

# Adolescent Literacy In Perspective

## Using Literacy Strategies in Mathematics and Science Learning

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# Reading and Writing to Learn in Mathematics: Strategies to Improve Problem Solving

by Clare Heidema

## Reading and Writing in Mathematics

Reading and writing in mathematics are of particular interest to educators because these processes are essential to both problem solving and concept development in mathematics. Martinez and Martinez (2001) discuss what happens when children read and write mathematics:

For starters, their learning incorporates some key ideas in the National Council of Teachers of Mathematics new *Principles and Standards for School Mathematics* (NCTM, 2000). They learn to use language to focus on and work through problems, to communicate ideas coherently and clearly, to organize ideas and structure arguments, to extend their thinking and knowledge to encompass other perspectives and experiences, to understand their own problem-solving and thinking processes as well as those of others, and to develop flexibility in representing and interpreting ideas. (p. 5)

Reading research clearly points to several characteristics of effective readers. They can:

- Locate key information
- Distinguish between main ideas and supporting details
- Modify their reading behaviors when faced with difficulty
- Ask questions before, during, and after reading
- Construct meaning as they read by monitoring comprehension, evaluating new information, connecting new information with existing ideas, and organizing information in ways that make sense

These characteristics also describe effective readers of mathematics and skills needed to be mathematics problem solvers.

## Reading and Writing Strategies for Problem Solving

Mathematics is about problem solving, and reading comprehension is an important component, especially for word problems. Writing, too, is a critical component, because students should monitor and reflect on the problem-solving process as well as communicate their thinking during problem solving.

Problem solving in mathematics often is viewed with a conceptual model proposed by George Polya (1957). Polya's model has four steps:

- 1. Understand the problem.** Determine what information is given, what is the unknown, what information is needed or not needed, and what is the context or conditions of the problem. Restate the problem to make sure terminology and facts are understood.
- 2. Devise a plan.** Consider how to go about solving the problem and what strategies would help in finding a solution. This may be as simple as selecting the numbers and operations demanded by the problem. It might include examining different ways to approach the problem, for example, comparing it to problems solved previously, or finding related problems, or making and checking predictions.
- 3. Carry out the plan.** Use the plan as devised, and check or prove that each action taken is correct.
- 4. Look back (and forward).** Examine the result or solution to make sure it is reasonable and solves the problem. Ask if there could be other solutions or if there are other ways to get a solution. Perhaps extend or generalize the problem.

Here is a quick preview of the strategies discussed in this article and how you might use them. The strategies are associated with Polya’s four-step model; i.e., each strategy includes the steps in Polya’s model.

- **K-N-W-S** and **SQRQCQ**. These are especially useful for helping students understand the steps in problem solving
- **Three-level guide**. This is a good choice for focusing on important facts or approaches.
- **Word problem roulette**. This strategy lends itself nicely to collaboration.
- **Process log and RAFT**. These two strategies are well suited to help students communicate their thinking.

For these reading and writing strategies to become an effective part of a student’s “toolbox,” teachers must provide instruction on how and when to use them. When providing instruction, consider the following teaching suggestions:

- Introduce one strategy at a time, and let students apply it several times while you observe what they are doing and where they may need help.
- Model and explain the use of a strategy in an activity that lets students see how and why to use it.
- Practice a strategy as a whole class before asking students to use it independently. During the whole-class activity, solicit and compare various responses on how the strategy can work.

## K-N-W-S

### Description of K-N-W-S

K-W-L (Ogle, 1986) is an active reading tool to help students build content knowledge by focusing on the topic and setting the purpose for the upcoming reading. During K-W-L, students list what they *know* about a topic (K), note questions they have and what they *want* to learn (W), and summarize what they *learned* (L). In a similar pattern, K-N-W-S allows students to use word problems to determine what facts they know (K), what information is *not* relevant (N), what the problem wants them to find out (W), and what *strategy* can be used to solve the problem (S).

In reading, the K-W-L strategy helps all students, no matter the age or achievement level, activate their prior knowledge, develop a purpose for the reading, and make connections between new information and familiar ideas. The K-N-W-S strategy does this as well. In addition, the K-N-W-S strategy allows students to plan, organize, and analyze how to solve word problems, while teachers can evaluate students’ understanding and possible misconceptions about word problems. The strategy allows students to focus on what effective students do when assigned word problems.

### Guidelines for Use of K-N-W-S

1. Draw a four-column chart on the board or chart paper. Hand out individual charts to students, or have students construct their own.
2. Using a word problem, model how the columns are used. Explain how you know which pieces of information belong in each area of the chart.
3. Students can work in groups or individually to complete K-N-W-S sheets for other word problems. Students can also be asked to write their reasoning for the placement of items in each column.

### Example of K-N-W-S

Video Heaven rents movies for \$3 a piece per night. The store also offers a video club plan. The plan costs \$100 per year and allows unlimited rentals at \$1 per movie per night plus two free rentals per month. How many movies must you rent in a year to make the video club worthwhile?

K	N	W	S
<b>What facts do I KNOW from the information in the problem?</b>	<b>What information do I NOT need?</b>	<b>What does the problem WANT to find?</b>	<b>What STRATEGY or operations will I use to solve the problem?</b>
\$3 to rent 1 movie. Club plan charges \$100/year. Each movie under the plan costs \$1. There are 2 free movies per month under the plan.	The video club plan allows an unlimited number of movie rentals.	How many movies must be rented in a year to make joining the club worthwhile?	Make a chart to compare the costs of both regular service and the club plan.  Write an inequality to compare the cost of the regular service to the cost of the club plan.

## SQRQCQ

### Description of SQRQCQ

The reading strategy SQ3R (*survey, question, read, re-cite, review*) was originated by Robinson (1961) as an independent study tool. SQ3R is based on the idea that if students are to recall and comprehend difficult text, they need to make a conscious effort and be engaged at each stage of the reading process. That idea is also an essential element of SQRQCQ, a six-step study strategy—*survey, question, read, question, compute (construct), question*—that was designed by Fay (1965) and was modeled after SQ3R. SQRQCQ is intended to assist students in reading and learning mathematics, in particular, solving word problems in mathematics. It allows students to organize in a logical order the steps necessary to solve a word problem.

This strategy can help students focus on a process to decide what a problem is asking, what information is needed, and what approach to use in solving the problem. It also asks students to reflect on what they are doing to solve the problem, on their understanding, and on the reasonableness of a solution.

### Guidelines for Use of SQRQCQ

Give students a description of the steps for SQRQCQ. Then model the strategy with one or two word problems before asking students to practice it with other word problems.

- 1. Survey.** Skim the problem to get an idea or general understanding of the nature of the problem.
- 2. Question.** Ask what the problem is about; what information does it require? Change the wording of the problem into a question, or restate the problem.
- 3. Read.** Read the problem carefully (may read aloud) to identify important information, facts, relationships, and details needed to solve the problem. Highlight important information.
- 4. Question.** Ask what must be done to solve the problem; for example, "What operations need to be performed, with what numbers, and in what order?" Or "What strategies are needed? What is given, and what is unknown? What are the units?"
- 5. Compute (or construct).** Do the computation to solve the problem, or construct a solution by drawing a diagram, making a table, or setting up and solving an equation.

- 6. Question.** Ask if the method of solution seems to be correct and the answer reasonable. For example, "Were the calculations done correctly? Were the facts in the problem used correctly? Does the solution make sense? Are the units correct?"

### Example of SQRQCQ

Marcie has 96 counters in three colors, red, blue, and yellow. She has twice as many red counters as blue and five times as many blue as yellow. How many counters of each color does Marcie have?

<b>Survey</b> Scan the problem to get a general idea of what it's about. Clarify terms.	Counters are in three colors. There are conditions on the 96 counters Marcie has.																
<b>Question</b> What is the problem about, and what is the information in the problem?	How many counters of each color does Marcie have?																
<b>Read</b> Identify relationships and facts needed to solve problem.	96 counters (red, blue, and yellow) #red is 2x #blue; #blue is 5x #yellow #red + #blue + #yellow = 96 #red = 2x #blue #blue = 5x #yellow																
<b>Question</b> What to do? How to solve the problem?	Write equations with variables $r$ , $b$ , and $y$ . Use substitution. Make a table and try numbers, keeping relationships, until the total is 96.  <table style="margin-left: auto; margin-right: auto;"> <thead> <tr> <th>#red</th> <th>#blue</th> <th>#yellow</th> <th>total</th> </tr> </thead> <tbody> <tr> <td>20</td> <td>10</td> <td>2</td> <td>32</td> </tr> </tbody> </table>	#red	#blue	#yellow	total	20	10	2	32								
#red	#blue	#yellow	total														
20	10	2	32														
<b>Compute (or construct)</b> Do the calculations or construct a solution.	Algebra: $r + b + y = 96$ $r = 2b$ and $b = 5y$ $2b + b + y = 96$ (sub. $r = 2b$ ) $2(5y) + 5y + y = 96$ (sub. $b = 5y$ )  $10y + 5y + y = 16y = 96$ Therefore $y = 6$ , $b = 30$ , and $r = 60$  Guess and Check: <table style="margin-left: auto; margin-right: auto;"> <thead> <tr> <th>#red</th> <th>#blue</th> <th>#yellow</th> <th>total</th> </tr> </thead> <tbody> <tr> <td>20</td> <td>10</td> <td>2</td> <td>32</td> </tr> <tr> <td>40</td> <td>20</td> <td>4</td> <td>64</td> </tr> <tr> <td>60</td> <td>30</td> <td>6</td> <td>96</td> </tr> </tbody> </table> Marcie has 60 red counters, 30 blue counters, and 6 yellow counters.	#red	#blue	#yellow	total	20	10	2	32	40	20	4	64	60	30	6	96
#red	#blue	#yellow	total														
20	10	2	32														
40	20	4	64														
60	30	6	96														
<b>Question</b> Is the algebra correct? Are the calculations correct? Does the solution make sense?	# blue is 30 (Five times as many blue as yellow) # yellow is 6 The total number of counters is 96.																

## Three-Level Guide

### Description of the Three- Level Guide Strategy

A three-level guide is a teacher-constructed graphic organizer that serves as the basis of a strategy that students can use to solve and get a deeper understanding of the word problem-solving process. With the organizer, students must evaluate facts, concepts, rules, mathematical ideas, and possible approaches to solving a given word problem.

Three-level guides for word problems, suggested by Davis and Gerber (1994), are modeled after a reading strategy using study guides devised by Herber (1978) and further developed by Morris and Stewart-Dore (1984) to help students think through the information in texts. Questions or statements in a study guide address three levels of comprehension: literal, interpretive, and applied.

To create a three-level guide for a word problem, teachers first do a process and content analysis. They think through their objectives for the problem, namely, what students should learn from the problem and what students should know and be able to do. Then they identify in the problem the essential information, the mathematical concepts and relationships, inferences from the relationships, and potential student difficulties. The questions or statements in the guide should help students to develop and appreciate three levels of understanding: the given and relevant information identified explicitly in the problem, the relationships or inferences implicit in solving the problem, and the conclusions or applications involved in solving the problem.

### Guidelines for Use of the Three-Level Guide Strategy

Construct guides for problems with three parts (levels). Part I includes a set of true or false facts suggested by the information given in the problem. Part II has mathematics concepts, ideas, or rules that might apply to the problem. Part III includes possible methods (e.g., calculations, creating a table or graph) to use to find a solution to the problem.

1. Introduce students to the three-level guide, and explain the kind of statements that are included in each part.

**Part I:** Students analyze each fact to decide if it is true or false given the information in the problem,

and they decide whether this fact can help them to solve the problem.

**Part II:** Students indicate which statements apply to solving the problem, that is, identify concepts or rules that are useful for this problem.

**Part III:** Students decide which calculations (or methods) might help them in solving the problem.

2. Model for students the use of a three-level guide in solving a problem.
3. Present students with a three-level guide for another problem, and direct them to complete the guide on their own or with a partner. In this step, students analyze information you have included in the guide to determine both its validity and its usefulness in solving the problem.
4. With advanced students, you might select word problems for which the students write three-level guides to share with the class or to exchange with a partner.

### Example of a Three-Level Guide

Read the problem. Follow the directions given for each part.

