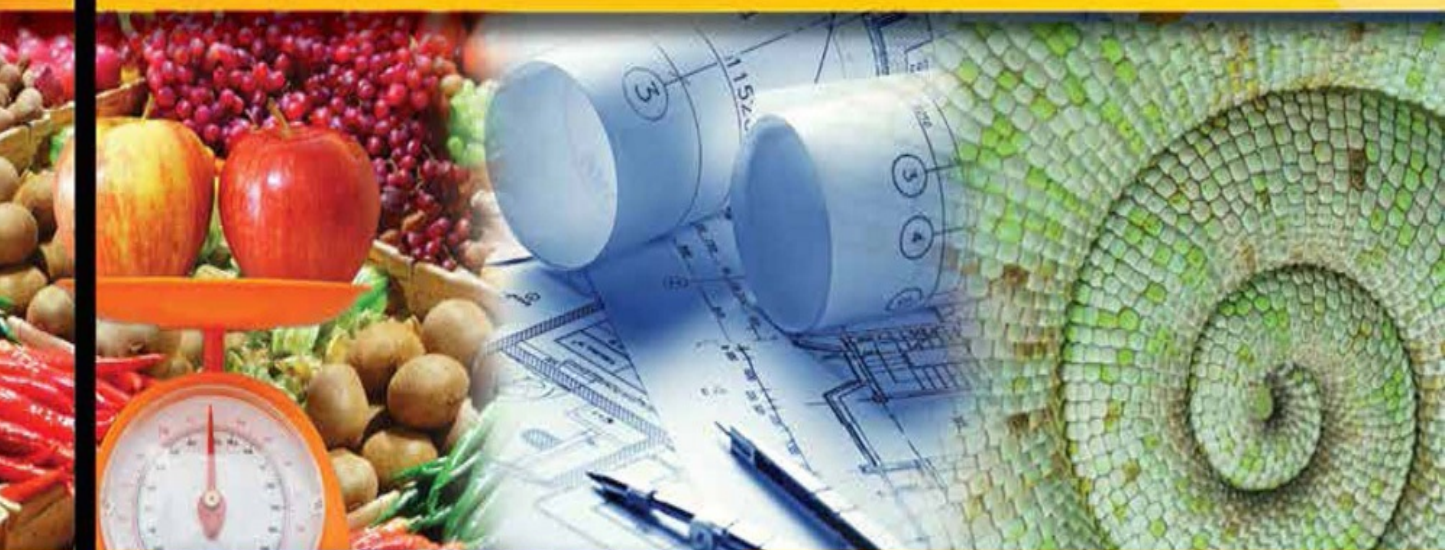




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Writing Strategies for Mathematics

Second Edition



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What Is Writing?

For thousands of years, humans have been communicating by writing down characters, symbols, numbers, or letters with implied meaning. Being able to write and to write well is more important today than ever before, given the complex world in which we live. Writing is the making of letters or characters that constitute readable matter with the intent to convey meaning. Writing demands that one not only knows how to read what one has written but also knows the rules of writing that dictate how characters or letters are to be written and therefore understood.

What is writing? Is it brainstorming? Is it spelling? Is it scribbling words and phrases? Is it a report? Is it a simple paragraph? Writing in the classroom can be simply defined as any symbolic representation (Hefflin and Hartman 2002). As Bena Hefflin and Douglas Hartman explain, the definition of writing includes representations that are “linguistic, graphic, pictorial, or otherwise.” This broad definition of writing welcomes a wide variety of writing formats.

Everyone Should Teach Writing

Because educators understand the need for improved reading and writing skills in students, there has been a renewed focus on teaching literacy skills within the Common Core State Standards (National Governors Association Center for Best Practices, Council of Chief State School Officers 2010) as emphasis is placed on the shared responsibility of teachers across disciplines and content areas to help students develop the necessary reading and writing skills to succeed in that particular subject, including mathematics. Pam Allyn supports this claim, making her argument for the shared responsibility of teachers to teach literacy skills as she closely analyzes the word *core* itself, noting that “the word *core* is a homonym: *core* and *corps*...[The Common Core] is at once about the *core* of why you teach and how you can enhance every aspect of your work...[It] is also about building a true *corps* of teachers, parents, and communities working together to ensure that *every* child has the certainty of gaining college-and career-ready outcomes,” shifting the responsibility from a single classroom teacher to a body of teachers, parents, and community members who are collectively responsible for ensuring the academic success of the children in their community (Allyn 2013, 4–5).

Most educators agree on the need for writing instruction in the content areas

but differ on where instruction should occur. Because of curriculum demands, many teachers feel there is not enough time to teach writing in the content areas; adding one more component is just too much strain on the time and quality of lessons. However, researchers claim that most writing assignments do not need to be graded, which eliminates a major concern about the teacher workload (Worsley and Mayer 1989; Hightshue et al. 1988; Self 1987). And writing assignments can serve as ongoing assessments of students' understanding of content knowledge, which informs future instruction and helps "teachers determine what students need and then design an appropriate instructional response" (Harvey 1998, 203). In this sense, writing instruction across the content areas cannot be overlooked as it is a powerful tool for assessing students' content mastery.

Writing is an instrument of thinking that allows students to express their thoughts and helps them understand and share their perceptions of the world around them. Teachers can give students power in their world by teaching them to write and to write well. The written word "enables the writer, perhaps for the first time, to sense the power of...language to affect another. Through using, selecting and rejecting, arranging and rearranging language, the student comes to understand how language is used" (Greenberg and Rath 1985, 12).

Literacy Demands

The literacy needs for the 21st century are tremendous. Literacy was defined a century ago as one's ability to write one's name. A literate person could write his or her name; an illiterate person could not. In 1940, more than "half of the U.S. population had completed no more than an eighth grade education," which is an evolving statistic as education continues to change and develop into the 21st century (National Center for Education Statistics 2013).

Education as an institution is similarly evolving to meet the demands of what it means to be considered literate in the 21st century. With the advent of the Common Core State Standards (National Governors Association Center for Best Practices, Council of Chief State School Officers 2010), students are considered literate individuals when:

1. They demonstrate independence.
2. They build strong content knowledge.
3. They respond to the varying demands of audience, task, purpose, and discipline.
4. They comprehend as well as critique.
5. They value evidence.

