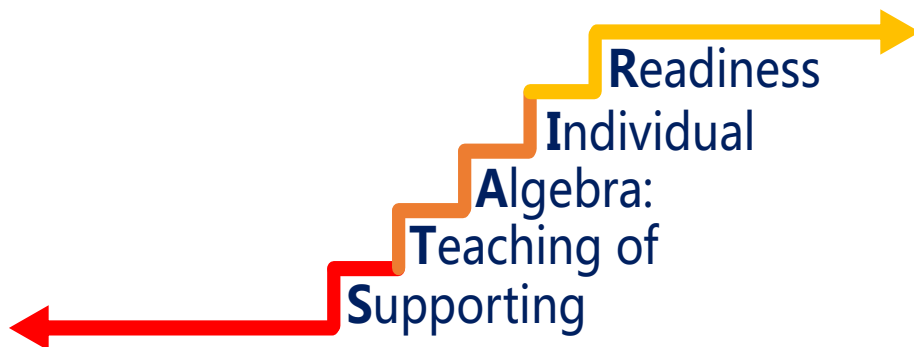


# PROJECT STAIR INSTRUCTIONAL GUIDE FOR MATHEMATICS



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Project STAIR is a federally-funded research project that supports middle-school mathematics teachers in implementing data-based individualization (DBI). STAIR coaches work with teachers to help support students who experience difficulty with math to develop algebra readiness skills needed to be successful in high school and beyond. Project STAIR is supported by the Office of Special Education Programs (OSEP) under grant H326M170006. The project is housed at the University of Missouri, Southern Methodist University, and the University of Texas at Austin.

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## Project STAIR

### Supporting Teaching of Algebra: Individual Readiness

# Project STAIR

# Instructional Guide

# for Mathematics

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In this guide, we provide suggestions for implementing evidence-based mathematics (math) instruction. We suggest you design an instructional platform and intensify the platform based on student needs.

#### WHAT IS EVIDENCE-BASED MATHEMATICS INSTRUCTION?

Evidence-based instruction is instruction based on the results of several high-quality research studies that find a practice to effectively improve students' math skills and understandings across a variety of settings.

In this guide, we provide an introduction to key evidence-based math practices. Additionally, we provide a brief description of the research-base that supports each practice, and we provide additional resources if you are interested in learning more.

# Project STAIR

## Supporting Teaching of Algebra: Individual Readiness

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# How to Use this Guide

## Math Instructional Practices

We highlight 7 evidence-based math practices.

### EXPLICIT INSTRUCTION

Explicit instruction includes proper modeling, practice, and support of math learning. Teachers should be purposeful in their explanations and interventions to ensure student participation and reflection.

### MULTIPLE REPRESENTATIONS

The use of multiple representations, including concrete, pictorial, and abstract representations allows students to have multiple access points in understanding the math concepts. There is no hierarchy between the three forms of representation, and it is important that students at all grade levels have access to these multiple forms of learning.

### MATH LANGUAGE

Math language includes the use of precise and concise formal math language. It is important that students hear, see, write, and practice speaking using the mathematically correct term, even at a young age. Teachers can explicitly teach math language and integrate it into their practice.

### WORD-PROBLEM INSTRUCTION

Many students benefit from explicit word problem instruction, including attack strategies to break down the word problem as well as schema instruction. Learning the different schemas, or structures, of word problems helps student identify strategies to solve each problem.

### MNEMONICS

Mnemonics includes devices or strategies to help students remember math concepts or the steps in a math procedure. Mnemonics can be a powerful tool to help students learn multi-step strategies or complex multi-component procedures.

### GRAPHIC ORGANIZERS

Graphic organizers are visual, or graphic, displays of math vocabulary, concepts, procedures, or relationships between larger math topics. Graphic organizers are an effective tool to help students organize their thoughts and implement complex math procedures.

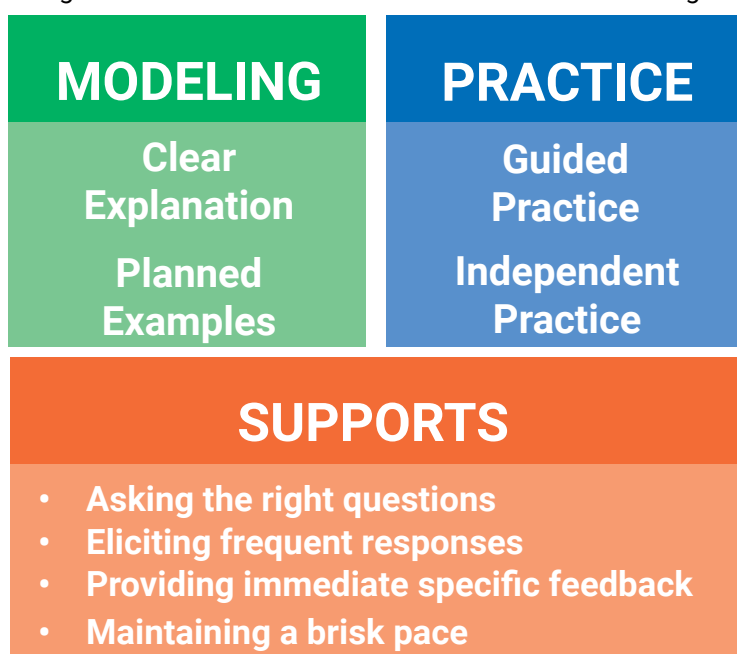
### FLUENCY BUILDING ACTIVITIES

To help students master math facts and math essentials, it is important they are provided frequent, brief opportunities to develop their fluency. Students can play games, use manipulatives, or practice their facts in a variety structured ways.