**Problem:** The markup rate on electronics at Ed's Electronics Mart is 35%. Ed, the store owner, bought 25 Boom speaker systems for a cost of \$70 each. What is the selling price of the Boom speaker system at Ed's Electronics Mart?

**Part I (Literal Comprehension)**  
*Directions:* Read the statements. Check column A if the statement is true according to the information in the problem. Check column B if the information will help solve the problem.

A (true or false?)	B (helpful?)	
_____	_____	Ed's markup rate is 35%.
_____	_____	Ed bought 25 Boom speaker systems.
_____	_____	The markup rate is less than ¼.
_____	_____	The cost to Ed for a Boom speaker system is \$70.
_____	_____	The selling price of a Boom speaker system is more than \$70.

**Part II (Interpretive Comprehension)**  
*Directions:* Read the statements. Check the ones that state mathematics ideas useful for the problem.

_____	Selling price is greater than cost.
_____	Markup equals cost times markup rate.
_____	Selling price equals cost plus markup.
_____	Markup divided by cost equals markup rate.
_____	The total cost of the systems is the cost of one system times the number of systems.

**Part III (Applied Comprehension)**  
*Directions:* Check the calculations that can be used in solving this problem.

_____	$0.35 \times \$70$	_____	$25 \times \$70$
_____	$25 \times 35$	_____	$(\$70 \times 35) \div 100$
_____	$1.35 \times \$70$	_____	$\$70 + (7/20 \times \$70)$

## Word Problem Roulette

### Description of Word Problem Roulette

The word problem roulette strategy comes from Davis and Gerber's (1994) discussion of content-area strategies for the secondary mathematics classroom. They suggest that students should discuss and write about the content of word problems and their solutions. The word problem roulette strategy is designed to give students an opportunity to collaborate on solving a word problem and then to communicate as a group the thought processes that went into finding a solution to the problem. The group presents its solution to the problem both orally and in writing.

The strategy involves students in a group problem-solving activity. They read a problem and, as a group, decide what the problem is about and what they might do to solve the problem. Students benefit from communicating their own thinking and from hearing how other students think about a problem. They have a chance to try out different ideas and to come to an agreement on a suitable method to solve a problem.

### Guidelines for Use of Word Problem Roulette

Choose word problems that are well suited to collaborative work.

1. Organize the class into cooperative groups of three or four students per group. Provide each group member with a copy of the word problem for the group. Explain to students that they are to solve this problem as a group.
2. First the group discusses how to solve the word problem. The group members talk to one another about what the problem is asking and their ideas for solving the problem, but they do this without writing or drawing on paper. During this step, the members of the group agree on a solution method and the steps for how they will solve the problem.
3. When the group members have agreed on a solution to the problem, they take turns writing the steps to the solution in words rather than mathematics symbols. Each group member writes one step or sentence and then passes the group solution paper to the next group member to add the next step or sentence. Group members may confer on what individu-

al members write, but the solution paper should have contributions from everyone in the group.

4. After all the groups have finished writing their solution papers, choose one group at a time to present its solution to the class. One member of a group reads the solution steps as they are written on the paper, and another group member writes the symbolic representation of this solution on the board.
5. After all the groups who have the same problem have presented their solutions, compare the methods and results of the different groups. If groups have different problems, volunteers from other groups may give an immediate review of a group's solution.

### Example of Problem for Word Problem Roulette

**Directions:**

Read the problem, and discuss a solution with your group. Do not do any writing during the discussion. When the group agrees on a solution and method to get the solution, write a group report explaining the solution. Each person writes one sentence or step and then passes the paper to another person to do the same. Use mostly words (not symbols) in the report. Everyone contributes in writing the report.

**Problem:**

A family of three adults and four children goes to an amusement park. Adult admission is twice as much as a child's admission. The family spends \$80 on admissions. How much is an adult admission? How much is a child's admission?

## Process Logs

### Description of Process Logs

Martinez and Martinez (2001) suggest what they call a process log for word problems. This strategy uses a *writing-math* worksheet in which students explain the word problem and the steps they will use to solve it. The worksheet guides the student with question prompts that lead them through the problem-solving process without dictating a method or the steps students use to solve the problem. Students are asked to use ordinary language as well as mathematical language in their explanations.

Using a process log, students write about their thinking during the problem-solving process. The questions they answer create a dialogue between what they know and what they are learning by doing the problem. In this way, students clarify their thinking about the problem and the mathematics involved, they translate mathematical ideas

and procedures into ordinary language, and they practice communicating about mathematics and reasoning in problem solving. Process logs are a type of learning log and have the advantage of reinforcing strategic learning processes that we associate with learning logs.

### Guidelines for Use of Process Logs

Prepare a writing-math worksheet for students with a word problem activity and an extra challenge. You can include additional question prompts as you consider other ideas you would like in a student's log. You might give students these directions on how to use this worksheet:

1. Use the writing-math worksheet as you think about and solve this problem. That is, "think aloud" on paper about the problem activity.
2. Try to personalize your explanations by writing in the first person; use *I*, *my*, *me*, and so on.
3. Use ordinary language as well as mathematical language.
4. Explain the problem itself as you write the steps involved.
5. Be sure to describe any special difficulties with the problem.
6. Explain your problem-solving process step by step.

### Example of Process Log

<b>Problem Activity</b>	
Christy works for 2 hours and 15 minutes each week doing yard work. She gets paid \$3 an hour for this work. How many weeks will it take Christy to earn enough money to buy a jacket that costs \$36.	
<b>Extra Challenge:</b> How much would Christy need to get paid per hour if she wanted to buy the jacket in four weeks?	
<b>Writing About Problem Solving</b>	
How many steps are involved in the problem?	There are two steps: I need to find (1) how many hours Christy must work and (2) how many weeks of work give her this number of hours.
What mathematics operations will you use?	Division ( $36 \div 3$ ) and multiplication. Some number $\times$ 2 hours 15 minutes.
Does the problem have special difficulties, things you have to watch out for?	I have to think about the time. 15 minutes is $\frac{1}{4}$ hour. This will make the multiplication problem easier.
What do you do first?	\$36 is the goal for Christy. At \$3 per hour she has to work 12 hours ( $36 \div 3 = 12$ ).
Then what...?	Each week she works $2\frac{1}{4}$ hours. I need to find a number (# weeks) to multiply times $2\frac{1}{4}$ so the result is equal to or more than 12.
Then what...?	I'll try 5. $5 \times 2\frac{1}{4} = 11\frac{1}{4}$ . 5 is too small.
Then what...?	It must be 6. $6 \times 2\frac{1}{4} = 13\frac{1}{2}$ . In $13\frac{1}{2}$ hours of work, Christy will make more than \$36, enough to buy the jacket.
What do you do to check your work?	I'll find how much Christy makes each week and then see how much she makes in 6 weeks. Each week: $\$3 \times 2\frac{1}{4} = \$6.75$ 6 weeks: $6 \times \$6.75 = \$40.50$ (more than \$36) 5 weeks: $5 \times \$6.75 = \$33.75$ (not enough)
How about the extra challenge?	To make \$36 in four weeks, she would have to earn \$9 each week. At \$4 per hour, she would earn \$9 each week ( $4 \times 2\frac{1}{4} = 9$ ).

## RAFT

### Description of RAFT

RAFT (Santa, 1988) is an acronym for the four critical pieces of writing: *role, audience, format, and topic*. It is an extended writing activity that expands the topics students have been studying. The RAFT strategy is an excellent way to involve students in explaining what they know about a topic. RAFT can be used as a culminating activity or assessment after students have studied a concept. Options for the students are provided in each of the four areas in order for the students to demonstrate their understanding in a nontraditional format.

Reading research states that students need and appreciate choices in their learning. The choices in the RAFT strategy affect the vocabulary, style, and focus of the writing and address the various learning styles. Students are encouraged to think creatively about the concepts they have been learning. They make connections and internalize ideas when they formulate concepts in a different mode and use them to do further investigations.

The RAFT strategy provides a method for students to synthesize information into a writing-to-learn episode. The National Council of Teachers of Mathematics encourages activities to interconnect mathematical ideas in order to produce a coherent whole. The RAFT strategy allows students to apply mathematics concepts in a fun way to explain what they have learned about a topic.

### Guidelines for Use of RAFT

1. Develop a list or brainstorm with students choices for:
  - **Role** of the writer (reporter, observer, eyewitness)
  - **Audience** for the writing (teacher, other students, parent, someone in the community)
  - **Format** to present the writing (letter, article, poem, diary, journal, instructions, advertisement, speech)
  - **Topic** for the writing (application of a procedure, reaction to an event, explanation of a mathematics concept)
2. Each student chooses a role, audience, format, and topic from the generated list. You may assign the same role to all students or let students choose from several different roles.
3. Provide class time for the work. You can conference with students and keep track of their progress on their RAFT choices.

4. Sharing the writing is important. Students can read to the entire class or read to smaller groups, if time is limited.

### Example of RAFT

Choose a role to communicate a mathematics topic to someone else. Be as thorough as possible in explaining the topic in the given format. If you want to change the format and audience, please ask. The roles and topic will stay the same.

Roles	Audience	Format	Topic
Zero	Whole numbers	Campaign speech	Importance of 0
Percent	Customers	Advertisement	Mental ways to calculate
Prime number	Jury	Instructions	Rules of divisibility
Container	Self	Diary	Volume measurements

### Our Goals for Students

*Principles and Standards* calls for excellence in mathematics for all students, and this requires high expectations for all students. Adding to or fine-tuning reading and writing strategies in our collection of teaching strategies can help us work with all students to attain these high expectations.

As mathematics teachers, our major goal for students is to learn the mathematics content: to retain important information, develop a deep understanding of concepts and topics, and apply and demonstrate knowledge. In addition, we want students to become independent learners: to gain control of their own learning, ask their own questions, find their own answers, and use critical thinking skills. The use of reading and writing strategies for word problems in mathematics gives us tools with which to help students become more effective readers and communicators in mathematics—or to put it another way, these strategies help us address our goals for all students.

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*Clare Heidema is a senior research associate at RMC Research Corporation in Denver, Colorado. She has teaching experience at all levels from elementary school to graduate school, has extensive background in professional development, and has written curriculum materials such as the Comprehensive School Mathematics Program. She is coauthor of Teaching Reading in Mathematics: A Supplement to Teaching Reading in the Content Areas Teacher's Manual.*

# Reading Through the Lens of Inquiry

by Terry Shiverdecker

Science teachers understand the importance of arming students with reading strategies that will help them get more out of their science reading experiences. We also know that decades of research support inquiry and the learning cycle model of instruction as teaching methodologies that lead to increased student achievement and a greater understanding of the nature of science. We sometimes struggle with finding a way to bring together these two important methods of constructing knowledge.

Our difficulty comes, in part, from our belief that science is something you do, not something you read about. At the same time, we know that reading skills support the doing of science. How can we successfully integrate reading strategies into science instruction while honoring the investigative, hands-on nature of inquiry? In this article I hope to identify the types of reading that science students do in class on a regular basis, to describe inquiry and the learning cycle, and to offer some examples of how well-known reading strategies support inquiry.

## Reading Science

Published science journals typically have at least one or more graphic displays and one mathematical expression per page of running text (Lemke, 2004). Considered as a whole, the text, graphical displays, and mathematical expressions present a complete picture of the topic being addressed. Remove any one of these elements, and the reader is left with an incomplete picture. Science textbooks and science articles in the popular media also rely upon multiple representations to accurately portray the topic being discussed.

It is difficult to represent scientific concepts with text alone. Consequently, the ability to read science materials requires skills that allow students to read procedural information; graphical displays including maps, charts, data tables, graphs, diagrams, and drawings; and mathematical expressions. Graphical displays may represent something as large as a galaxy or as small as a cellular component, they may be enhanced to show us what the naked eye cannot see, or they may be computer-simulated models. Reading science also requires understanding

Science teachers have the task of examining suggested reading strategies through the lens of inquiry to identify the ones that support inquiry and improve students' ability to read science.

the shorthand the scientific community has developed to represent complex ideas, e.g., vectors, chemical equations.

