

High School Mathematics Lesson Plan: Workplace Applications for Algebraic Expressions

Introduction

Each lesson in the Adolescent Literacy Toolkit is designed to support students through the reading/learning process by providing instruction before, during, and after reading/learning.

Note that lessons incorporate the *gradual release of responsibility* model. When this model is used within a single lesson and over several lessons, students are provided with enough instruction and guidance to use the literacy strategies on their own. The following lesson includes some examples of explicit instruction and modeling, guided practice, and independent practice, but students need more practice and feedback than is possible within the context of a single lesson.

Bold print indicates a direct link to the *Content Area Literacy Guide* where readers will find descriptions of literacy strategies, step-by-step directions for how to use each strategy, and quadrant charts illustrating applications across the four core content disciplines.

The following lesson plan and lesson narrative show mathematics teachers how they can incorporate the use of literacy strategies to support high school students to learn mathematics content and concepts. The lesson is designed for one block period (80–90 minutes) or two traditional classes (50 minutes).

Instructional Outcomes

NCTM Standards: 8.2 Selects and uses appropriate concrete materials for learning mathematics. 8.8 Demonstrates the ability to lead classes in mathematical problem solving, developing in-depth conceptual understanding, and help students develop and test generalizations. 10.2 Apply fundamental ideas of linear algebra.

Content Learning Outcome: Students will develop purpose for learning algebraic expressions by connecting the algebraic concepts to a variety of workplace problems.

Literacy Support Strategies and Instruction

Before reading/learning: **Problematic Situation** (guided practice)

- Materials: A list of teacher-summarized **Problematic Situations** for workplace problems that require solutions using algebraic expressions directly derived from the workplace application or integration examples in the text chapter.

During reading/learning: **Problematic Situation with Paired Reading** (guided practice)

- Materials: Technical math or Algebra text chapter on algebraic expressions for addition, subtraction, multiplication, and division that includes workplace application examples that use algebraic expressions to solve a problem.

After reading/learning: **Problematic Situation** (guided practice)

Before Reading/Learning (20 minutes)

Literacy outcome: Students will develop purpose for learning algebraic expressions and reading mathematics text by making before-reading predictions about how workplace problems involving mathematics can be solved.

Teacher preparation: Create a set of workplace problems called **Problematic Situation** that are directly related to workplace applications, integrations, or word problems in the text chapter.

- The intent of the **Problematic Situation** is to help students set a purpose for learning algebraic expressions and for reading the related text chapter by making a connection between career problems and mathematical solutions.
- The ideas in the Sample **Problematic Situation Template** illustrate how a **Problematic Situation** is summarized to stimulate interest and inquiry and how they are presented to students in a format for them to write predicted solutions before reading, and actual solutions during reading.

Sample Problematic Situation Template

Directions: Read each problem in the left column. Select three problems and brainstorm ways to solve them. If you finish early, try to solve the other two problems. Use the middle column to record the brainstormed ideas before reading. You will fill out the third column during reading.

Problem	Possible Ways to Solve the Problem	Text Solution/Evidence (list page #s)
You deliver oil for an oil company. You're supposed to deliver 1375 gallons to a customer who has two empty tanks. Your work order only says <i>Tank 2 holds 275 more gallons than Tank 1</i> . How can you be sure you don't overfill either tank?		
You are a nurse. The doctor's note says the patient needs her medicine diluted with $\frac{2}{5}$ water, but the bottle of medicine says it contains 2L of medicine and 6L of water. You know if the patient gets too little or too much medicine, she may have a serious and possibly fatal reaction. What will you do?		
You are a farmer with a very limited budget. You need to fence in chickens on your square tract of land that is divided into two equal parts by one line of fence that runs parallel to one of the sides. This line will separate the chickens and roosters. You can only afford to buy 75m of wiring. How will you know if that's enough to build the chicken fencing?		
You work for a lawn equipment company. You have an angry customer who ruined his engine by failing to mix the right amount of gasoline with oil. He's yelling at you, "It says it's 15 parts of gasoline to 1 part of oil, but you sold me a mixture that is 75% gasoline. What am I supposed to do to make 8L of the mix?" What will you do to solve the problem and explain the amounts to him?		
You are a heating, ventilation, and air conditioning (HVAC) mechanic. Your boss sent you out alone on a job and said "Get it done." You find out on arrival that the monitoring system for the building reads 35 degrees Celsius, but the repair manual for the chiller measures everything in Fahrenheit. How will you get the chiller set to the correct temperature to cool the building?		