6. They use technology and digital media strategically and capably.
7. They come to understand other perspectives and cultures.

Furthermore, students who meet the standards outlined in the Common Core State Standards by the time they leave high school are “prepared to enter college and workforce training programs” with success (National Governors Association Center for Best Practices, Council of Chief State School Officers 2010). There is a clear movement toward fostering the skills necessary for students to succeed in real-world contexts and thrive as productive citizens and workers. This need to develop productive members of the workforce is in line with alarming findings related to dropout rates and the U.S. economy (Wolk 2011, 75):

An analysis by the Alliance for Excellent Education (2010) shows that the U.S. economy would grow significantly if the number of high school dropouts were cut in half. If just half of these students had graduated, research shows, they would have generated more than \$4.1 billion in additional earning every year, and states and localities would have received additional taxes of more than \$535 million. If the nation continues to lose students at the present rate, about 13 million students will drop out in the next 10 years at a financial loss of \$3 trillion (Alliance for Excellent Education, 2009).

The cost of high school dropouts to the economy is clear and an unfortunate statistic that cannot be ignored in the midst of today’s economic state. But what can classroom teachers do to remedy these findings? Why are students dropping out of high school at such an alarming rate? Does the desire to drop out begin in high school or long before? Research suggests that the reasons behind student-dropout rates take root long before students make the active choice to drop out. In fact, experts in the field claim that to make a lasting difference in high school dropout rates, “[w]e must understand and focus on why students choose to leave school. Dropping out is not an impulsive decision. The process begins long before high school, often by the 4th or 5th grade. More often than not *it is rooted in the failure of students to learn to read*—not just decode the English language, but to read and understand what they read” (Wolk 2011, 77; italics added). Teachers need to develop in students the *desire* to read, to actively read, to habitually read, and to read with comprehension and purpose. When students read an extensive amount of literature and informational texts, they absorb the variety of language being used and apply it to their written work. Students are experiencing failure in reading at an early age, which significantly impacts their motivation to read, write, and develop the skills necessary to be considered college and career

ready. We must examine how to effectively motivate students to read and write and instill the lifelong love for reading that goes hand-in-hand with reading independence, comprehension, and deep learning expressed through writing. But to understand how to instill this thirst for reading and writing, teachers must first understand *who* their students are and how 21st-century learners have very different learning needs from previous generations during a time when technology and digital learning played a small role in students' lives both in and out of the classroom.

Technology and 21st-Century Learning

It is no secret that technology is changing education like never before and consequently the lives of young people growing up in the “Net Generation.” As such, what it means to be literate in the context of advanced technology is not the same definition from even a decade ago. In “Comprehending and Learning From Internet Sources: Processing Patterns of Better and Poorer Learners,” Susan Goldman et al. (2012) note that technology is “changing the face of literacy,” stating that people of all ages look to the Internet to resolve a variety of problems that “arise in academic, personal, interpersonal, and occupational contexts” (356–357). Students are looking to the Web for their schoolwork, marking the development of 21st-century skills crucial to students' ability to strategically navigate and “critically evaluate information sources for their relevance, reliability, and consistency” as nearly anyone can post information—regardless of its validity—to the Internet.

Having said that, it is no wonder that the strategic use and navigation of technology and digital media is included in the Common Core State Standards definition of literacy in the 21st century. Students must learn to integrate and evaluate the information they encounter on a daily basis from diverse media, including both print and digital resources, whether in school or at home. We have entered a new era in education, and this era is deeply tied to the technological advances that now permeate our modern lives. Today, children can use a cell phone to take a picture before they can speak. A typical three-year-old can turn on a computer and begin a game program without assistance from an adult. Students in school can use the Internet and online libraries to access information from remote locations. They can interview experts in faraway locations through email.

According to Susan Metros, Professor of Clinical Education at the University of Southern California, college students today are “media-stimulated, but not necessarily media-literate” (quoted in Wagner 2008, 183–184). But today's college students are not the same learners who are presently immersed in today's elementary and secondary education system. Bearing this in mind, the

Common Core State Standards emphasize the development of those skills in preparation for college and careers beyond the classroom. The hope is that students become media-literate as they meet the standards outlined by the Common Core and are able to navigate the complexities of the digital realm. Now, more than ever, it is each content area teacher's responsibility and duty to prepare students for the reading and writing demands of our technological age. In order to become effective and efficient readers and writers, students need to use comprehension strategies automatically and independently. Students need teacher guidance to help them become independent readers, writers, and learners so they not only understand what they read but can also question it and write about it.

The Reading/Writing Connection

According to Gay Su Pinnell (1988), "As children read and write they make the connections that form their basic understandings about both. Learning in one area enhances learning in the other. There is ample evidence to suggest that the processes are inseparable and that we should examine pedagogy in the light of these interrelationships. Hence, the two activities should be integrated in instructional settings. Teachers need to create supportive situations in which children have opportunities to explore the whole range of literacy learning, and they need to design instruction that helps children make connections between reading and writing." Additionally, "a considerable mismatch between reading phases and writing phases is a red flag to indicate that instruction is not balanced," so providing students with opportunities to read and write will help to remedy this imbalance and work towards building students' overall literacy skills (Gentry 2006, 35). Moreover, J. Richard Gentry goes on to say that "[c]hildren who receive little opportunity to write in school...and too little appropriate writing instruction sometimes excel as readers but struggle as writers and spellers" (35).

Writing is the expression of ideas and thoughts gathered while reading. Mathematics texts are often heavily loaded with difficult vocabulary words and complex concepts that are challenging for students to understand. Encouraging students to both read and write about mathematics topics helps them understand the information presented. When students read content without writing about it, they miss a crucial step in the process of understanding the information because "writing serves as a vehicle for learning both content standards and standards of written expression" (Combs 2012, 12).

The connection between reading and writing is complex and intricate, placing the act of reading as a necessary and crucial counterpart to writing: "Reading

cannot be separated from writing. It's neither research-based, practicable, nor sensible to read first without writing. Students must connect reading and writing everyday (Routman 2005). It has to be writing *and* reading first" (Gentry 2006, 145). In fact, this notion is especially true for young writers as nearly "half of the time that beginning readers invest in a piece of writing is spent on reading rather than writing. Many children reread multiple times as they write even a single word!" (Calkins, Hartman, and White 2005, 87). Essentially, the skills one uses to write are the same skills one uses to read (2005).