# Utilize Explicit Instruction

## DEFINITION

Teachers should be explicit in the modeling and practicing of math. In the figure below, interventions should be divided between modeling and practice. Modeling includes a step-by-step explanation and clarity in the language used during explanations. Practice includes practice with the teacher (i.e., guided practice) as well as independent practice. During modeling and practice, teachers should use supports, such as asking a variety of question types, eliciting student responses and providing immediate corrective feedback while maintaining a brisk pace.



## WHAT DOES THE RESEARCH SAY?

Explicit and systematic instruction is essential when providing math intervention (Fuchs et al., 2021). In reviews of math intervention, explicit instruction is often noted in almost all interventions (Jitendra et al., 2018; Stevens et al., 2018).

Researchers have used explicit instruction to teach a variety of math content, including operations (Milton et al., 2019; Parker et al., 2019), fractions (Bouck et al., 2017; Dyson et al., 2020), word-problem solving (Bottge et al., 2014; Jitendra & Star, 2012), algebra (Bouck et al., 2019; Bryant et al., 2020), and math writing (Hughes & Lee, 2020).

# Utilize Explicit Instruction

## EXAMPLE: MODELING

### MODELING

Clear  
Explanation  
Planned  
Examples

State the goal and  
its importance.

Model steps.

Use precise math  
language.

"To solve 26 plus 79, we first decide about the operation. Do we add, subtract, multiply or divide?"

"The plus sign tells us to add. So, we'll add 26 plus 79. We'll use the partial sums strategy. First, we add 20 plus 70. What's 20 plus 70?"

...

"Finally, we add the partial sums: 90 and 15. 90 plus 15 is 105."

### MODELING

Clear  
Explanation  
Planned  
Examples

Use examples.

Also use non-  
examples.

$$24 / 6 \quad 28 \div 7 \quad 35 \overline{) 5}$$

$$32 \div 8 \quad 42 \div 7 \quad 25 - 5$$

## EXAMPLE: PRACTICE

### PRACTICE

Guided  
Practice

Independent  
Practice

Teacher and student  
practice together.

Student practices with  
teacher support.

"Let's work on this problem together. First..."

"Now you'll practice a problem on your own. Don't forget to use your attack strategy."

# Utilize Explicit Instruction

## EXAMPLE: SUPPORTS

### SUPPORTS

Asking the right questions

Ask low-level and high-level questions.

“What is 7 times 9?”  
“How would you solve this problem?”

Eliciting frequent responses

Vary responses, such as: classwide, individual, partner, write on paper, write on whiteboard, thumbs up, etc.

“Turn and discuss the formula for perimeter with your partner.”  
“Write  $2 + 6$  on your whiteboard.”

Providing immediate specific feedback

Provide affirmative and correct feedback.

“Let’s look at that again. Tell me how you added in the hundreds column.”

Maintaining a brisk pace

Be planned and organized.

“Grab your bag of manipulatives as you enter the classroom.”

## ADDITIONAL RESOURCES

[National Center on Intensive Intervention Course on Explicit Instruction](#)

[Vanderbilt IRIS Center Module on Explicit Instruction](#)

[Explicit Instruction Homepage](#)

