Rigor in Mathematics

Educational Leadership:Teaching for the 21st Century:Six Steps to Better Vocabulary Instruction

September 2009 | Volume **67** | Number **1** **Teaching for the 21st Century** Pages 83-84 Robert J. Marzano

In their research, classroom teachers have taught us something about how to best use specific instructional strategies. Let's begin with a strategy for teaching vocabulary referred to as *the six-step process* (Marzano, 2004). It involves the following steps:

1. **Provide a description, explanation, or example of the new term.**
2. **Ask students to restate the description, explanation, or example in their own words.**
3. **Ask students to construct a picture, pictograph, or symbolic representation of the term.**
4. **Engage students periodically in activities that help them add to their knowledge of the terms in their vocabulary notebooks.**
5. **Periodically ask students to discuss the terms with one another.**
6. **Involve students periodically in games that enable them to play with terms.**

   (Teachers use the first three steps when introducing a term to students. Steps 4, 5, and 6, which needn't be executed in sequence.)

What Teacher Research Found

Over the last five years, I have been involved in more than 50 studies that involve this strategy. In all these studies, teachers used the strategy with one class but did not use it with another. Then they compared the results.

These studies have taught us several things about this six-step strategy. First, the strategy works at every grade level, from kindergarten to high school. Second, it works better if you use all the steps without leaving any out. In one middle school study, teachers found that the *whole* process enhanced students' achievement much more than the parts of the process in isolation did. Third, although the majority of studies indicate that the process enhances student achievement, some studies indicate that it doesn't.

Happily, the research is also beginning to tell us what does or doesn't make the strategy work. Here's what we've learned so far:

- When students copy the teacher's explanation or description of a term instead of generating their own explanation, the results are not as strong. Ideally, student explanations should come from their own lives.
- The third step in the process is crucial—having students represent their understanding of a new term by drawing a picture, pictograph, or symbolic representation. When students do this step well, achievement soars.
- Games seem to engage students at a high level and have a powerful effect on students' recall of the terms. Games not only add a bit of fun to the teaching and learning process, but also provide an opportunity to review the terms in a nonthreatening way. After the class has played a vocabulary game, the teacher should invite students to identify difficult terms and go over the crucial aspects of those terms in a whole-class discussion.

Educational Leadership:Common Core: Now What?:Closing in on Close Reading

by Nancy Boyles December 2012/January 2013 | Volume **70** | Number **4**
Common Core: Now What? Pages 36-41

What Is Close Reading?

Essentially, close reading means ***reading to uncover layers of meaning that lead to deep comprehension***. The Partnership for Assessment of Readiness for College and Careers (PARCC) supplies clarification useful for teaching with Common Core standards in mind:

> Close, analytic reading stresses engaging with a text of sufficient complexity directly and examining meaning thoroughly and methodically, encouraging students to read and reread deliberately. Directing student attention on the text itself empowers students to understand the central ideas and key supporting details. It also enables students to reflect on the meanings of individual words and sentences; the order in which sentences unfold; and the development of ideas over the course of the text, which ultimately leads students to arrive at an understanding of the text as a whole. (PARCC, 2011, p. 7)

If reading closely is the most effective way to achieve deep comprehension, then that's how we should teach students to read. But that description doesn't match much of the instruction I've witnessed in recent years.

Craft Technique	Possible Questions
Imagery, including comparisons: • Similes • Metaphors • Personification • Figurative language • Symbols	What is being compared? Why is the comparison effective? (typically because of the clear, strong, or unusual connection between the two) What symbols are present? Why did the author choose these symbols?
Word choice	What word(s) stand out? Why? (typically vivid words, unusual choices, or a contrast to what a reader expects) How do particular words get us to look at characters or events in a particular way? Do they evoke an emotion? Did the author use nonstandard English or words in another language? Why? What is the effect? Are there any words that could have more than one meaning? Why might the author have played with language in this way?
Tone and voice	What *one* word describes the tone? Is the voice formal or informal? If it seems informal, how did the author make it that way? If it's formal, what makes it formal? Does the voice seem appropriate for the content?
• Sentence structure • Short sentence • Long sentences • Sentence fragments • Sentences in which word order is important • Questions	What stands out about the way this sentence is written? Why did the author choose a short sentence here? (for example, so it stands out from sentences around it, for emphasis) Why did the author make this sentence really long? (for example, to convey the "on and on" sense of the experience.) Why did the author write a fragment here? (for example, for emphasis or to show a character's thoughts) Based on the order of the words in this sentence, which word do you think is the most important? Why? What was the author trying to show by placing a particular word in a certain place?