It is not enough to be able to read in isolation each of these many ways that science is represented. Students must integrate these multiple representations in order to construct meaning (Lemke, 1998). One of the challenges science teachers face is determining how to foster these skills without sacrificing inquiry.

## Inquiry

Inquiry is the method through which students investigate natural phenomena to build their understanding of science content and processes. Students involved in inquiry are:

- Making observations
- Asking scientifically oriented questions
- Collecting, representing, and interpreting data
- Drawing conclusions
- Communicating results

Participating in inquiry requires a set of process skills that can be separated into basic and integrated process skills (Padilla, 1990). The basic skills are:

- Observing
- Inferring
- Measuring
- Communicating
- Classifying
- Predicting

The integrated process skills are:

- Controlling variables
- Defining operationally
- Formulating hypotheses
- Interpreting data, experimenting
- Formulating models

Inquiry-based teaching occurs along a continuum. On one end of the continuum is teacher-guided inquiry. In teacher-guided inquiry, the teacher provides the question, the data, the evidence, and the procedure. The teacher tells the students how to analyze the data and how to use the evidence to formulate an explanation. On the other end of the continuum is learner self-directed inquiry. In learner self-directed inquiry, the learner asks the question, decides what evidence to collect, formulates an explanation after analyzing the evidence, and forms a reasonable and logical argument to communicate the explanations (Center for Science, Mathematics, and Engineering Education, 2000). Most classroom inquiry falls somewhere between these two extremes.

## What Is the Role of Reading During Inquiry?

Throughout inquiry, students may need to read procedures, diagrams, data tables, safety information, mathematical expressions, and other written representations used in science such as chemical formulas, flowcharts, and schematics. It may not be immediately apparent how reading strategies can be used during these times when students are actively engaged in hands-on explorations. At these times, reading is typically short in duration and intermittent.

## Learning Cycle

The learning cycle is a framework for doing inquiry. The learning cycle was developed in the late 1960s by Robert Karplus and others as they developed the Science Curriculum Improvement Study materials (Fuller, 2002). Since that time, it has undergone many revisions. These revisions have resulted in several versions of “E” learning cycle models, with the number of “E” phases ranging from four to seven. Regardless of the version used, the learning cycle instructional model supports inquiry. For this discussion we will use a widely accepted model built around the following phases: *engage*, *explore*, *explain*, and *expand*,

with *assess* integrated into each of the E phases. Here is a description of each phase.

**Engage:** Instruction is planned to help students mentally focus. Engagement practices capture students’ attention, stimulate thinking, and help students access prior knowledge.

**Explore:** Instruction is planned to get students actively involved with science content and skill by doing substantive intellectual work. Exploration practices give students time to think, plan, investigate, observe, and organize collected information.

**Explain:** Instruction provides for classroom debriefing, discussion, reading, and reflective writing to clarify and verify valid scientific understandings. Explanation practices offer students opportunities to analyze, interpret, and compare their explorations with other sources of content knowledge. Student reflection supports clarified and modified understandings.

**Expand:** Instruction promotes conceptual expansion through teacher questioning organized around appropriate benchmarks and grade-level indicators, guiding students to organize new understanding of concepts and skills and apply them to novel or real-world situations. Expansion practices give students opportunities to connect, apply, and evaluate applications of science and technology.

**Assess:** Instruction integrates best practices in assessment into all parts of a learning cycle. This helps focus assessment on science concepts, skills, and the range of cognitive demands from recalling valid science accurately to the application of science and the evaluation of technological solutions. Assessment practices provide students and teachers with information and feedback to improve student work, enhance learning, and modify teaching and learning activities to meet students’ learning needs. (Woodruff, 2008)

Various types of reading tasks are more or less appropriate at each phase of the learning cycle. Likewise, various reading strategies may be more or less appropriate at each phase of the learning cycle. Additionally, the learning cycle approach can be used for research-based inquiries. Table 1 shows various reading strategies (most suggested by Barton and Jordan, 2001) that could be used in each phase of the learning cycle.

Learning Cycle Phase	Reading Strategy
Engage	Anticipation guide, directed reading/thinking activity, graphic organizer, K-W-L and K-W-H-L, problematic situation
Explore	Anticipation guide, directed reading/thinking activity, pairs read, PLAN (predict, locate, add, note)
Explain	Directed reading/thinking activity, graphic organizer, group summarizing
Expand	Directed reading/thinking activity, graphic organizer, and K-W-L and K-W-H-L
Assess	Anticipation guide, directed reading/thinking activity, PLAN, problematic situation

**Table 1**

What might a reading strategy in Table 1 look like? Here are two examples:

*Anticipation guides* are sets of questions designed to activate students' prior knowledge, help students focus on their reading, and generate interest in the topic. Anticipation guides can be a series of true-false questions that students answer before and after reading (Fisher & Frey, 2008). Or they can be a series of questions in which students compare their opinions with those expressed in the reading selection (Barton & Jordan, 2001).

An anticipation guide could be used as part of a teacher-guided inquiry in which the teacher provides the laboratory procedure. After the lab has been introduced but before the students are given the procedure, ask them to complete a short anticipation guide. You could include questions that would activate prior knowledge by asking about data collection techniques, safety procedures, or previously learned content; questions that would focus attention on the aspects of the procedure you want students to pay particular attention to; and/or questions that would generate interest by asking students to anticipate outcomes.

*Sample Anticipation Guide for Yeast Respiration Lab*

Before Reading			After Reading	
True	False		True	False
		This investigation will require multiple trials.		
		This investigation will require that I wear goggles.		
		Boiling water will be added to the yeast sample.		
		The effect of water temperature on yeast respiration will be tested.		

A *K-W-H-L chart* is very similar to the K-W-L chart in which students list what they know and what they want to know prior to reading. After reading, students complete the final column, indicating what they have learned. The K-W-H-L chart includes a column for the student to list *how* they will find out what they want to know.

This strategy could be useful in student-directed inquiries. Students could complete a K-W-H-L chart after reading the scenario for the Separation Science Lab (<http://www.ohio-ohio.org/record/2609.aspx>) to determine what they need to know prior to designing their experimental procedure. The scenario describes a train wreck that has resulted in a chemical spill. The students are told that the spill mixture consists of three substances that must be separated. The following example represents what students might produce after reading the scenario.

*K-W-H-L Chart*

<b>K</b> What I know	<b>W</b> What I want to know or solve	<b>H</b> How I will discover what I want to know	<b>L</b> What I learned
Naphthalene is used in the activity.	What is naphthalene?  What are the safety considerations for naphthalene?	MSDS (material safety data sheet)  MSDS	

## Final Thoughts

Integrating reading strategies into science instruction while honoring the investigative, hands-on nature of inquiry is not an easy task. Generally speaking, science teachers do not have sufficient expertise in reading to confidently implement the reading strategies suggested by reading experts. Likewise, reading experts do not have sufficient expertise in science content and processes to provide the depth of guidance science teachers need. I suspect that in time these two bodies of knowledge will come together in a way that is immediately helpful to science teachers. In the interim, science teachers have the task of examining suggested reading strategies through the lens of inquiry to identify the ones that support inquiry and improve students' ability to read science.

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*Dr. Terry Shiverdecker is a science content specialist at the Ohio Resource Center. She began her career in education as a high school science teacher at Russia Local School in Shelby County. While at Russia, she taught both physical and biological sciences, served on curriculum committees, and designed and taught a course for the Concord Consortium's Virtual High School. In addition, her teaching experience includes adjunct work at the University of Cincinnati and Wright State University, Lake Campus. Terry was also director of secondary curriculum and instruction for the Shelby County Educational Service Center.*

## Using the Newspaper to Involve Students in Science Literacy

by Sylvia L. Clark

On the first day of school, I greet my new flock of students with anticipation and excitement. I tell them all about the biology topics and activities we will cover over the school year. I introduce them to their textbook and explain how reading for understanding will help them in the classroom setting and help them to understand how science connects to their daily lives. Now, mind you, their main interest and excitement at this time is wrapped up in two simple questions: "What animals do we get to cut up?" and "When do we get to cut them up?" I stop everything at that moment and ask if anyone knows the correct scientific terminology for "cutting up" (*dissection*). I go on to give the definition and explain the importance of "knowing science" versus memorizing words and definitions.

With eyes upon me, I tell the students I have no doubt that they are capable of reading most of the words in their textbook and that they could memorize, with little difficulty, words and phrases for short-term purposes such as quizzes and perhaps tests. But what I want more than anything else is for them to understand the relevance of the science they read.

I inform my students that science and technology are all around us and that science-related articles can be found in any syndicated daily newspaper. My students are not impressed or excited. Newspapers are for old, isolated, out-of-touch-with-the-world individuals. Who reads the newspaper anymore, let alone for scientific information, especially when one can find information on the Internet? So one of my ongoing science literacy activities is to have students *read* a newspaper.

It is simple, yet effective. Each grading period my students have an assignment that requires them to read and respond to a current science- or technology-related newspaper article. The idea of the assignment is to show that science is all around us. Through their reading, students learn about various technologies and how they can be of benefit. They come to understand the relationship of one area of science to other areas of science and non-

science disciplines. They begin to recognize science as worthwhile and meaningful to them and eventually to all of us.

The students are not limited to reading the local newspaper. However, the newspaper they choose must be in circulation at least five days a week and be syndicated. The students are not allowed to use the Internet, and no magazines are permitted. The idea is to stress to students that there are other sources of information beyond the Internet. And while looking for a science-related article, students can become familiar with the rest of the newspaper. (This activity would work well with students accessing a newspaper online; the only caveat is that students might not browse the rest of the paper.) If the students do not have access to a newspaper at home, newspapers are bound to be available in the high school, in either the office, library, or study hall or from teachers who bring their papers from home. There is no excuse for not completing this assignment. The assignment requirements are straightforward:

- The students must give the name of the newspaper, the article title, and date the article appeared. (I research newspapers the students use that are unfamiliar to me.) I require the students to turn the newspaper article in with the questions. It must be the newspaper print, no copies.
- The students have a response sheet that asks three questions they must answer:
  1. What is the most interesting or exciting thing about this article?
  2. What are your attitudes or feelings (positive or negative) toward this article?
  3. What experiences can you share with others that may help them understand your view(s) of this article?

These questions have no right or wrong answers. My hope is that students will develop their own thoughts and opinions, along with gaining the knowledge and understanding of what I mean when I say that science is all around them. As the school year proceeds, students do become more comfortable writing and expressing their scientific views.

When students understand the science they read, they gain a stronger understanding of key scientific principles. They develop thinking skills and the ability to solve real-life situations. As teachers, we cannot teach a one-time unit on science literacy and be done with it. It has to be consistently threaded in our lessons.

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*Sylvia L. Clark has been teaching for 17 years. She currently teaches biology at Bath High School in Lima. She has a B.S. in biology from Kentucky State University and a master's in education from the University of Dayton.*

## Science Literacy: Get Real!

by *Scott Barber*

To understand my approach to scientific literacy, you need to understand my path to the classroom. I graduated from Iowa State University in 1987 and entered the business world. I returned to college in 1993 to become a teacher. Between those years I continued to learn in a *real-world* setting. I was never assigned a textbook, received a vocabulary sheet, or took a standardized test in the business world. However, my professional literacy and bank of knowledge were tested daily. The years I spent outside the classroom have formed my approach to teaching scientific literacy. The world is changing, and the science content of today might not be the same science content of tomorrow. Content is important in standards-based education, but the process of striving toward scientific literacy creates a lifelong learner and a scientifically literate adult.

What is meant by scientific literacy? According to the National Science Education Standards:

Scientific literacy means that a person can ask, find, or determine answers to questions derived from curiosity about everyday experiences. It means that a person has the ability to describe, explain, and predict natural phenomena. Scientific literacy entails being able to read with understanding articles about science in the popular press and to engage in social conversation about the validity of the conclusions. Scientific literacy implies that a person can identify scientific issues underlying national and local decisions and express positions that are scientifically and technologically informed. A literate citizen should be able to evaluate the quality of scientific information on the basis of its source and the methods used to generate it. Scientific literacy also implies the capacity to pose and evaluate arguments based on evidence and to apply conclusions from such arguments appropriately.