Teacher facilitation:

- 1) Explicitly explain the **Problematic Situation** strategy and how students will be using it:
 - Remind students the math they learn in high school is necessary to perform many technical jobs, such as veterinary science, engineering, and medical careers.
 - Tell students that, to stimulate their interest in the upcoming math chapter, they will first predict answers to several workplace problems.
 - Explain they'll be using a literacy strategy called **Problematic Situation**, which is a real-life application problem a teacher or a learner visualizes and makes predictions about the solution before reading in order to stimulate interest and purpose for reading and learning. During reading, the reader seeks the direct solution to the problem or gathers evidence or ideas about a good solution. After reading, students will compare their predicted solution to the solution presented in the math chapter.
 - Tell students they should envision themselves in these workplace environments in the role of the employee who has to resolve the problem. Their solutions should reflect how they would solve the problem on the job and how they would want their boss to think about them and their work.
- 2) Pass out the **Problematic Situations**.
 - Ask pairs of students to read the **Problematic Situations** on the template and discuss how to solve at least three of the problems.
 - Do not mention that the **Problematic Situations** can be solved by an algebraic solution, in order to assess how many students thought to use algebraic solutions on their own.
- 3) Circulate while students are brainstorming to observe how they approach problem solving. Use this as an opportunity to individually guide students.
 - See if students are guessing the solutions could involve use of an algebraic expression.
 - Observe how many students are generating solutions for solving the problems themselves or relying on others to resolve it. For example, they might say "I'll calculate it by..." which is self-reliant or they might say, "Call the doctor" which is relying on someone else. In addition to immediate assessment and feedback to individual students, this trend information will be helpful at the end of the lesson when you discuss the need for workers to be self-reliant in their jobs.

During Reading/Learning (40 minutes)

Literacy outcome: Students will read the math chapter to confirm their predicted solutions using peer support to comprehend and summarize difficult text.

Teacher facilitation:

- 1) Explain in this section of the lesson, students will use **Paired Reading** to read, discuss, and make connections with the **Problematic Situations** and the math text.
 - Explain during **Paired Reading**, students will alternate reading a part of the text, such as a paragraph or short section, with the listener summarizing the paragraph and the reader "approving" the summary. Then the students switch roles of reader and summarizer.
 - If one person gets stuck, he or she can ask the partner for help. If they both get stuck, they should go back to the text and re-read to see if they can answer their

question.

- Explain that since the goal is for students to practice reading and understanding written math explanations more independently, they should ask for teacher assistance only after this process has been followed.
- 2) Tell the students they should record the way the text solved the **Problematic Situations** as they find the section of the text that explicitly shows the algebraic answer to the problem.
 - Students should summarize the solution and add it in the last column of the **Problematic Situation** along with the page number.
 - Students should study the algebraic equation used to derive the exact answer.
 - 3) Circulate among the pairs to ensure students are following the **Paired Reading** process by alternating reading and summarizing and, as needed, help them see where and how the text leads them to the answers.

After Reading/Learning (25 minutes)

Literacy outcome: Students will use peer discussion to deepen their analytical thinking and real world applications for new algebraic concepts.

Teacher facilitation:

- 1) Ask pairs of students to move into groups of four (two pairs) to share and compare their responses to the **Problematic Situation**.
 - Groups should agree on the page(s) where evidence was located that supports the solution.
 - Groups should discuss the algebraic solution so each student understands how it is mathematically calculated.
- 2) Conclude the lesson by having students review their initial solutions to guide a discussion of direct problem solving versus depending on others to solve problems.
 - Explain that teachers often frontload information or provide answers to help students learn. Ask them how the workplace will be different, guiding them to realize that in most jobs, employees are expected to know how to problem solve on their own and make specific recommendations to their bosses, rather than having to always ask others for an answer.
 - Ask them to count and record how many of their original predictions involved math, how many involved a task they would themselves do, and how many involved passing on the work to someone else, such as a boss or product help desk.
 - Stress that teachers, like bosses, give initial directions, but both eventually want the students/employees to be independent in their work.
 - Tell students that, in the workplace, employees are expected to read technical manuals independently, so it is important to learn to read math text in addition to learning from teacher instruction.
 - At the end of the class, collect the **Problematic Situations**, review student responses, and tally the types of predictions generated: involving math, doing the task themselves, and passing on the work to others.
 - Use the data to reinforce the concept that technical jobs often require employees to solve problems independently or with their peers, including reading technical manuals involving mathematics, and many problem solutions will involve algebraic expressions.

