identity of being unable to learn math (Hull & Greeno, 2006). Gresalfi et al. (2009) propose that competence does not exist independent of context but as interaction in an activity system of students, teacher, curriculum, equipment, and classroom environment. Competence should be viewed as “the interaction between the opportunities that a student has to participate competently and the ways that individual takes up those opportunities” (p. 50). The interaction includes whether the teacher respects students’ problem-solving processes, including mistakes. It is possible for teachers to create an atmosphere in which students can arrive at wrong answers but still be considered competent at mathematics.

In the study, Gresalfi and colleagues (2009) examined conceptions of competence by eighth- and sixth-grade math teachers with different instructional styles. The grade 8 teacher focused on helping all students use predetermined procedures. Student struggles were framed as lack of understanding to be fixed with the teacher’s help. In the sixth-grade classroom, the teacher helped students in an open-ended activity. When students struggled, the teacher helped them articulate what was difficult and ways to work through it. The teacher helped students explain confusing ideas to one another. The conception of competence influenced whether wrong answers were OK. When the sixth-grade teacher acknowledged that tasks were difficult and would take several attempts, students persevered in problem solving.

An apprenticeship approach necessitates shifting away from didactic instruction to active problem solving (Zorica, Cindric, & Destovic, 2012). Polya’s problem-solving process, and models based on it, includes the final step of verifying solutions (Passmore, 2007). Schwarz and Linchevski (2007) offer an example of how missing the verification step may inhibit learning. The authors examined conditions leading to conceptual change among 60 high school students. Pairs were instructed to arrive at a consensual answer to a block-weighting task that demonstrated proportional reasoning. The authors manipulated the task’s design by having pairs work under different conditions, including with or without a balance. Pairs experienced more conceptual change when they could verify their solutions. Pairs without the balance either agreed and ended conversation or disagreed but remained polarized, unable to endorse their answers as right or wrong. Results suggested it was peer interaction guided by verification that enabled conceptual change.

Although the NCTM and CCSS standards encourage students to verify their own answers, doing so can be challenging. There may be times when teachers need to identify student misconceptions and redirect them (Sfard, 2007). Part of the apprenticeship model includes the expert’s responsibility to recognize when the novice needs help and to offer as much coaching as needed for active learning to resume (Collins, Brown, & Newman, 1989). My conclusions include suggestions for how teachers help students verify solutions and share their reasoning.

Conclusions: Educational Implications

This review suggests some strategies for secondary mathematics teachers to encourage students to communicate their reasoning. This communication may take different forms and occur from student to teacher or among students. But even when students work together, mathematics teachers remain experts to whom students often turn to verify their work. This insight implies a careful balance for teachers to commit to allowing students to work through their thinking while being available to help as needed. Part of the teacher’s responsibility is to direct students’ attention to the procedures they use, so that students do not focus on right answers without understanding the process and underlying concepts (Johnson & Watson, 2011). Asking probing questions can deepen students’ understanding (Bennett, 2010). Any learning strategies should reinforce that getting the answer is only one step in understanding math. As indicated by Gresalfi et al. (2009), teachers can influence the extent to which making errors is an acceptable part of learning by consistently acknowledging difficult tasks and the role that mistakes play in developing expertise.

Another implication is that mathematical literacy lends structure to children’s reasoning, particularly in the way students verify their solutions. Even when students have learned how to verify, they tend to skip this stage (Pugalee, 2004). Teachers can help students to construct mathematical understanding by requiring them to share their reasoning and verification processes orally or in writing. In Pugalee’s analysis, students who wrote about verification were more successful at problem solving than were students who verbalized them in think-alouds. Others have found that written explanations are generally more precise than verbal ones (Pimm & Sinclair, 2009).

Writing assignments to help students verify their reasoning are possible. For example, teachers may assign double-entry diaries, with one column for solving and a second column for explaining reasoning (Miller & Koesling, 2009). Students may find that others have different approaches to the same problem, which may be recorded as a third column. As formative assessment, the double-entry diary allows teachers to judge how well students reason and to adjust instruction accordingly. Diaries may be used as prewriting before group work to structure conversation with peers. As summative assessment, the teacher may evaluate diaries for how well students explain their reasoning. Depending on how the assignment is structured, teachers could use the diaries to analyze students' grasp of any of the CCSS standards.

Teacher collaboration can be a powerful strategy, too. Secondary teachers working in teams could undertake study of the CCSS standards to identify the learning progressions contained within them (Rothman, 2011). Learning progressions scaffold the skills that students learn, from simple to complex,

reflecting how apprentices slowly build expertise. To design a constructivist curriculum, learning progressions may include the hypothetical learning of an "average" student, and multiple pathways for the learning of actual students (Battista, 2011). Identifying learning progressions in the CCSS for secondary mathematics will be more challenging than for earlier grades, which are described by grade level. For example, third graders learn about fractions as numbers, fourth graders learn to add and subtract fractions, and fifth graders learn to multiply and divide fractions (NGA Center & CCSSO, 2010). The secondary standards are organized by six conceptual categories, not by grade level. Identifying learning progressions will require some work by teachers. When that is accomplished, teacher teams can discuss ways to teach each progression that draw students into conversations. The team may include a literacy specialist to suggest specific strategies aligned with the learning progressions and the values and norms of mathematical literacy.

Regardless of discipline, teachers work hard to connect students' existing knowledge to academic knowledge. Anyone who has taught is aware of how challenging that is, especially when we devote ourselves to teaching all students well. Learning how to include students in a discipline's discourse is one challenge among many, yet it provides a starting point. By studying how experts communicate, we lay the groundwork for sharing our understanding with students. We are in a challenging era of American education, in which demands made on teachers are increasing, yet adequate retraining is rare. As pressure mounts to rapidly improve levels of adolescent literacy, teachers need suggestions about how to reach learners that relate to existing standards. Implementation may prove to be the downfall of the Common Core State Standards if teachers don't know how to teach in the recommended ways (Gewertz, 2012). Understanding how to incorporate disciplinary discourse offers a glimpse at successful implementation.

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Take Action

STEPS FOR IMMEDIATE IMPLEMENTATION

To involve students in mathematical discourse, teachers can try the following:

- ✓ Create your own double-entry diary as a model. As a minilesson, share your problem-solving steps and verification. Include pictures and other visual mediators as appropriate, plus alternative procedures. By regularly sharing your reasoning and verification strategies, you encourage students to emulate you.
- ✓ Brainstorm with your district's literacy specialist about strategies that encourage communication. Examples that are easy to incorporate include journals, concept maps, discussion of how and why students arrived at their answers, or open problems that have multiple entry points and multiple solutions.
- ✓ Engage colleagues in a lesson study for an area in which you predict students will struggle. Prepare for the first meeting by studying Common Core standards and identifying where your grade-level team could improve. Share your insights about strategies that draw students into discussions.

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More to Explore

CONNECTED CONTENT-BASED RESOURCES

Many resources focus on getting students communicating. For example:

- Small groups writing, speaking, and reading high school geometry: www.youtube.com/watch?v=T0Ece-WqToU
- How the Common Core standards change math instruction: www.teachingchannel.org/videos/common-core-state-standards-high-school
- Tenth graders discussing problem-solving in algebraic stations: www.teachingchannel.org/videos/high-school-algebra-lesson
- Authentic examples, visual mediators, and partner talk in a middle school Algebra I class: www.teachingchannel.org/videos/algebra-mixture-problems
- A middle school math teacher writes about mathematical discourse: www.teachingchannel.org/blog/2013/04/05/mathematical-discourse/