Mathematical Reasoning

A Workshop by GED Testing Service®

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Key Points

Use this slide to begin the session with an opportunity for the participants to introduce themselves to the rest of the group. You can do this through an ice-breaker activity of your choosing, or you may wish to have individuals introduce themselves and then indicate one thing that they want to learn from the workshop.

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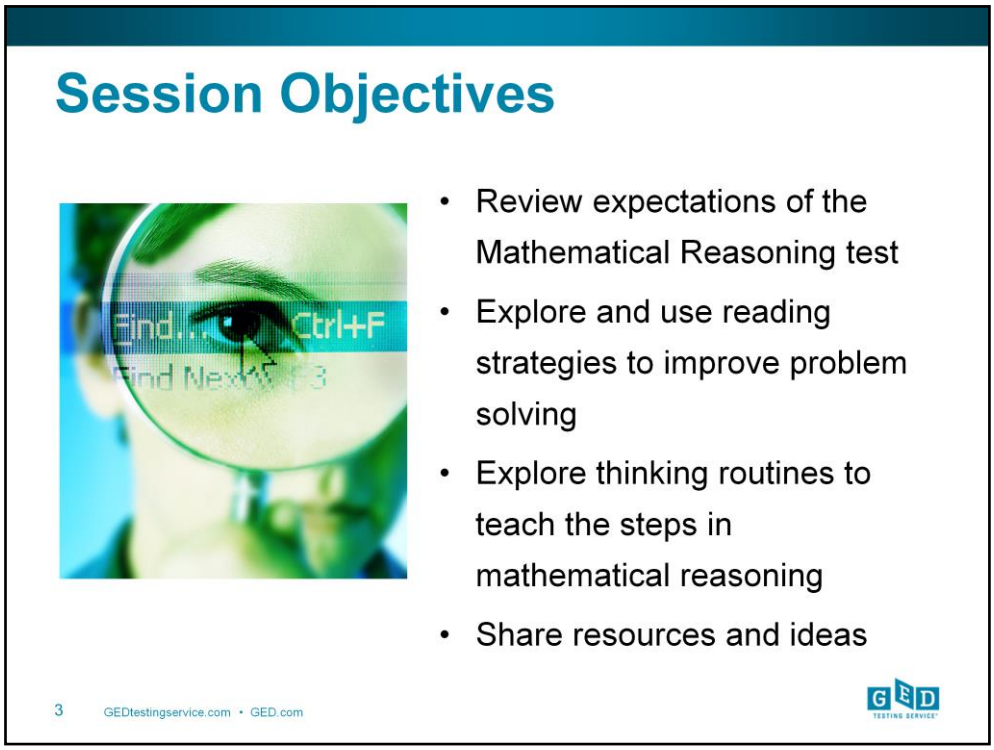

Key Points

Review the objectives of the session. Emphasize the importance of exploring strategies and using those strategies during activities included in the session. Explain that during the session, participants will have an opportunity to review a number of resources that they can use in the classroom.

At this point, you may want to briefly walk participants through the contents of their materials. Explain that they should feel free to write on the activities in the book, since they have clean copies in the resource section of the workbook that they can copy and use in the classroom.

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Key Points

This section will provide a very brief overview of the Mathematical Reasoning test and PLDs and HIIs. If participants are new to the field, additional time may be needed in this area.

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Mathematical Reasoning

Overview

- One test with calculator allowed on most items
- Content
  - 45% - Quantitative Problem Solving
  - 55% - Algebraic Problem Solving
- Texas Instruments - TI 30XS Multiview™
- Integration of mathematical practices

Item Types

- Technology-enhanced items
  - Multiple choice
  - Drag-drop
  - Drop-down
  - Fill-in-the-blank

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Key Points

Review the information on the slide. For veteran instructors, this will be a quick review. New instructors may need explanation of some of the items.

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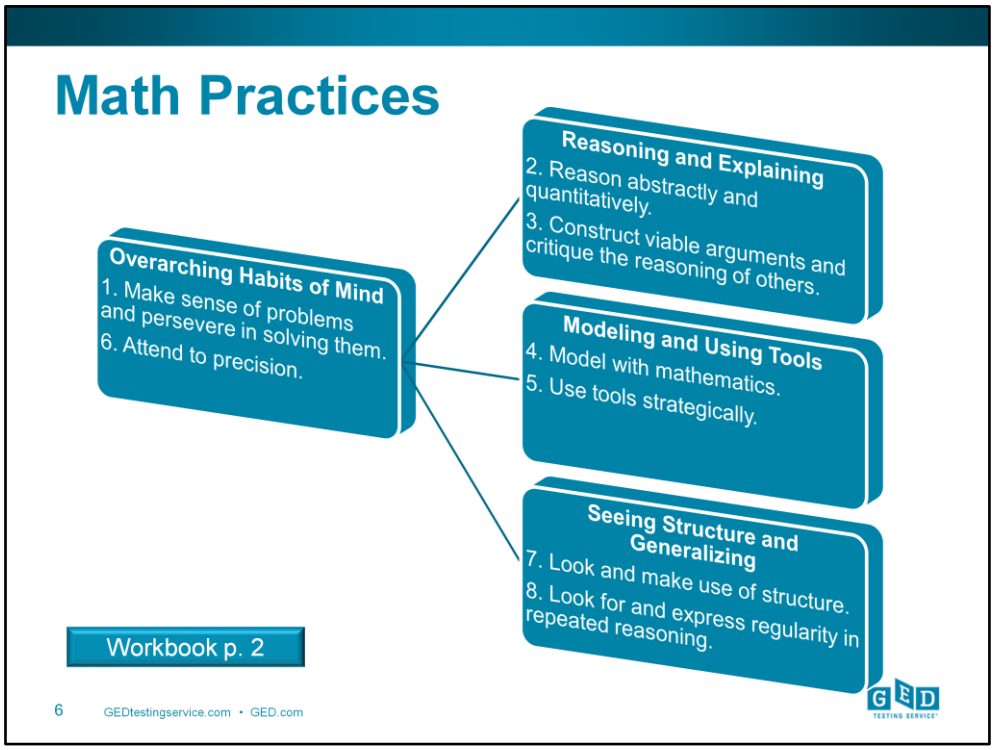

Key Points

Review the information on the slide. Discuss how these practices are integrated into different question types.

Note: The following is background information on math practices.

Standards for Mathematics

Mathematical practices are not standards that are taught in isolation. Instead, these standards connect with content standards at each level. The standards of mathematical practice are the "how" of math – how students become participatory practitioners of math.

Overarching Habits of Mind

The eight practices fall into four basic categories. First, you have the "habits of mind" that students need as effective mathematical thinkers:

1. Make sense of problems and persevere in solving them. In this practice, students know how to explain a problem and solve it.
6. Attend to precision. One of the most important elements within this practice is the attention to precision. In this practice, students understand math terms, recognize symbols, and apply concepts to new situations.

Reasoning and Explaining

2. Reason abstractly and quantitatively. In other words, mathematically proficient students know how to reason in mathematics, not just compute. Many students can compute or do

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basic math calculations. However, they don't know how to use those skills to determine how to solve problems.

3. Construct viable arguments and critique the reasoning of others. Mathematically proficient students analyze situations and determine what they need to do in order to solve a problem.

Modeling and Using Tools

4. Model with mathematics. This practice is the student's ability to analyze the relationships among numbers and other information and solve a word problem. They know how to transfer knowledge from one problem to another. They know how to solve a problem and determine whether or not the answer is reasonable.

5. Use tools strategically. It is essential that students know how to use the tools of mathematics. Students need to be able to use technology whether that is a calculator or a spreadsheet to solve problems.

Seeing Structure and Generalizing

7. Look and make use of structure. An essential practice is the ability to see patterns. Students need to see these patterns from basic number properties, such as the distributive or commutative property, to more complex patterns found in algebraic expressions.

8. Look for and express regularity in repeated reasoning. Mathematically proficient students see not only the process but also the shortcuts, and they understand the concept that is behind the shortcut. It is not enough for students to learn a shortcut. They have to understand the underlying concept and how it can be used in different types of problems. Last, but certainly not least, they can evaluate the problem and determine if their solution is reasonable.

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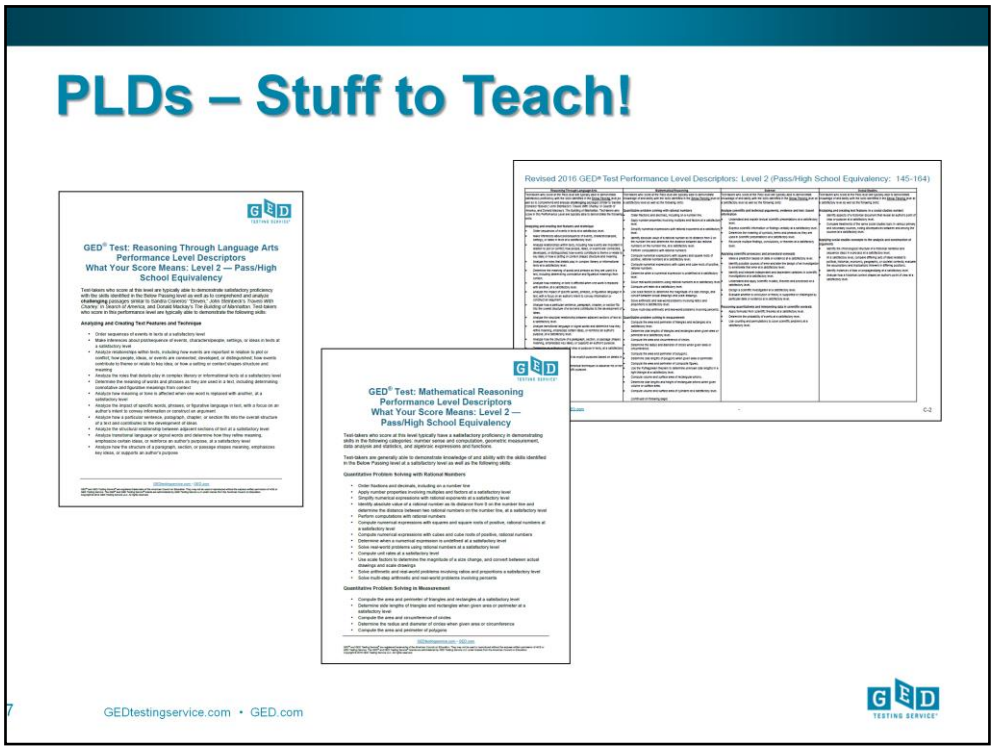

Key Points

What do you need to teach in your GED® Preparation program? Well, it's really not a secret. Performance Level Descriptors, better known as PLDs tell us what we should be teaching. Let's look a little closer at PLDs.

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Key Points

We always seem to have too much content to teach and too little time. Plus, we are often faced with multi-level and multi-area classrooms. So, how do we use the PLDS?

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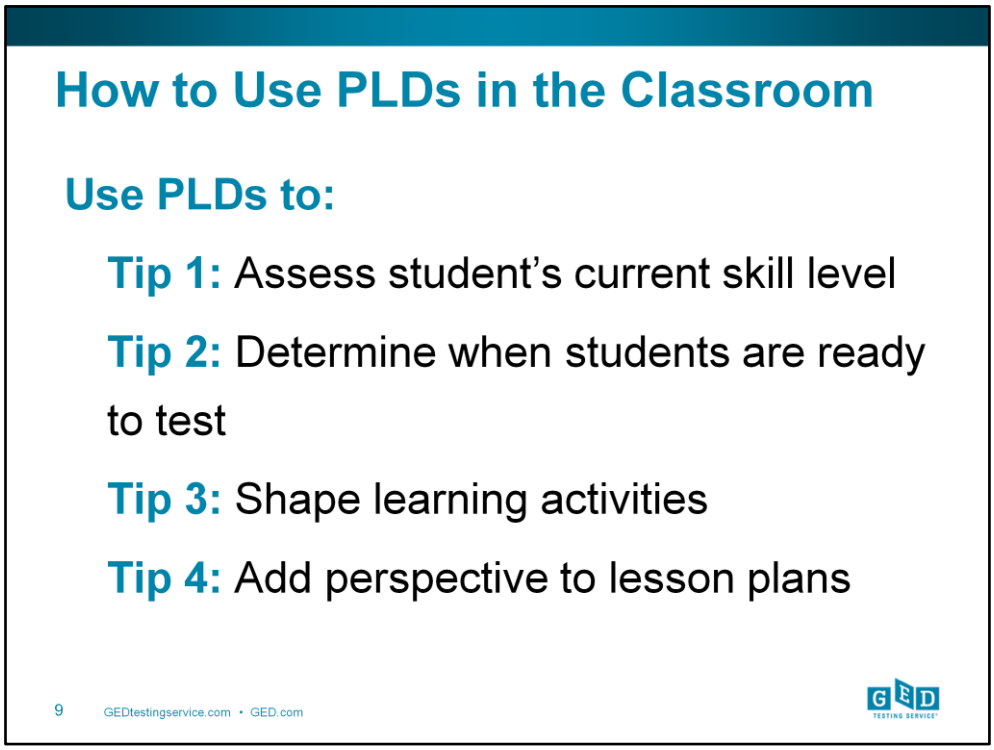

Key Points

There are many different ways that we can use PLDs to assist us in developing an effective curriculum. Here are four tips to get started.

Tip 1: Use PLDs to assess a student's current skill level

Identify where to focus in order to develop the skills students need to move to the next performance level

Tip 2: Use PLDs to determine when students are ready to test
Determine if a student should take GED Ready® or the GED® test

Use with the Enhanced Score Report's personalized study plan to create a plan for developing student skills

Tip 3: Use PLDs to shape learning activities
Set learning objectives in your classroom based on the PLDs

Determine if you need to adjust how you're approaching the content

Work one-on-one with students to help develop needed skills

Tip 4: Use PLDs to add perspective to lesson plans
Determine how prepared your students are and create lesson plans accordingly

Identify the gaps in your students' skills and develop focused lesson plans to address those gaps

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High Impact Indicators

- Important skills that are widely applicable
- May currently receive light coverage during GED® test preparation
- Lend themselves to straightforward instruction

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Key Points

Have you heard about High Impact Indicators? While all of the indicators listed in the Performance Level Descriptors describe skills that are essential for test-taker success, GEDTS has provided us with specific PLDs that are termed High Impact Indicators (HII).

What are High Impact Indicators and how were they determined? The GEDTS® extensively analyzed test-taker performance on the operational GED® test. They examined differences in performance between those who scored between 140-149 and those who scored 150-159 in each content area.

Those results were then examined based on the following factors:

- Were the skills widely applicable?
- How much coverage do the skills typically receive during GED® test preparation?
- Could these skills be taught in a straightforward manner in instructional programs?

These are definitely important skills to that should be taught in our classroom.

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High Impact Indicator for Math

Indicator	What to look for in student work. Students' work shows they have…
Q.4 Calculate dimensions, perimeter, circumference, and area of two-dimensional figures **Q.5 Calculate dimensions, surface area, and volume of three-dimensional figures**	• identified the dimensions of a geometric figure from a diagram, then substituted the values for those dimensions into the appropriate formula for geometric measurement, then calculated the resulting numerical expression. • calculated the perimeter of polygons. • identified the shapes that comprise a composite figure.

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Key Points

Before we look at strategies, let's first look at one example of a High Impact Indicator. We know that in Mathematical Reasoning students need to have a basic understanding of two- and three-dimensional figures and the ability to calculate such things as perimeter, circumference, surface area, and volume.

To assist us in assessing this indicator, students should be able to:

- Identify the dimensions of a geometric figure from a diagram, then substitute the values for those dimensions into the appropriate formula for geometric measurement, then calculate the resulting numerical expression.
- Calculate the perimeter of polygons.
- Identify the shapes that comprise a composite figure..

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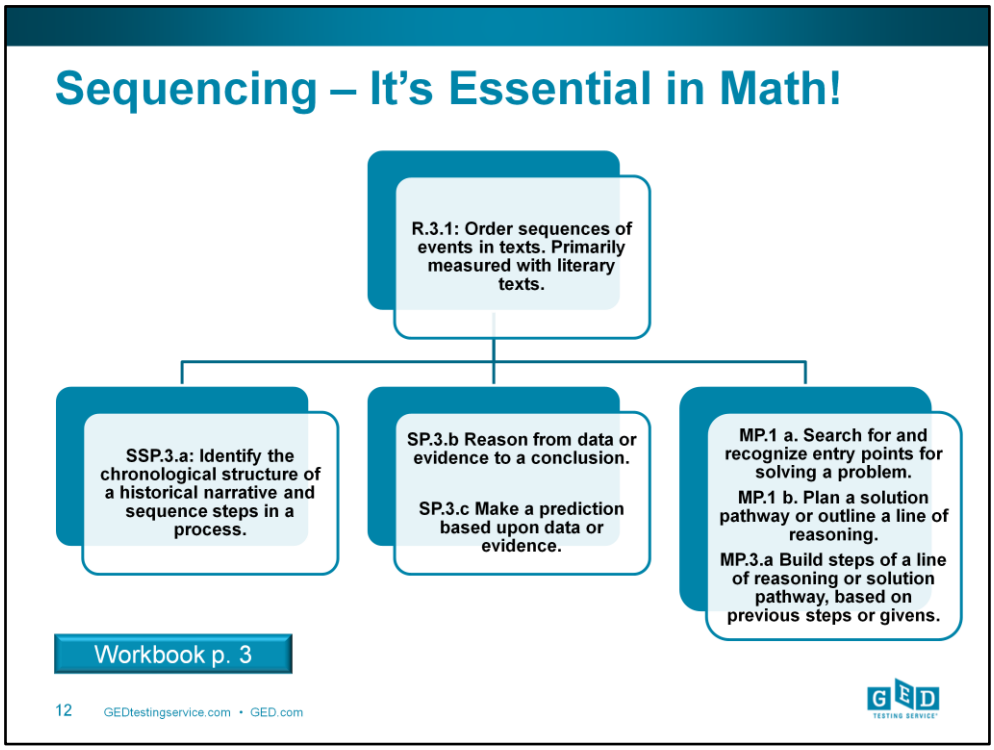

Key Points

Another High Impact Indicator is sequencing. Yes, the chart shows that this is a High Impact Indicator for RLA. But, where else do we see sequencing on the GED® test? Is there a relationship between this indicator and indicators in other content areas?

We know that students need be able to determine the sequence of events in a literary work. Being able to determine sequence also allows students to follow a historical narrative or see how a series of events led to a certain outcome. Think about science. The scientific method is a sequence of steps taken to prove or disprove a hypothesis. Most importantly having the ability to sequence properly allows students to identify the point at which they can begin solving a problem in mathematics. Students need to be able to set up a plan or a sequence of steps in order to solve a problem. Think about the challenges many students have in identifying the correct number of steps required to complete a multi-step problem. How many students don't take the correct steps to the logical and correct conclusion of a problem?

It is important to remember that the GED® test is integrated across the content areas. There is a relationship that occurs between many of the different indicators from one area to another. That is why as we look at different strategies, we should always assess

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them for usability across different content areas.