However, that is not to say that the reading/writing connection should be simplified to have you believe that reading is only involved in writing when students reread drafts for revising and editing. As noted by Stephanie Harvey (1998, 60), "Samuel Johnson once said, 'The greatest part of a writer's time is spent reading, in order to write; a writer will turn over a half library to make one book.'" Reading and writing cannot be examined in isolation; both modes of literacy complement each other, similarly building the skills necessary for college and careers beyond the classroom.

Motivating Students to Write

Today's students are radically different learners from those of us who Marc Prensky rightfully terms "digital immigrants" in today's digital age (quoted in Wolk 2011, 166). Bearing this in mind, teachers must be prepared to identify the evolving motivational needs of their students in order to spark the desire to write in the content areas.

Intrinsic and Extrinsic Motivation

To provide students with a motive to write is to provide them with relevant and real reasons to write, instilling within them a desire or a need for writing. In order to motivate today's 21st-century learners who are, according to John Seely, "growing up digital," teachers must explore new motivational strategies to adapt to the changing needs of today's students (quoted in Wagner 2008, 170).

There is no doubt that today's world is drastically different from the world 100 years ago. So, why is it often the case that educators implement motivational strategies that are similarly outdated and no longer relevant to the students they seek to motivate? In Bob Sullo's *Activating the Desire to Learn*, he makes the argument that teachers' instruction should be evolving to meet the motivational needs of their students instead of rigidly adhering to ineffective strategies of the past (2007, 5):

Given that we've spent a century or so believing that external stimuli explain human behavior, teacher training programs typically require educators to learn how to systematically reward and punish students. Many educators thus see themselves as responsible for shaping the behavior of students by extrinsically rewarding them for compliance. Yet ironically, our system of rewarding students for academic achievement devalues the very thing we say we want: learning. 'If it weren't for the reward we are offering, what we are teaching you would not be worth learning.' In short, a system of education based on rewards and punishment is fundamentally anti-educational.

In this sense, *extrinsic* motivation is a form of motivation external to students, a form in which rewards and punishments are tangible and concrete. But as Sullo (2007) argues, extrinsic motivation does not seek to instill the lasting desire or need to write.

Intrinsic motivation is the alternative to extrinsic motivation and a form of

motivation that has longterm, lasting results. Educators need to demonstrate the value of writing by making the writing process relevant to students' lives and important to their success both in and out of the classroom.

Interests

Many motivational strategies exist to help generate student interest in particular writing tasks, but one strategy to promote interest in writing focuses on fostering the lifelong love for *reading* that extends beyond the day-to-day reading tasks of classroom life. As aforementioned, intrinsic motivation has longterm results, which makes intrinsically motivating students to write the preferred method of motivation. To do this, teachers should become familiar with students' interests as early in the school year as possible, provide students with reading materials throughout the year that are specific to their interests, and tailor writing assignments to students' needs and interests. Once these high-interest texts are made available, students are more likely to be self-motivated to read because they *want* to discover more about the topics that interest them, oftentimes inspiring them to write extensively on nonfiction topics that interest them most. Reading texts of interest allows students to fine-tune their literacy skills in the context of reading experiences that are interesting, familiar, and comfortable for them, in turn providing them with the confidence and practice needed to effectively navigate and write about texts that are more advanced, unfamiliar, or unexciting. Additionally, reading from a variety of informational texts allows students to use them as mentor texts for writing assignments by absorbing the structure, language, and style of the nonfiction writing they read, which students can apply in their own nonfiction writing.

Unfortunately, many students do very little reading and writing, and some do not read or write at all outside of school, which makes the act of writing a difficult skill to teach: How can you teach students to write when they have limited exposure to good models of informational writing? It is for this reason that teachers, especially mathematics teachers, must encourage and provide many opportunities for students to read and write about engaging materials. According to Rosalie Fink, “[r]eading interest inventories are easy to administer and modify to fit each student’s age or developmental stage” (2006, 18). Distributing surveys is a quick and confidential way to ask questions of your students that are geared toward discovering interests that may otherwise be overlooked. These surveys may also help you assign writing tasks that are specific to students’ interests, which motivates students to first read a variety of informational texts on their topic of interest before delving into expressing their understanding through writing. As we all know, interests can take many shapes, so ask questions that are purposeful in

determining your students' interests and helpful in locating texts about these interests, such as categorical topics related to family, sports, friends, hobbies, books, movies, dream careers, food, music, or any other subject. There are a variety of student-interest surveys available online you can use to inspire your own survey, or you can create a survey of entirely your own making.

An Authentic Audience

Students today must “respond to the varying demands of audience, task, purpose, and discipline,” according to the Common Core State Standards (2010). The mere act of publishing students' polished pieces of writing is motivating in and of itself: “Recognizing students' writing by publishing it may be the single most powerful task of the writing process” (Combs 2012, 167). What better way to show students that their writing is valued and taken seriously than to publish their work for all to see, thus providing students with an authentic audience to view and constructively critique their work? The act of publishing student writing—on the classroom walls, in the school hallways, or even on a classroom website or blog—prompts students to write with purpose in mind as they tailor their written work for public display. Additionally, the structure of the writing process—prewriting, drafting, revising/editing, and publishing—is inherently interactive and engaging for students as they collaborate and work together to workshop their writing and improve their literacy skills (Peregoy and Boyle 2005, 215):

When you use the process writing approach, writing ceases to be a solitary activity and becomes a highly interactive group endeavor. Of course, individuals ultimately own their work. However, throughout the phases of the writing process, they have worked with the whole class, in pairs, and in small groups, brainstorming ideas, focusing on their topics, considering ways to express themselves, revising their papers, getting ready for publication, and, finally, sharing their polished pieces with the entire class. Thus, the process approach calls for group collaboration and support at every phase: prewriting, writing (drafting), revising, editing, and publishing.