# Utilize Explicit Instruction

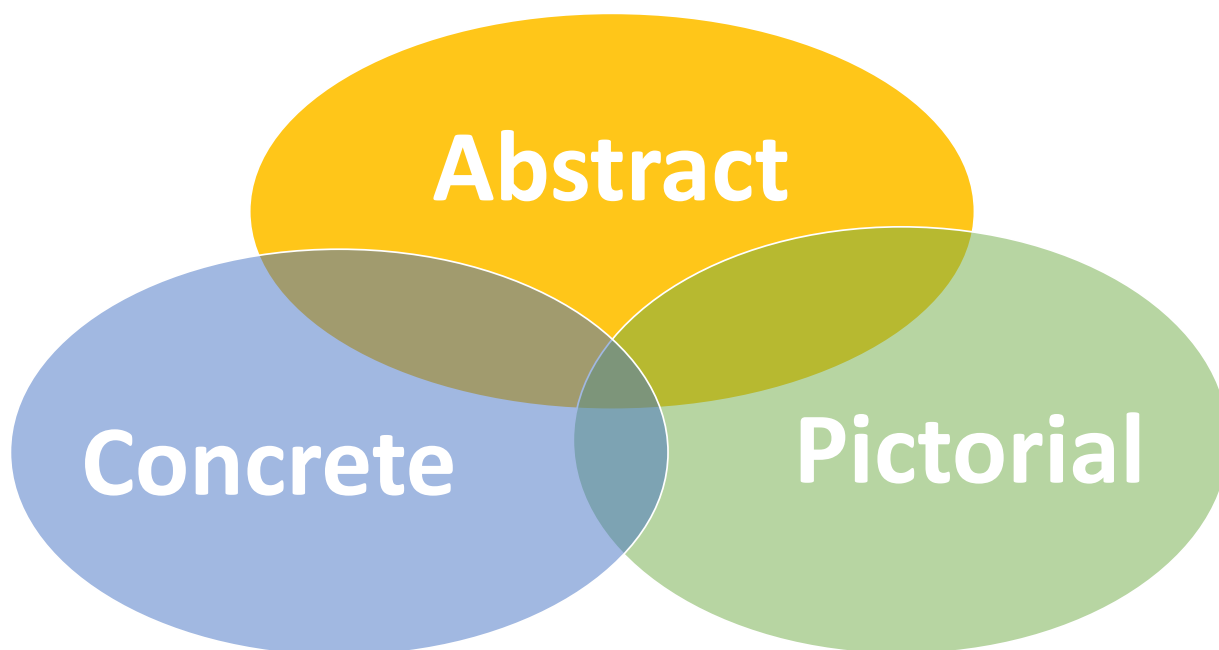
## PROCEDURES

<b>Clear Explanation with Precise Language</b>	When modeling, start with a clear explanation about why the math is important. For example, say, "Today, we are learning about division. This is important because sometimes you have to share objects or things with your friends." This will help students start to make the connection between math and real life. Precise language includes the formal language of math. For example, say "numerator" instead of "top number" or "product" instead of "answer."
<b>Model Steps</b>	While modeling, model the steps to solve a problem. Involve your students in the process by asking questions and giving them opportunities to respond. Modeling should feel like a dialogue between you and your students.
<b>Planned Examples and Non-Examples</b>	Plan the examples you choose for your interventions. For example, when modeling a division problem, think about the different ways to show division and how you want to represent the problems. Include non-examples to help students understand when to apply the strategy you have modeled.
<b>Guided Practice</b>	You and the students practice problems together. Provide scaffolding so students can start to see how they can solve these problems on their own.
<b>Independent Practice</b>	Students practice independently while you provide feedback. Ensure that students are able to complete problems on their own before they begin independent practice.
<b>Supports: Questions</b>	During both modeling and practice, ask a mix of low-level questions (to check for understanding) and high-level questions (to learn what students understand about different concepts and procedures).
<b>Supports: Responses</b>	During both modeling and practice, provide opportunities for students to respond. Typically students should respond at least every 30 to 60 seconds during modeling and guided practice.
<b>Supports: Feedback</b>	During both modeling and practice, provide affirmative feedback. Make the affirmative feedback specific to math. Provide corrective feedback when necessary.
<b>Supports: Brisk Pace</b>	During both modeling and practice, maintain a brisk pace by being prepared, organized, and ready to teach in order to maximize time spent learning.

# Multiple Representations

## DEFINITION

Teachers should use multiple representations to help students understand different math concepts and procedures. Multiple representations include concrete representations. These are hands-on tools students can use to show math in different ways. Multiple representations also includes pictorial representations. These might be pictures, graphs, or organizers printed or drawn on a two-dimensional surface. Pictorial representations could also include virtual manipulatives accessed via technology. Finally, multiple representations includes abstract representations of math presented with numerals, symbols, and words.

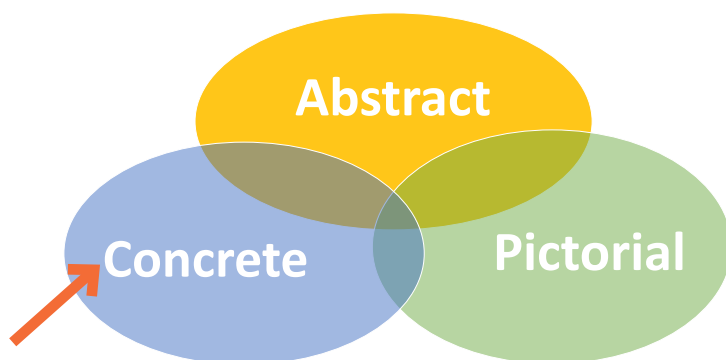


## WHAT DOES THE RESEARCH SAY?

When students use multiple representations, their math performance increases (Bouck & Park, 2018). This is true for hands-on tools (Namkung & Bricko, 2021), virtual manipulatives (Bouck et al., 2018), and graphic organizers. Multiple representations have been used to increase student understanding of operations (Bennett & Rule, 2005), fractions (Bouck et al., 2020), word-problem solving (Xin et al., 2020), geometry (Strickland & Maccini, 2012), and algebra (Scheuermann et al., 2009).

# Multiple Representations

## EXAMPLE: CONCRETE REPRESENTATIONS



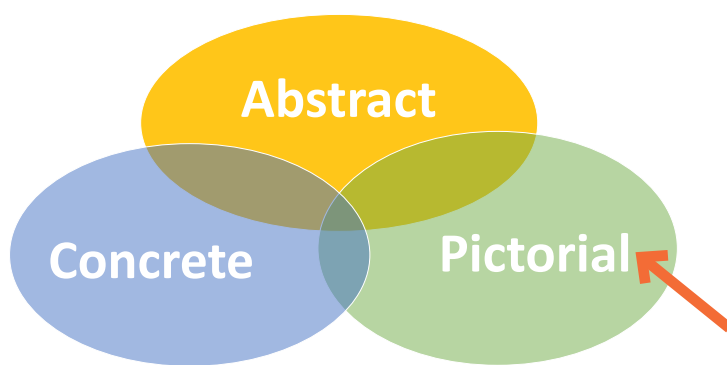
Concrete representations include three-dimensional objects or virtual manipulatives.