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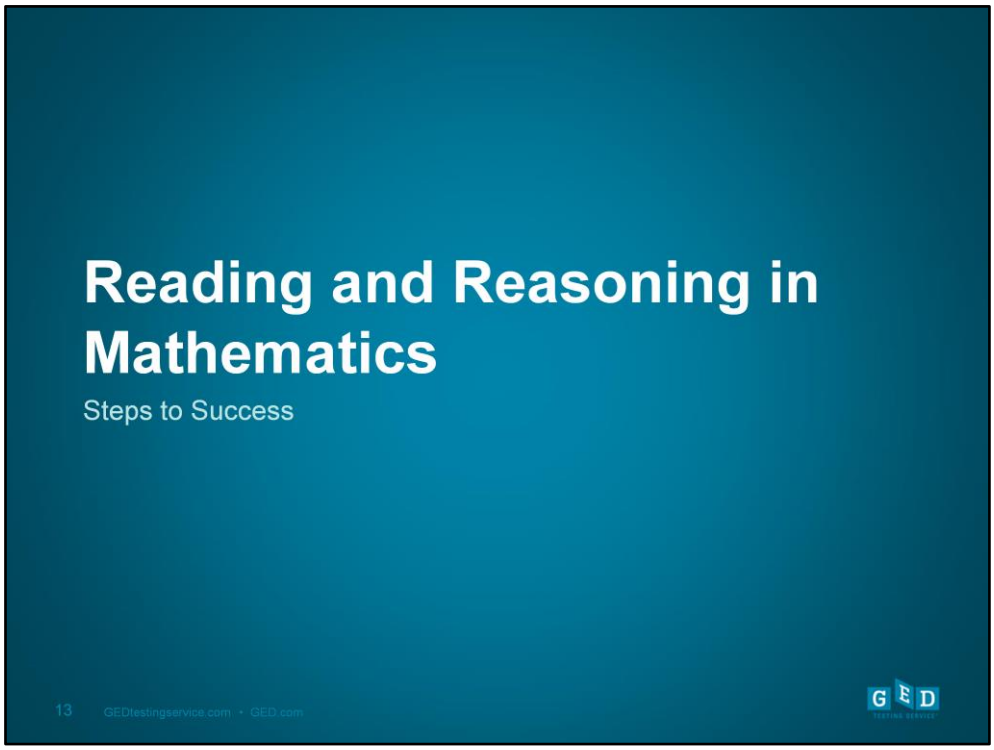

Key Points

One area that crosses all content areas is the skill of close reading. While we don't often think about teaching reading in a mathematics class, being an effective reader is an essential skill in becoming an effective problem solver.

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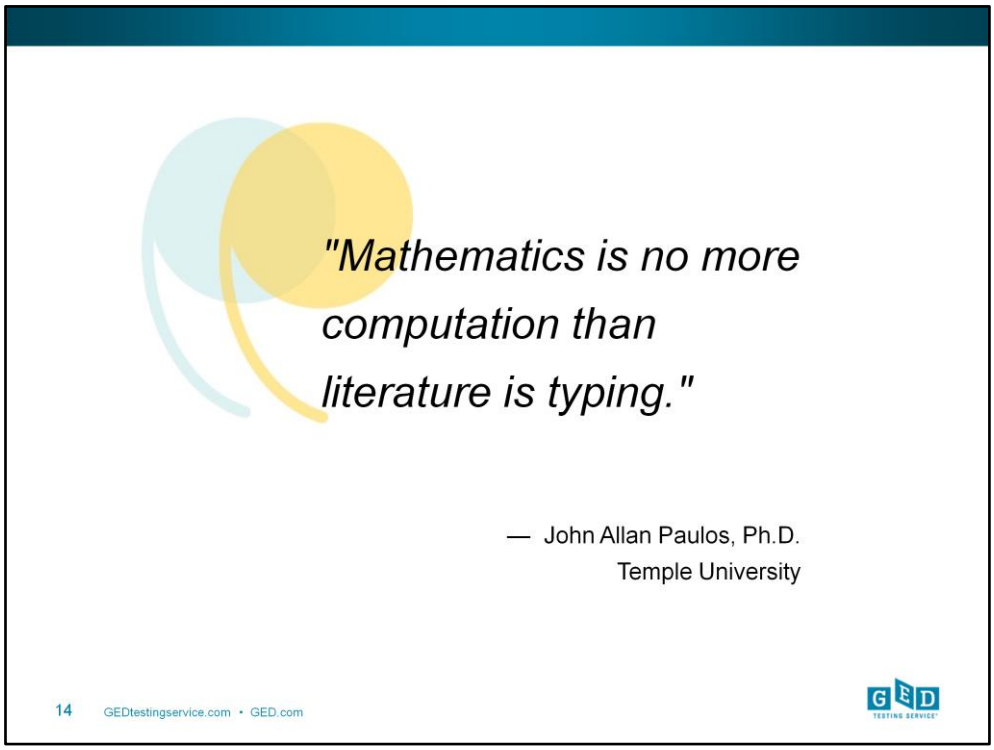

Key Points

Review the quote from Dr. Paulos and emphasize the importance of looking beyond basic computation, a level at which many students are comfortable and fairly competent, to conceptual understanding which can be used to solve problems academically and in real-life.

Note: The following information is provided as background information regarding Dr. Paulos.

John Allen Paulos is a well-known author, popular public speaker, and former monthly columnist for *ABCNews.com*, the *Scientific American*, and the *Guardian*. Professor of Math at Temple University in Philadelphia, Dr. Paulos earned his Ph.D. from the University of Wisconsin.

His recent book (November, 2015) is *A Numerate Life - A Mathematician Explores the Vagaries of Life, His Own and Probably Yours*. Other writings of his include I*nnumeracy* (NY Times bestseller for 18 weeks) and *A Mathematician Reads the Newspaper* (on the Random House Modern Library's compilation of the 100 best nonfiction books of the century).

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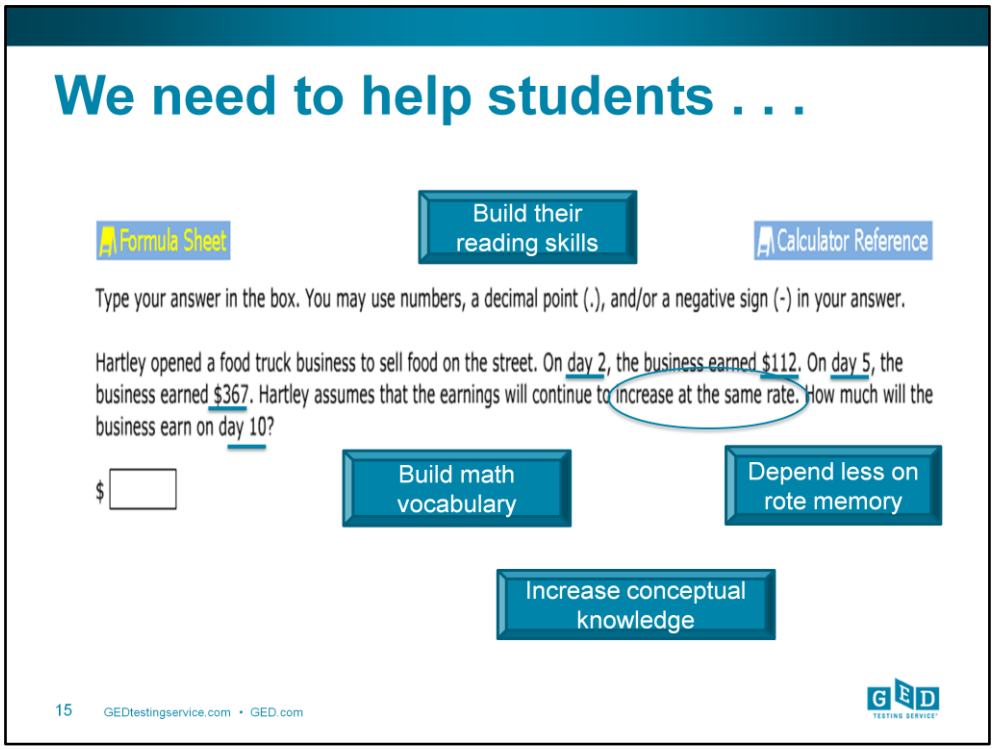

Key Points

So what can we do to help our students become more effective math problem solvers? Think for a moment about the skills that effective readers have. Now, think how these skills would impact your students' ability to read, analyze, and solve math problems. Each of the items listed is essential in students being able to understand what the math problem is telling them, as well as what they need to do to solve that problem.

Note: Animations are included with this slide. Review the animations prior to conducting the training, so that you are aware of each and can comment it again.

Build their reading skills. Students need practice in closely reading math problems. They need to be able to slow down and look at the details of a problem. The details of this problem focus on the numbers and days as well as the question that is being asked.

Build math vocabulary. If students are going to be able to read and understand problems, they need to know the vocabulary of math – not just words, but symbols as well. In this case, students need to know what the phrase "to increase at the same rate" means.

Depend less on rote memory and increase conceptual knowledge. There are many rules in math. However, memorizing is not the best approach. In this case, the equation that would be need to be known is complex. The student may or may not be able to recall the equation. However, if the student has conceptual understanding of a linear relationship, the student can solve the problem whether through use of a formula or through another heuristic. Students need conceptual understanding in mathematics.

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Two Essential Strategies

Helping students learn *how to learn* is critical to aiding the development of higher-order thinking skills

- **Modeling** is one way to teach students how to learn
- **Scaffolding** allows students to practice with diminishing support—to build confidence and competence

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Key Points

Discuss how two strategies, modeling and scaffolding, can support visual thinking in the classroom and help student learn how to learn through development of higher-order thinking skills. Emphasize how both are dependent on the teacher using a more direct approach to instruction.

- Modeling requires the teacher to clearly demonstrate how he/she thinks through a problem and works to a solution. This requires that teachers work slowly and thoughtfully through a problem so students can see how the “thinking process” is used to arrive at a reasonable solution.
- Scaffolding requires that teachers understand where students are in the learning process in order to help build students confidence and competence. In scaffolding instruction, the concept or skill to be taught is broken in smaller parts with each part building on the previous part.

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The Payoff for Students

- When higher-order thinking skills are used, students carry the knowledge longer.
- Knowledge gained from higher-order thinking processes is more easily transferrable…and that knowledge becomes accessible for solving new problems.

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Key Points

What is the payoff for modeling and scaffolding? Review bulleted items.

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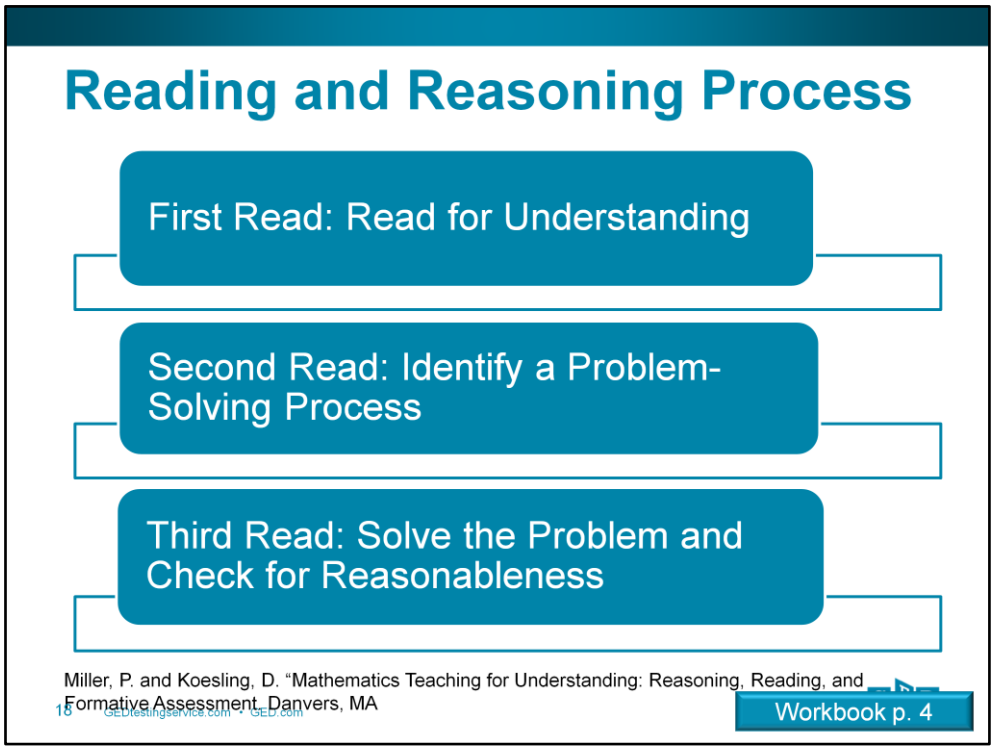

Key Points

Miler and Koesling in *Mathematics Teaching for Understanding: Reasoning, Reading, and Formative Assessment* outline a three-step process for helping students use their reading and reasoning skills in order to solve problems. The process involves multiple readings of the problem. Each step in the process is essential if students are going to build the reading and reasoning skills necessary to be effective problem solver.

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First Read: Read for Understanding

- Read through the problem aloud – noting your reactions to what you're reading.
- What vocabulary do you not know?
- What's the real-world context of the problem?
- Is there a picture that can help you visualize the problem?
- What questions are being asked?

Miller, P. and Koesling, D. "Mathematics Teaching for Understanding: Reasoning, Reading, and Formative Assessment." Danvers, MA

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Key Points

Briefly review the questions that students should be asking themselves as they do a first read of the problem.

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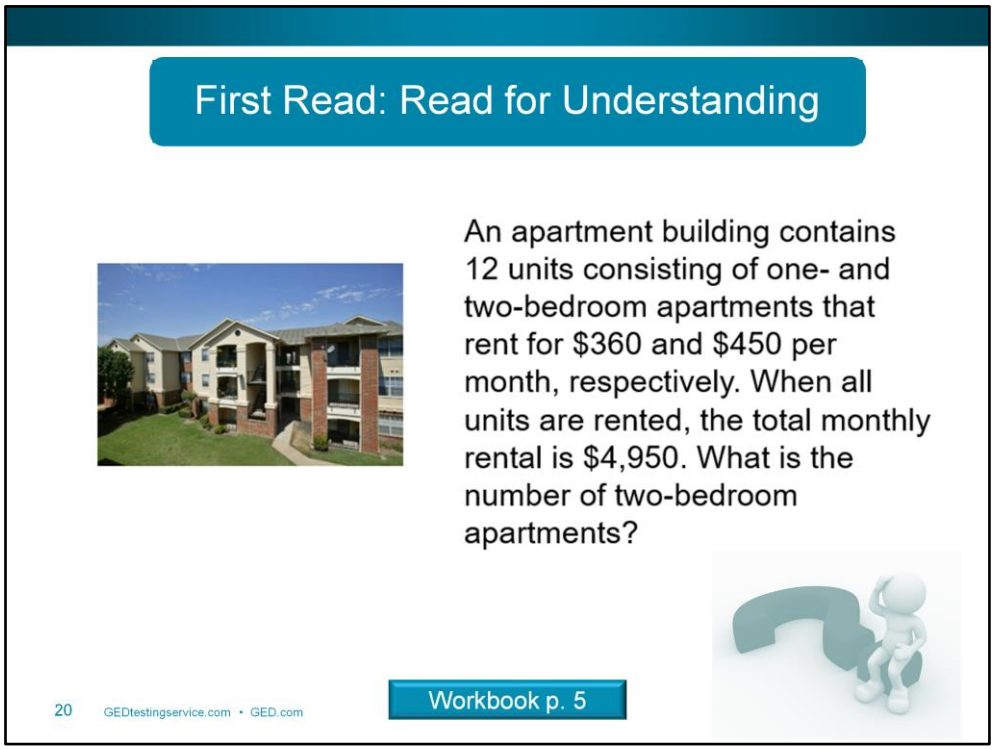

Key Points

First Read: Read for Understanding

The first read sets the stage for solving the problem. In a first read, students make sure that they understand the vocabulary that is used. If there are visual representations, such as a graph, they should also look at it to see if there is information that might be useful as they read for understanding.

Note: Take on the role of the classroom teacher and walk the participants through the word problem using the following text as a reference.

Read the math problem. Are there any words with which students may not be familiar? What about the word "respectively"? Would students know that respectively provides them important information about the costs of a one-bedroom versus a two-bedroom apartment? Maybe they don't know the word, but they can use their own background knowledge to make the assumption that a one-bedroom apartment would cost less than a two-bedroom apartment.

Now that you've read the problem, what is the real-world context of the problem? Could your students explain what this problem is about in their own words? In this case, the problem is about apartments and how much they cost per month.

What does the problem ask you to do? It asks you to determine how many of the 12 units are two-bedroom apartments. As an effective problem solver, you would ask yourself these questions subconsciously. You set the stage for problem solving by gathering information and getting a "feel" for the problem. Unfortunately, most students head straight for the numbers in a problem and try to attempt a solution from there without understanding the context or in some cases what is being asked.

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Answer - 7

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Tiered Vocabulary

Workbook p. 6

Absolute value	Additive inverse	Algorithm
Attribute	Constant	Distance formula
Exponent	Function	Dependent variable
Independent variable	Linear	Numerical expression
Profit	Property	Proportional gain
Rate of change	Strategy	Value

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Key Points

Note: This slide has two animations. Click to reveal the Tier 2 and Tier 3 vocabulary words.

In the problem that you just read, most of the vocabulary was very clear. There were no high-level math vocabulary words. However, the word "respectively" may have posed a problem for students. That word is considered a high-utility word – or a word that can be used in many different contexts.

When looking at vocabulary, there are basically three tiers of words that students need as they grow as learners.

Tier 1 – Everyday words, familiar to most students primarily learned through conversation. These are the words that students learned early in their homes and in school. You may be familiar with words from the Fry or Dolch list.

Tier 2 – High-utility academic vocabulary found in many content texts, cross-curricular terms. If you are interested in identifying even more of these words, you may want to download the Academic Word List handout included in the resources for this course. The Academic Word List was developed at the University of New Zealand and represents 500 words that are most commonly found in postsecondary text.

Tier 3 – Domain-specific academic vocabulary. Now, look at this list of words – notice how they are domain-specific, i.e., tied directly to mathematics. Would your students recognize and understand these words? Most adult learners need significant work in

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building their mathematical vocabulary.