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## The Event

I try to introduce a science investigation through a real-life event—say, a hurricane. Making science relevant to a student’s life is an important hook in developing scientific literacy. A common statement made by students to teachers is “Why do we have to know this?” Adding real-life relevance to standards-based teaching anticipates the question and bonds relevance with literacy.

## The Words and Concepts

Once the event has been introduced, the words and concepts necessary for literacy need to be identified and introduced to the students. Textbooks, published lesson plans, and other educational resources often identify the key words and concepts. But other resources, such as magazine articles, newspaper articles, podcasts, websites, and television programs, usually do not provide these. What they do provide, though, is an opportunity for students to create their own key words and concepts lists. Thus, key terms and concepts can be introduced by the teacher and school texts, discovered by the students, or found through a combination of both methods.

So, for example, when studying hurricanes, students might consult these resources:

- Print: Textbooks, newspapers, magazines
- Internet: Operation: Monster Storms (Jason Project), National Hurricane Center (NOAA), About Hurricanes (NASA), Nova Science Now

And from these resources, students might construct a list of these words and concepts: *convection, water cycle, thermal energy, storm surge, eye, eyewall, atmosphere, energy transfer, low pressure, high pressure, fronts.*

## The Understanding

Once the key terms and concepts are introduced, they need to be framed in a manner that students can understand. From my experience, looking up words in a glossary or using a predetermined definition does not help most students make a thorough or lasting connection with the words and ideas. Students need to create their own meaning or definition in a context that they can under-

stand and relate to. I use any credible resource available for students to explore the meaning of the key terms and concepts—online resources, print resources, video resources, previous student knowledge, and anything else that would help students. This means that after the students create their lists, they revisit the resources they culled the words from in the first place to see how they were used and to get the gist of what they mean.

The next step is to get students to actively use the key terms and concepts. I have found that a very good way to do this is to engage students in inquiry-based investigations. These might require the students to do experiments, data analysis, online gaming, or role playing. During the process of investigation, students gain added conceptual development of the key terms and concepts. As students show, grow, and internalize developmental meaning, I challenge them to something called “street talk.”

## Making It Real

*Street talk* is a way for students to share their personal working definitions for the key words and concepts in a way that middle school students talk. Reciting a definition from a resource does not show understanding. But successfully putting key words and concepts in a street-talk format shows that students truly understand!

To continue with our example of hurricanes, here is a standard definition taken from the University of Illinois website (WW2010 Project), followed by a street-talk version:

*Hurricanes are tropical cyclones with winds that exceed 64 knots (74 mi/hr) and circulate counter-clockwise about their centers in the Northern Hemisphere (clockwise in the Southern Hemisphere).*

*Hurricanes are formed from simple complexes of thunderstorms. However, these thunderstorms can only grow to hurricane strength with cooperation from both the ocean and the atmosphere. First of all, the ocean water itself must be warmer than 26.5 degrees Celsius (81°F). The heat and moisture from this warm water is ultimately the source of energy for hurricanes.*

*Related to having warm ocean water, high relative humidities in the lower and middle troposphere are also required for hurricane development. These high hu-*

*midities reduce the amount of evaporation in clouds and maximize the latent heat released because there is more precipitation. The concentration of latent heat is critical to driving the system.*

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Hurricane formation is kind of like a recipe. The ocean water has to preheat to at least 81 degrees F. The heat trapped in the water provides the heat for the hurricane to cook. The air above the ocean must be humid like in the summer when the air feels warm and sticky/moist. The heat travels from the ocean to the moist air and is then released (latent heat) into the atmosphere. If this continues to happen, thunderstorms develop and begin to rotate counterclockwise. When the spinning storm reaches 74 mph, it's a hurricane.

Once students have reached the street-talk level, you can decide how you want them to use their newly formed vocabulary. This is the part I call "making it real." Making it real means not only that the students have created a meaning that is real to them but that they have also connected learning to a real-world event. Here are some ways that I assess making it real:

- During labs and experiments, I record when students successfully "street-talk" the key words and concepts while conducting the lab or experiment.
- In a data analysis investigation, the students must use the key words and concepts in their final report, whether it be written or verbal.
- For role playing and online gaming, students must communicate or demonstrate the key words and concepts.
- I also use traditional testing.

Scientific literacy will last a lifetime, and as teachers, that is our ultimate goal—what we all want our students to achieve. And to keep me on target with helping my students achieve it, I frequently visit the definition of scientific literacy when planning lessons as I weave in the strategy-philosophy formed by experiences in my years outside K–12 education.

*Scott Barber teaches seventh grade science at Roehm Middle School in Berea. He has a B.S. in speech from Iowa State University, an education degree from Baldwin-Wallace College, and a master's from Ashland University. Barber was selected as one of Cleveland's most interesting people in 1999 by Cleveland Magazine and was a 2001 WOW award recipient from the Great Lakes Science Center for his innovative teaching techniques. He was also the 2000 recipient of the NTTI Teacher of the Year. Barber is a National Board Certified teacher, a member of NSTA, and an ORC Ambassador. You can contact him at [sbarber@bera.k12.oh.us](mailto:sbarber@bera.k12.oh.us).*

## Addressing Literacy in the Science and Mathematics Classrooms

*by Kerri Matheny*

Literacy is a scary word to many science and mathematics teachers. According to the *National Science Education Standards* (National Research Council, 1996), "Scientific literacy entails being able to read with understanding articles about science in the popular press and to engage in social conversation about the validity of the conclusions." *Principles and Standards for School Mathematics* (NCTM, 2000) defines mathematical literacy as "having an appreciation of the value and beauty of mathematics and being able and inclined to appraise and use quantitative information." What do these two definitions of literacy have in common? Consider one more definition of literacy. In the article "The New Literacies" (Miners & Pascopella, 2007), literacy is "the ability to read and make sense of written symbols in a variety of settings and subject areas and then be able to locate information, evaluate it critically, synthesize it, and communicate it."

What does this mean to science and mathematics teachers who have had very little formal training in teaching reading? It means that math and science teachers need to use strategies in their classrooms that explicitly help students to read and understand math and science content.

I remember my first year of teaching science when I expected students to look up the vocabulary words posted on the board and then know the definitions of the words. Obviously, it did not take very long for me to discover that this was not an effective way to teach vocabulary. My search began for ways to increase the vocabulary development and reading comprehension of my students. After many years of classroom teaching and working as a math and science curriculum coordinator, I have found some strategies that work for a variety of age ranges and ability levels. All these strategies are “stolen” from the work of other educators. A few of my favorites are described below. I have divided them into three categories: vocabulary, comprehension, and writing.

### Vocabulary Strategies

*Word questioning.* Students use a graphic organizer—a web—to document what they think a word means, what parts of the word they recognize, and what makes the word important to know. A sample for the word *polynomial* is shown in Figure 1:

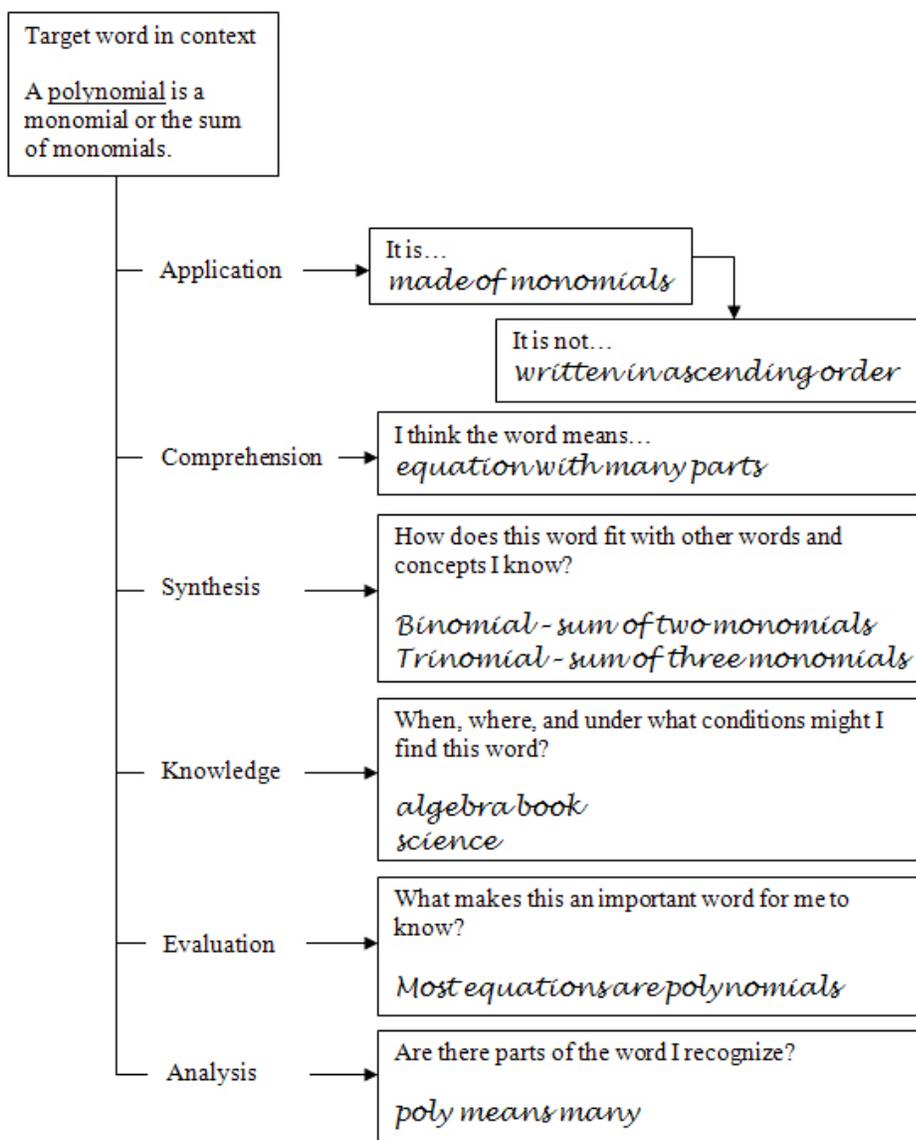


Figure 1

*The Frayer model.* In this five-box graphic organizer, students write a word in the middle box; and in the other four boxes, they define the word, give characteristics, and list examples and nonexamples. This is also a great strategy for younger students since pictures can be drawn in the boxes. Figure 2 shows a diagram based on the Frayer model.

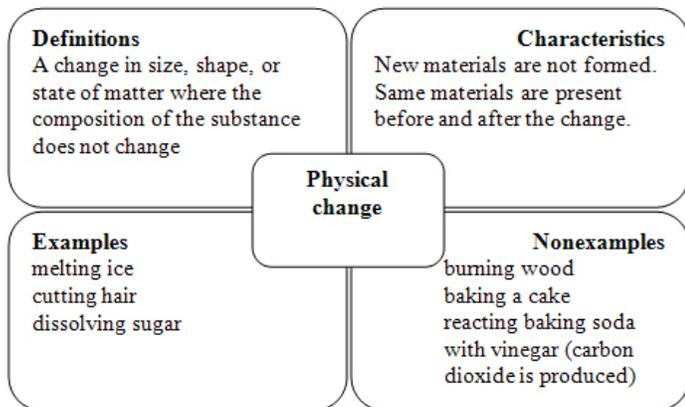


Figure 2

*Semantic feature analysis.* Another strategy for learning vocabulary is semantic feature analysis. Students fill out a grid to help them compare a term with other terms that fall in the same category. When the grid is completed, students have a visual reminder of how certain terms relate to each other. Figure 3 offers an example using the term *polygons*.

Semantic Feature Analysis Grid

Terms	Polygons					
	convex	equilateral	equiangular	4 sided	3 sided	opposite sides are parallel
Square	✓	✓	✓	✓		✓
Rectangle	✓		✓	✓		✓
Triangle	✓				✓	
Rhombus	✓	✓		✓		✓
Trapezoid	✓			✓		

Figure 3

## Comprehension Strategies

*Key concept synthesis.* Students identify the most important ideas or concepts within the text, and then they explain the concept in their own words and record connections to other concepts. This strategy is best used with the sections of a chapter.