Shown below are examples of manipulatives, but many manipulatives can be used to teach a variety of math topics.

Operations	Whole Numbers	Fractions	Algebra	Geometry

# Multiple Representations

## EXAMPLE: VISUAL REPRESENTATIONS



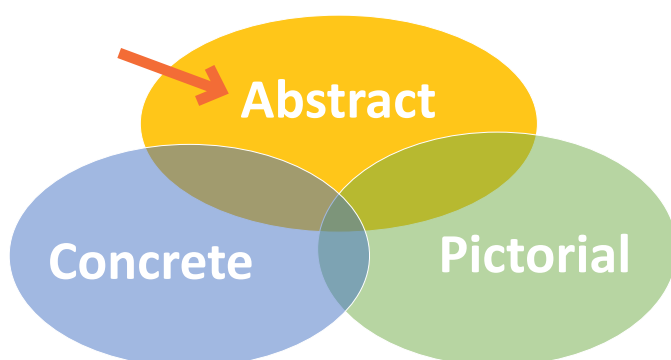
Visual representations include two-dimensional objects and virtual manipulatives.

Shown below are examples of manipulatives, but many manipulatives can be used to teach multiple math topics.

Operations	Whole Numbers	Fractions	Algebra	Geometry

# Multiple Representations

## EXAMPLE: ABSTRACT REPRESENTATIONS



**Abstract representations include symbols and numerals.** It is beneficial to always have the abstract representation present when working with additional representations as well.

**78 = 7 tens and 8**

$$4 + 9 = 13$$

$$x - 6 = 9$$

$$\begin{array}{r} 4,156 \\ + \underline{789} \end{array}$$

### ADDITIONAL RESOURCES

[National Council of Teachers of Mathematics: Multiple Representations](#)

[Vanderbilt IRIS Center Module on Visual Representations](#)

[Virtual Manipulatives Library](#)

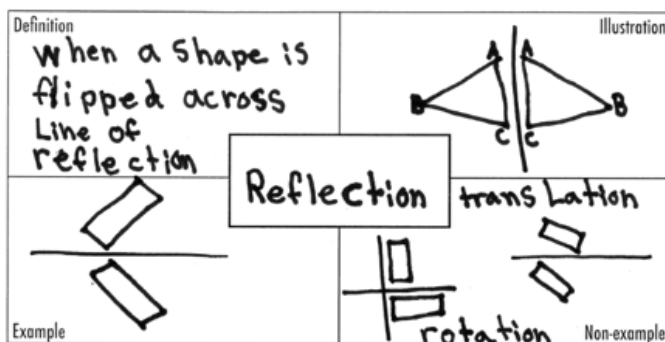
# Math Language

## DEFINITION

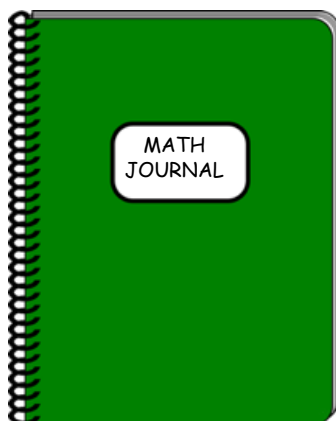
Teachers should be sure to use precise and concise math language. Math terms should be explicitly taught. Precise math language includes the formal math terms that accurately portray a math concept or procedure. For example, teachers should say **numerator**, not *top number*. When teachers use concise math language, they use short but accurate and student-friendly definitions when they introduce and discuss math concepts.

## WHAT DOES THE RESEARCH SAY?

Research suggests that teachers and students should have multiple opportunities to access and use precise and concise math language (Powell et al., 2019). Teachers who use informal language or casual terms such as *box* instead of **cube** are setting students up for later failure and confusion when they are assessed using the formal language or move to another classroom in which a different term is used. Instead, it is important that teachers use the mathematically correct and exact term for the concepts they are teaching. Teachers should explicitly teach math terms just as they would teach math concepts to students.



In addition to explicitly teaching math terms, teachers can also use Frayer models, math journals, word walls with student-friendly definitions and images, and vocabulary practice sheets (depicted here starting at the top and moving counter-clockwise).



### numerator

The term in a fraction that tells how many parts of a fraction.

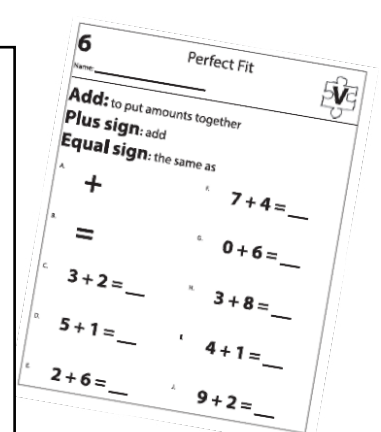
$\frac{2}{3}$     $\frac{2}{3}$    In these fractions, 2 is the numerator.

---

### ones

The digit representing 1.

In the number 4.23, 4 is in the ones place.