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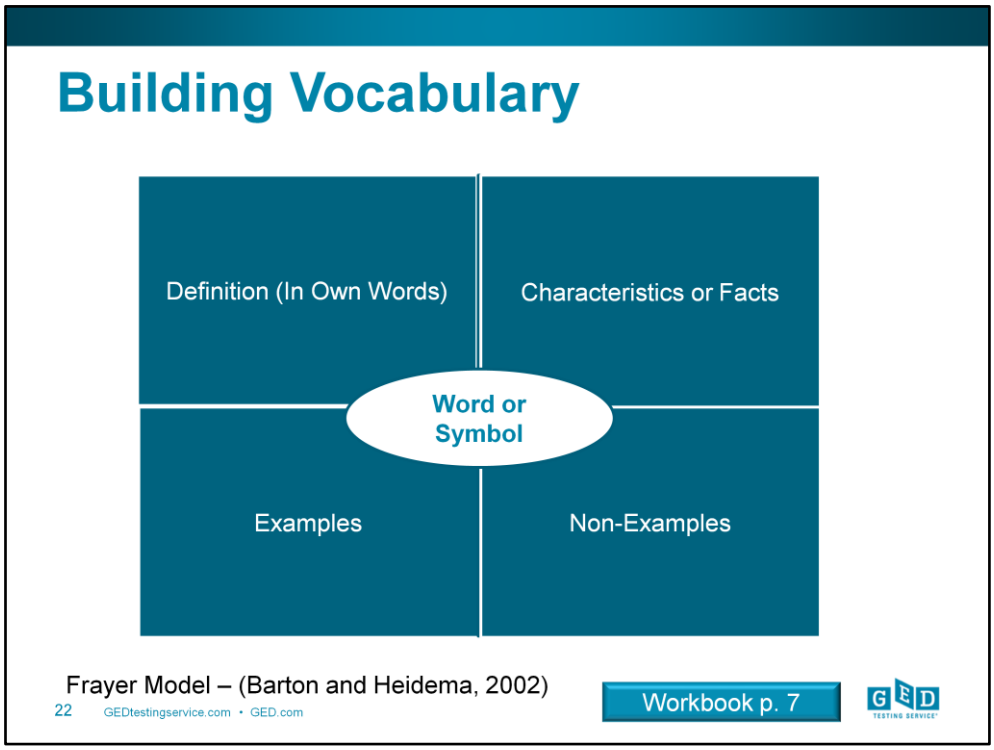

Key Points

Sometimes, students need a graphic organizer that they can use in order to learn a math term and to build conceptual understanding related to that term. This is the Frayer Model. Students add information to the organizer as they work with the term or symbol. This graphic organizer can be used for terms that students find most challenging.

Students begin by writing the term or symbol in the oval. Next, students should include a definition that is in the student's own words – not a textbook definition. Next, students include facts or characteristics of the term or symbol. While some graphics organizers, ask students to provide examples, most do not include non-examples. The Frayer Model, with its inclusion of both, helps students have a better understanding of the term and the concepts behind it.

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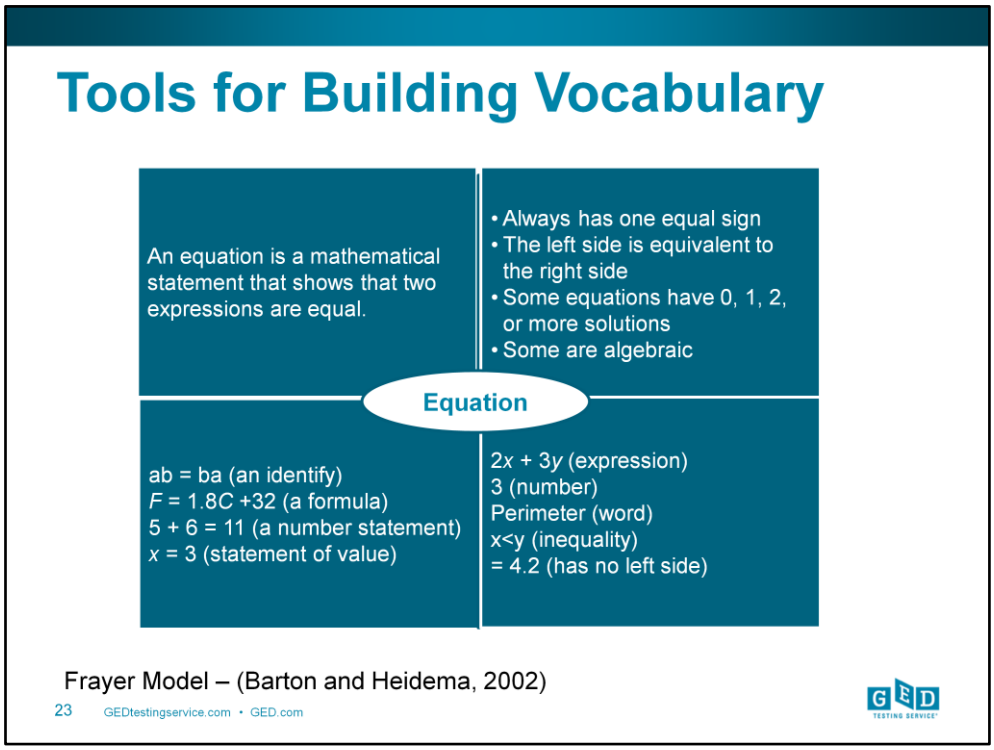

Key Points

Review the example provided on the slide. Make note of the examples and non-examples provided and how students may get confused if they can't clearly differentiate between the two.

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Second Read: Identify a Problem-Solving Process

- What is the pertinent information in this problem?
- What problem-solving strategies could I use?
- Which of those problem-solving strategies is best suited for this problem?
- How will I represent the problem in the symbolic language of mathematics?
- What mathematical details will I select as I reason and solve this problem?

Miller, P. and Koesling, D. "Mathematics Teaching for Understanding: Reasoning, Reading, and Formative Assessment." Danvers, MA

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Key Points

Briefly review the questions that students should be asking themselves as they do a second read of the problem.

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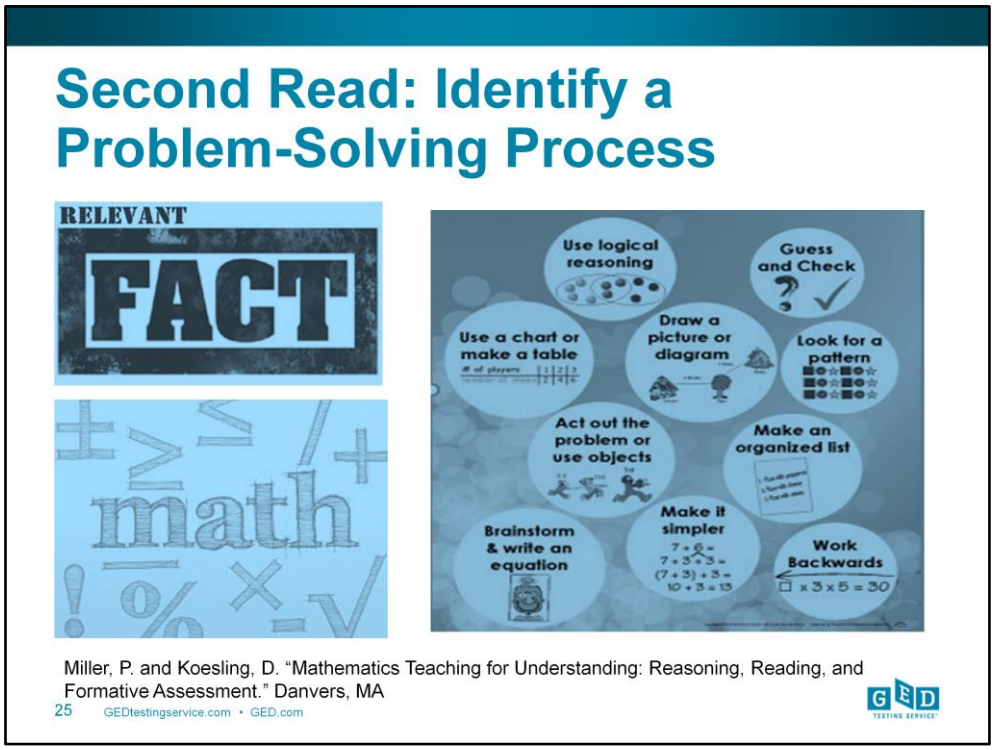

Key Points

Note: There are three animations on this slide. Click to view each graphic.

The second read of a word problem requires that students identify the FACTS of the problem. Without the facts relevant to solving the problem, the student will arrive at an incorrect answer. Likewise, if irrelevant facts are used the student will also arrive at an incorrect answer.

Also important in the second read is the student's determination of an appropriate thinking strategy or heuristic that he/she can use to approach solving the problem. Does the student need to draw a table or picture? Would it be helpful to look for a pattern or make a list? There are a number of different approaches that can be taken. Sadly, many students turn to the infamous "guess and check" strategy too often. They need to broaden the number of strategies at their disposal.

Last, but not least in this read, the student needs to determine the math operations that will be needed. Without this second read, students will not have everything they need in order to solve a problem – and solve it correctly.

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Begin with the Basics

Noticing

- Allows all students to participate
- Work independently or in groups
- What is stated in the problem
- What are the "givens" of the problem

Wondering

- Is the planning part
- Talk about strategies to use
- Restate the problem
- Pose questions about what they noticed
- Allows students to slow down and think
- Brainstorm, list, and discuss ideas

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Key Points

For strong problem solvers, the basics of "noticing" and "wondering" are second nature. In fact, it is often done subconsciously. For students who are not strong problem solvers, these two activities need to be taught. They are part of the questioning that happens during the first and second read of a problem. Noticing generally occurs during that first read. What students notice in a problem leads them to asking questions or "wondering". These two activities assist the student in identifying the strategies or heuristics to be used and the computations that should be made to solve the problem.

Teachers need to practice these skills with students so the skills become second nature.

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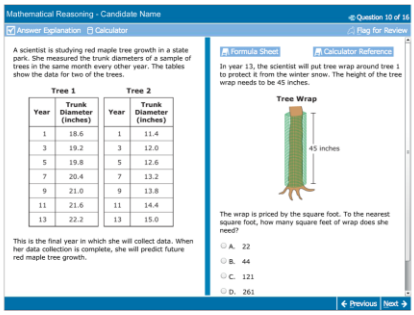
Try It!



What do you notice?	What do you wonder?

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Workbook p. 8

Key Points

As a group, have participants use this problem and determine what they notice and what they wonder. Start with what they notice about the problem. Then proceed to what they wonder based on what was noticed. There is no need to solve the problem. Simply have participants determine a process for doing so.

Discuss with teachers the importance of integrating these two activities into the problem-solving process – more practice leads to greater success.

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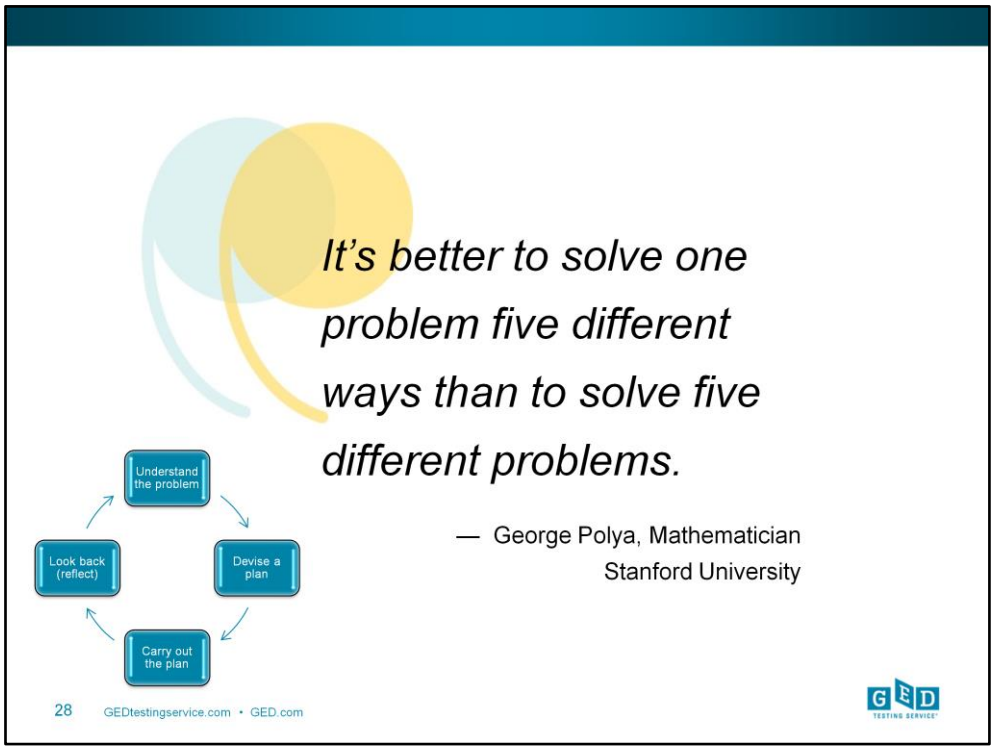

Key Points

George Polya can rightly be called the father of problem solving in mathematics education. His four step process serves as the basis for the mathematical problem solving.

1) Understand the problem
2) Devise a plan
3) Carry out the plan
4) Look back

These steps provide test-takers with a framework for building solution pathways when working with mathematical content. Students in adult education classrooms often want to just "do" the problem. This is analogous to the approach students often taken to writing – they just "write." Students need to understand that solving problems requires planning, drafting (trying the plan), checking results, and making "edits and revisions" if the answer is not correct or reasonable.

The primary issue is to ensure that students have other approaches at their disposal. As Dr. Polya says, "It's better to solve one problem five different ways than to solve five different problems."

Note: As you move through the next series of slides, the participants will have a chance to learn about a number of heuristics and see how they can incorporate them into the problem solving process.

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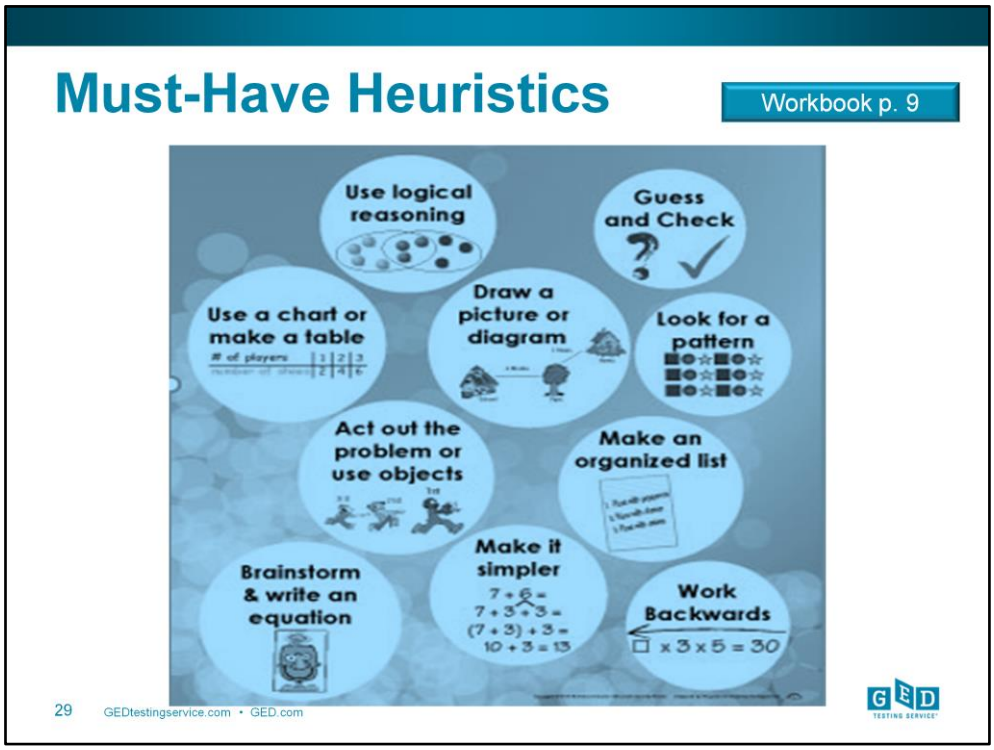

Key Points

Explain that as you move through the next series of slides, the participants will have a chance to learn about a number of heuristics and show they can incorporate them into the problem-solving process. Explain that the following problems are not examples of GED® test items. Rather, they are examples that enable students to clearly see how a thinking strategy or heuristic can be used.

After students learn the basic strategies, teachers may want to identify specific items from the GED® Mathematical Reasoning Item Sampler to help students identify different heuristics that could be used to solve those problems. This would make a great small or large group activity providing students with a chance to talk through problems and discover that many problems can be solved in multiple ways.

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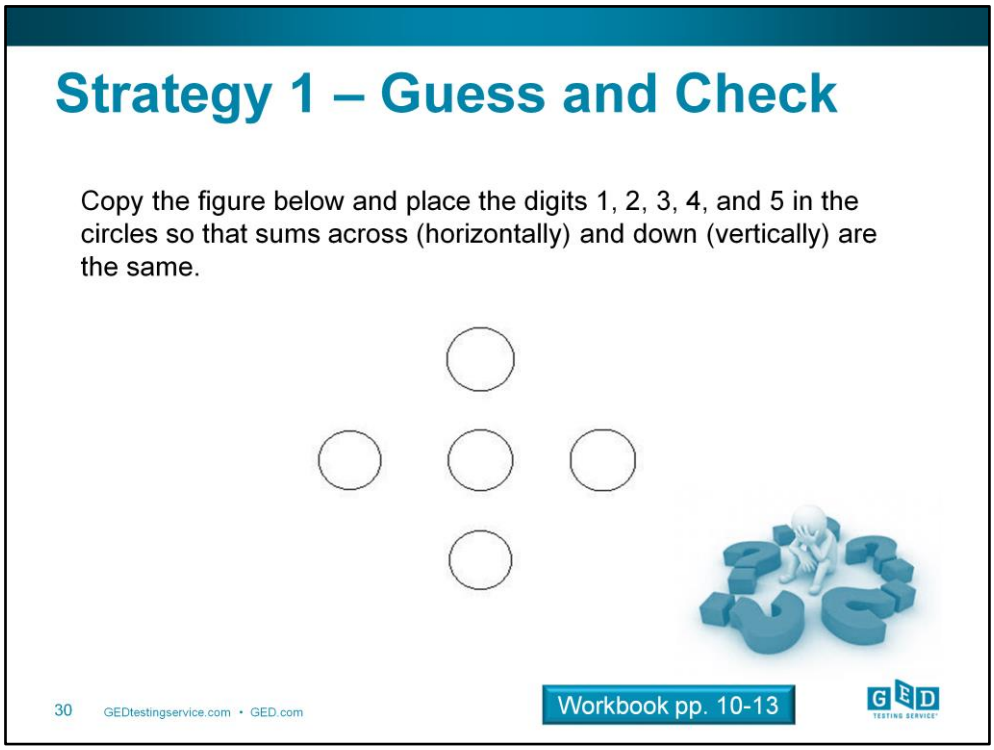

Key Points

Have participants use the strategy to solve the problem.

Ask if there is more than one solution. Discuss the results and the thinking process used to derive the results.

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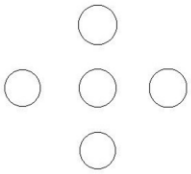
Guess and Check

Copy the figure below and place the digits 1, 2, 3, 4, and 5 in the circles so that sums across (horizontally) and down (vertically) are the same.



Possible solutions:

	2			3			2	
1	3	5	2	1	5	1	5	4
	4			4			3	

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Key Points

Display the results and the fact that 2 and 4 cannot be placed in the middle circle. Have participants discuss why.