Key ideas or concepts (Include the page number)	Put the concept or idea in your own words	Explain why the concept or idea is important, and make connections to other concepts
1. Most of the Earth's surface is covered by water, but all water is not alike (p. 150)	Saltwater is different from freshwater	Organisms that live in saltwater have structures that allow them to conserve water. Organisms in freshwater must be able to expel excess water.
2.		

Figure 4

*Anticipation Guides.* Students agree or disagree with statements about the assigned reading prior to doing the reading. As students read, they must document where in the text their initial judgment was supported or refuted. Figure 5 presents an example based on a reading about digestion.

**Anticipation Guide: Digestion Problems**

Name \_\_\_\_\_ Date \_\_\_\_\_

**Before reading pages 118–120:** In the space to the left of each statement, place a check mark if you agree or think the statement is true.

**During or after reading:** Add new check marks next to the original answers you still agree with, and cross out the check marks next to the answers for which you have changed your mind. Keep in mind that this is not like a "traditional" worksheet. You may have to think about what you read and "read between the lines." Use the space under each statement to note the pages and paragraphs where the information supports your thinking.

\_\_\_\_\_ 1. Digestion problems are caused by the people themselves.

\_\_\_\_\_ 2. Diarrhea is the opposite of constipation.

\_\_\_\_\_ 3. If you are allergic to certain foods, it is because your body thinks these foods are a virus.

\_\_\_\_\_ 4. You can die from constipation.

\_\_\_\_\_ 5. Ham and bacon are not good for you.

Figure 5

## Writing Strategies

*Write and toss.* Students respond to a question posed by the teacher and write freely for a few minutes. Questions are usually simple—for example, “Tell me everything you remember about photosynthesis.” Students then wad up their response and toss it to another student. After 15 seconds of tossing the paper wads around, students open a paper wad response and share it with the class. The teacher and students can then discuss any misunderstandings and important details. This is a great way to check for understanding. Variations of this include collecting the writings for assessment or having students “grade” and edit the writing of another student.

*Real-world writing.* Students write how a concept is related to its application in the real world and explain the concept in a way that the “general public” would understand it. A variation is to have students explain the concept as if they were teaching it to students in a lower grade. This forces students to restate some of the jargon from the textbook in their own words and set their explanation in a framework that they can really understand.

## And More

If you want to find more information on including literacy in content-area instruction, here are three great resources:

Forget, M. A. (2004). *Max teaching with reading and writing: Classroom activities for helping students learn new subject matter while acquiring literacy skills.* Victoria, BC: Trafford Publishing.

Hammerman, E., & Musial, D. (2008). *Integrating science with mathematics and literacy: New visions for learning and assessment* (2nd ed.). Thousand Oaks, CA: Corwin Press.

Keeley, P. (2005). *Uncovering student ideas in science: Formative assessment probes.* Arlington, VA: NSTA Press.

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*Kerri Matheny taught science in every grade from 7 to 12 for ten years in southwestern Ohio and tutored math. For the past two years, she has been employed as the District Science and Mathematics Coordinator for Springboro Community City Schools. She is currently completing her EDD in curriculum and instruction at the University of Phoenix School of Advanced Studies.*

## Some Approaches to Learning Science Vocabulary and Concepts

by Cheryl Zachry

### Traditional Fare

Each year in my sixth grade science class, students begin their study of plate tectonics with the challenge of learning vocabulary. The study of plate movement is very abstract, and students have minimal background knowledge from personal experience. Most students come with a basic understanding about the layers of the Earth from their studies in elementary school. Some words, such as *crust*, *mantle*, and *core*, are friendly and easy to spell and have some relevance to other things in the students' experiences. However, when the students start discussing *divergent*, *convergent*, *transform boundaries*, *lithosphere*, and *asthenosphere*, vocabulary can become a stumbling block since these words conjure few connections with students' prior knowledge.

I have used traditional approaches to help break down the syllables of the words, and this does help students connect new words with prefixes and vocabulary they already know. For the word *divergent*, for example, the *div* at the beginning of the word reminds students of the word *divide*. The word *convergent* starts with *con*, which students can relate to the word *connect*, and this helps them remember that the plates push together in this type of boundary. *Transform* is more easily understood by students to mean "change"; but students do make the connection with the plates changing position—with the plates sliding horizontally. When we discuss *lithosphere* and *asthenosphere*, the students know that a sphere is a three-dimensional ball shape. The prefixes for these words, though, are not familiar and do not foster connections, and so we might have to look at other strategies to help students understand better.

### A New Recipe of Sorts

Over the years there are often a few students who get the plate movements mixed up on assessments, despite our strategies. Some students need another, more concrete connection. What cements their understanding is seeing or experiencing the movements of the plates and describing and writing their observations while acting out each plate movement. A book called *Geology Rocks: 50 Hands-on Activities to Explore the Earth* (by Cindy Blobaum) suggests using icing and graham crackers to allow students to demonstrate plate movements (this is nicely illustrated in "Push Those Plates" on the Montana Bureau of Mines and Geology's site Hey Dude!! What's Shakin'? web page, <http://www.mbmgs.mtech.edu/kids/shakin.htm>). We found the icing to be expensive and a little too thick to be workable, and so we spread the pudding that comes in pudding cups thinly over sheets of aluminum foil. Students, working in pairs, use their own graham crackers to act out each movement, and the students follow up by eating the lab materials—except the foil!

Students record the procedure to be used in their journals before they begin. They clearly explain in their journals that the graham crackers are pieces of lithosphere (or tectonic plates) and that the pudding represents the asthenosphere (thick, sticky, upper mantle). In groups they discuss whether each material was a "good" model and the reasons why and record their observations. Students then write a finished lab report that provides a chance to use the new vocabulary and concepts they've mastered.

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*Cheryl Zachry teaches sixth grade and serves as the science coordinator for VanGorden Elementary in the Lakota Local School District. She has a B.S. in elementary education and an M.Ed. in educational psychology with special education certification, both from Miami University. She has completed 30 additional semester hours exploring science topics and methodology.*

A Look at the OGT

## Nonfiction Text and the Math and Science OGT

by Nicole Luthy

Often when we think of school-based reading, texts like novels and poems first spring to mind. For middle and high school students, most of their school-related reading is nonfiction. Yet teachers find that despite the amount of nonfiction reading students encounter, they continue to experience difficulty in comprehending texts and completing tasks that are centered on nonfiction texts. Daily reading tasks often extend beyond traditional textbook reading and include responding to problems, following lab instructions, interpreting graphics, analyzing documents, and carrying out other comparable activities.

The range of reading that students are required to do in school is mirrored on the various forms of the Ohio Graduation Test. On the OGT reading test, students answer questions that are directly related to a passage on the test. For other content areas, students must combine their knowledge of the content being assessed with their experiences in reading, analyzing, and interpreting non-fiction texts.

This column examines the literacy demands of the math and science OGT. Let's begin by considering the following two released items from previous OGT math and science assessments. As you preview each item, think about the content that students need to know and the literacy skills and strategies they must employ in order to arrive at the correct answer.

The first example is a math item.

The average salary for all department store workers in a certain area is \$255 a week. The weekly salaries of the 7 employees in the Acme Department Store are given in the table below.

### Acme Employees' Salaries

Employee Number	Salary
Employee 1	\$240
Employee 2	\$245
Employee 3	\$245
Employee 4	\$250
Employee 5	\$252
Employee 6	\$260
Employee 7	\$420

In your **Answer Document**, determine the measures of center (mean, median and mode) of the 7 salaries.

Specify which of these measures of center the management could use to represent the salaries in an argument against pay increases. Explain your answer.

Specify which of these measures of center the labor union could use to represent the salaries in an argument for pay increases. Explain your answer.

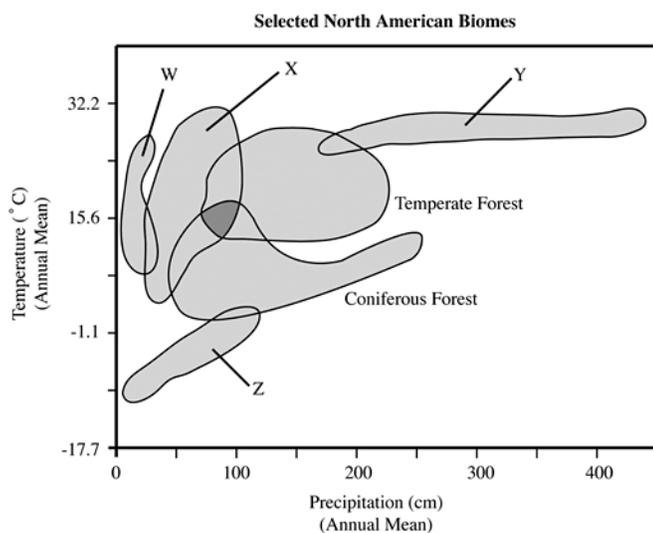
Source: Ohio Graduation Test for Mathematics, March 2005, Ohio Department of Education.

For this math item, students need to know how to determine mean, median, and mode for the salaries of the workers listed on the table. In order to receive the maximum of four points, the students must also be able to interpret information that is represented graphically, compare and contrast information, and formulate and justify an argument.

The next example is a science item:

## Biomes

The following graph shows the ranges of temperature and precipitation for six American biomes, two of which are identified by name.



Locate biome W and the temperate forest on the graph. Based on the information provided, describe one similarity and one difference between the climates of these two biomes. Respond in the space provided in your Answer Document.

Source: Ohio Graduation Test for Science, March 2005, Ohio Department of Education.

This science item assesses students' understanding of the climate of biomes as well as their ability to analyze and communicate scientific information. As observed for the math item, students must also be able to interpret graphs, compare and contrast information, and provide support for their answers.

The application of mathematical and scientific processes is an important aspect of student learning for both disciplines. In the course of learning math and science, students encounter content represented in multiple formats, and those formats are likely to differ across texts. By providing varied opportunities for students to use a wide range of texts, teachers can support content learning and at the same time increase students' facility in responding to different types of assessment items.

Building familiarity with graphics and analytic problems through the use of textbooks and ancillary materials develops students' confidence in reading and communicating information. The skills required for comprehending math and science content (as assessed on the OGT) are not likely to be taught in English classrooms. Students will benefit most from the meaningful integration of literacy strategies into math and science instruction that is designed to improve their learning of that content. Further, teachers of that content have the greatest expertise in navigating the texts found in those disciplines.

## What makes nonfiction reading challenging for students?

Reading nonfiction texts, including OGT assessment items, presents many problems for students, especially those who struggle with reading. A sampling of math and science items from the OGT revealed the following literacy demands (this is not an exhaustive list):

- Establishing a purpose for reading
- Decoding and comprehending unfamiliar vocabulary terms
- Interpreting complex graphics
- Determining the importance of information
- Synthesizing information for note taking or for writing a response
- Asking questions about the content and how the writer represents information
- Monitoring comprehension and recognizing when meaning making has been interrupted
- Forming mental models and visual images while reading
- Making connections to previously learned concepts
- Comparing and contrasting information

- Understanding cause-and-effect relationships
- Formulating arguments and making justifications using evidence from the text and from previously learned content
- Making observations and drawing inferences
- Identifying key ideas and important details

It is not sufficient to think of items only as assessments of mathematics and science content. These items must also be thought of as types of nonfiction text. As you preview the categories and test examples in the following section, consider both the content and literacy skills that students need to respond to the items. What are the implications for your instructional practices?

### What types of assessment items appear on the math and science OGT?

Student learning on the math and science OGT is assessed in numerous ways. The sample of problems presented here shows the range of formats that appear on the tests. The variety of items stresses the importance of instruction that combines content learning with an emphasis on text analysis.

### Sample Assessment Items

#### Analytic problems

A town is conducting a survey to determine if the residents would use a new recreation facility. The survey must represent all different types of people who live within the town. Three different survey locations were proposed: a golf course, a day care center and a shopping mall. Every fifth person at the location would be asked to take part in the survey.

In your **Answer Document**, determine which of the three proposed survey locations would provide the least amount of bias. Show your work or provide an explanation for your answer.  
Source: Ohio Graduation Test for Mathematics, March 2004, Ohio Department of Education.