The writing process is collaborative and active, which is highly motivating for 21st-century learners. Moreover, “In *Growing Up Digital* (1998), Don Tapscott said that this ‘Net Generation’ watches much less television than did its parents. The television is not interactive, and this generation prefers to be active participants in all that they do,” which marks the writing process as highly engaging for today's active learners (Tileston 2004, 3). In addition to having students be active participants throughout the writing process, the mere act of collaborating with one another is an authentic experience with an

audience: the students' peers. This collaboration serves to motivate students to produce writing that takes into account the demands of their peers (audience) while also helping students to develop the Speaking & Listening skills outlined in the Common Core State Standards (National Governors Association Center for Best Practices, Council of Chief State School Officers 2010).

The Classroom Library

Given the connection between reading and writing, providing students with access to high-interest, engaging texts is critical to their success in developing proficiency in writing. One of the easiest and most effective ways to improve literacy is to allow time for students to read during class. Students who frequently read a wide variety of materials have better vocabularies and better reading comprehension skills that can be applied in their written work. As Randall Ryder and Michael Graves (2003) point out, wide reading fosters automaticity in students because it exposes them to more words in different contexts, provides them with knowledge on a variety of topics, and promotes lifelong reading habits.

Teachers can create a mathematics library corner in their classroom libraries by collecting and providing high-interest mathematics texts for students to read. Mathematics teachers have an intimate knowledge of mathematics-based reading materials for a wide range of reading abilities, so they can recommend books to any student to read outside of class. Lesley Mandel Morrow, president of the International Reading Association (2003–04), explains that research indicates children in classrooms with literature collections read 50 percent more books than children in classrooms without such collections. As such, this percentage likely translates into the sheer volume of writing students are able to produce. According to Harvey (1998, 4), “the best nonfiction writing emerges from topics the writer knows, cares, and wonders about and wants to pursue,” which makes the availability of high-interest texts critical to the development of students' written abilities. With the availability of high-interest texts, students are able to identify their interests and pursue topics that they find highly engaging to write about.

High-Interest Texts

Working with the school librarian or media specialist and parent organizations is a great way to build a sizeable collection of texts for their classrooms, which can be a mixture of informational and fictional books from which students can choose to read based on their interests. Bear in mind that this library may serve to generate the interest to read and write about a variety of

texts on many different subjects, so providing students with a wide range of texts from which to choose will be beneficial in fostering students' desire and motivation to read and write. In addition to simply providing students with informational and fictional texts, be sure to provide texts that are at your students' readiness levels and also texts that may present more of a challenge. The rich diversity of language students will encounter from immersing themselves in high-interest texts will serve as models of good mathematics writing around which students can mirror their own writing, allowing them to express their understanding and comprehension of mathematical concepts coherently and purposefully. Especially with interest-based texts, students can build their prior knowledge about a given topic at a less challenging reading level, in turn preparing them to apply their understanding through writing. "Michael Pressley and his colleagues (2003)...found high-motivational and high-performing classrooms were, above all, filled with books at different levels of text difficulty. Conversely, on their list of the characteristics of classroom practices that undermine motivation and achievement is: 'The teacher does not give students opportunities to have power over their own learning. Students do not have choice in their work'" (Calkins, Ehrenworth, and Lehman 2012, 50), which is counterproductive to what we as teachers aim to achieve in the context of the Common Core: fostering the literacy skills students need to be "college and career ready." Furthermore, according to Fink, "the more a student reads in one content area, the 'richer' or better that student's reading becomes in that content area," which in turn will translate into students' success with writing in the content areas as they absorb the academic language of the informational texts available to them (2006, 79). This notion is in line with Fink's other findings regarding the language acquisition of English language learners, which is applicable to all students' language acquisition: "to encourage striving readers...to read [and write] about their interests, teachers should create their own content area libraries full of enticing materials at all readability levels" (81).

Oftentimes students are unaware they have interest in a particular topic until they encounter it for the first time, so providing a variety of interest-based texts can only serve to offer students a wide variety of texts from which to read and topics about which to write. Additionally, research suggests that the most influential factor in motivating students to read is "ensuring the students [have] easy access to high-interest texts," so making these high-interest texts available to your students is an important factor to consider when developing your classroom library (Calkins, Ehrenworth, and Lehman 2012, 50). To support students' nonfiction writing, it is important to provide them with a variety of high-interest mathematics reading materials that both motivate and inspire them throughout the writing process:

- **Number and Operations** (counting, addition, subtraction, multiplication, division, skip counting, place value, etc.)
- **Measurement and Data** (length, width, perimeter, area; graphing, table making, chart making)
- **Geometry** (shape recognition, polygons, etc.)
- **Operations and Algebraic Thinking** (patterning, functions, etc.)
- biographies of famous mathematicians (Archimedes, Isaac Newton, George Cantor, Leonardo Fibonacci, René Descartes, etc.)

Differentiation

Below-level students will benefit from scaffolding as well. They may need to be constantly reminded to refer to their rubric—which should be adapted to address their individual needs—to meet the expectations of the assignment. Teachers can provide graphic organizers during the prewriting phase to help these students get started in an organized fashion. When revising and editing, teachers can model how to identify errors and make changes so that these students have a clear understanding of this difficult stage of the writing process.

Above-level students can be challenged at each step of the writing process to work more independently, create longer or more elaborate pieces, use multiple sources, write from different points of view, incorporate richer vocabulary, or write with a greater variety of sentence structures. Teachers should also adapt rubrics to challenge these students.

The English language learner should not be left out of this discussion. Second language acquisition for English language learners is strikingly similar for native English speakers and non-native English speakers: *“English reading and writing development processes are essentially similar for both English learners and native English speakers... That is, in reading, all learners gradually come to use their developing English language knowledge, their world knowledge, and their understanding of print conventions to make sense of written text. Similarly, in writing, they use their developing English language knowledge, world knowledge, and understanding of print conventions to put their ideas on paper”* (Peregoy and Boyle 2005, 159). In looking at this statement, it is clear that the relationship between reading and writing is not exclusively reserved for native English speakers; language acquisition—whether first or second language acquisition—is largely similar for all students, so the explicit instruction of both reading *and* writing strategies will help to remedy any imbalances in reading and writing skills

you identify in your English language learners.