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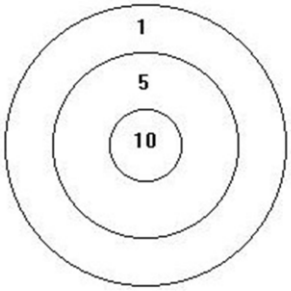
Strategy 2 – Make a List

Three darts hit this dart board and each scores a 1, 5, or 10. The total score is the sum of the scores for the three darts. There could be three 1's, two 1's and one 5, one 5 and two 10's, and so on. How many different possible total scores could a person get with three darts?



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Key Points

Have participants use the strategy to solve the problem.

Ask if there is more than one solution. Discuss the results and the thinking process used to derive the results.

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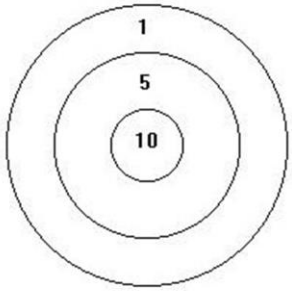
Make a List

# of 1's	# of 5's	# of 10's	Score
3	0	0	3
2	1	0	7
2	0	1	12
1	2	0	11
1	1	1	16
1	0	2	21
0	3	0	15
0	2	1	20
0	1	2	25
0	0	3	30



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Key Points

There are 10 possible scores. Ask what would happen if they just started calling out different scores without being organized. The answer – they would probably repeat scores.

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Strategy 3 – Draw a Diagram

In a stock car race, the first five finishers in some order were a Ford, a Pontiac, a Chevrolet, a Buick, and a Dodge.

- The Ford finished seven seconds before the Chevrolet.
- The Pontiac finished six seconds after the Buick.
- The Dodge finished eight seconds after the Buick.
- The Chevrolet finished two seconds before the Pontiac.

In what order did the cars finish the race? What strategy did you use?

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Key Points

Have participants use the strategy to solve the problem.

Ask if there is more than one solution. Discuss the results and the thinking process used to derive the results.

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Draw a Diagram

In a stock car race, the first five finishers in some order were a Ford, a Pontiac, a Chevrolet, a Buick, and a Dodge.

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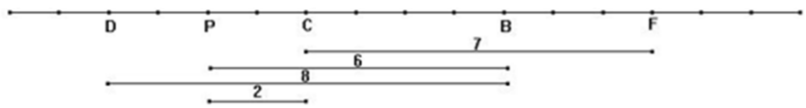
In what order did the cars finish the race? What strategy did you use?



The order is: Ford, Buick, Chevrolet, Pontiac, Dodge.

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Key Points

Discuss the use of number lines as a way for students to determine the results of the race. Ask if there are any other strategies that could be used. Discuss those strategies.

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Strategy 4 – Make a Table or Chart

South Point Amusement Park has a special package for large groups: a flat fee of $20 and $6 per person.

If a club has $100 to spend on admission, what is the largest number of people who can attend?

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Key Points

Have participants use the strategy to solve the problem.

Ask if there is more than one solution. Discuss the results and the thinking process used to derive the results.

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Make a Table or Chart

South Point Amusement Park has a special package for large groups: a flat fee of $20 and $6 per person.

If a club has $100 to spend on admission, what is the largest number of people who can attend?

# of people	Cost X $6	+ $20	Total fee	Result
10	60	20	80	Too low
15	90	20	110	Too high
13	78	20	98	Too low
14	84	20	104	Too high

Answer: At most, 13 people can attend for $100 and they will have $2 left over.

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Key Points

Discuss the advantages and disadvantages of using a table. Ask if there are any other strategies that could be used. Discuss those strategies.

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Strategy 5 – Find a Pattern

Continue these numerical sequences by finding the next three numbers for each group.

1, 4, 7, 10, 13, ___, ___, ___

19, 20, 22, 25, 29, ___, ___, ___

2, 6, 18, 54, ___, ___, ___

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Key Points

Have participants use the strategy to solve the problem.

Ask if there is more than one solution. Discuss the results and the thinking process used to derive the results.

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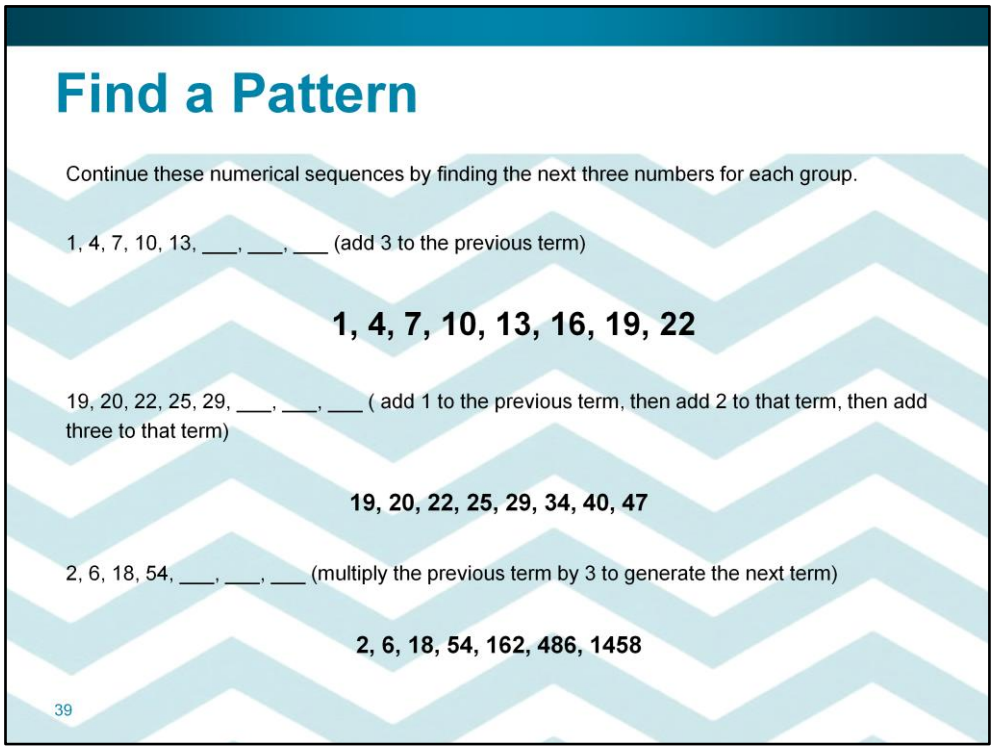

Key Points

Discuss how students could best approach determining the sequence of numbers and the use of patterns to do so.

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Strategy 6 – Make it Simpler

The houses on Main Street are numbered consecutively from 1 to 150.

How many house numbers contain at least one digit 7?

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Key Points

Have participants use the strategy to solve the problem.

Ask if there is more than one solution. Discuss the results and the thinking process used to derive the results.

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Make it Simpler

The houses on Main Street are numbered consecutively from 1 to 150.

How many house numbers contain at least one digit 7?

Break the problem down. First determine how many houses have a seven in the units place. (15)

7, 17, 27, 37, 47, 57, 67, 77, 87, 97, 107, 117, 127, 137, 147

Next, determine how many houses have a seven in tens place. (10)

70, 71, 72, 73, 74, 75, 76, 77, 78, 79

Take out any duplicates (1)

Answer – 24 houses contain at least one digit 7.

Key Points

Discuss how students might get on the wrong track in identifying the number of houses containing at least one digit 7.

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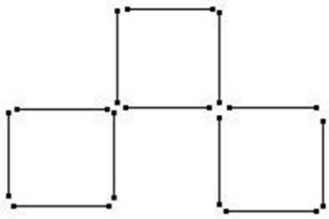
Strategy 7 – Act It Out or Use Objects

The figure shows twelve toothpicks arranged to form three squares. How can you form five squares by moving only three toothpicks?



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Key Points

Have participants use the strategy to solve the problem.

Ask if there is more than one solution. Discuss the results and the thinking process used to derive the results.

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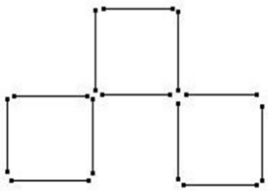
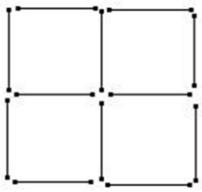
Act It Out or Use Objects

The figure shows twelve toothpicks arranged to form three squares. How can you form five squares by moving only three toothpicks?



Answer: One of the squares is formed by the outer boundary of the arrangement. There was no requirement that each of the five squares must be congruent to each of the others.



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Key Points

Working with manipulatives can be a very effective way for students to solve problems. Discuss how teachers could use more manipulatives to help students improve their thinking strategies when solving problems. Remind teachers that while students can't take manipulatives into the GED® Mathematical Reasoning test, they can certainly draw an object on the laminated cards provided for their use.

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Strategy 8 – Work Backwards

Brady was trying to decide when to get up in the morning. He needs 45 minutes to get ready for the workshop he plans to attend. It takes him 25 minutes to drive to the adult center where the workshop will be held. He wanted to get to the center 20 minutes early to stop by his classroom and pick up some materials. If the session starts at 7:30 a.m., what time should he get up, if he wants to give himself 10 extra minutes in case the traffic is bad?

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Key Points

Have participants use the strategy to solve the problem.

Ask if there is more than one solution. Discuss the results and the thinking process used to derive the results.

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Work Backwards

Brady was trying to decide when to get up in the morning. He needs 45 minutes to get ready for the workshop he plans to attend. It takes him 25 minutes to drive to the adult center where the workshop will be held. He wanted to get to center 20 minutes early to stop by his classroom and pick up some materials. If the session starts at 7:30 a.m., what time should he get up, if he wants to give himself 10 extra minutes in case the traffic is bad?

Start with the time he has to be at the workshop – 7:30

He needed 20 minutes to go by the classroom – 7:10

He drove for 25 minutes – 6:45

He needed 45 minutes to get ready – 6:00

To allow for 10 minutes in case the traffic was bad – 5:50

Key Points

Working with time can be challenging for students, especially elapsed time. This is an excellent example of a problem where students can work backwards in order to derive a correct response.

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Strategy 9 – Brainstorm and Write an Equation

Two apples weigh the same as a banana and a cherry. A banana weighs the same as nine cherries. How many cherries weigh the same as one apple?

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Key Points

Have participants use the strategy to solve the problem.

Ask if there is more than one solution. Discuss the results and the thinking process used to derive the results.

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Brainstorm and Write an Equation

Two apples weigh the same as a banana and a cherry. A banana weighs the same as nine cherries. How many cherries weigh the same as one apple?

You will need to use three variables.

- A = the weight of an apple
- B = the weight of a banana
- C = the weight of a cherry

2A = B + C
B = 9C
Substituting: 2A = 9C + C
2A = 10C A = 5C

Answer: 5 cherries weigh the same as 1 apple

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Key Points

Students need to be able to show the relationship between each item within the problem. Using variables and the substitution allows them to do so.

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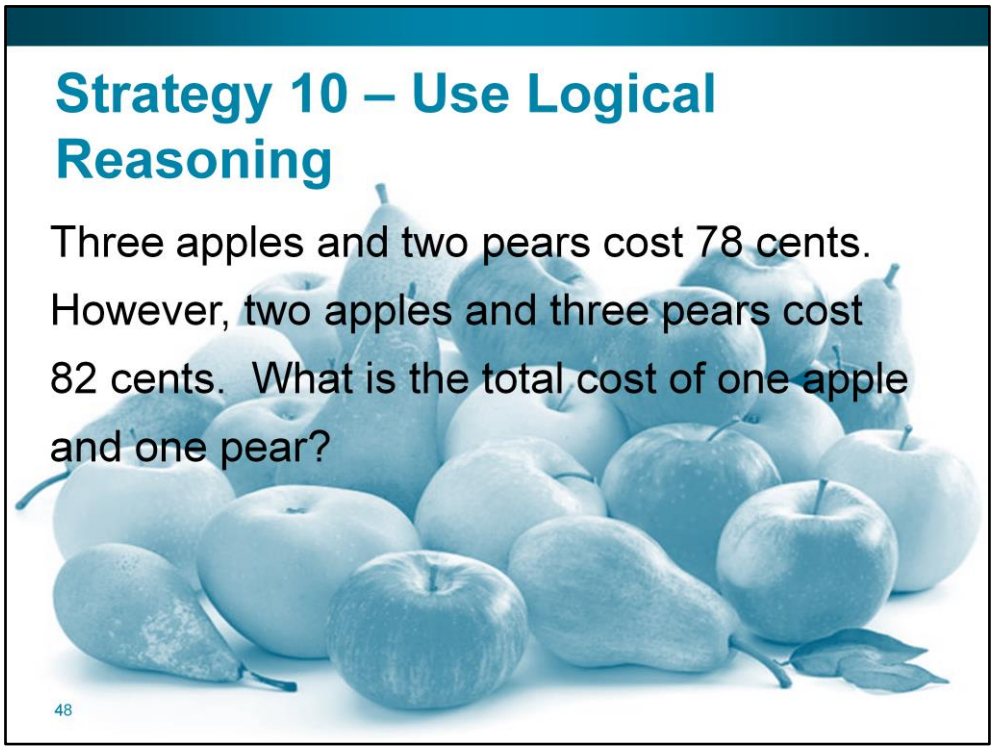

Key Points

Have participants use the strategy to solve the problem.

Ask if there is more than one solution. Discuss the results and the thinking process used to derive the results.

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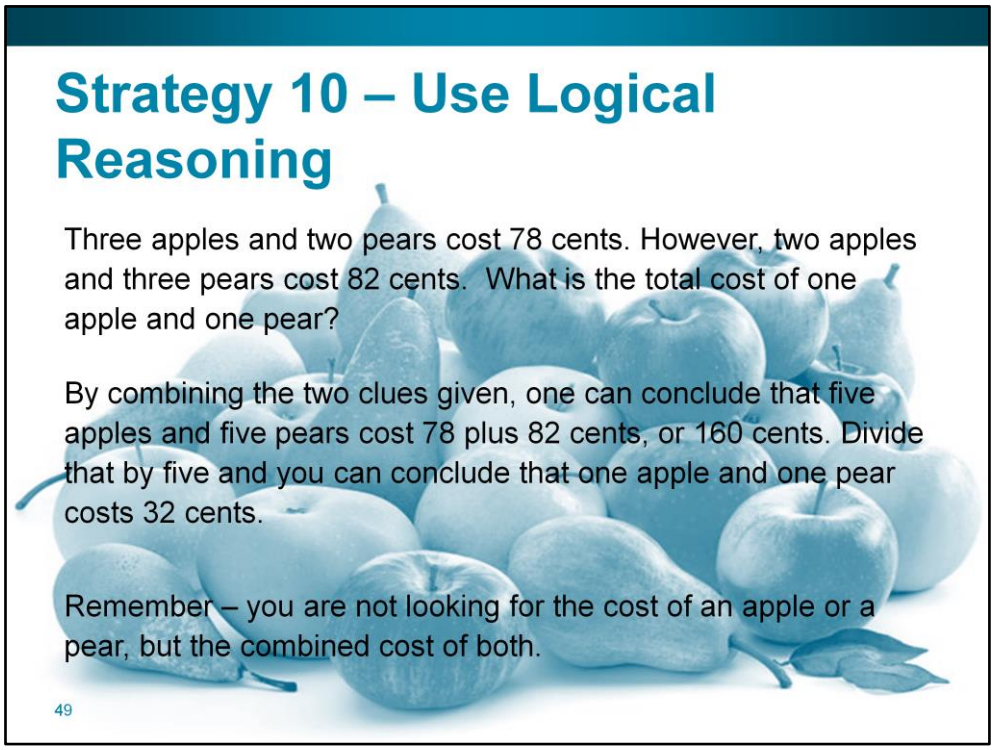

Key Points

While this is not an example of a GED® Mathematical Reasoning test question, it is an excellent example of students having to apply logical reasoning to determine a solution. This type of problem requires that students not jump to conclusions about looking for the cost of a single item, but rather at the combined costs. In a problem like this, students have to focus on the details of the problem.

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Third Read: Solve the Problem and Check for Reasonableness

- Now that I understand the problem's content, how can I best use my math skills to solve the problem?
- Am I answering the right question?
- How should the answer to the question be expressed?

Miller, P. and Koesling, D. "Mathematics Teaching for Understanding: Reasoning, Reading, and Formative Assessment." Danvers, MA

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Key Points

It's time for a third read, where you will solve the problem and then go back to see if it is reasonable and most importantly does it answer the right question. Sadly, some students get a "right" answer, but it isn't for the question that is asked. Remember, multiple choice items contain distractors – answers that could be easily derived, but are based on faulty reasoning, inclusion of irrelevant information, or use of the wrong output or units.

Students need to see their teachers model the three-read process. They need to practice using the process both as their teacher guides them and then independently. Effective problem solvers do not become so overnight. It requires time and patience. However, the payoff is well worth the personal investment as students transfer their problem solving from the classroom to higher education and ultimately to the workplace.

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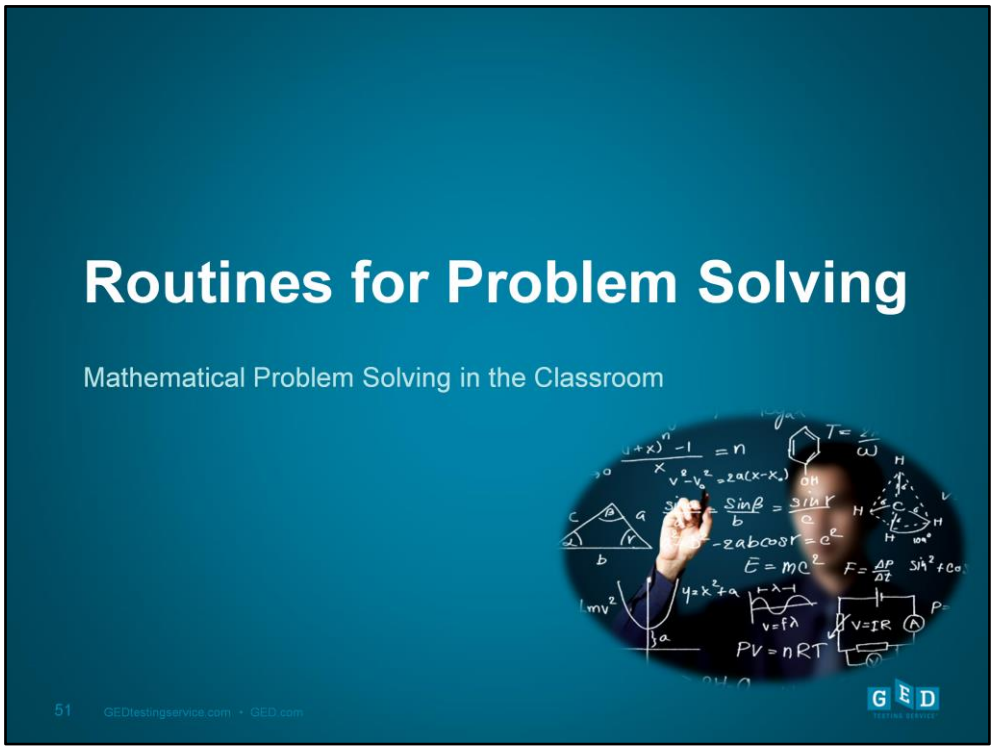

Key Points

So far, we have looked at using a three-read process and multiple heuristics to help students become better problem solvers. Now, it is time to put these pieces together in a routine that students can use now and into the future.