Telemedicine is defined as the practice of medicine from a distance. It allows doctors to communicate with patients and other health care workers from a remote area. Early ways of transmitting medical information included the postal service and telegraph. Identify two advances in technology that have improved the speed and accuracy of modern telemedicine.

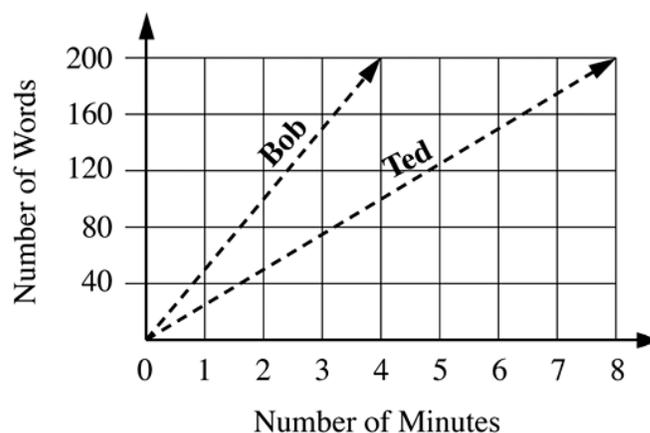
Explain how each improves the ability of doctors to treat or diagnose patients.

Respond in the space provided in your **Answer Document**.

Source: Ohio Graduation Test for Science, March 2006, Ohio Department of Education.

### Graphs

Ted and Bob each must type a 1,500-word research paper. The graph below represents their normal typing rates.

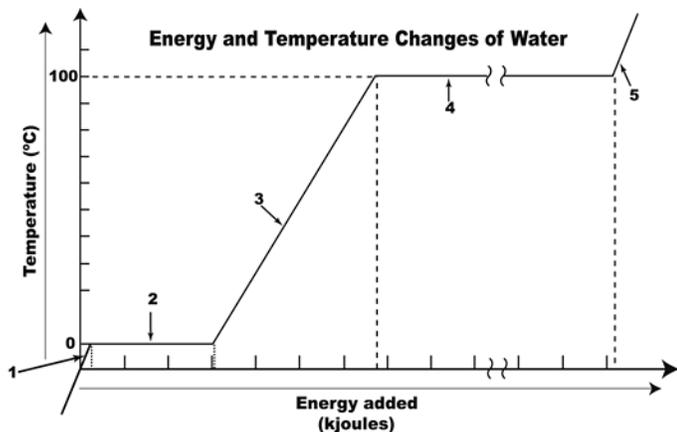


Based on the information in the graph, which of these is a valid conclusion?

- A. Bob can type his research paper in half the time it takes Ted to type his paper.
- B. Ted can type his research paper in half the time it takes Bob to type his paper.
- C. Ted will take 4 minutes longer than Bob to type his research paper.
- D. Bob will take 4 minutes longer than Ted to type his research paper.

Source: Ohio Graduation Test for Mathematics, March 2005, Ohio Department of Education.

The following graph shows the change in temperature of a sample of  $H_2O$ , which begins as ice, as thermal energy is added.



Which region of the graph represents water ( $H_2O$ ) in the liquid form only?

- A. 1
- B. 2
- C. 3
- D. 4

Source: Ohio Graduation Test for Mathematics, March 2006, Ohio Department of Education.

### Charts and tables

The first five rows of a number array are shown below.

Row 1					1
Row 2				2	3
Row 3			4	5	6
Row 4		7	8	9	10
Row 5	11	12	13	14	15

What is the sum of the numbers in row 8?

- A. 175
- B. 224
- C. 231
- D. 260

Source: Ohio Graduation Test for Mathematics, March 2005, Ohio Department of Education.

The maximum heart rate is the highest number of beats per minute recommended for a person while exercising. The rate is dependent upon the age of the person as shown below. The relationship is linear.

Age	Maximum Heart Rate
10	210
15	205
20	
25	
30	
35	
40	
45	
50	

In your Answer Document, copy and complete the table.

Write an equation that can be used to find the maximum heart rate for any age. Show your work or provide an explanation for how you determined your equation.

Source: Ohio Graduation Test for Science, March 2006, Ohio Department of Education.

Use the partial periodic table to answer question 27.

<table border="1"> <tr><td>6</td></tr> <tr><td><b>C</b></td></tr> <tr><td>Carbon</td></tr> <tr><td>12.0107</td></tr> </table>		6	<b>C</b>	Carbon	12.0107	<p>— Atomic number</p> <p>— Symbol</p> <p>— Name</p> <p>— Average Atomic Mass</p>
6						
<b>C</b>						
Carbon						
12.0107						

**Partial Periodic Table of the Elements**

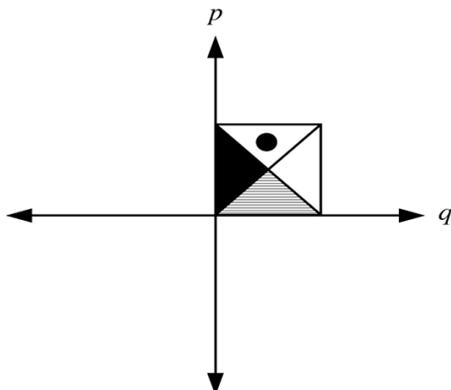
IA 1								VIIIA 18
1	2							
H Hydrogen 1.00794	He Helium 4.0026							
IIA 2A		IIIA 13	IVA 14	VA 15	VIA 16	VIIA 17		
3	4	5	6	7	8	9	10	
Li Lithium 6.941	Be Beryllium 9.0122	B Boron 10.811	C Carbon 12.0107	N Nitrogen 14.0067	O Oxygen 15.9994	F Fluorine 18.9944	Ne Neon 20.1797	
11	12	13	14	15	16	17	18	
Na Sodium 22.9898	Mg Magnesium 24.3050	Al Aluminum 26.98154	Si Silicon 28.0855	P Phosphorus 30.9738	S Sulfur 32.065	Cl Chlorine 35.4527	Ar Argon 39.948	
19	20							
K Potassium 39.0983	Ca Calcium 40.078							

27. A neutral atom of silicon has
- A. 12 electrons
  - B. 13 electrons
  - C. 14 electrons
  - D. 15 electrons

Source: Ohio Graduation Test for Science, March 2005, Ohio Department of Education.

### Diagrams and cross sections

By the end of summer vacation, Callie had completed one-fourth of a quilt, as shown in the diagram below.

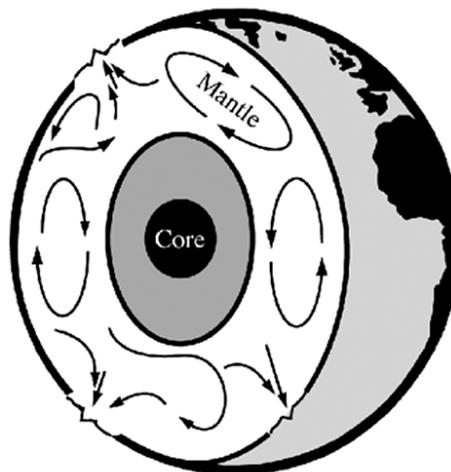


To finish the quilt, Callie plans to reflect the design of the completed portion over lines  $p$  and  $q$  until all 4 portions are complete.

In your Answer Document, copy the diagram above. Add the reflections of the completed portion of the quilt on the same sketch to show how the entire quilt will look when it is finished.

Source: Ohio Graduation Test for Mathematics, March 2005, Ohio Department of Education.

### Earth's Cross Section

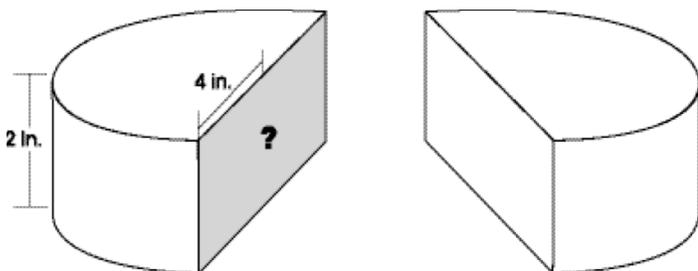


Scientists believe that forces in Earth's mantle move Earth's crustal plates. What do the arrows in the diagram represent?

- A. Ocean currents
- B. Gravity
- C. Convection currents
- D. Wind patterns

Source: Ohio Graduation Test for Science, March 2005, Ohio Department of Education.

Gene has a cylinder with radius 4 inches and height 2 inches. He cut the cylinder in half along the length of the diameter, as shown in the diagram below.



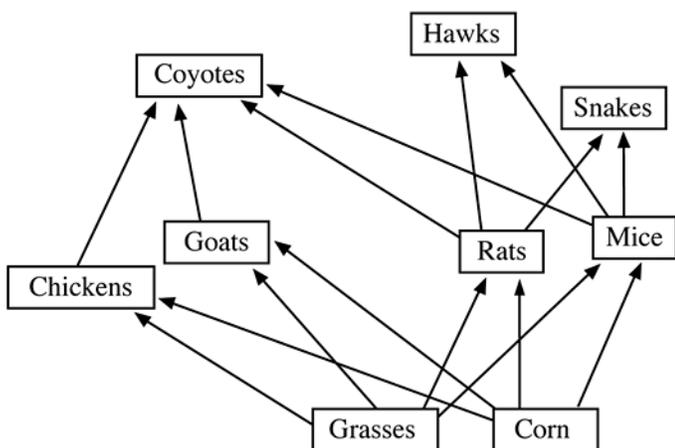
What is the area of the shaded cross-section?

- A. 48 square inches
- B. 24 square inches
- C. 16 square inches
- D. 8 square inches

Source: Ohio Graduation Test for Mathematics, March 2004, Ohio Department of Education.

### Conceptual diagrams and scale drawings

Use the farmland food web to answer question 9.



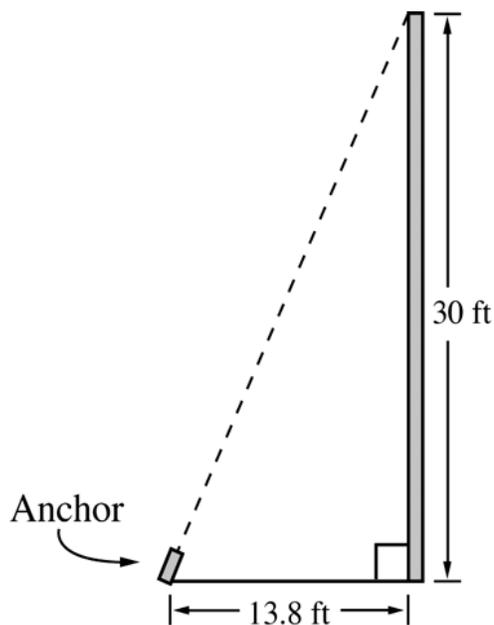
9. Many people who raise chickens and other small farm animals consider coyotes to be pests. These people have decreased the coyote population in many parts of the United States.

Which of these is likely a result of the decrease in the number of coyotes in the area?

- A. The mouse population has increased.
- B. The hawk population has decreased.
- C. The grass population has increased.
- D. The goat population has decreased.

Source: Ohio Graduation Test for Science, March 2005, Ohio Department of Education.

The anchoring wire of a telephone pole has snapped and needs to be replaced. The telephone pole is 30 feet tall. The anchor for the wire is 13.8 feet from the bottom of the pole.



Which of these is approximately the minimum length necessary for the new wire?

- A. 10 ft
- B. 21 ft
- C. 35 ft
- D. 44 ft

Source: Ohio Graduation Test for Mathematics, March 2005, Ohio Department of Education.

Brian and Caleb walked 5 kilometers north from their car to set up their tent. They hiked 3 kilometers east from their campsite to look for firewood. Then they walked 2 kilometers south. Caleb said that after they had walked the 2 kilometers south, they were the same distance from their car as they were from their tent.