# Math Language

## EXAMPLE: PRECISE & CONCISE LANGUAGE

precise

“The **denominator** is the number of equal parts that make the whole.”

concise

“A **difference** problem is two amounts compared for the difference.”

“To show the fraction, look at the **denominator**. A **denominator** of 5 means I need to break the whole into 5 equal parts.”

“To use **partial sums**, add the hundreds, then add the tens, then add the ones. Finally, add all the **partial sums**.”

<p><b>Coefficient</b> <b>Constant</b> <b>Term</b> <b>Variable</b></p> <p>term      term      term</p> $2x^2 + x - 3$ <p>variable coefficient      variable      constant</p> <p>A</p>	<p><b>Integers</b> <b>Irrational numbers</b> <b>Natural numbers</b> <b>Rational numbers</b> <b>Whole numbers</b></p> <p>irrational</p> <p>rational integers whole natural</p> <p>B</p>	
<p><b>Equation</b> <math>9x - 4 = 7x</math> <b>Expression</b> <math>9x - 4</math> <b>Formula</b> <math>a^2 + b^2 = c^2</math> <b>Function</b> <math>f(x)</math> <b>Inequality</b> <math>9x - 4 &gt; 6x</math></p> <p>C</p>	<p><b>Improper fraction</b> <math>\frac{8}{5}</math> <b>Mixed number</b> <math>1\frac{3}{5}</math> <b>Proportion</b> <math>\frac{2}{5} = \frac{8}{20}</math> <b>Ratio</b> 4:3 <b>Unit fraction</b> <math>\frac{1}{6}</math></p> <p>D</p>	<p><b>Factor</b> <math>1 \times 8 = 8</math> <math>2 \times 4 = 8</math> factor      factor <b>Multiple</b> <math>8 \times 1 = 8</math> <math>8 \times 2 = 16</math> multiples of 8</p> <p>E</p>

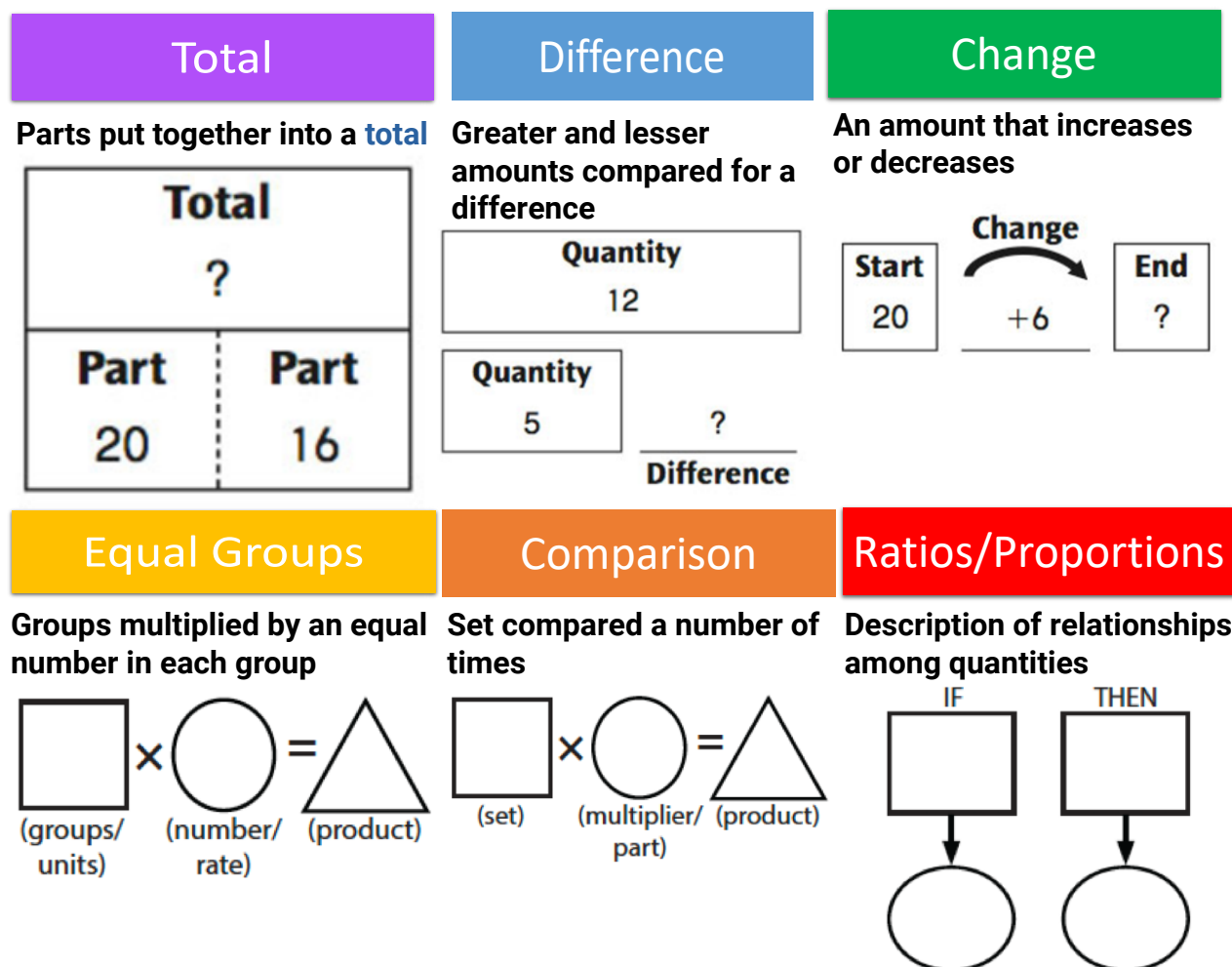
# Word-Problem Instruction

## DEFINITION

Many students require explicit instruction in solving word problems. It is important that teachers do not focus on teaching key words (Karp et al., 2019), but instead teach students how to use an attack strategy for working through word problems (Powell & Fuchs, 2018). High-quality attack strategies require the students to read the problem, create a plan for solving the problem, solve the problem, and check the answer. Attack strategies should be flexible to address any word problem.