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Goals and Givens

Active Reading Strategy for Problem Solving

- Read problem closely
- Identify the goal – the task(s) to be completed
  - Paraphrase what author wants to be done
  - Write in own words
- Identify the givens – information relevant to solving the task
  - Look for key terms

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Workbook pp. 14-15

Key Points

Goals and Givens is an active reading strategy for problem solving. It incorporates all of the different steps that have been discussed. It pulls those steps into a clearly defined plan that requires students to:

- Read the problem closely so they can:
  - Identify the goal or task(s) to be completed
  - Identify the givens of the problem – the relevant information needed to meet the goal or the task

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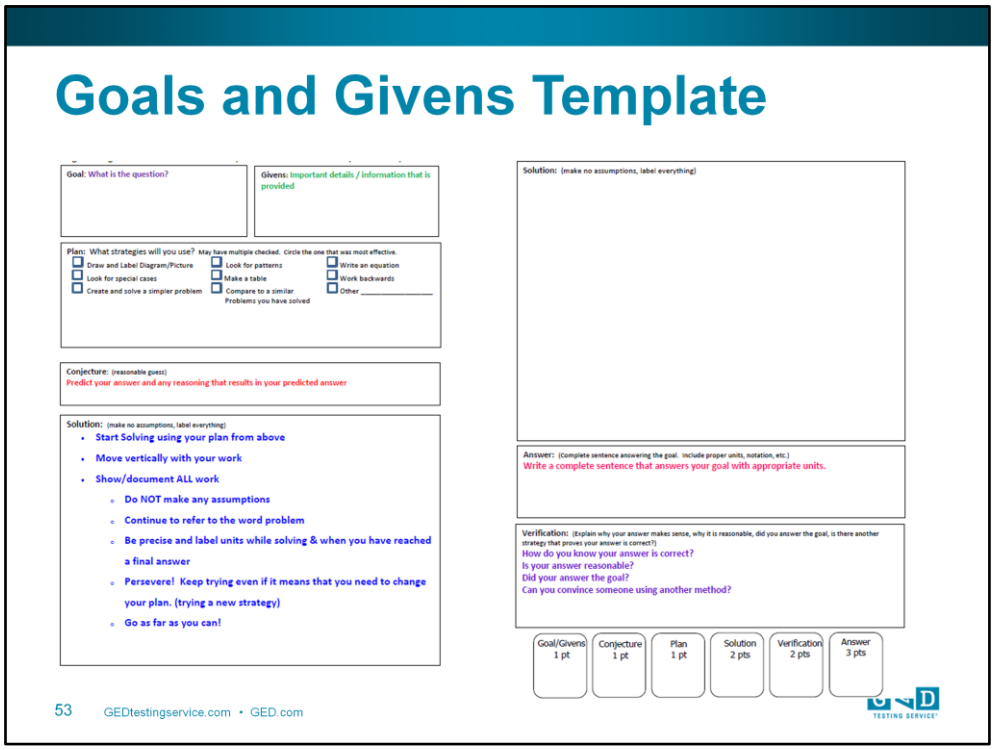

Key Points

Have participants look at each element of the Goals and Givens graphic organizer provided by Phoenix Union High School Literacy Resource Guide - *Read Like a Mathematician*. Briefly discuss each of the elements. Emphasize the link between the three-read process and the heuristics included in the “Plan” portion of the graphic organizer.

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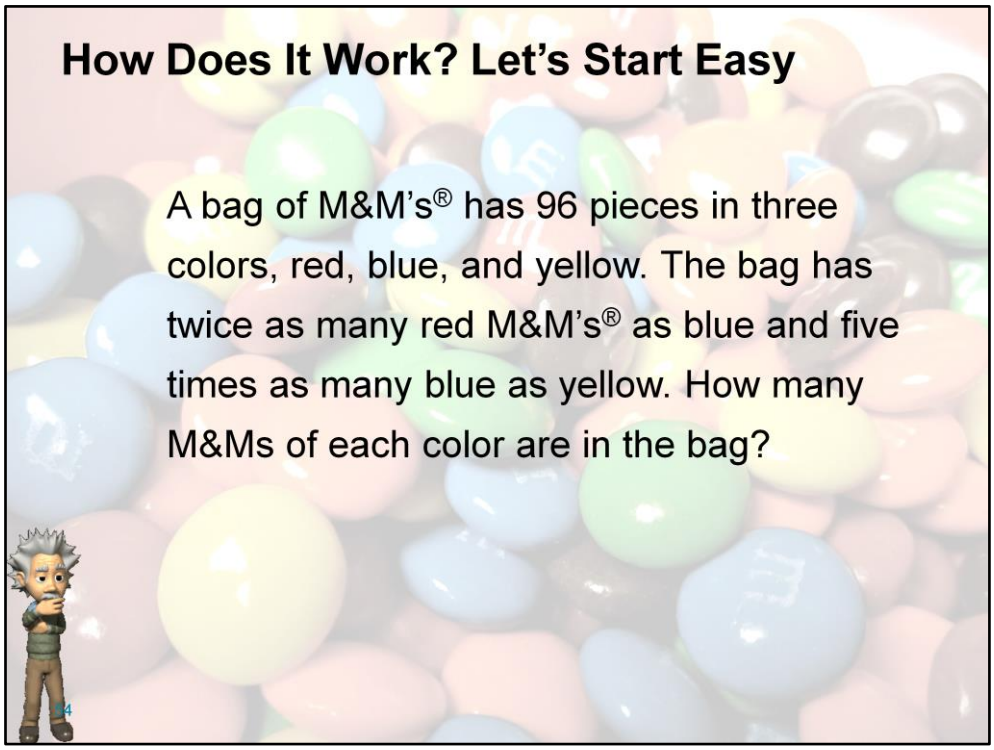

Key Points

Have participants closely read the problem. Use the following slides to take them through the key components of the Goals and Givens graphic organizer.

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Goals and Givens

Goals	Givens
Find out how many M&M's® of each color are in the bag.	Total of 96 pieces 3 colors – red, blue, yellow 2x red = blue 5x blue = yellow

What strategies will you use? May have multiple checked.

__Draw/label Diagram __Guess and Check __Make it Simpler	__Look for patterns _X_Make a table __Act out or use objects	_X_Write an equation __Word backwards __Other_____

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Key Points

Discuss each element and how the information is used to first address the Goal and then the Givens of the problem. Discuss the heuristics identified. Ask if there are other heuristics or strategies that could be used to solve the problem.

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Solve It!

Make a Table	Write an Equation
	Write an equation. Use substitution. r + b + y = 96 r + b + y = 96 (r = 2b and b = 5y) 2b + b + y = 96 (substitute r = 2b) 2(5y) + 5y + y = 96 (substitute b = 5y) 10y + 5y + y = 16y = 96 so y = 6 y = 6, b = 30, r = 60

Red	Blue	Yellow	Total
20	10	2	32
30	15	3	48
40	20	4	64
50	25	5	80
60	30	6	96

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Key Points

Show the participants how the problem can be solved by using the two selected heuristics – make a table and write an equation. Discuss the advantages and disadvantages of each.

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Use Goals and Givens!

Workbook p. 16

Mathematical Reasoning - Candidate Name

Question 10 of 16

Answer Explanation | Calculator | Flag for Review

A scientist is studying red maple tree growth in a state park. She measured the trunk diameters of a sample of trees in the same month every other year. The tables show the data for two of the trees.

Tree 1

Year	Trunk Diameter (inches)
1	18.6
3	19.2
5	19.8
7	20.4
9	21.0
11	21.6
13	22.2

Tree 2

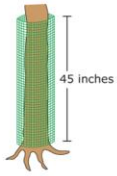
Year	Trunk Diameter (inches)
1	11.4
3	12.0
5	12.6
7	13.2
9	13.8
11	14.4
13	15.0

This is the final year in which she will collect data. When her data collection is complete, she will predict future red maple tree growth.

Formula Sheet | Calculator Reference

In year 13, the scientist will put tree wrap around tree 1 to protect it from the winter snow. The height of the tree wrap needs to be 45 inches.

Tree Wrap



The wrap is priced by the square foot. To the nearest square foot, how many square feet of wrap does she need?

- A. 22
- B. 44
- C. 121
- D. 261

Previous | Next

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Key Points

Have participants use the Goals and Givens graphic organizer and solve the problem. Discuss the heuristics identified to solve the problem and why a specific heuristic was selected.

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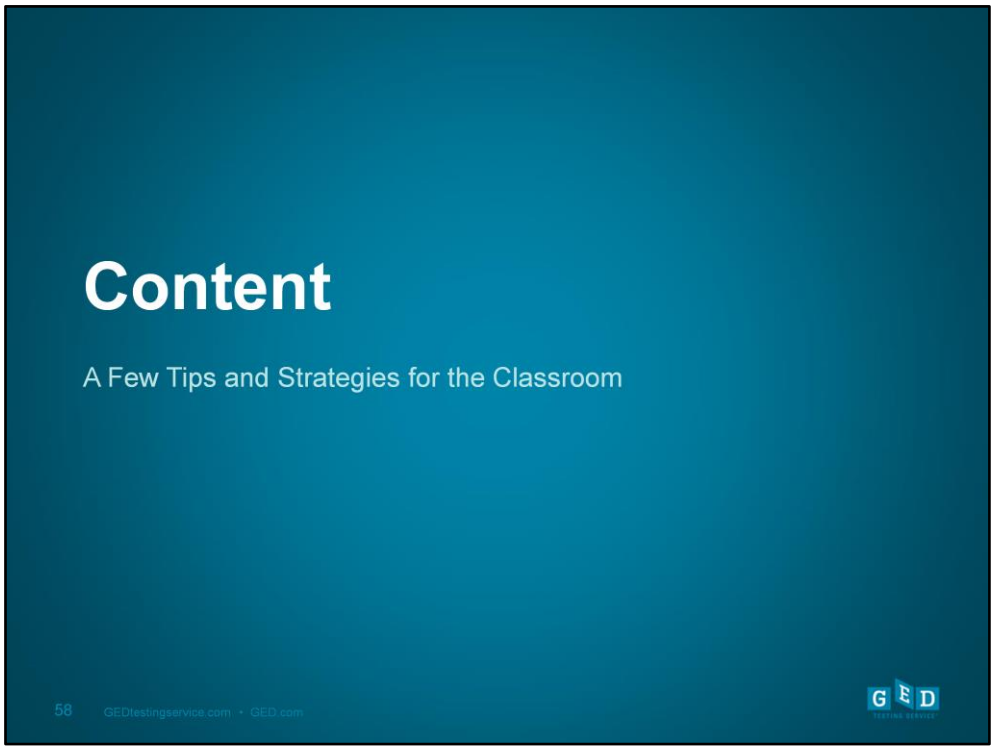

Key Points

Teachers always want to know where to focus their attention when it comes to specific content within mathematics. This section includes some quick tips and strategies that teachers can use in various areas of mathematics to solve some of the “little” problems that can turn into bigger issues.

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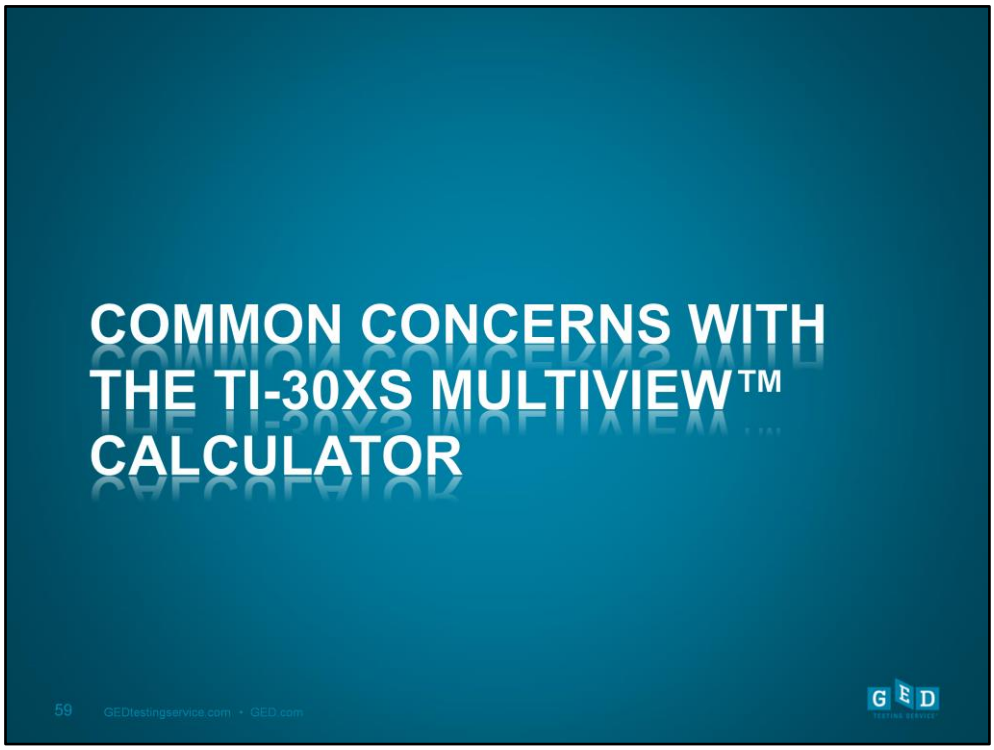

Key Points

Share with participants that students need to be proficient using mathematical tools. The calculator is one such tool. The next slides will provide some basics that all students should know.

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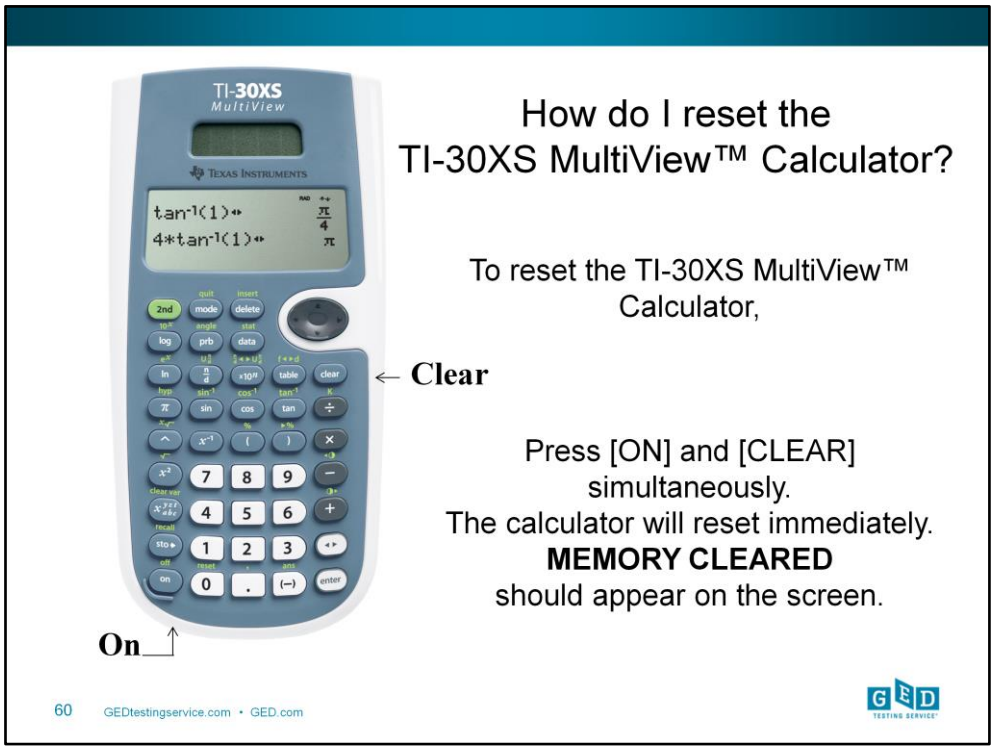

Key Points

Explain that students often have problems with some of the most basic elements of working with the TI-30XS MultiView™. In most cases, this comes back to students not having adequate time to work with the calculator. In addition, students often fail to take advantage of the calculator tutorial, which is easily accessible to them.

Briefly review the points on the slide. Model for the participants how to use each of the keys. Use of an emulator or a document camera (such as an Elmo) are great ways to model the different functions or operations of the calculator. If these are not available, use of a calculator chart can also be used.

You may wish to have participants bring their own calculators to the training.

Note: The calculator tutorial from GEDTS is located at:
http://www.gedtestingservice.com/ged_calc_en_web/

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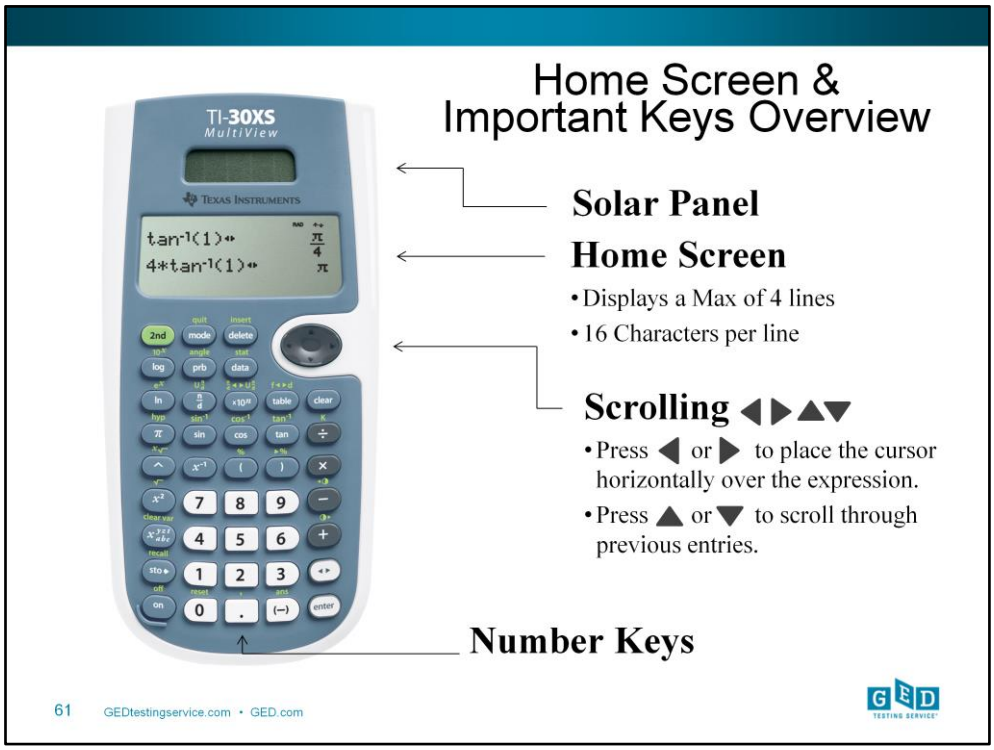

Key Points

Briefly review the points on the slide. Show participants how each of the keys work, specifically the scrolling function.