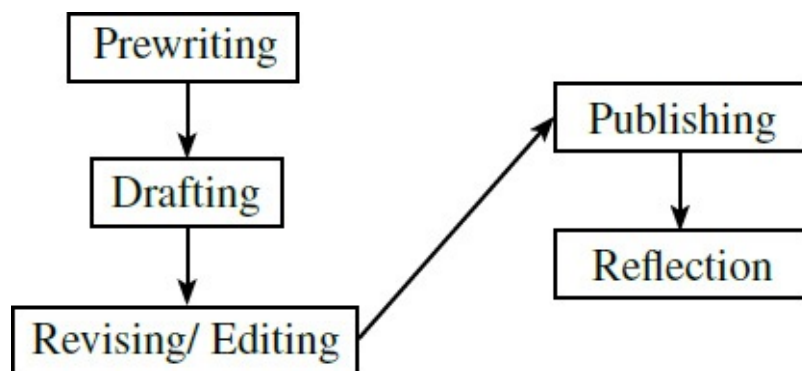
The demographics of students in our classrooms today is becoming increasingly more diverse, prompting teachers to differentiate their instruction to allow for students of all backgrounds and languages to develop the skills necessary to succeed. And with this growing diversity, it is important to note that English language learners often struggle with more than just accessing content but also with developing literacy skills in the context of unfamiliar cultural references, tales, and legends that native English speakers are naturally more familiar with. Because the Common Core State Standards emphasize the shared responsibility of teachers across content areas to help students learn to read and write critically, providing English language learners with access to texts that will help develop their overall reading ability is also essential to developing their writing skills. English language learners “will benefit from actively seeking exposure to language and social interaction with others who can provide meaningful input in the second language. Furthermore, they—and you, the teacher—can enhance students’ English language skills by placing language learning in meaningful and interesting contexts” (Dunlap and Weisman 2006, 11).

It is our responsibility to provide students with meaningful and interesting contexts to learn language and build their literacy skills. The ability to access content and demonstrate mastery of particular skills and knowledge through writing hinges on each student’s ability to dissect and interact with texts, unquestionably marking the act of reading as a necessary skill to succeed with informational academic writing. When implementing the writing strategies in this book, discuss the importance of using a variety of writing strategies to express their understanding of the new information they glean from their reading of informational texts so that the importance of reading, writing, and developing fine-tuned literacy skills is effectively communicated and made known. The explicit instruction of the writing strategies provides English language learners with meaningful contexts for learning language, so this discussion is of the utmost importance in establishing a reason for writing in the content areas, not only for your English language learners, but for all of your students. In doing so, teachers simultaneously aid in the development of students’ collaborative, communicative, and group-based skills emphasized in the Common Core State Standards’ Speaking & Listening skills, subsequently helping all students to strategically communicate and interact with those around them within the context of the English language.

The Writing Process

“A writer,” say James Britton et al. (1975, 47), “draws on the whole store of his experience, and his whole social being, so that in the act of writing he imposes his own individuality.” The most complex form of writing is the college-level argumentative essay. Taking notes is the least complex form of writing. Writing for meaning and expressing oneself to others is intricate and complex work. Using the writing process helps the writer take a piece of writing from the beginning, or brainstorming, to the end, or the published piece. This process is especially important to follow as students write mathematics reports and other writing assignments. The writing process at the emergent writing level is usually conducted as a group, though on occasion it is done individually. Students in higher grades who have more familiarity with the writing process can complete it individually.

What is the writing process? It includes prewriting, drafting, revising/editing, publishing, and reflection. Read the description of the writing process steps below. There are different points to consider at each step of the writing process.



Prewriting

This is the phase where all writing begins. At this stage, writers generate ideas, brainstorm topics, web ideas together, or talk and think about ideas. Teachers explain that students may get writing ideas from personal experiences, stories, pictures, magazines, newspapers, television, and a variety of other sources.

This phase sets the foundation for a specific piece of writing. Before brainstorming or prewriting can begin, students need instruction on the genre or format (data report, journal entry, visual presentation, etc.), audience (the teacher, fellow classmates, mathematics competition judges, etc.), and purpose (to explain, to persuade, to inform, etc.). These elements impact the

types of information to brainstorm.

Students need to have a clear understanding of a mathematics topic before they are expected to write or report on it. Teachers can provide resources for research and model note-taking strategies. Mathematics topics are often complex and difficult to understand, so discussion will help prepare students to write. Such strategies as Note-Taking (pages 123–136) and Using Diagrams and Maps (pages 137–172) can help students organize the major points in their writing.

What does prewriting look like?

- researching a chosen topic, using print and digital sources
- analyzing the characteristics of the intended genre
- examining sample writing pieces
- discussing the topic with the teacher, a partner, or the class
- brainstorming ideas about the topic
- using webbing or other graphics to organize information
- discussing the assessment tool

Drafting

At the drafting stage of the writing process, students begin to put their ideas on paper. Students need to keep in mind the genre or format, audience, and purpose. For beginning writers, pictures and drawings may very well be part of the composition. Teachers should encourage students to write as much as they can on their own throughout the writing process.

Another area that students struggle with is writing in an orderly manner. Students should already have graphic organizers, notes, or outlines from the prewriting stage that can help them sequence and organize their writing.

What does drafting look like?

- working fairly quickly
- leaving blank spaces for missing words
- guessing at spelling
- focusing on simply putting ideas on paper
- using notes or graphic organizers to stay focused
- drafting a preliminary version of the writing assignment (story, letter, report, essay, etc.)

Revising/Editing

This phase of writing consists of two parts: revising looks at the organization and the structure of the writing while editing looks at the mechanics of the writing. Students must understand how to do both. When revising, students analyze their writing for the required traits: sequencing words in a data report, descriptive language in a mathematics fiction story, topic sentences and supporting details in a persuasive essay. They also ask questions of their writing: *Does it make sense? Is anything out of order? Should anything be added or deleted?* Use the Self-Assessment strategy (pages 239–241) to give students an opportunity to evaluate their own writing. Use the Teacher Conference strategy (pages 244–245) to give students feedback throughout the writing process.

What does revising and editing look like?