Educational Leadership:Feedback for Learning:Seven Keys to Effective Feedback

By Grant Wiggins September 2012 | Volume **70** | Number **1**
Feedback for Learning Pages 10-16

Whether feedback is just there to be grasped or is provided by another person, helpful feedback is goal-referenced; tangible and transparent; actionable; user-friendly (specific and personalized); timely; ongoing; and consistent.

Educational Leadership:Expecting Excellence:Rigor Redefined

by Tony Wagner
October 2008 | Volume **66** | Number **2**
Expecting Excellence Pages 20-25

One of my first conversations was with Clay Parker, president of the Chemical Management Division of BOC Edwards—a company that, among other things, makes machines and supplies chemicals for the manufacture of microelectronics devices. He's an engineer by training and the head of a technical business, so when I asked him about the skills he looks for when he hires young people, I was taken aback by his answer.

"First and foremost, I look for someone who asks good questions," Parker responded. "We can teach them the technical stuff, but we can't teach them how to ask good questions—how to think."

"What other skills are you looking for?" I asked, expecting that he'd jump quickly to content expertise.

"I want people who can engage in good discussion—who can look me in the eye and have a give and take. All of our work is done in teams. You have to know how to work well with others. But you also have to know how to engage customers—to find out what their needs are. If you can't engage others, then you won't learn what you need to know."

I initially doubted whether Parker's views were representative of business leaders in general. But after interviewing leaders in settings from Apple to Unilever to the U.S. Army and reviewing the research on workplace skills, I came to understand that the world of work has changed profoundly.

Today's students need to master seven survival skills to thrive in the new world of work. And these skills are the same ones that will enable students to become productive citizens who contribute to solving some of the most pressing issues we face in the 21st century:

1. Critical Thinking and Problem Solving

"Yesterday's answers won't solve today's problems."

"The challenge is this: How do you do things that haven't been done before, where you have to rethink or think anew? It's not incremental improvement any more. The markets are changing too fast."

2. Collaboration and Leadership

Teamwork is no longer just about working with others in your building, "Technology has allowed for virtual teams.

"Kids just out of school have an amazing lack of preparedness in general leadership skills and collaborative skills," he explained. "They lack the ability to influence."

3. Agility and Adaptability

"has to think, be flexible, change, and use a variety of tools to solve new problems. We change what we do all the time. I can guarantee the job I hire someone to do will change or may not exist in the future, so this is why adaptability and learning skills are more important than technical skills."

4. Initiative and Entrepreneurialism

You'll never be blamed for failing to reach a stretch goal, but you will be blamed for not trying. One of the problems of a large company is risk aversion…"

5. Effective Oral and Written Communication

Mike Summers of Dell said, "We are routinely surprised at the difficulty some young people have in communicating: verbal skills, written skills, presentation skills. They have difficulty being clear and concise; it's hard for them to create focus…

…the complaints I heard most frequently were about fuzzy thinking and young people not knowing how to write with a real voice.

6. Accessing and Analyzing Information

"There is so much information available that it is almost too much, and if people aren't prepared to process the information effectively it almost freezes them in their steps."

7. Curiosity and Imagination

"People who've learned to ask great questions and have learned to be inquisitive are the ones who move the fastest in our environment because they solve the biggest problems in ways that have the most impact on innovation."

Is high school tough enough

While many decry the lack of rigor in the high school curriculum, it is difficult to find consensus about what rigor is. Dictionary definitions of the word refer to strictness and severity, but when referring to academic rigor, many educators use phrases such as "challenging content" and "competitive curriculum." Educators, researchers and organizations have defined academic rigor in a number of ways:

- Rigor is "the need for high school core courses to focus on the essential knowledge and skills needed for success in postsecondary education." (ACT, 2007)
- Rigor is "a demanding yet accessible curriculum that engenders critical-thinking skills as well as content knowledge." (social research group MDRC as quoted in Hechinger Institute, 2009)
- Rigor means that students should "raise questions, think, reason, solve problems and reflect." (former Atlanta Superintendent Beverly L. Hall as quoted in Hechinger Institute, 2009)
- A rigorous curriculum is "focused, coherent, and appropriately challenging." (Michigan State Professor William Schmidt as quoted in Hechinger Institute, 2009)

Researcher Clifford Adelman offers a more specific definition, but prefers the phrase "academic intensity" rather than rigor in his transcript studies (1999, 2006). In his reports, he found that the academic intensity of a student's high school courses was a better predictor of whether the student would complete a bachelor's degree than class rank, grade point average, or test scores (Adelman, 1999, 2006). This effect is especially true for African American and Hispanic students.