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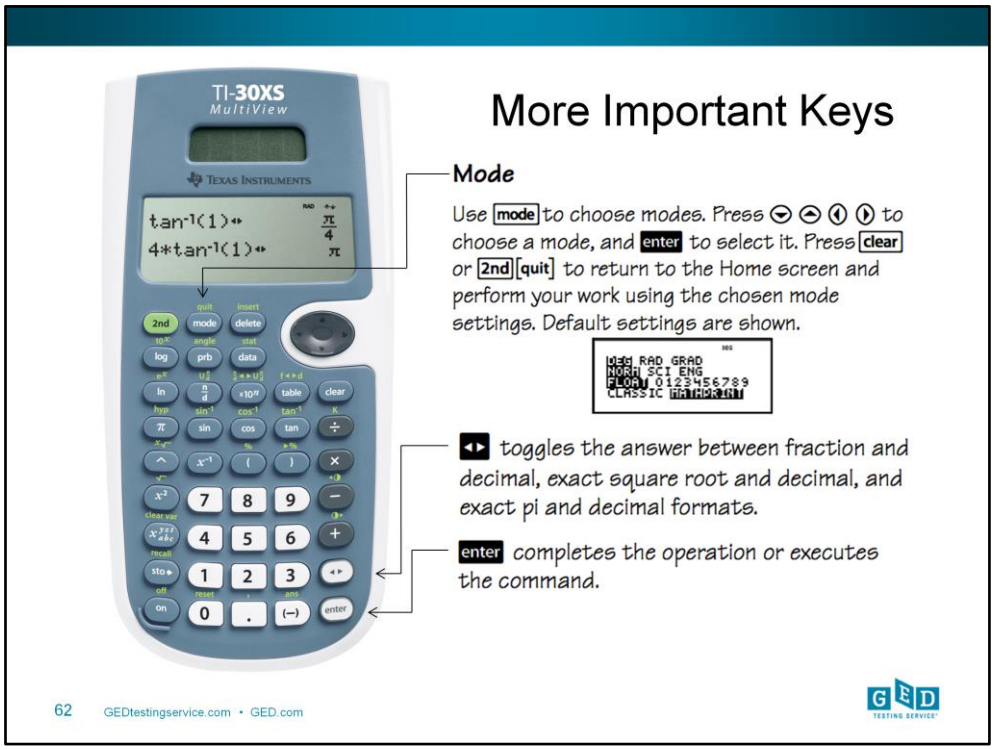

Key Points

Briefly review the points on the slide. Show participants how to change the Mode, as well as how the toggle key works.

The standard setup Mode of DEG, NORM, FLOAT and MATHPRINT are sufficient for our students in their preparation for the test.

The toggle key changes the form of the answer. For example, from fraction to decimal.

The enter key displays the answer.

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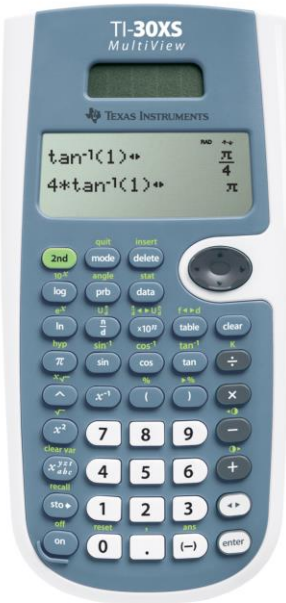

Classic vs. MathPrint Mode

Classic mode displays inputs and outputs in a single line.

$1/2(6+4) \div 3$ $\quad$ $5/3$

MathPrint mode displays most inputs and outputs in textbook format. Use MathPrint mode for better visual confirmation that math expressions have been entered correctly and to better reinforce the correct math notation.

$\frac{1}{2}(6+4) \div 3$ $\quad$ $\frac{5}{3}$

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Key Points

Briefly review the points on the slide and model the two different print modes.

Classic and MathPrint mode displays the output differently. MathPrint mode allows our students to check their work with more accuracy.

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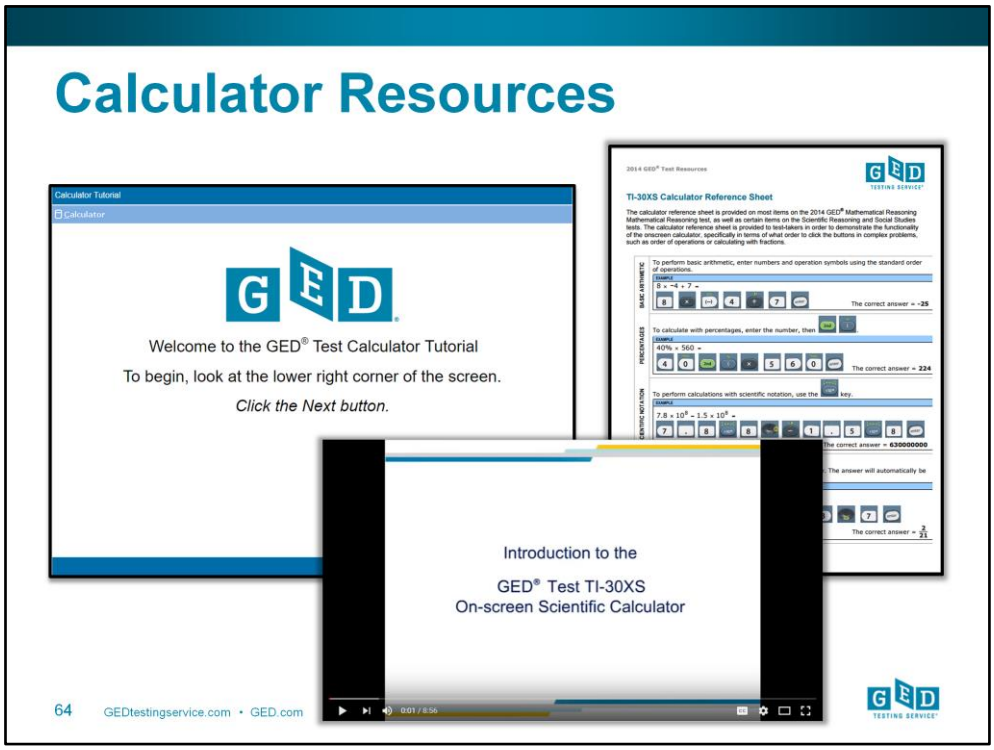

Key Points

Don't forget the resources available on the GED Testing Service® website, including the calculator tutorial, the YouTube video on the calculator, and the TI-30XS Calculator Reference Sheet.

Note: Show participants where each of the resources is located on the GED .com website and the GED Testing Service® YouTube Channel.

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Key Points

One of the High Impact Indicators focuses on issues related to geometric reasoning, specifically surface area. The following slides provide a very effective strategy for working with surface area.

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Formulas

Figure	SA Formula	V Formula
Rectangular prism	SA = ph + 2B	V = Bh
Right prism	SA = ph +2B	V = Bh
Cylinder	SA = $2\pi rh + 2\pi r^2$	V = $\pi r^2 h$
Pyramid	SA = ½ps + B	V = 1/3Bh
Cone	SA = $\pi rs + \pi r^2$	V = $1/3\pi r^2 h$
Sphere	SA = $4\pi r^2$	V = $4/3\pi r^3$

p = perimeter of base with area B; π = 3.14

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Key Points

Students often see the formulas for surface area particularly challenging. They get lost in the symbols used. Think about the fact that students are used to seeing area designated with an “A”. However in working with surface area, the formula includes the use of area “B”. As a result, students are just not sure what to do.

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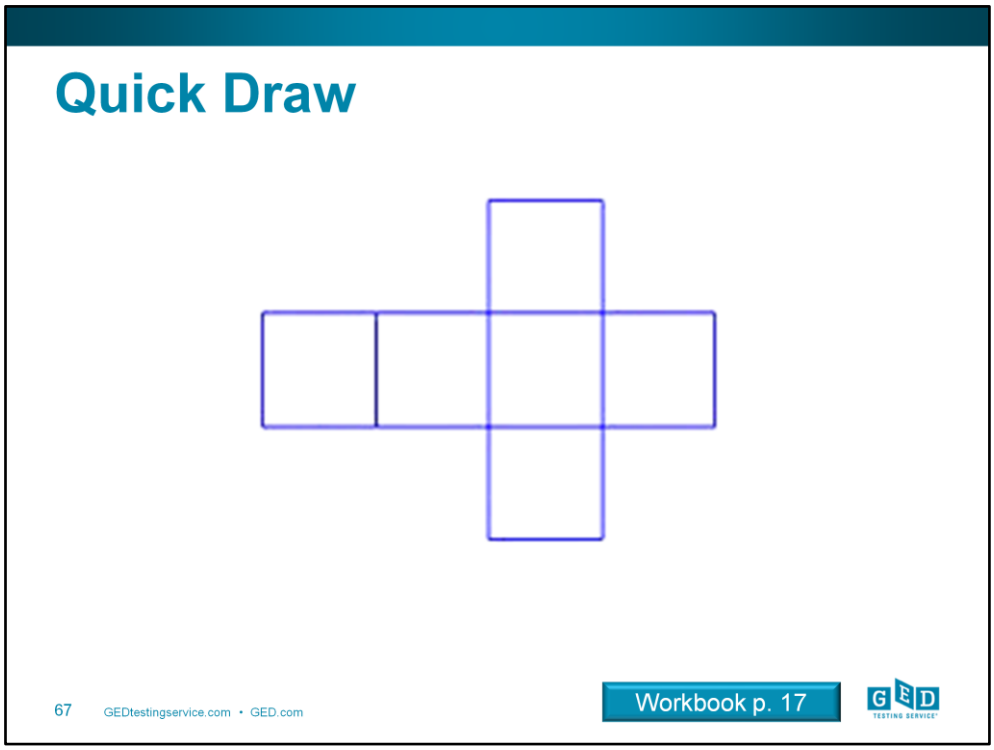

Key Points

This activity requires that you show the drawing for 3-5 seconds, hide the drawing, and ask participants to replicate it in their workbook. To hide the drawing, just click the mouse. To reveal the drawing again, click a second time. After participants complete the quick draw., ask them to identify the figure. Discuss how they came to that conclusion.

The figure is a cube.

Reference:

Grayson Wheatley, formerly of Florida State University and Purdue University, feels strongly about mental imagery in math. He believes that **"All meaningful mathematics learning is imaged-based."** His book ***Quick Draw*** provides teachers with short activities to engage students in mental imagery, thus helping to improve their spatial sense. This activity has been drawn from his book.

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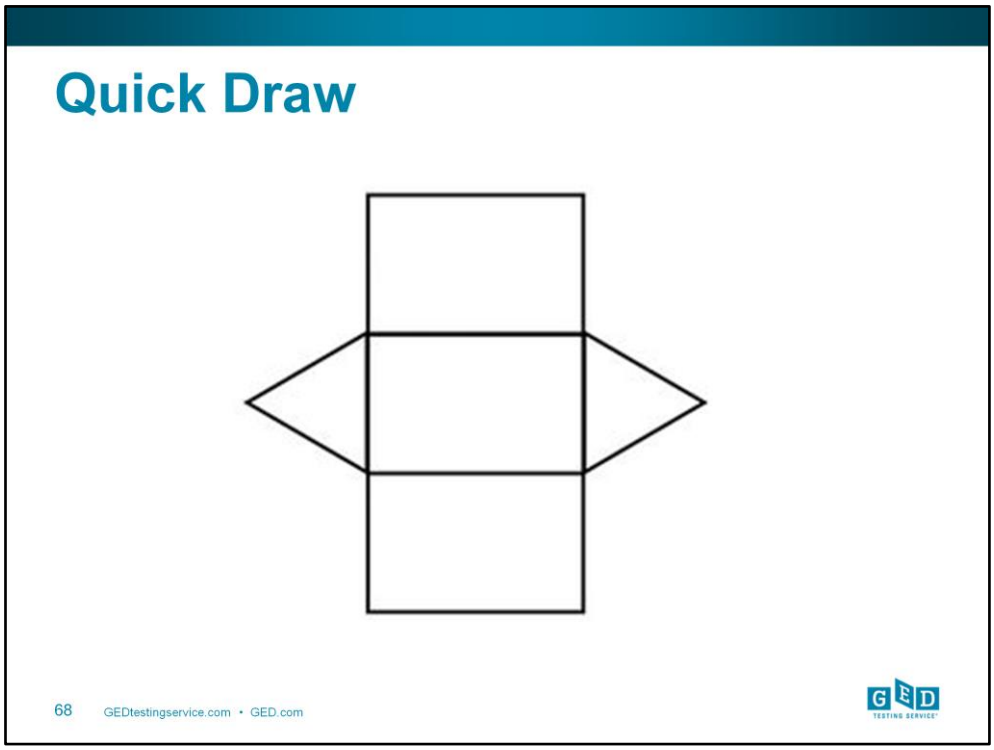

Key Points

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The figure is a rectangular prism.

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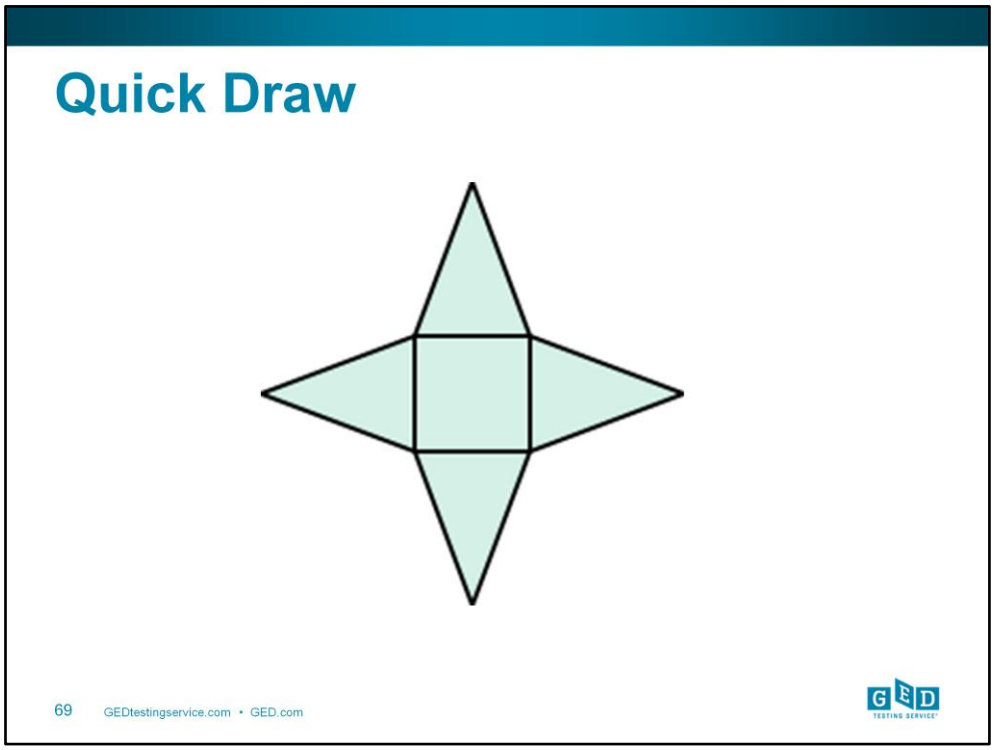

Key Points

This activity requires that you show the drawing for 3-5 seconds, hide the drawing, and ask participants to replicate it in their workbook. To hide the drawing, just click the mouse. To reveal the drawing again, click a second time. After participants complete the quick draw., ask them to identify the figure. Discuss how they came to that conclusion.

The figure is a square pyramid.

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Two Ways to Do It

Surface area can be computed by using the formula or by finding the area of each surface and adding them up!

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Key Points

Explain that surface area can be computed two ways.

- Using a formula
- Finding the area of each surface or face of the figure and adding them up

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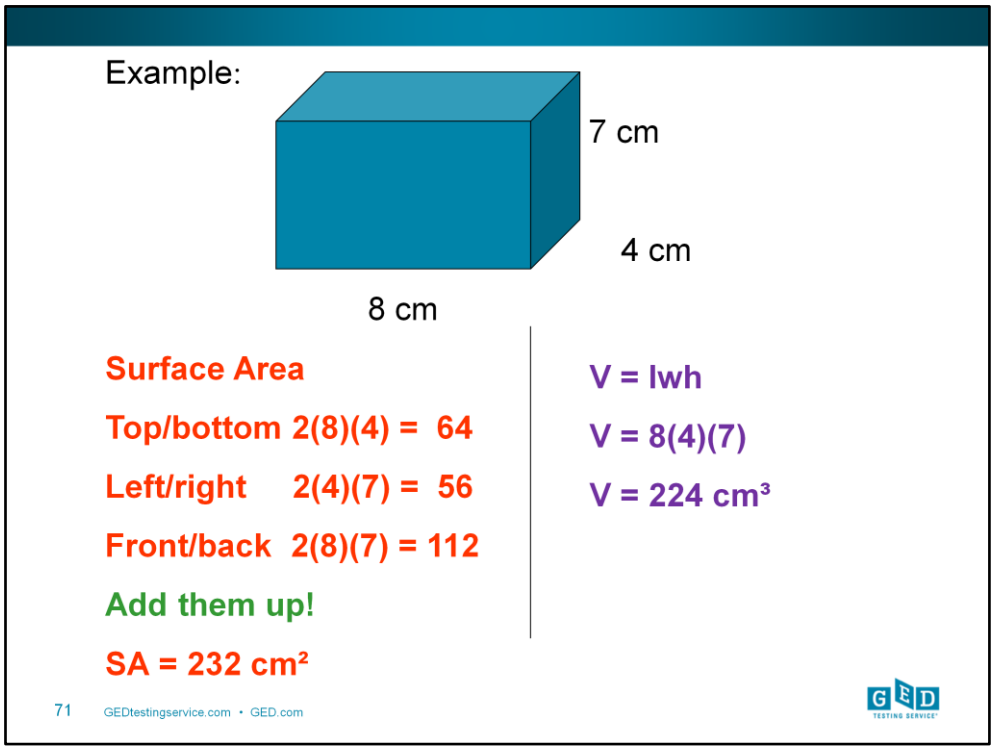

Key Points

Discuss the computations made to find the area of each face of this figure and the final calculation of the surface area. Explain that volume does not create the same type of problem for students in that they are used to each of the symbols included in the formula

- l=length
- w = width
- h = height

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Use Nets to "Catch" Some Skills

A **net** is the shape that is formed by unfolding a three-dimensional figure. In other words, a **net** is composed of all of the faces of the figure.

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Key Points

Review the definition of a net.