## WHAT DOES THE RESEARCH SAY?

In addition to teaching students to use attack strategies, it is also important to introduce schemas (Jitendra et al., 2015). A schema refers to the structure of the word problem. There are three primary additive schemas: Total, Difference, and Change problems. There are also three multiplicative schemas: Equal Groups, Comparison, and Ratio/Proportion problems.



# Word-Problem Instruction

## EXAMPLE: SCHEMAS

### Total

Max baked 40 cookies and 75 brownies. How many baked goods did Max bake?

### Difference

The Brazos River is 840 miles. The Red River is 1,360 miles. How much longer is the Red River?

### Change

There were 23 passengers on the bus. Then, 13 more passengers boarded the bus. How many passengers are on the bus now?

### Equal Groups

Mark has 2 boxes of crayons. There are 24 crayons in each box. How many crayons does Mark have?

### Comparison

Jill picked 6 apples. Meg picked 2 times as many apples as Jill. How many apples did Meg pick?

### Ratios/Proportions

There are 176 slices of bread in 8 loaves. If there are the same number of slices in each loaf, how many slides of bread are in 5 loaves?

# Mnemonics

## DEFINITION

Mnemonics are a device or strategy designed to help students remember a strategy, concept, or series of steps. Many mnemonics include a series of letters in which each letter represents a step or component of an intervention (e.g., SOLVE: *Study the problem, Organize the facts, Line up a plan, Verify your plan with action, Examine your results*). Mnemonics can be a helpful tool for students with limited working memory or as students are first learning the steps in a complex intervention.

## WHAT DOES THE RESEARCH SAY?

Mnemonic devices or mnemonic strategies are evidence-based components that have been shown to aid students in mastering math concepts (Cuenca-Carlino et al., 2016; Freeman-Green et al., 2015). Mnemonics can be used to help students remember the components in a multi-step process, including advanced algebraic procedures. Mnemonics are also often found as part of word problem instruction. Mnemonics can be used to remember an attack strategy or a cognitive or meta-cognitive strategy.

Matt bought 1 orange and 3 apples for a total of \$2.25. The orange cost \$0.60. The apples each cost the same amount. What amount did Matt pay to buy each apple?

U	$P_1 + P_2 = T$	G x N = P
P	$0.60 + ? = 2.25$	3 x ? = 1.65
S	$? = \$1.65$ for	$? = \$0.55$
✓	apples	per apple

## EXAMPLES: MNEMONICS

### RIDE

Read the problem.

Identify the relevant information.

Determine the operation and unit for the answer.

Enter the correct numbers and calculate, then check the answer.

### UPS CHECK

Understand: Read the problem.

Plan: Choose a strategy.

Solve: Show all your work.

Check: Explain & justify your answer.

### SOLVE

Study the problem.

Organize the facts.

Line up the plan.

Verify the plan with computation.

### RIDGES

Read the problem.

I know statement.

Draw a picture.

Goal statement.

Equation development.

Solve the equation.

### ADDITIONAL RESOURCES

[IRIS Center Modules](#)

[LD Online Resources](#)

### RICE

Read and record the problem.

Illustrate your thinking.

Compute.

Explain your thinking.

# Graphic Organizers

## DEFINITION

Graphic organizers are visual or graphic representations of procedures or relationships within a math concept. Similar to mnemonics, graphic organizers can be a useful tool in helping students to remember specific procedures. Alternatively, graphic organizers can be used to help students better understand the relationship between math concepts or learn math vocabulary. Depending on the purpose of the graphic organizer, students can either be presented with a prepared graphic organizer or students may benefit from drawing their own graphic organizers.

## WHAT DOES THE RESEARCH SAY?

Graphic organizers have been shown to be an effective tool to help students learn new material, practice multi-step procedures, and make connections between math concepts for a deeper conceptual understanding (Shin & Bryant, 2017; van Garderen, 2007). Graphic organizers are often used as part of multi-component interventions, and can be tied with mnemonics and explicit instruction to help students master math concepts.