Dougherty, Mellor, and Jian (2006) followed more than 67,000 8th graders in Texas to determine the impact of taking AP courses. Students who took AP courses were at least twice as likely to graduate from college in five years compared with those who did not. The gains were particularly noteworthy for under-represented minority and low-income students.

However, authors of two other studies note that some AP research may fail to control for the student's non-AP curriculum (Klopfenstein and Thomas, 2006 and Geiser and Santelices, 2004). Looking at 28,000 Texas high school graduates who attended 31 four-year Texas public institutions in the fall of 1999, Klopfenstein and Thomas found that students who took AP courses performed the same as students who took a non-AP curriculum strong in math and science.
Geiser and Santelices (2004) analyzed data from 81,445 students who enrolled in the University of California system between 1998 and 2001, with particular attention to finding relationships between AP course enrollment in high school and college performance and retention. The authors measured student success through first-year GPA

and retention from first to second year of college. They found that just the number of AP and Honors courses on a student's transcript did not predict college success. While strong scores on SAT II exams (subject-specific tests) and AP exams did make a difference, the paper then used regression analysis to control for factors such as socio-economic status and race and concluded there was little to no relationship between AP or honors enrollment in high school and performance or retention in college. However, they did find a relationship between AP exam scores and later performance in college courses in the same subject.

So what is AP's impact? Given the popularity of AP courses, it would be helpful to see more research since it is challenging to control for self-selection factors. Though it is difficult to separate out the effects of AP coursework from the abilities of students motivated enough to take AP coursework, it does seem students are more prepared for college work after taking the courses. Also, research showing higher college success rates for African American and Hispanic students who took AP in high school is a particularly encouraging finding. However, as with all strategies examined here, AP coursework alone may not solve all the challenges of post-secondary success.

Chapter 2. Reading in the Mathematics Classroom by Diana Metsisto

James Bullock (1994) defines mathematics as a form of language invented by humans to discuss abstract concepts of numbers and space. He states that the power of the language is that it enables scientists to construct metaphors, which scientists call "models." Mathematical models enable us to think critically about physical phenomena and explore in depth their underlying ideas. Our traditional form of mathematics education is really training, not education, and has deprived our students of becoming truly literate. Knowing what procedures to perform on cue, as a trained animal performs tricks, is not the basic purpose of learning mathematics. Unless we can apply mathematics to real life, we have not learned the discipline.

If we intend for students to understand mathematical concepts rather than to produce specific performances, we must teach them to engage meaningfully with mathematics texts. When we talk about students learning to read such texts, we refer to a transaction in which the reader is able to ponder the ideas that the text presents. The meaning that readers draw will depend largely on their prior knowledge of the information and on the kinds of thinking they do after they read the text (Draper, 2002): Can they synthesize the information? Can they decide what information is important? Can they draw inferences from what they've read?

Research has shown that mathematics texts contain more concepts per sentence and paragraph than any other type of text. They are written in a very compact style; each sentence contains a lot of information, with little redundancy. The text can contain words as well as numeric and non-numeric symbols to decode. In addition, a page may be laid out in such a way that the eye must travel in a different pattern than the traditional left-to-right one of most reading. There may also be graphics that must be understood for the text to make sense; these may sometimes include information that is intended to add to the comprehension of a problem but instead may be distracting. Finally, many texts are written above the grade level for which they are intended (Barton & Heidema, 2002).

Most mathematics textbooks include a variety of sidebars containing prose and pictures both related and unrelated to the main topic being covered. In these we might find a mixed review of previous work, extra skills practice, a little vignette from an almanac, a historical fact, or a connection to something from another culture. Such sidebars often contain a series of questions that are not part of the actual exercises. Although they are probably added to give color and interest to the look of the page, they can be very confusing to readers, who might wonder what they are supposed to be paying attention to. Spending time early in the year analyzing the structure of the mathematics textbook with students can help them to read and comprehend that text.