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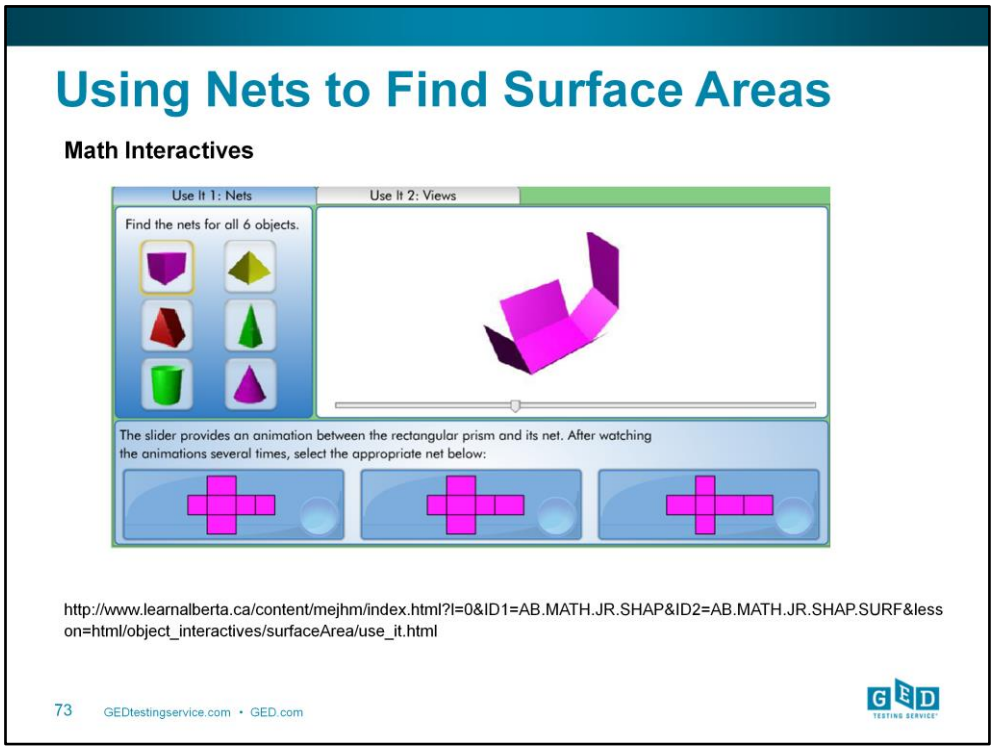

Key Points

If time permits and access is available, visit the *Math Interactives* site so participants can see how the process of using a net works to determine surface area.

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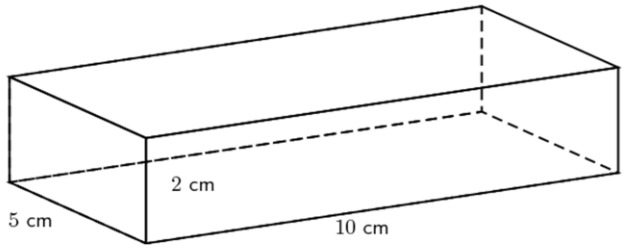
Using Nets to Find Surface Areas

Find the surface area of the rectangular prism by using a net.



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Workbook pp. 18-19

Key Points

Have participants use the graph paper provided in the workbook and draw a net that represents the figure shown. Have them then calculate the surface area for the figure.

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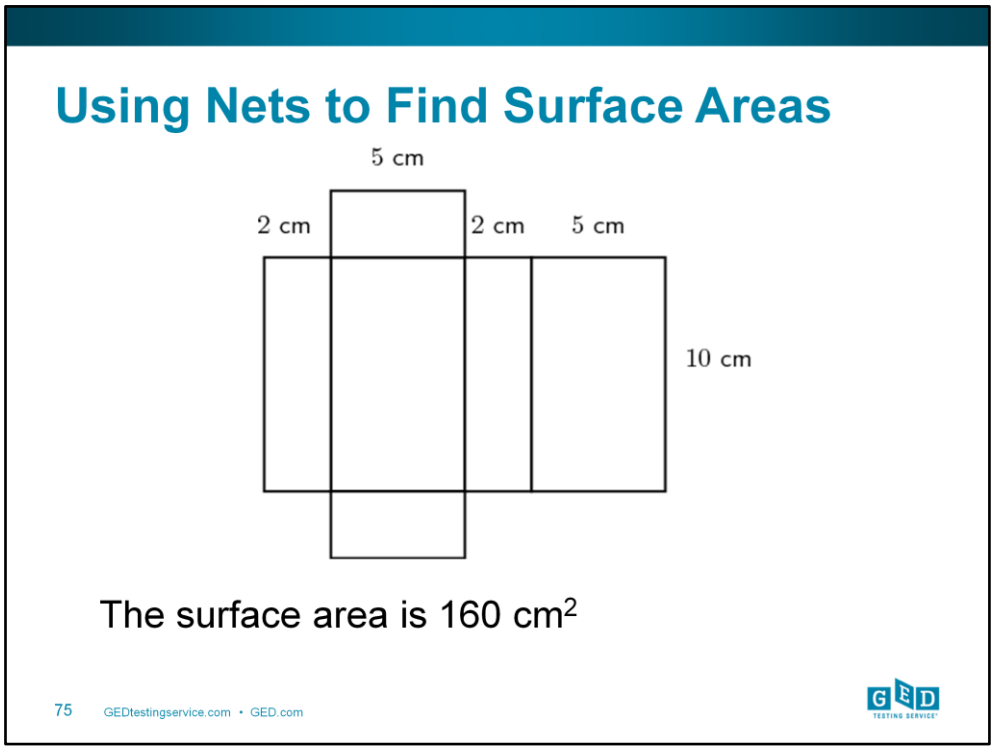

Key Points

Discuss how this activity can be used with adult basic education students, as well as those in a GED® preparation class. Discuss how students could literally count the square units on the graph paper to determine the area for each rectangle and then add then up.

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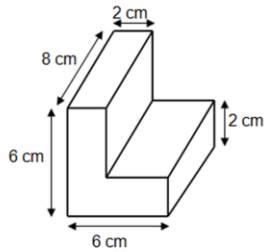
Using Nets to Find Surface Area

The diagram shows a prism constructed from two rectangular prisms.

Draw the net for the solid and mark the lengths.

Calculate the surface area of the solid.



Workbook pp. 18-19

Key Points

If time permits, can have participants try an composite shape.

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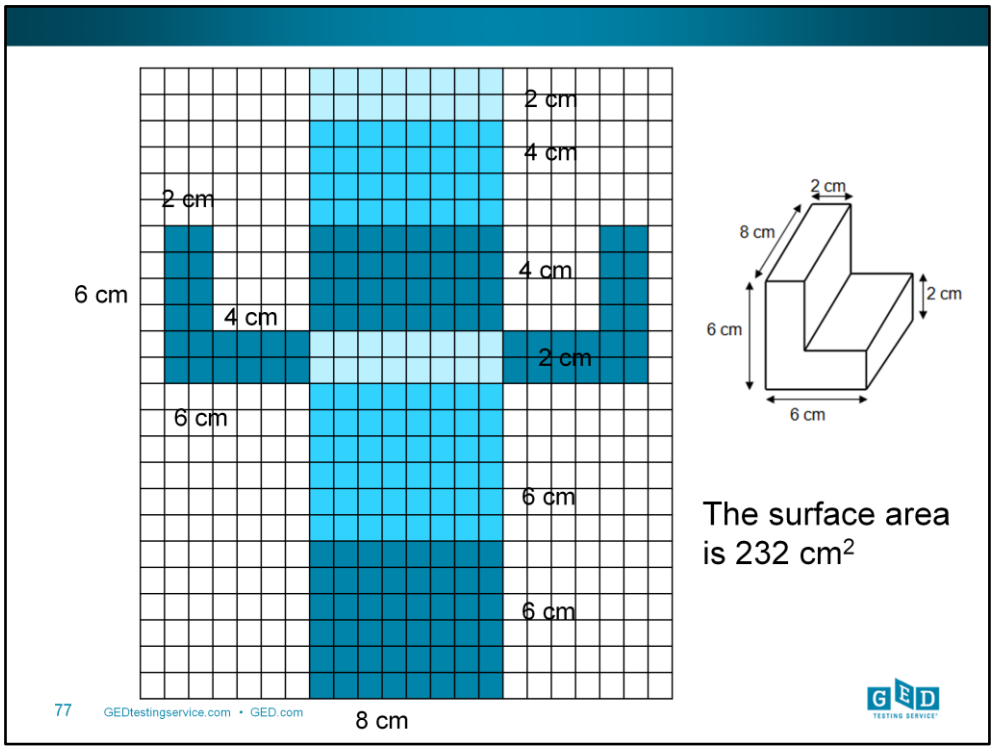

Key Points

Sample answer for activity.

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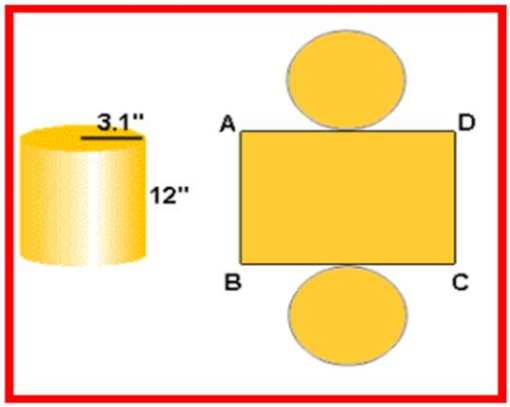
Surface Area of a Cylinder

Imagine that you can open up a cylinder like so:

You can see that the surface is made up of two circles and a rectangle.



The length of the rectangle is the same as the circumference of the circle!

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Key Points

Discuss how a net can be used to find the surface area of a cylinder.

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Mathematical Reasoning - Candidate Name

Question 10 of 16

Answer Explanation Calculator Flag for Review

A scientist is studying red maple tree growth in a state park. She measured the trunk diameters of a sample of trees in the same month every other year. The tables show the data for two of the trees.

Tree 1

Year	Trunk Diameter (inches)
1	18.6
3	19.2
5	19.8
7	20.4
9	21.0
11	21.6
13	22.2

Tree 2

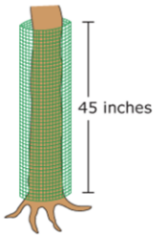
Year	Trunk Diameter (inches)
1	11.4
3	12.0
5	12.6
7	13.2
9	13.8
11	14.4
13	15.0

This is the final year in which she will collect data. When her data collection is complete, she will predict future red maple tree growth.

Formula Sheet Calculator Reference

In year 13, the scientist will put tree wrap around tree 1 to protect it from the winter snow. The height of the tree wrap needs to be 45 inches.

Tree Wrap



The wrap is priced by the square foot. To the nearest square foot, how many square feet of wrap does she need?

- A. 22
- B. 44
- C. 121
- D. 261

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Previous Next

Key Points

Ask participants in their students would have had an easier time with this question if they had understood the concept of nets.

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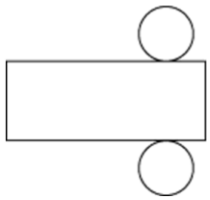
Let's Try It!

I want to paint the outside of a decorative pillar that has a height of 48 inches and a diameter of 16 inches. One small canister of paint will cover about 200 square inches. How many small canisters of paint will I need to paint the cylinder?

- What do I need to know?
- What type of net can I draw?
- What formula can I use?



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Workbook pp. 21-22

Key Points

If time permits, have participants actually draw a net and solve the problem. If time is limited, discuss the problem and how it could be solved using nets.

Note: The following is provided as reference material for the trainer.

Closed cylinder

Surface Area = 2*Base area + Rectangle area

2*Area of base (circle) = $2*\pi r^2$

Area of rectangle = Circle circumference * height

Surface Area of Closed Cylinder = $(2\pi r^2 + 2\pi rh)$ sq units

Find the area of the tube by multiplying the circumference of the circle base by the height of the cylinder.

Find the area of one of the circle bases.

Double the area of the circle for the top and bottom of the cylinder.

Add the area of the two circles and the area of the tube surface.

Answer: 14 small canisters

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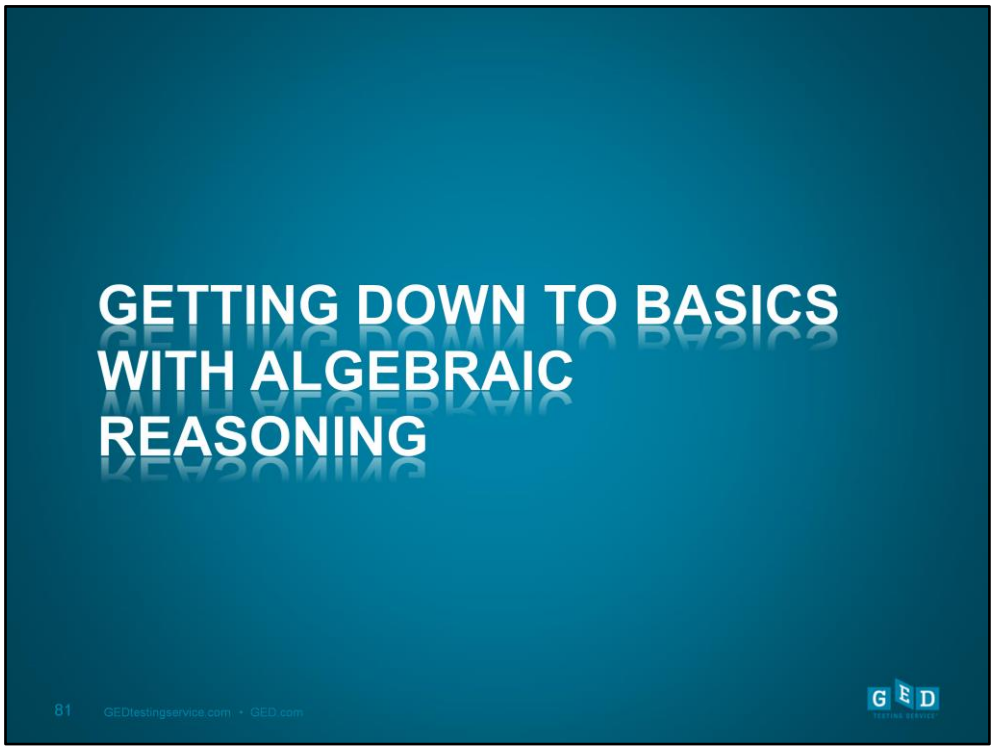

Key Points

Sometimes it really does come down to some of the most basic knowledge that creates problems for students. The following slides provide information on some “quick fixes” related to algebraic reasoning.

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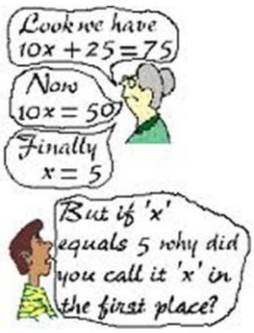
Remember . . .

- Arithmetic is doing something to numbers to get an answer.
- Algebra is exploring the relationships between numbers.



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Key Points

There is a difference between arithmetic and algebra. Review the bulleted items.

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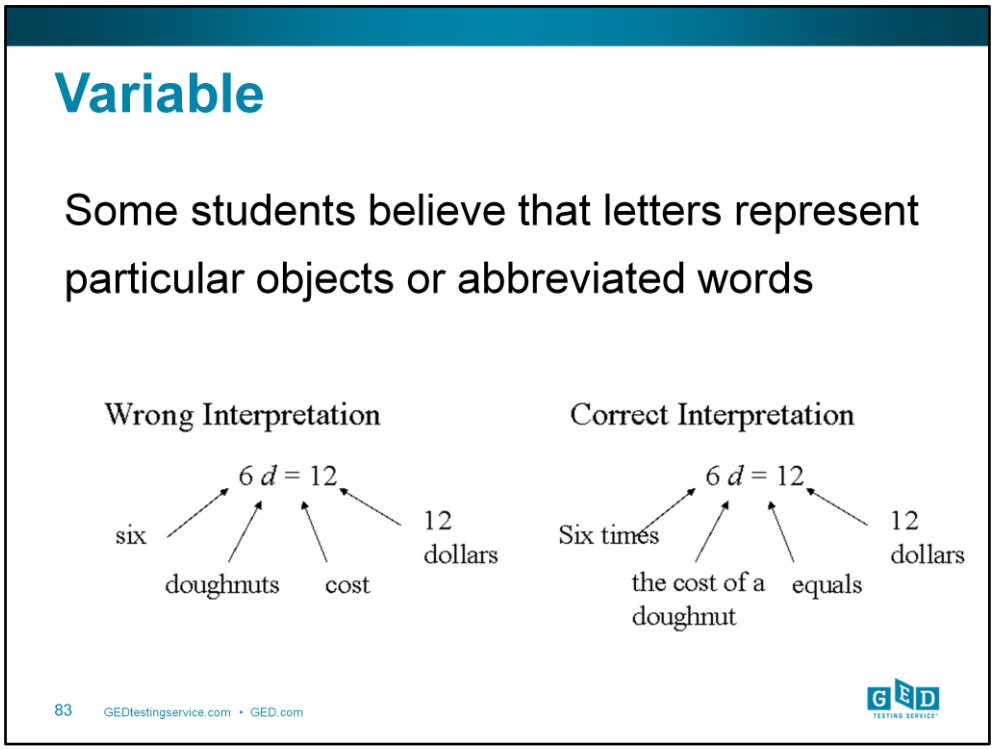

Key Points

Students have difficulty discriminating among the different ways letters may be used. In arithmetic, letters are first encountered in formulas, which are generally provided as procedural guides. The student is asked to substitute the appropriate quantities to determine the perimeter, area, or volume. Letters in the formulas are actually variables, but they are rarely discussed as such. A letter can also represent a specific number that is currently unknown but should be determined or “found” (e.g.,). A letter can also represent a general number, which is not one particular value. Finally, letters can represent variables, each of which represents a range of unspecified values along with a systematic relationship among them (Kieran 1992, p. 396).

Teachers often assume that students can easily navigate among these different uses and meaning of letters, but interviews with adult students indicate this is not necessarily so (Jackson and Ginsburg 2008). Understanding the use of variables is crucial for student success in algebra. Some students believe that letters represent particular objects or abbreviated words because of their alphabetic connection. For example: students may see 3d as representing three dogs if the problem referenced dogs. Review the two interpretations provided. Discuss the differences between them and why students need to learn how to correctly interpret an expression or equation.

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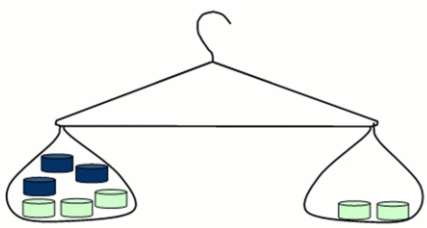
Confusion About the Equal Sign

The equal sign stands for balance or equality.

The concept of balance can be used to reinforce the idea of equality – both sides of the number sentence need to be the same, the equation needs to balance.



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Key Points

Review the information on the slide. Explain that students need to understand that an equal sign does not announce an answer, but rather shows a relationship. Students need to fully understand equivalency. If they learn this at an early age or when working with very basic mathematical computation skills, the concept will flow easily to algebra.

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Symbolic Notation

A Few Examples

Sign	Arithmetic	Algebra
= (equal)	. . . And the answer is	Equivalence between two quantities
+	Addition operation	Positive number
-	Subtraction operation	Negative number

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Key Points

Review the table of symbols and how each appear to students, whether working in arithmetic and algebra.