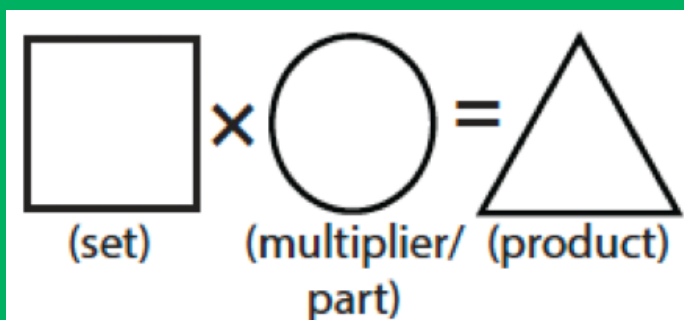
<b>Define:</b>	<b>Characteristics:</b>
<b>Example:</b>	<b>Non-example:</b>

The graphic organizer is a large rectangle divided into four quadrants by a vertical and a horizontal line. The top-left quadrant is labeled 'Define:', the top-right 'Characteristics:', the bottom-left 'Example:', and the bottom-right 'Non-example:'. A smaller, empty rectangular box is positioned in the center, overlapping the four quadrants, intended for a title or topic.

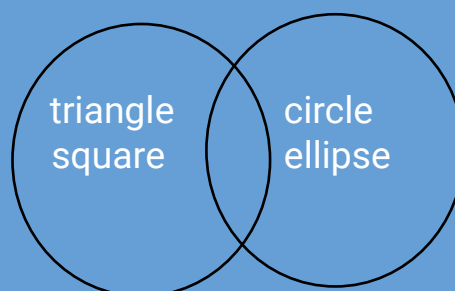
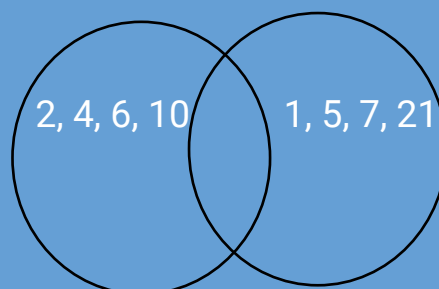
# Graphic Organizers

## EXAMPLES: GRAPHIC ORGANIZERS

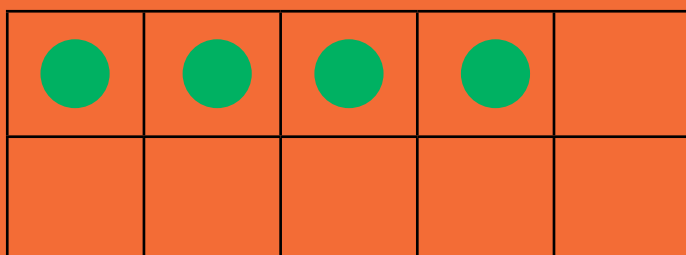
### COMPARISON SCHEMA



### MATH LANGUAGE OR MATH CONCEPT VENN DIAGRAM



### TEN FRAME



## ADDITIONAL RESOURCES

[National Center on Intensive Intervention Resources](#)

[Understood Graphic Organizers](#)

# Fluency Building Activities

## DEFINITION

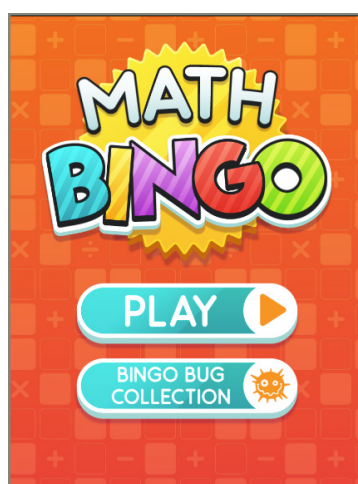
Fluency building activities provide opportunities for students to master math facts and other necessary math knowledge. When students are fluent in math facts, they can spend more energy solving problems or tackling complex problems. In addition to math facts, as students mature, it is recommended that they become fluent in determining equivalent and benchmark fractions, determining common denominators, and adding, subtracting, multiplying, or dividing positive and negative integer patterns.

## WHAT DOES THE RESEARCH SAY?

It is recommended that all teachers include brief fluency building activities everyday in math class (Burns et al., 2010). Fluency practice is important for students with limited working memory or students who experience difficulty with math. When students are fluent in essential math facts and math understandings, it frees up cognitive processing power which can then be devoted to more complex math. Students who struggle with math often benefit from explicit instruction in learning math facts and strategies.

BRIEF  
(1-2 min)

DAILY  
(everyday)



# Fluency Building Activities

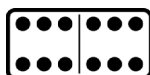
## EXAMPLES: FLUENCY BUILDING ACTIVITIES

### Roll the Dice



___ + ___ = ___	___ + ___ = ___
___ + ___ = ___	___ + ___ = ___
___ - ___ = ___	___ - ___ = ___
___ - ___ = ___	___ - ___ = ___

### Dominoes



___ + ___ = ___	___ + ___ = ___
___ + ___ = ___	___ + ___ = ___
___ - ___ = ___	___ - ___ = ___
___ - ___ = ___	___ - ___ = ___

### Cards



___ + ___ = ___	___ + ___ = ___
___ + ___ = ___	___ + ___ = ___
___ - ___ = ___	___ - ___ = ___
___ - ___ = ___	___ - ___ = ___

### File Folder

6 + 3 =	9
1 + 7 =	8
6 + 4 =	10
7 + 3 =	10
2 + 7 =	9
5 + 6 =	11
4 + 7 =	11
7 + 8 =	15
6 + 7 =	13
7 + 9 =	16
7 + 6 =	13
8 + 7 =	15
7 + 0 =	7
9 + 6 =	15
6 + 0 =	6
6 + 8 =	14