Like all student-completed literacy strategy templates, these completed **Problematic Situations** provide valuable data for teacher reflection. The completed **Problematic Situations** should not be graded. They should be used to assess student learning and make decisions about next steps in teaching.

Suggested Subsequent Lessons

The teacher can gradually transfer the responsibility for creating **Problematic Situations** to the students by having small groups work together while reading the next chapter. Ask the students to create a **Problematic Situation** that can be resolved through the mathematical concepts and write it up in a similar fashion to those they solved for algebraic expressions. To help students learn from one another, the teacher can put all of the groups' **Problematic Situations** on a handout or front board and ask pairs of students to solve half of them, not including the one they created. Then the group who created the problem could lead the after-reading discussion, modeling how they constructed the **Problematic Situation** and used evidence from the text to support it. In later lessons, students can create **Problematic Situations** before reading by previewing the text chapter (e.g., introduction, headers, bold print vocabulary, and chapter summary) and making connections with their own knowledge and experiences.

Problematic Situations can also be paired with other literacy support strategies like **Quick Writes**, **RAFT**, or **Analytic Graphic Organizers** to deepen students' understanding of content.

High School Mathematics Lesson Narrative: Workplace Applications for Algebraic Expressions

Teachers: As you read the lesson narrative, think about the following questions. You may want to discuss them with fellow mathematics teachers.

- *What does the teacher do to support students' literacy development and content learning before, during, and after reading/learning?*
- *What challenges do you anticipate if you were to implement this lesson in your own classroom? How would you prepare to meet these challenges?*
- *How would you make improvements to this lesson?*

It was the third week of class and Ms. Dylan could already see many students in her Career and Technical Education Algebra course were struggling when they read the descriptive sections in the technical mathematics textbook. She knew they understood the content better when she frontloaded information, explained vocabulary, and provided examples of how mathematics is used in real world situations. Many avoided even trying to read the textbook chapters, relying solely on her to explain the mathematics concepts. She worried that, in the technical careers many would be entering right after high school, they would need to be able to independently read challenging technical text and apply the information to real world problem solving.

She wondered what else she could do. She'd never had any reading training. At lunch she asked another teacher, "What do you do when your students can't read their textbook?" Her colleague shared an idea about a strategy she'd learned the previous summer, called **Problematic Situation**. "I know lots of us try to set up problems ahead of time, but we're not really doing **Problematic Situations**. This strategy extends frontloading and problem posing to a level that really gets students to think before and during reading." Ms. Dylan decided to try using the **Problematic Situation** format to engage students' interest and give them a more authentic reason to read the mathematics text.

Before Reading/Learning

Ms. Dylan knew if she began the lesson by saying they were going to study algebraic expressions, there would be collective groans. So she decided to begin in a different way. She began the lesson, "Many of you have said you're eager to go to work and begin making money. All jobs require problem solving. Can anyone think of some examples?" Slowly discussion began and students shared problems their parents or older siblings were facing in various careers. "Great answers," she complimented them. "Today you and a partner will be looking at problems that commonly arise in different jobs and predicting how they could be solved."

She passed out the **Problematic Situation** handout which posed authentic problems related to oil delivery, nursing, farming, lawn equipment sales and repair, and HVAC building maintenance mechanics. She had selected these problems because the text gave a specific explanation of how algebraic expressions could solve the problem, but she didn't tell the students the text contained the answers.

"As you can see on this handout, five workplace problems are listed. I want you to form into pairs and brainstorm as many ideas as you can about how you could solve each of the problems. Think about your own experiences and use anything you already know to solve the problem. Try for at least one solution to three of the problems, but if you can answer all five, or think of two or three solutions for a problem, that would be great! The strategy you're using is called **Problematic Situation**. By visualizing a problem and making predictions about it before reading, it will be easier for you to understand the mathematics text because you'll have a real

purpose in mind when you read. Like a detective, you'll be seeking evidence to see if your predicted solution is accurate."

With less grumbling than usual, the students began reading the problems together and listing possible solutions in the middle column of the template. As she circulated to answer questions and explain vocabulary, she noticed several pairs were writing solutions like, "Ask my dad" or "Call the doctor" rather than creating a solution themselves. She decided it would be very important at the end of the period to help students see when they are avoiding problems rather than solving them. She would need to tell them most employers expect employees to problem-solve on their own or with their work team.

During Reading/Learning

"Next, each of you will read the section of the chapter that relates mathematics to your problem." She wrote the chapter title *Algebraic Expressions* on the board along with the page numbers and, as she expected, many students immediately groaned. "Yes, sometimes reading a mathematics text is hard. So you're going to use **Paired Reading** to read these six pages and help each other understand. Your specific goal is to find evidence that helps solve the five **Problematic Situations**."