Strategic Reading

Literacy researchers have developed some basic strategies for reading to learn. Here is a summary of strategies outlined by Draper (2002):

Before reading, the strategic reader

- Previews the text by looking at the title, the pictures, and the print in order to evoke relevant thoughts and memories
- Builds background by activating appropriate prior knowledge about what he or she already knows about the topic (or story), the vocabulary, and the form in which the topic (or story) is presented
- Sets purposes for reading by asking questions about what he or she wants to learn (know) during the reading episode

While reading, the strategic reader

- Checks understanding of the text by paraphrasing the author's words
- Monitors comprehension by using context clues to figure out unknown words and by imagining, inferencing, and predicting
- Integrates new concepts with existing knowledge, continually revising purposes for reading

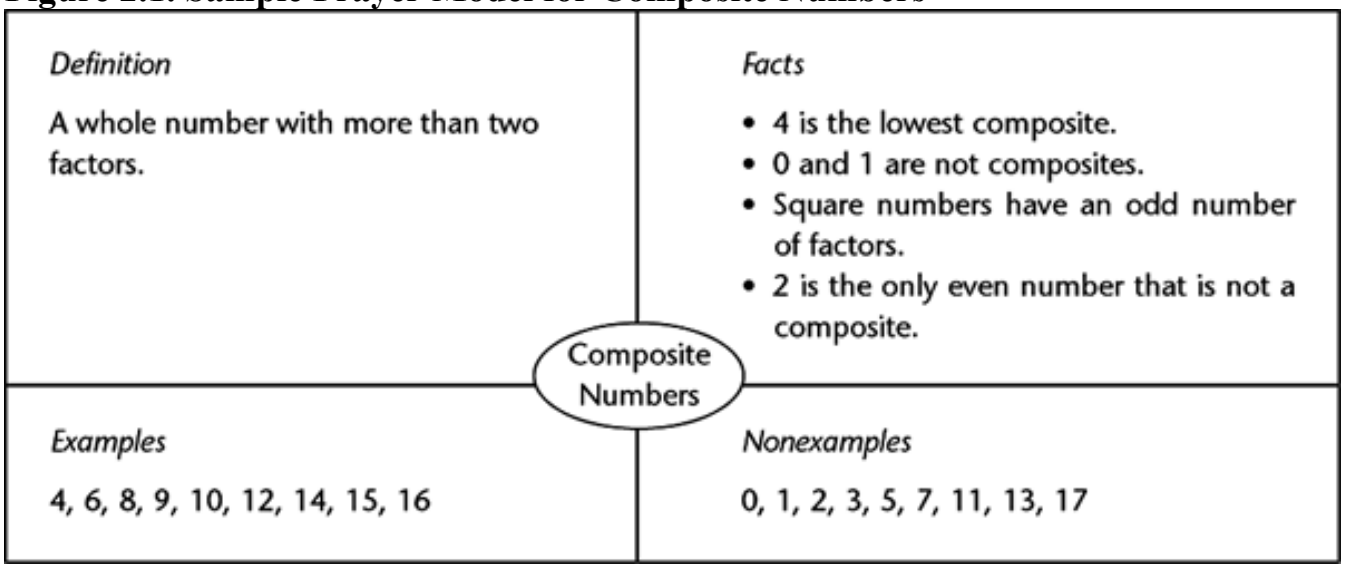
After reading, the strategic reader

- Summarizes what has been read by retelling the plot of the story or the main idea of the text
- Evaluates the ideas contained in the text
- Makes applications of the ideas in the text to unique situations, extending the ideas to broader perspectives. (p. 524)

Mathematics teachers can use this general outline in several ways. They can model the process by reading the problem out loud and paraphrasing the author's words and then talking through how they use context clues to figure out word meanings. Before reading, teachers can ask questions that they want students to consider as they approach a mathematics problem. Teachers can probe about the reading's vocabulary by asking questions such as, “Are we clear on the meaning of all of the words?” or “Does the context help or should we look the word up?” Also significant are questions about the meaning of the problem, such as, “Can I paraphrase the problem?” “Does the problem make sense to me?” or “Does my understanding incorporate everything I've read?”

In the Frayer Model, a sheet of paper is divided into four quadrants. In the first quadrant, the students define a given term in their own words; in the second quadrant, they list any facts that they know about the word; in the third quadrant, they list examples of the given term; and in the fourth quadrant, they list nonexamples.

Figure 2.1. Sample Frayer Model for Composite Numbers



The Frayer Model