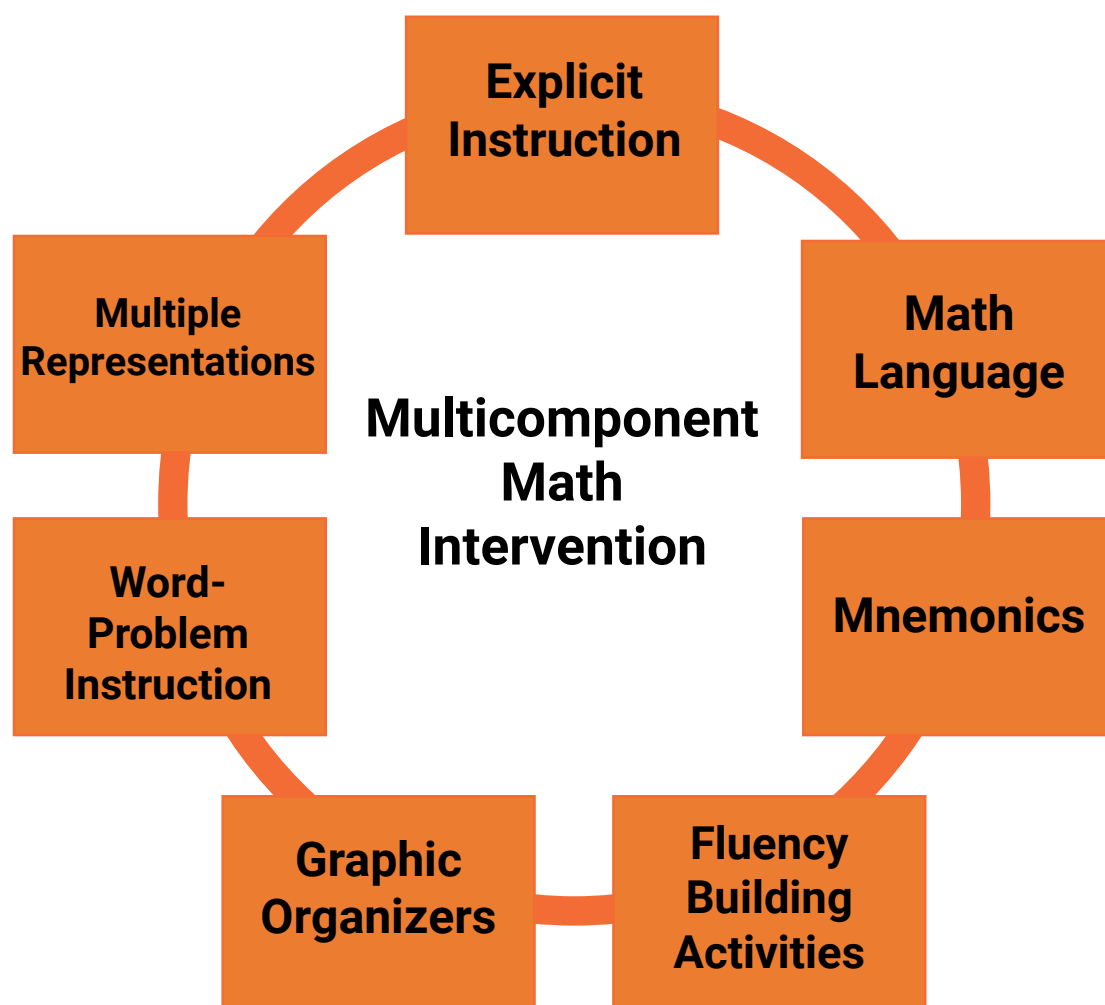
## ADDITIONAL RESOURCES

[Combining Explicit Instruction and Mastery Practice to Build Fact Fluency Article](#)

# Multicomponent Interventions

## KEY CONSIDERATIONS

Many math interventions include many, if not all, of the components discussed in this guide. Therefore, this makes it difficult to determine which component(s) are responsible for student learning. Instead, researchers can only evaluate the impact of the overall intervention. Therefore, when designing an intervention, it is important to consider which components align with the goals of the intervention. For example, if designing a word problem solving intervention, mnemonics, graphic organizers and attack strategies all support student learning and align well with each other.

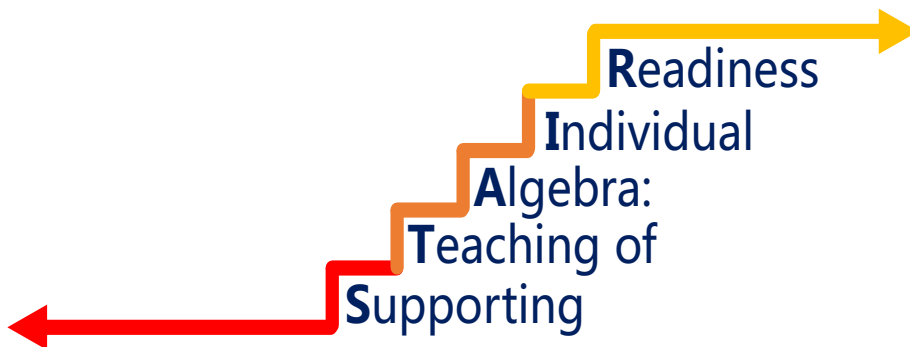


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