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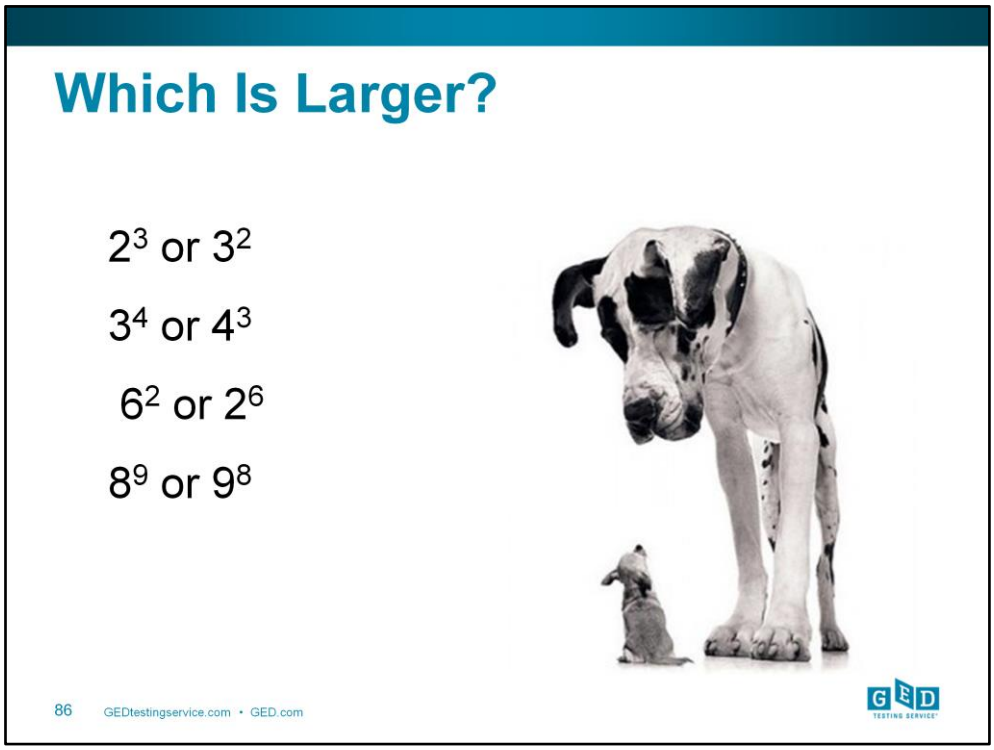

Key Points

Students still struggle with exponents. This is problematic in so many ways. It impacts the answer they get when working with formulas, such as the Pythagorean Theorem. It also impacts them when working with scientific notation. The key is to work with students to understand that 2^3 or 3^2 do not represent the same value. The issue appears to occur when students encounter 2^2 as the first exponent with which they deal. If possible, a different base, such as 10^2 or 5^2, to start the process.

Answers for each example.
3^2
3^4
2^6
9^8

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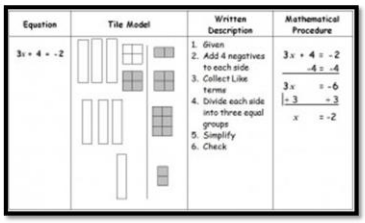
Use Multiple Representations

- Start with the concrete
- Represent problems using symbols, expressions, and equations, tables, and graphs
- Model real-world situations
- Complete problems different ways (flexibility in problem solving)



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Key Points

In middle school, students learn that there are multiple ways to represent problems. However, rarely in adult education mathematics classes do we use the same process and represent problems in multiple ways. Problems can be represented using symbols, expressions, equations, tables, graphs, etc.

Remind instructors that presenting information through real-world situations is one of the best ways to allow students to make the connection and thus retain the information.

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Would you teach multiplication . . .

This Way?	This Way?
3,452 x 267	3,452 x 267 =

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Key Points

Note: This slide includes animation.

Ask the teachers if they would teach basic multiplication in a vertical or horizontal manner. Discuss why they would use the vertical method.

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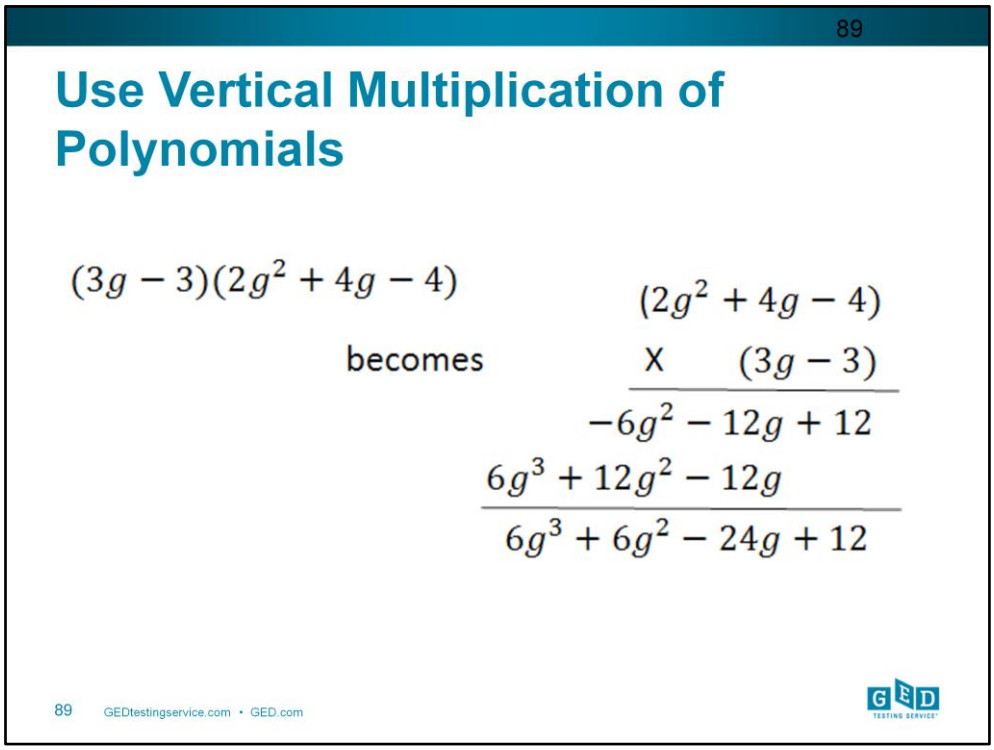

Key Points

Ask teachers how they most often teach the multiplication of polynomials. Would they use a vertical or horizontal manner? Discuss why the vertical method would be helpful for students.

Note: You may wish to model the process of vertical multiplication of polynomials on chart paper so that participants can see the process in action.

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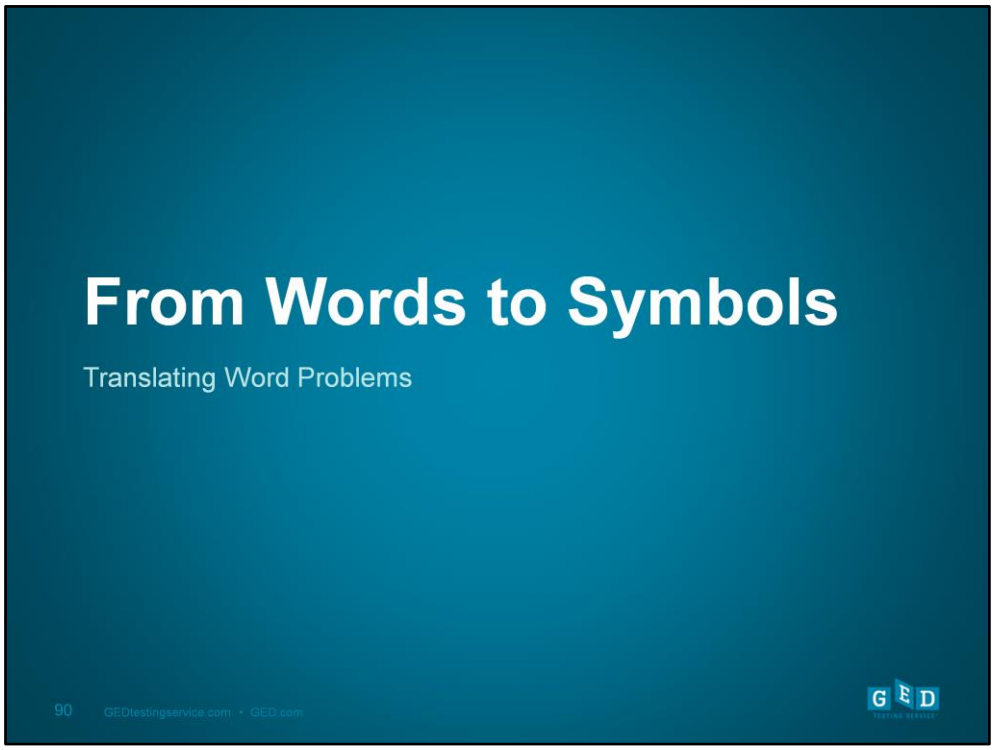

Key Points

Students may recognize symbols when they see them. However, they often have difficulty when faced with a word problem in translating words to symbols.

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What would your students do?

Mathematical Reasoning - Candidate Name

Question 14 of 16

Answer Explanation Calculator Flag for Review

Formula Sheet Calculator Reference

There are s steps from the pedestal to the head of the Statue of Liberty. The number of steps in the Washington Monument is 27 less than 6 times the number of steps in the Statue of Liberty. Which expression represents the number of steps in the Washington Monument in terms of s?

A. $27 < 6s$

B. $6(s - 27)$

C. $6s - 27$

D. $6s < 27$

Previous Next

1. Guess
2. Select "C" because they haven't used it in a while
3. Skip it
4. Sign up for a retest

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Workbook p. 23

Key Points

Have teachers view the problem and then determine what they think students would most likely do. Discuss how some students would just get confused by the wording in the problem and guess or even skip it. Explain that students don't have to skip these types of problems; they just need to have a strategy for reading the problem and translating it.

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What students need to do!

1. Read the problem carefully and determine what you are trying to find
2. Assign a variable to the quantity that must be found
3. Write down what the variable represents
4. Write an equation for the quantities given in the problem
5. Solve the equation
6. Answer the question
7. Check the solution for reasonableness

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Key Points

Briefly review each of the steps that students need to take when translating a problem from words to symbols.

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Practice Translating

Jennifer has 10 fewer DVDs than Brad.

$j - 10 = b$ *(common answer, but incorrect)*

Insert the words and see the difference in the equation.

j (has) = b (fewer) – 10

so

$j = b - 10$

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Key Points

Use this slide to demonstrate how students often work from left to right in translating a problem, thus ending up with the wrong interpretation (and answer).

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Use a Math Translation Guide

English	Math	Example	Translation
What, a number	x, n, etc.	Three more than a number is 8.	n+ 3 = 8
Equals, is, was, has, costs	=	Danny is 16 years old. A CD costs 15 dollars.	d = 16 c = 15
Is greater than Is less than At least, minimum At most, maximum	> < ≥ ≤	Jenny has more money than Ben. Ashley's age is less than Nick's. There are at least 30 questions on the test. Sam can invite a maximum of 15 people to his party.	j > b a < n t ≥ 30 s ≤ 15
More, more than, greater, than, added to, total, sum, increased by, together	+	Kecia has 2 more video games than John. Kecia and John have a total of 11 video games.	k = j + 2 k + j = 11
Less than, smaller than, decreased by, difference, fewer	-	Jason has 3 fewer CDs than Carson. The difference between Jenny's and Ben's savings is $75.	j = c – 3 j – b = 75
Of, times, product of, twice, double, triple, half of, quarter of	x	Emma has twice as many books as Justin. Justin has half as many books as Emma.	e = 2 x j or e = 2j j = c x ½ or j = e/2
Divided by, per, for, out of, ratio of __ to __	÷	Sophia has $1 for every $2 Daniel has. The ratio of Daniel's savings to Sophia's savings is 2 to 1.	s = d ÷ 2 or s = d/2 d/s = 2/1

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Workbook p. 24-25

Key Points

Explain that one way to help students move past problems with translation is to use a Math Translation Guide. This guide can help students learn to associate specific words with math symbols and enable them to avoid some of the mistakes that they commonly make when working with word problems.

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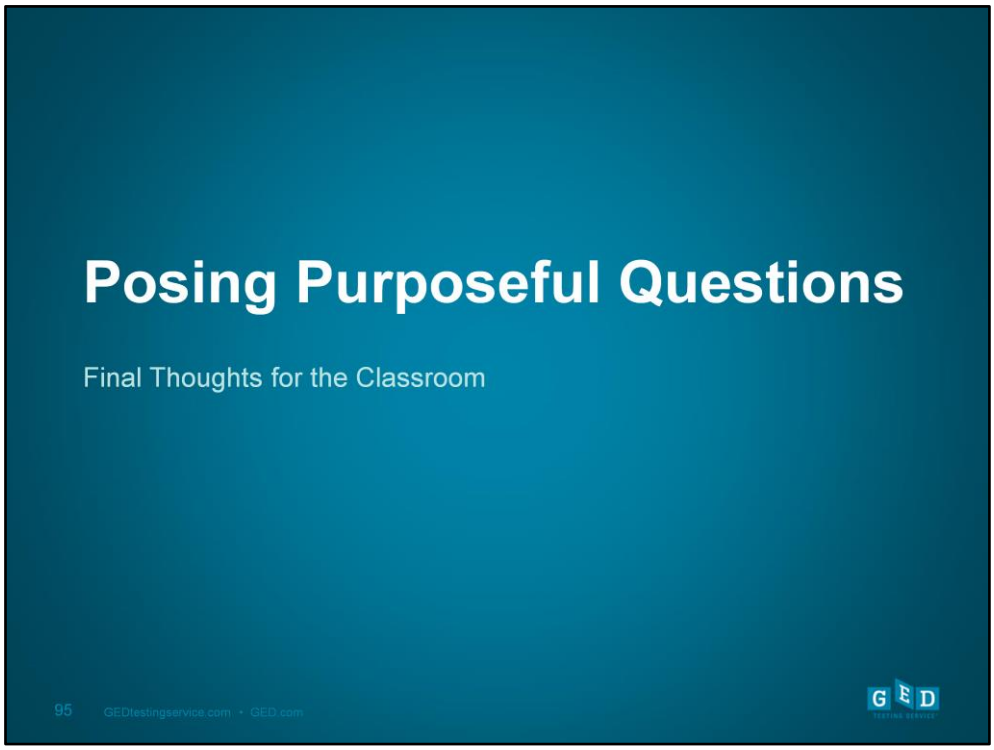

Key Points

In this presentation, you have learned about the importance of incorporating close reading into mathematics, how to help students expand their thinking strategies or heuristics to give students more options for problem solving, and a routine that incorporates a graphic organizer. Each of these areas requires that students gain more effective questioning skills. In this last section, it is time to think about the questions that teachers pose to their students.

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Posing Purposeful Questions

Effective teaching of mathematics uses purposeful questions to assess and advance students' reasoning and sense making about important mathematical ideas and relationships.

Four Types of Questions

1. Gathering Information
2. Probing Thinking
3. Making the mathematics visible
4. Encouraging reflection and justification

Effective Teaching and Learning. (2014). In *Principles to Actions : Ensuring mathematical success for all* (p. 36). Reston, VA: NCTM.

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Key Points

Discuss the different types of purposeful questions. The next slides identify some samples. Share with participants that they will want to include these types of questions into their math classroom to assist students in building their mathematical reasoning skills.

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Purposeful Questions

Question type	Description	Examples
Gathering information	Students recall facts, definitions, or procedures.	• When you write an equation, what does the equal sign tell you? • What is the formula for finding the area of a rectangle?
Probing thinking	Students explain, elaborate, or clarify their thinking, including articulating the steps in solution methods or the completion of a task.	• As you drew that number line, what decisions did you make so that you could represent 7 fourths on it? • Can you show and explain more about how you used a table to find the answer to the Smartphone Plans task?

Effective Teaching and Learning. (2014). In *Principles to Actions : Ensuring mathematical success for all* (p. 36). Reston, VA: NCTM.

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Workbook p. 26

Key Points

Review the types of questions for each of the areas.

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Purposeful Questions

Question type	Description	Examples
Making the mathematics visible	Students discuss mathematical structures and make connections among mathematical ideas and relationships.	▪ What does your equation have to do with the band concert situation? ▪ How does that array relate to multiplication and division?
Encouraging reflection and justification	Students reveal deeper understanding of their reasoning and actions, including making an argument for the validity of their work.	• How might you prove that 51 is the solution? • How do you know that the sum of two odd numbers will always be even?

Effective Teaching and Learning. (2014). In *Principles to Actions : Ensuring mathematical success for all* (p. 36). Reston, VA: NCTM.

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Workbook p. 26

Key Points

Review the types of questions for each of the areas.

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The Challenge

- Increase instruction on problem-solving strategies
- Increase emphasis on geometric and algebraic thinking
- Provide instruction in higher-order mathematics
- Shift focus from “rules or processes” of mathematics to deeper understanding of “why”
- Incorporate close-reading strategies into the math classroom
- Have high expectations of all students

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Key Points

Review each of the bulleted items.

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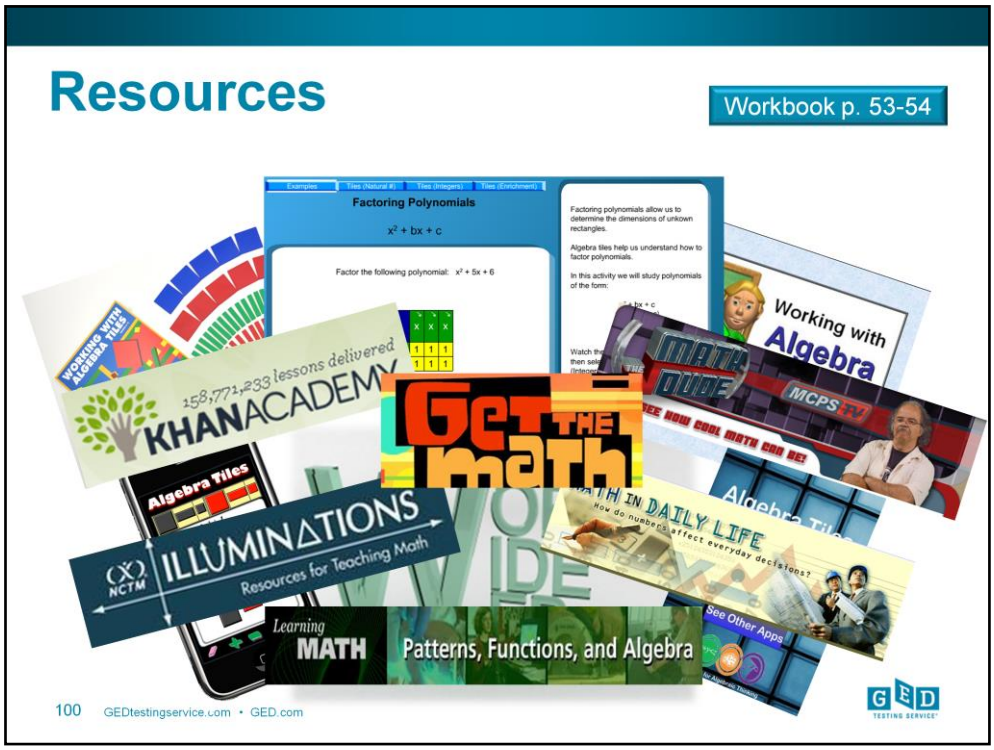

Key Points

Take time to briefly review the online resources provided in the workbook.

Note: You may wish to access some of the websites and show participants the resources. An actual demo of web resources provides a great incentive for participants to "check them out" after the training.

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