- reading the writing aloud to make sure that it makes sense
- adding missing information
- deleting unnecessary, incorrect, or duplicate information
- proofreading for spelling, capitalization, grammar, and punctuation
- self-analysis by students
- conferences with peers or the teacher

Publishing

Publishing allows students to write for an authentic audience and celebrate their hard work. It occurs after the other steps are completed and students are ready to produce the final copy, which can be handwritten or typed on a computer. Teachers should consider the abilities of their students. The goal is to present the written information attractively so others can enjoy it.

What does publishing look like?

- creating a final copy
- adding illustrations, borders, a cover, etc.
- sharing orally
- publishing “in-house” in a class book
- posting on a classroom website, blog, social media site, or other digital platform

Reflection

Reflection is a key element in the writing process. It encourages the writer to think about his or her writing, look at the writing from a different point of view, and see progress in the writing effort. Reflection also allows the writer to look back at brainstorming and the beginning of a writing project to see if the original goals were met.

What does reflection look like?

- Reading what has been written and asking the following questions:

Is that what I wanted to say?

Is there more I should have written?

Which is my favorite part in this writing?

Did I write this piece the way I planned?

What can I learn from this assignment?

How can I continue to improve my writing?

The Writing Process Center

As previously stated, the writing process involves the different stages from developing an idea to publishing a piece of written work. Students need support to create a finished product. Teachers can set up permanent stations throughout their classrooms for each stage of the writing process. This not only motivates students at each stage of the writing process but also makes it easier to incorporate all stages of the process. This way, students will have access to all the materials needed to work through the writing process. Here are some ideas for each station of the writing process:

- **prewriting**—texts with writing suggestions and ideas, story starters, writing samples, pieces of writing about mathematics, blank graphic organizers, books and magazines about mathematics topics, and encyclopedias
- **drafting**—established rubrics and criteria, music available for students who need a relaxing environment as they write, resources, pencils, erasers, floor pillows, and comfortable places to sit and write
- **revising**—peer editing checklists, samples of quality writing, rubrics, and word lists (such as a list of vivid verbs to replace more overly used verbs)
- **editing**—dictionaries, thesauruses, writing reference books, colored pens

or pencils, and proofreading checklists

- **publishing**—computers, pens, bookbinding materials, sample finished products, a printer, colored pencils for illustrations and diagrams, rulers, a variety of lined and unlined paper, and access to the Internet for digital publication

Bulletin Board Writing Display

Student exposure to writing is often limited. Therefore, it is imperative for the teacher to provide students with a wide variety of writing samples relating to mathematics (Ryder and Graves 2003). These samples should be available for students to look at and use as models. Designate a bulletin board in the classroom to display these writing samples or devote a page on the classroom website that showcases exemplary writing samples. Be sure to add to the collection frequently so that students remain interested and curious about the new additions. Encourage students to bring in samples of writing that are related to mathematics. This will also help them locate and identify mathematics-related writing samples.

Writing Across the Curriculum

Mathematics teachers may wonder where writing fits in the mathematics curriculum. What do run-on sentences have to do with fractions and exponents? The answer lies in the fact that writing is the means through which students are able to articulate complex mathematical terms and synthesize concepts. Writing is a tool that students can use to understand and dissect the subject of mathematics. It is a tool that allows students to translate complex ideas into words and language they understand.

There is an overemphasis on the process of writing instead of using writing to assist comprehension and understanding (Fisher and Frey 2004). In general, writing assignments in mathematics mainly consist of asking students to write the answers to the questions at the end of the textbook chapter, with an occasional mathematics journal response with little direction from the teacher. Evidence shows mathematics achievement increases when students are actively engaged in reading, thinking, and writing about what they are learning.

Research shows that there are two forms of writing that need to take place across all subject matters being taught. One form is called *writing to learn*, and the other form is *learning to write*. Anne Walker (1988) explains that the two forms are parts of a virtual circle. Writing allows students to become active in their learning. Active learning requires active thinking. In order to write, students need to be actively thinking (Steffens 1988; Walker 1988). A teacher who works as a facilitator of knowledge will encourage deeper thinking, therefore increasing student understanding (Self 1987; Hamilton-Wieler 1989).

Does Writing Across the Curriculum Work?

Research studies (Gere 1985; Barr and Healy 1988) seem to suggest that writing in the content areas does make a difference. Mary Barr and Mary Healy state that “schools succeed when the emphasis by both teachers and students is on writing and thinking about relevant and significant ideas within the subject areas.” The encouragement of writing across the curriculum leads to higher-order thinking skills (Gere 1985), especially in consideration of the fact that “colleges are consistently reporting that incoming students have weaker reading and writing skills than the freshman classes before them...and findings also show that our children are not demonstrating writing skills that will allow them to eventually perform well in the workplace” (Allyn 2013,

10). Writing across the curriculum will aid students in developing the literacy skills they need to communicate their understanding for college and beyond. Additionally, shifts in student attitudes have been documented as a great benefit to writing across the curriculum (Winchester School District 1987). And with the evolving needs of today's learners and the variety of multigenre, multimodal texts they will encounter, "the ability and propensity to read and understand nonfiction is a necessary skill for students involved in inquiry and research," marking the act of writing across the curriculum as a necessity to students' success outside the classroom (Harvey 1998, 69).

Is there enough time to write and cover all the objectives and demands of the mathematics curriculum? Research shows that writing can help meet those objectives and demands. Here are three time-saving advantages to consider (Worsley and Mayer 1989; Hightshue et al. 1988; Self 1987):

- Mathematics teachers find that they need less review time if students write about the concepts.
- Mathematics teachers spend less time reteaching content after testing if they have incorporated writing strategies in the curriculum.
- Most writing in mathematics classrooms does not need to be heavily graded, so the teacher's workload is decreased.

Ideas and Questions to Consider

The emphasis on literacy is not enough. The new emphasis is on *content literacy* (Fisher and Ivey 2005). Content literacy supports the view that students construct knowledge through activities such as reading, discussion, and writing. Students must begin to personally connect with the content information they are learning and gathering as they study mathematics.

Douglas Fisher and Nancy Frey (2004) explain that learning is language-based. Telling students information is not sufficient. Students must think about, read about, talk about, and write about information in order to synthesize it and to retain it. Reading and writing are critical to all learning. Questions to ask about how to incorporate reading and writing into content area learning are suggested by Hefflin and Hartman (2002):

- How do you determine what to write about?
- What is the goal and the purpose of the writing?
- How will the writing be assessed?
- What is being activated or constructed by the writing?
- What supports the bridge between what students write and read?