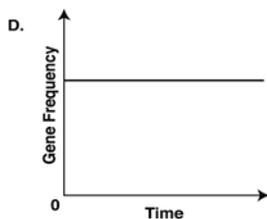
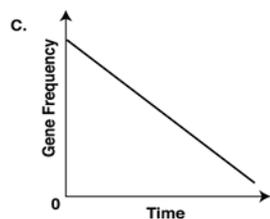
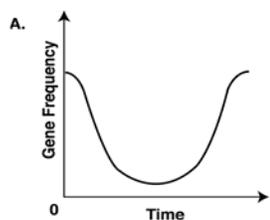
In your Answer Document, determine whether Caleb was correct by drawing a sketch of their hike and comparing the distances. Show your work.

Source: Ohio Graduation Test for Mathematics, March 2005, Ohio Department of Education.

### Conceptual diagrams and scale drawings

A group of students designs an experiment to test how an herbicide affects pepper plants and weeds. Eight plots are tested, each of which holds 25 pepper plants and a variety of weeds. Plots 1 and 2 are not treated; plots 3–8 are treated with varying amounts of weed-killing herbicide. The weeds are counted in each plot during week 1. The herbicide is applied during week 2, and the weeds are counted again in week 3. The data are shown in the table below.

Plot	Herbicide Dose	Number of Pepper Plants That Die Before Producing Fruit	Week 1 Number of Weeds	Week 3 Number of Weeds
1	No herbicide application	3	30	33
2	No herbicide application	5	35	40
3	50% of recommended dose	3	42	24
4	100% of recommended dose	3	43	14
5	100% of recommended dose	4	47	7
6	100% of recommended dose	6	42	3
7	150% of recommended dose	12	43	2
8	150% of recommended dose	15	43	5



38. A single weed in plot 6 has a genetic mutation that allows its cells to transport herbicide out through the cell membrane before the weed is harmed. Suppose a student allows weeds to grow in plot 6 and then periodically treats them with herbicide.

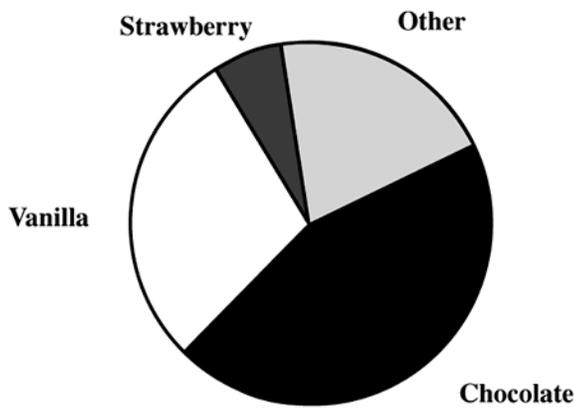
Which graph best represents the expected frequency of the mutant gene in the weed population over time?

Source: Ohio Graduation Test for Science, March 2006, Ohio Department of Education.

Age Group	Chocolate	Vanilla	Strawberry	Other	Total
Under 12 years	30	41	4	7	82
12 to 20 years	52	39	9	21	121
21 to 45 years	31	25	12	47	115
Older than 45	8	11	22	7	48

The circle graph below represents the flavor preferences for one of the four age groups.

### Ice Cream Flavor Preferences



Which age group's preferences are represented in the graph?

- A. Under 12
- B. 12 to 20
- C. 21 to 45
- D. Over 45

Source: Ohio Graduation Test for Mathematics, March 2005, Ohio Department of Education.

### What instructional practices are effective for improving students' nonfiction reading?

The use of visual or graphic representations is common on the OGT. Although important for success on the graduation test, understanding visual and analytic texts is a skill that students need in their everyday lives. Integrating literacy strategies into content instruction will help students to make explicit connections between those strategies and content learning. Effective practices include those in which teachers:

**Coordinate nonfiction reading, including textbook reading, with more experiential learning activities.** To aid comprehension, students need some background knowledge about the content prior to reading. Use non-fiction texts to reinforce and cement concepts introduced through lessons and activities.

**Use prereading or text preview strategies to orient students to the text.** Before reading or making reading assignments, "walk" students through the text, pointing out the way the text is organized, the focus of the content, and troublesome words. Help students to establish a purpose for reading and to make connections to other concepts.

**Model the use of literacy strategies by reading content-specific texts.** Not all text can be approached in the same manner. Students must be able to match their literacy strategies with the demands of the texts. Think-alouds, explicit strategy lessons, and guided instruction are ways to demonstrate the application of literacy strategies.

**Teach vocabulary, paying attention to both semantic and structural features of the words.** Concept maps, semantic feature analysis charts, word maps, and Venn diagrams allow students to learn word meanings and analyze structures.

**Provide graphic organizers for note taking and synthesis of important information.** Use writing frames, T-charts, and column notes to guide students through texts.

Covering every possible question type that students may face on the state tests is not a realistic goal. Instead you can help students to approach a variety of texts confidently by teaching skills that can be applied flexibly across content areas.

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This OGT column originally appeared in the December 2006 issue of *Adolescent Literature In Perspective*.

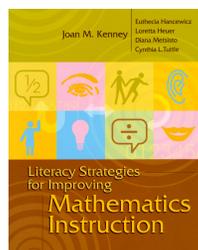
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*Nicole Luthy is the Assistant Director of the Ohio Resource Center and the Project Director for AdLIT. A former classroom teacher and consultant for the Ohio Department of Education, she has experience in staff development and curriculum and assessment.*

### For Your Bookshelf

## Books by Kenney et al., Barton and Heidema, and Barton and Jordan

by Judy Spicer and Terry Shiverdecker



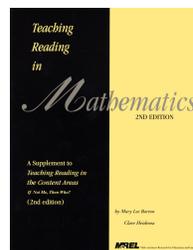
*Literacy Strategies for Improving Mathematics Instruction*, by Joan M. Kenney, Euthesia Hancewicz, Loretta Heuer, Diana Metsisto, and Cynthia L. Tuttle (Association for Supervision and Curriculum Development, Alexandria, VA, 2005)

In this slim volume, mathematics teachers, literacy instructors, and curriculum leaders will find a powerful rationale for using vocabulary and reading comprehension literacy strategies to make mathematics more accessible to all students.

In the opening chapter, Joan Kenney explores the implications of considering mathematics as a language and how the complexity of the English language can create learning problems for students. In subsequent chapters, four coauthors demonstrate how literacy strategies can support the development of student understanding when reading, writing, problem solving, and using graphic representations in mathematics contexts. These chapters feature scenarios based on the authors' teaching experiences. Included are examples of using literacy strategies with ELL and special needs students. Samples of student work are found throughout the book. The book concludes with Kenney's description of school environment characteristics that support the changes needed to achieve mathematics success for all students.

*Literacy Strategies for Improving Mathematics Instruction* is very appropriate for professional book discussion groups. The publisher's website features a study guide with chapter-based discussion questions.

—Judy Spicer



*Teaching Reading in Mathematics, 2nd ed.*, by Mary Lee Barton and Clare Heidema (McREL, Mid-continent Research for Education and Learning, Aurora, CO, 2002)

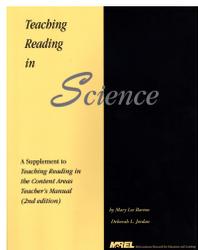
Authors Mary Lee Barton and Clare Heidema present a clear rationale for why vocabulary and reading skills are important to students' mathematics learning. The book's informative first half discusses what reading in mathematics means and then examines the elements of the learning process. The book explains the interaction of reader, climate, and text during reading. Illustrations, practical examples, and implications for instruction are included. Six straightforward assumptions about learning, based on recent research, are presented as a link between learning theory and reading theory. The assumptions supply the context for applying the reading strategies found in the book's second half.

The book features thirty-five reading strategies (divided into vocabulary development, information text comprehension, and reflection strategies) that are appropri-

ate for use in mathematics classrooms. Some strategies, such as the Frayer model and knowledge rating chart, may be familiar, but the authors enrich these familiar ideas with mathematically relevant examples and suggestions. Each strategy's multipage presentation includes an explanation of how the strategy can help students learn mathematics, suggestions for using the strategy, and classroom-ready reproducible materials.

The content and format of *Teaching Reading in Mathematics* make it a good choice for mathematics teacher groups working together on lesson development.

—Judy Spicer



*Teaching Reading in Science* by Mary Lee Barton and Deborah L. Jordan (McREL, Mid-continent Research for Education and Learning, Aurora, CO, 2001)

*Teaching Reading in Science* presents reading strategies in the context of the learning cycle. This is particularly helpful to science teachers who are familiar with the learning cycle and use this model to support inquiry-based teaching. The reading strategies are divided into three phases of cognitive development: vocabulary, informational text, and reflection strategies. Multiple strategies are provided for each phase of cognitive development. Each strategy is presented in a way that helps science teachers see the value of the strategy. The information describes the strategy, tells which stages of the learning cycle the strategy complements, and explains how to use the strategy. Several examples are provided for each strategy. Another feature science teachers will find particularly helpful is the section titled "Guidelines for Promoting Conceptual Change." The guidelines align well with the phases of the learning cycle and provide strategies for more effective use of science textbooks. Additional information on interactive elements of reading and strategic processing is also included.

—Terry Shiverdecker

*Judy Spicer is a mathematics contents specialist at the Ohio Resource Center. She has taught mathematics at the high school and community college levels, has done writing about mathematics curriculum materials and related issues, and has served as the mathematics content specialist in the development of two education-related digital libraries. Judy is a frequent presenter at national conferences.*

*Dr. Terry Shiverdecker is a science content specialist at the Ohio Resource Center. She began her career in education as a high school science teacher at Russia Local School in Shelby County. While at Russia, she taught both physical and biological sciences, served on curriculum committees, and designed and taught a course for the Concord Consortium's Virtual High School. In addition, her teaching experience includes adjunct work at the University of Cincinnati and Wright State University, Lake Campus. Terry was also director of secondary curriculum and instruction for the Shelby County Educational Service Center.*

From the ORC Collection

## More Resources for Using Literacy Strategies in Mathematics and Science Learning

Here are some resources from the ORC collection related to this month's theme, Using Literacy Strategies in Mathematics and Science Learning.

### Mathematics Teachers

#### Instructional Resources

The Mathematics Bookshelf (<http://www.ohiorc.org/for/math/bookshelf/default.aspx>) identifies resources that contain illustrated books and teaching suggestions that can engage students in mathematics using literature. Here are three that are especially relevant to this month's theme:

#### The King's Chessboard

ORC# 11120

<http://www.ohiorc.org/record/11120.aspx>

The books *One Grain of Rice* and *The King's Chessboard* tell the same classic tale of the astounding effect of doubling a single grain of rice each day over a period of 30 days. In *The King's Chessboard* the protagonist is a wise man and the quantity of rice is analyzed in terms of weight. In *One Grain of Rice* the protagonist is a young girl and the quantity of rice is analyzed in terms of the number of grains. Both books are beautifully illustrated.

#### How Much Is a Million?

ORC# 11106

<http://www.ohiorc.org/record/11106.aspx>

This picture book illustrates the height of a million students, the time it takes to count to a million, the volume of a million goldfish, and the area of a million dots for stars. For comparison, students are challenged to imagine a billion and then a trillion of each measure. The as-

sumptions made in estimating each quantity are listed at the back of the book for easy reference. This book would work nicely in conjunction with these ORC-recommended lessons: Too Big or Too Small?, Count on Math: Making Your First Million, and How Can I Relate?

#### If You Hopped Like a Frog

ORC# 11117

<http://www.ohiorc.org/record/11117.aspx>

This book uses the astounding capabilities of various animals to introduce the idea of ratio and motivate proportional reasoning in middle grades students. For example, "If you hopped like a frog, you could jump from home plate to first base in one mighty leap. If you were as strong as an ant, you could lift a car!" At the end of the book, pertinent documentation is provided so students can use their own measurements to calculate what they would be able to do if they had capabilities proportional to those of animals

The Problem Corner ([http://www.ohiorc.org/for/math/problem\\_corner/default.aspx](http://www.ohiorc.org/for/math/problem_corner/default.aspx)) presents problems that require careful reading. Get your feet wet with these two, which are right on topic:

#### The Commuter

ORC# 10124

<http://www.ohiorc.org/record/10124.aspx>

This problem, at first blush, looks like a fairly typical distance-rate-time problem and is a good one to pose after students have worked a few DRT problems. Drawing a diagram will help the students reason out the solution. This mathematically rich problem was prepared by the Ohio Resource Center to accompany the Mathematics Program Models for Ohio High Schools developed by the Ohio Department of Education.