She briefly reviewed the ground rules of **Paired Reading**. "Take turns reading a paragraph at a time, with the listener summarizing the paragraph and the reader "approving" the summary. Then switch roles." She added that if one gets stuck, they can ask their partner for help. If they both get stuck, they should go back to the text and re-read. "Only after you've tried this process can you ask me any questions. The goal is for you to practice reading and understanding written mathematics explanations on your own. As you find the answers, be sure to describe the solution in the third column of your **Problematic Situation** handout. And here's the real challenge of the day—study the algebraic equation that gives you the exact answer to the **Problematic Situations** and be ready to discuss how it was constructed."

Three pairs formed and began to work immediately. They enjoyed getting to talk with one another in mathematics class and the **Problematic Situations** were interesting. But some of the other students looked frustrated and, as usual, they looked to Clarence to speak up for them. "Why are we doing this? I can't read this book. Why can't you just tell us what to do?" complained Clarence.

"Because almost every job will require you to figure out things on your own or with your co-workers without having to always ask the boss what to do. For example, Clarence, you've said you want to be a veterinarian's aide. You're going to have to refer to technical manuals to figure out the quantities of medicine to give to an animal based on factors like weight and age. That's usually based on an algebraic formula. The vet will certainly want to approve your decisions, but most bosses want employees to analyze the problem and figure out the best solution. You'll need to do your own thinking, and part of high school is helping you learn how to do that on your own." Unconvinced, but urged by his buddy Dave to get started, Clarence reluctantly opened his textbook and listened as Dave began to read. Following their lead, the other pairs opened their books, too.

As Ms. Dylan circulated to remind students to follow the back-and-forth, reader-summarizer process as they hunted for evidence for the **Problematic Situations**, students gradually seemed more comfortable as they read and talked softly with one another. Ms. Dylan noticed that several students, who never raised their hands in class, probably from fear of being teased for wrong answers or not understanding, were hesitantly summarizing the paragraph to their friends. Ms. Dylan smiled as students realized all of the job problems were directly explained

and solved in the text. They saw each algebraic expression was expressed in numbers and symbols, then the algebraic operation was explained in words and graphics related to the job problem. The job photos helped too, she observed. As partners encouraged each other, she could hear the discussions deepening as the students worked to understand the difficult concepts. Most of the students were writing solution descriptions and two groups even discussed how the equations for a few of the problems were derived.

After Reading/Learning

As pairs began to finish their work, Ms. Dylan had them blend the pairs into groups of four. She gave them the directions: "Compare your proposed solutions and the solution given in the text for each problem. Which solution is best and why?" While groups appeared to easily agree on the mathematics solution for most problems, Ms. Dylan heard much argument about whether the nurse or the doctor is responsible for mixing the medicine if the pharmacist has sent large bottles instead of individual doses.

With ten minutes left in the class, she called them back together as a whole group to debrief. "How'd you do on your predictions for solving the problems?" "I was right that measurement was involved," gloated Wayne, who had worked in his dad's small engine repair shop on many weekends. "People are always messing up on how to mix the oil and gas for their motors, and it's really kind of easy to figure it out. But who would have thought this is algebra?" Another student said this was an interesting class because her mom was sick and had to take a lot of medicines. Another added that his dad was a building mechanic and often mentioned how much math was involved in his work.

After hearing a few more reactions, including Clarence's expected response that he hoped next time she'd just explain everything to them, Ms. Dylan explained the final task was to revisit their **Problematic Situation** brainstorming list and count up the types of solutions they had generated. "How many did you have that involved math? How many did you have where you tried to solve the problem yourself? How many did you have where you tried to pass over the problem to someone else?" She tallied the results on the board for the whole class: 55 math, 45 by myself, 82 pass it to someone else. She could see the data made its point. Many students hadn't predicted math was involved in the solutions, even though they were in a math class. She ended the class with a discussion of what employers want from employees, focusing on self-reliance to solve problems and to access information from technical manuals or online. When Alex blurted out, "And to help us out, I'll bet you're going to keep on having us try to read and solve math problems more on our own, aren't you?" she smiled. "Yes, I am, and by the end of the year I predict you'll be really good at it, too—you guys did a great job today!"

Ms. Dylan collected the **Problematic Situation Templates** as students filed out the door. She was anxious to see how some of the pairs approached this task and to think about what it might tell her about individual students' learning today.