- Who does the writing in mathematics class?
- What role does discussion play in preparing to write?
- What role does discussion play during writing?
- How will you know the writing activity or assignment is successful?
- How will you know when to use which writing strategy?

Writing to Learn

Writing helps create the bridge between the content knowledge and understanding. Reading from the textbook and answering the questions is a very passive way to learn and not engaging for today's learners. A wide variety of writing assignments and activities can help students become actively engaged in mathematics. Examples include mathematics journals, free writes, vocabulary journals, observation reports, topic analyses, diagrams, and charts. All of these writing formats encourage students to think about mathematics and connect prior knowledge or experiences with new learning.

Writing to learn is expressive writing that encourages students to write about what they are thinking and learning. Examples of this type of writing are journal entries, reflections, reading responses, question-answering, personal notations, etc.

Not all writing-to-learn activities must be graded. Teachers should offer feedback and comments but should not feel compelled to grade the spelling, grammar, organization, and content of these writing activities. The purpose of writing-to-learn activities is to promote active learning, encourage discussion, engage all students, and encourage thinking. There is usually a required time set aside to complete the writing. These less formal writing assignments may be expanded into more formal assignments.

Writing to Apply

When students use their new knowledge in mathematics to write in a more formal manner, they are writing to apply. In these activities, students are asked to analyze and synthesize information and then communicate their thoughts in a coherent, organized manner. This type of writing can be more challenging for students because they need to not only understand the content and be able to process it at a higher level but also communicate it using the strategies of the writing process, the features of the chosen genre, and the conventions of the grade level. Teachers are most likely comfortable with this type of writing in mathematics class, as it may have been what they were

exposed to in school.

One familiar example of this type of writing is a research report. However, there are many other options to consider: microthemes, friendly letters, business letters, fictional stories, and more. Unlike writing-to-learn activities, writing-to-apply activities are meant to be graded. With these assignments, students are showing what they have learned, demonstrating their capability to communicate in a formal writing format. A variety of assessment options are described in Part 3 of this book.

Assessing Student Writing

To be effective in communicating their learning through writing, students need ongoing feedback throughout the writing process in order to develop their ideas and revise their written work. And in the same way that the writing process occurs in phases, assessment of written work should similarly occur in phases as an ongoing, collaborative process with students. Assessment of student writing can take many different shapes, including providing students with clear, straightforward rubrics to assess and guide their final work, and more informal feedback in the form of conferring with students and comments on written work.

Rubrics

Students' writing should be formally assessed at the end of the writing process as students submit final, polished pieces that demonstrate their understanding of mathematics concepts and topics. Providing students with straightforward rubrics that clearly lay out your expectations is effective in sharing which components of students' writing will be evaluated and each component's quantifiable importance. In doing so, you inform students which pieces of their writing hold the greatest significance for that particular assignment and which skills they should focus on most. However, in order to create a well-crafted rubric, you must first identify the learning objectives of the assignment and how much weight to give to each component on the rubric.

Consider evaluating students' mastery of content knowledge and students' writing skills in different categories, allowing for you to both evaluate how well they understand the concept being investigated through writing and how well they articulate their understanding through their written work. As appropriate to the assignment, assign each category (e.g., Ideas, Audience, Structure, Mathematical Understanding) a quantifiable value (e.g., 1–10 or A–F) that students understand and skills that students are prepared to demonstrate (e.g., *Strong audience awareness; Engages the reader*

throughout). Distribute rubrics to students to support them as they set out to begin a writing task, continuing to refer to your expectations throughout the writing process as they work toward completing the assignment. This way, you reiterate your expectations and support students' growth as writers in a very clear and straightforward manner where skills and expectations are both attainable and quantifiable.

Informal Feedback

After distributing rubrics and thoroughly discussing your expectations for a particular assignment, confer with your student writers during the writing process to provide them with an informal setting to workshop their writing and to improve their written communication prior to evaluating their final work.

Conferring

Conferring with students is a form of assessment that is interactive, and the immediacy of your verbal feedback is invaluable to students' development as writers. Ask students about their work, their ideas, their understanding of mathematics concepts, and their grasp of the conventions of writing, among other questions. Model for students the best strategies for editing and revising their work. Whether conferring with students individually or in small groups, constructively critique students' writing by acknowledging areas where students have met or are working toward meeting your expectations and areas that need improvement, being mindful to not overload students with excessive, unfocused comments. Your informal feedback should guide students in the direction of meeting the criteria for the assignment but not to the point where revising their work seems like an impossible task. Allow students to maintain ownership of their work by suggesting "options or open-ended alternatives students can choose for their revision path" (University of Nebraska–Lincoln Writing Center 2013). In doing so, students learn both to assess their own writing and to revise accordingly. Conferring with the young writers in your classroom is crucial to their development and growth as writers.

Written Comments

As students work toward meeting the expectations for a particular writing assignment, reviewing their drafts and providing them with specific and focused feedback is vital to their success in conveying their mathematics knowledge through writing. When reviewing students' drafts, making notes on their work may prove effective in identifying specific areas in need of improvement (e.g., marking misspelled words, grammatical errors, or unclear

and unfinished thoughts). Identifying these areas of improvement will inform your instruction, allowing you to modify your explicit teaching of the writing strategies in order to help students become better writers. Apart from specific feedback, you can evaluate the written work as a whole (e.g., writing comments at the end of a paper), with less focus on particulars and more emphasis on the overall success of the written piece in meeting the expectations identified in the rubric.

Spotlight Reading

Providing students with informal feedback can be an enjoyable moment as well where students are excited to share their work with the class. Set aside a time each week for students to read aloud and share the writing they have accomplished or are working on. These writings may be less formal pieces such as journals, free writes, or feature analyses, or they may be formal writing pieces like observation reports. This practice keeps students focused and aware of an audience as they write, and it allows them the opportunity to give and receive feedback. It is an effective way to validate the hard work and effort of students and may even eliminate the need for the teacher to formally assess a piece of writing. Finally, this spotlight reading also provides an opportunity for students to hear their writing aloud. They will automatically think of things they are learning about mathematics objectives and they will become more aware of what they need to change to improve their writing.