#### Treasure Map

ORC# 10136

<http://www.ohiorc.org/record/10136.aspx>

A treasure map has bizarre directions that seem a little vague but, indeed, locate a treasure accurately. Students construct examples on a worksheet to help them form a conjecture as to what is going on. They then undertake a formal proof of the conjecture. It is quite a surprise as to what is ultimately behind these vague directions. This mathematically rich problem was prepared by the Ohio

Resource Center to accompany the Mathematics Program Models for Ohio High Schools developed by the Ohio Department of Education.

### Professional Readings

#### **Unlocking the Mystery of Mathematics: Give Vocabulary Instruction a Chance**

ORC# 11864

<http://www.ohiorc.org/record/11864.aspx>

This classroom vignette explores teaching vocabulary in the mathematics' classroom. Ohio teacher Bizzie Cors tackles reading comprehension and vocabulary instruction head-on in "Unlocking the Mystery of Mathematics: Give Vocabulary Instruction a Chance." She provides some excellent tips for engaging and motivating students with explicit strategies for vocabulary instruction.

#### **A Case for Using Reading and Writing in a Mathematics Classroom**

ORC# 4360

<http://www.ohiorc.org/record/4360.aspx>

In this article, Sarah Kasten describes her experiences with incorporating reading and writing into mathematics curriculum. She explains that students receive a more complete education when different strategies of teaching mathematics are used as a part of instruction. These strategies include reflecting, using sources of information beyond the "official" textbook, and explaining problem-solving processes and results in writing. She discusses her use of the novel, *The Number Devil*, to motivate and engage ninth-grade students in learning mathematics. Kasten's successes are easy to model for any educator willing to experiment with using different strategies to create a positive learning environment for students.

#### **Literacy Strategies for Improving Mathematics Instruction**

ORC# 11856

<http://www.ohiorc.org/record/11856.aspx>

*Literacy Strategies for Improving Mathematics Instruction* is a book published by the Association for Supervision and Curriculum Development (ASCD) that blends current research on language literacy with practitioner evidence of the unique challenges of transferring language skills to

the mathematics classroom. Excerpts from the book are available at this website, including the Preface, Chapter 1, Chapter 2, and related references and resources. Especially valuable is the *Study Guide*, which includes discussion and reflection questions for each chapter in the book.

#### **A Look at the OGT: Building Vocabulary in the Content Areas**

ORC# 11866

<http://www.ohiorc.org/record/11866.aspx>

"A Look at the OGT" in the October 2008 issue of "Adolescent Literacy In Perspective" reveals some good strategies for building vocabulary in the content areas. Ohio educator Carol Damian shares her insights and methods, sample OGT test questions and problems, and her experience with teaching tough vocabulary that commonly occurs in high-stakes testing. Teachers will appreciate that Damian uses sample test questions in mathematics, science, and social studies to discuss ways to teach content-area vocabulary.

#### **Reading and the Mathematics OGT**

ORC# 8012

<http://www.ohiorc.org/record/8012.aspx>

In this article, ORC Executive Director Peggy Kasten addresses how important being able to "read" mathematics problems is for being able to solve those problems. Kasten identifies two important ways of reading -- creating mental images and understanding -- as necessary components for being able to understand what a mathematics problem is asking. She then takes those reading elements and shows how they are integral to solving two sample Ohio Graduation Test mathematics problems. Her approach is targeted towards helping teachers prepare students for success on the Mathematics Ohio Graduation Test.

### Webcasts

#### **Webcasts for Mathematics: A Look at the OGT**

<http://www.ohiorc.org/for/math/ogt/default.aspx>

#### **Strategies and Discussion Model for Item Analysis video**

<http://www.ohiorc.org/webcast/view.aspx?id=15>

**Vocabulary, Visualization, and Implications—Improving Student Achievement on Geometric Test Items** (Webcast Article)

ORC# 11588

<http://www.ohiorc.org/record/11588.aspx>

This article was written as background information for viewers of the first in a series of three webcasts discussing issues related to the mathematics portion of the Ohio Graduation Test (OGT). The first webcast, aired April 29, 2008, focused on analysis of student responses to geometry items on the OGT. This article discusses several examples of student reasoning and considers the implications for teaching.

**Increasing Student Success on Constructed-Response Items video**

<http://www.ohiorc.org/webcast/view.aspx?id=17>

**Adapting Literacy Strategies to Improve Student Performance on Constructed-Response Items**

(Webcast Article)

ORC# 11602

<http://www.ohiorc.org/record/11602.aspx>

This article was written as background information for viewers of the last in a series of three webcasts discussing issues related to the mathematics portion of the Ohio Graduation Test (OGT). The third webcast, aired May 8, 2008, focused on student responses to constructed-response, or short-answer, items on the OGT. This article discusses ways of adapting various reading strategies to help students improve their answers to constructed-response items.

## Science Teachers

### Professional Readings

**A Look at the OGT: Considering Science**

ORC# 8009

<http://www.ohiorc.org/record/8009.aspx>

This column describes the science portion of the Ohio Graduation Test, examines some science items, and looks at instructional strategies that can be used to increase student achievement in science. ORC Science Content Specialist Terry Shiverdecker provides a thorough description of the test, including sample problems, and then discusses what students will need to be able to do in order to

solve those problems. A unique characteristic of the science portion of the OGT is that questions are categorized based on cognitive demand. These four categories include questions about (1) recalling/identifying accurate science; (2) communicating understanding/analyzing science information; (3) demonstrating investigative processes of science; and (4) applying concepts/making relevant connections with science.

**Make Science Reading Fun and Meaningful in Middle School!**

ORC# 4361

<http://www.ohiorc.org/record/4361.aspx>

In this article, middle school teacher Teresa Null explores teaching reading strategies in her science classroom by teaching units through scientific storylines. In small groups, students read aloud an assigned paragraph in order to share, respond to, and determine the meaning of the text. The small groups then report to the rest of the class and in the process, become “experts” on their passages through “teaching” the rest of the class. The groups also create one question generated by their readings. The whole class then tries together to respond to the question. Null discusses potential difficulties for teachers carrying out this activity, helpful advice for teachers thinking about using this strategy in their classrooms.

**Writing to Represent Scientific Knowledge—Thinking Beyond the OGT**

ORC# 12099

<http://www.ohiorc.org/record/12099.aspx>

The article written by Dr. Sarah Woodruff, the director of Ohio’s Evaluation and Assessment Center for Mathematics and Science Education, reports on the role of scientific discourse in science learning, discusses writing to represent learning, and offers strategies for representing-to-learn throughout the learning cycle.

### Webcasts

**Webcasts for Science Instructional Strategies: A Look at the OGT**

<http://www.ohiorc.org/for/science/ogt/default.aspx>

**Nonfiction Reading and Science Instruction video**

<http://www.ohiorc.org/webcast/view.aspx?id=5>

### **Reading Science—Reading the OGT**

ORC# 11387

<http://www.ohiorc.org/record/11387.aspx>

This article written by Carol Damian, Worthington Schools, discusses the importance of nonfiction reading in the science classroom, shares ways to support readers as they grapple with science vocabulary and expository text, and presents two graphic organizers that students can use to analyze questions and develop responses to OGT-like items.

### **Writing to Represent Scientific Knowledge video**

<http://www.ohiorc.org/webcast/view.aspx?id=47>

### **Writing to Represent Scientific Knowledge—Thinking Beyond the OGT**

ORC# 12099

<http://www.ohiorc.org/record/12099.aspx>

The article written by Dr. Sarah Woodruff, the director of Ohio's Evaluation and Assessment Center for Mathematics and Science Education, reports on the role of scientific discourse in science learning, discusses writing to represent learning, and offers strategies for representing-to-learn throughout the learning cycle.

### **Mini-Collections**

#### **Managing Science Vocabulary**

[http://ohiorc.org/bookmark/view\\_a\\_folder.aspx?folderID=13635](http://ohiorc.org/bookmark/view_a_folder.aspx?folderID=13635)

#### **Incorporating Reading into Inquiry Lessons**

[http://ohiorc.org/bookmark/view\\_a\\_folder.aspx?folderID=13636](http://ohiorc.org/bookmark/view_a_folder.aspx?folderID=13636)

#### **Literacy Support Strategies & ORC Science Lessons**

[http://www.ohiorc.org/bookmark/view\\_a\\_folder.aspx?uid=9681&folderID=13954](http://www.ohiorc.org/bookmark/view_a_folder.aspx?uid=9681&folderID=13954)

#### **Writing to Represent Scientific Knowledge**

[http://www.ohiorc.org/bookmark/view\\_a\\_folder.aspx?folderID=16678](http://www.ohiorc.org/bookmark/view_a_folder.aspx?folderID=16678)

### \* ORC Records

In case you are not familiar with ORC's records, here is a very brief explanation of the resource commentaries and other resource information found in the records.

Each commentary is part of a larger record created by the Ohio Resource Center. The commentaries describe high-quality Internet-based resources in the areas of mathematics, science, and reading. In addition to the commentaries, the records specify grade levels appropriate to the resources and align the resources to the relevant Ohio standards, benchmarks, and indicators (providing an excellent way to help teachers implement the Ohio standards in their classrooms) plus much more. Each resource can be accessed directly from the record.

To find out more about ORC resources and records, go to ORC's Frequently Asked Questions page.

## Adolescent Literacy In Perspective

Each issue of *Adolescent Literacy In Perspective* highlights a topic in adolescent literacy. Here you can read teacher-written articles, see what experts in the field are saying, gain insight from students, and find resources for classroom use.



### About the Ohio Resource Center for Mathematics, Science, and Reading

The Ohio Resource Center works to improve teaching and learning among Ohio teachers by promoting standards-based, best practices in mathematics, science, and reading for Ohio schools and universities. The Center's resources are available primarily via the web and are coordinated with other state and regional efforts to improve student achievement and teacher effectiveness in K-12 mathematics, science, and reading. To learn more about ORC, visit the website at [www.ohiorc.org](http://www.ohiorc.org).

The Ohio Resource Center is a project of the State University Education Deans, funded by the Ohio General Assembly, and established by the Ohio Board of Regents. ORC is located on the campus of the Ohio State University and is affiliated with OSU's College of Education and Human Ecology.



The Office of Literacy is part of the Ohio Department of Education. The ultimate goal of the Office of Literacy is to help all students become proficient readers. The initiatives from this office communicate research-based practices and attempt to build an awareness and understanding for a richer, broader view of adolescent literacy in schools and communities. The office engages in statewide collaborations with other institutions and agencies. AdLIT is one of many collaborations that bring together a variety of constituents and stakeholders in promoting adolescent literacy. For more information, see <http://www.ode.state.oh.us/GD/Templates/Pages/ODE/ODEDetail.aspx?page=3&TopiRelationID=890&Content=10467>.

### What Is AdLIT?

Advancing Adolescent Literacy Instruction Together (AdLIT) is designed to address the unique literacy needs of adolescent learners by promoting and supporting effective, evidence-based practices for classroom instruction and professional development activities in Ohio's middle and secondary schools.

### AdLIT Staff

**Executive Director, ORC** Margaret Kasten

**Associate Director, ORC** David Majesky

**Assistant Director, ORC** Nicole Carter Luthy

**Managing Editor** Judy Duguid

**Graphic Designer** Andrew Ault

**Contributing Editor** Carol Brown Dodson

**Contributing Editor** Sheila Cattlebury

**Web Developer/Engineer** Jerrod Kennedy

**Web Developer/Engineer** Constance Buckley

**Administrative Support** Gale Martin

### Affiliated Staff

**Science Content Specialist** Terry Shiverdecker

**Mathematics Content Specialist** Sigrig Wagner

**Mathematics Content Specialist** Judy Spicer

### Project AdLIT

**Ohio Resource Center for Mathematics,  
Science, and Reading**

1929 Kenny Road  
Columbus, Ohio 43210-1079

**Hours** Monday-Friday, 8 a.m.-5 p.m.

**Telephone** (614) 247-6342

**Fax** (614) 292-2066

**Email** [web@ohiorc.org](mailto:web@ohiorc.org)