Writing instruction

What Great Teachers Do to Encourage Writing

- 1. Share vocabulary-rich books and reading materials about the subjects you are studying in mathematics class.** Megan Sloan (1996) explains that the best source of learning about mathematics vocabulary is reading good books that use the words. This allows the teacher to introduce them, allows the opportunity for students to hear them in context, and provides an opportunity to discuss the mathematics vocabulary words.
- 2. Provide plenty of time for students to experience the writing process** (Corona, Spangenberg, and Venet 1998). It takes time to teach the writing process, but it is worth it. Taking a writing project from planning to publication is very meaningful to students because it validates their efforts and understanding of mathematics concepts.
- 3. Allow time for students to evaluate others' writing and receive teacher feedback** (Corona, Spangenberg, and Venet 1998). Writing is communication. Students need to share their writing with others, both giving and receiving feedback from peers and teachers. This helps to cement students' understanding of mathematics concepts. The process also provides teachers with the opportunity to clarify and reteach concepts as needed.
- 4. Offer daily writing opportunities to your students.** "A writer-centered classroom emphasizes using written expression to communicate ideas. Writing is an important part of all areas of the curriculum" (Corona, Spangenberg, and Venet 1998, 29). Be sure to include a wide variety of assignments. Some assignments might be more formal while others may be more casual. Also include a range of different types of writing such as journal entries, outlines, poetry, reports, short stories, etc. Students usually benefit from having a choice regarding what they are asked to write about. Encourage students to use mathematics vocabulary when they write.
- 5. Encourage students to be aware of and look for new and interesting mathematics words.** Students can browse through books looking for words that catch their attention and add them to their vocabulary journals. They may also be assigned to look for specific mathematics words that are being studied in class. Finally, create a

Word Wall in your classroom (see pages 34–38).

- 6. Incorporate practice and repetition as a way for students to become familiar with vocabulary words and how they are to be used** (Laflamme 1997). Students can be exposed through writing, discussions, modeling, classroom exercises, and reading.
- 7. Teach students the strategies to read, understand, and write about increasingly complex text.** These same strategies can help students work through difficult concepts to arrive at deep learning. Students who can recognize text patterns will be better prepared to use those patterns in their own writing (Fisher and Ivey 2005).
- 8. Focus students' reading and writing on big ideas. Don't get caught up in the details.** Rote learning does not lend itself to lifelong learning. Focusing on themes, concepts, and big ideas lends itself to linking new information to prior knowledge as well as life experiences and events that are happening in the world today.

Writing Venues in the Mathematics Classroom

Mathematics teachers can easily incorporate the same techniques that language arts teachers have used for years to help students become more strategic and skilled writers and to help them comprehend and write about the mathematics materials they encounter. There are a variety of ways to teach students new ideas and to incorporate writing into the mathematics curriculum. The first is to consider changing class configurations to use writing in mathematics. Content-area teachers often lecture to the whole class and seldom pair students together or assign small groups to work together for reading and writing. Following are suggestions for the types of configurations a mathematics teacher can consider:



Large groups are best for:

- introducing a new writing strategy
- modeling think-alouds to show how good writers work through a piece of writing
- practicing think-alouds to apply a strategy to students' own writing and allowing students to share their experiences and ideas using the strategy



Small groups are best for:

- providing more intensive instruction for students who need it
- introducing above-level students to a new writing piece or strategy so that they can apply it independently to more challenging writing assignments
- preteaching new strategies and vocabulary to English language learners or below-level students



Conferences are best for:

- checking students' understanding of mathematics concepts and the writing strategies being used
- providing intensive writing strategy instruction for students who may need extra attention
- coaching students in how they might reveal their thinking by writing to others
- pushing students to use a strategy to think more deeply than they might have imagined possible
- individually editing and correcting student writing



Pair students with partners:

- to discuss free writes, dialogue journals, think-pair-share, etc.
- to edit and gather input on product writing pieces

Habits of Highly Effective Writers

Nell Duke and P. David Pearson (2001) have established that good readers read and write a lot. They also set goals, make predictions, and read selectively. Many of the same practices of good readers are also done by good writers. Here are some more specific suggestions for highly effective writers:

- **Good writers write all the time.** The more experience one has writing, the better writer he or she becomes. Learning to write takes practice and more practice!
- **Good writers read a lot.** Reading provides a great model for writers as to what the finished product looks like (Fisher and Ivey 2005). Students who read will know how to write better than those who do not.
- **Good writers are aware of correct spelling.** There are no excuses for poor spelling. Commit to learning and using correct spelling in writing—even in the rough draft, if possible. Good writers use all the resources available and understand the limitations of computer spell-check programs.
- **Good writers appreciate critiques and feedback.** Good writers have a “thick skin” and ask for input and suggestions from many different sources.
- **Good writers keep a learning log handy.** The learning log can be used to store good writing ideas, to document what is being learned, to activate prior knowledge, and to question what is being learned (Brozo and Simpson 2003; Fisher and Frey 2004). Using this learning log also helps cement learning and helps students avoid writer’s block.
- **Good writers write for a variety of purposes.** Learning to write in a variety of formats makes for a well-rounded, experienced writer. Teachers should expose students to different types of mathematics writing formats.
- **Good writers read and edit other people’s writing.** Good writers look for opportunities to work with others to improve their writing. Peer editing groups are an excellent way to get feedback and reinforcement from peers. This feedback is important for the self-image of the writer (Gahn 1989). Editing others’ work will also help students recognize writing errors, such as an off-topic response, a weak topic sentence, a lack of supporting detail, weak vocabulary, and errors in spelling or grammar.
- **Good writers think objectively.** Good writers need to be able to step back and really look at their writing. Some writers are so happy to be done with their writing that they never really look at it again.
- **Good writers read it out loud!** Teachers can encourage students to give their writing a voice. Many errors or additions are discovered when a student listens to the writing being read aloud.
- **Good writers use and create rubrics and checklists.** Mary Huba and

Jann Freed (2000) reiterate the importance of using and creating rubrics and checklists, which help to clarify the expectations for writing assignments. Rubrics and checklists also enable students to become self-directed in mastering the content learning.

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