“Solving the Problem of Equality”

Closing the achievement gap in math

Dr. John Mighton

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The Research

Extraneous Information Can Get in the Way of Problem Solving

Kaminsky, J.A., & Sloutsky, V.M. (2014) *Extraneous perceptual information interferes with children's acquisition of mathematical knowledge.*

Attitude and Mindset Are Important

Dweck, C.S. (2008) *Mindset and math/science achievement.*

Challenges Need to be Scaffolded into Manageable Chunks

Sweller J. (1998) *Cognitive load during problem solving: Effects on learning.*

Basic Knowledge is Important

Ansari et al, (2013) *Why Mental arithmetic counts: Brain activity during single digit arithmetic predicts high school math performance.*

It's Important to Fade Concreteness Effectively

Fyfe et al. (2015) *The benefits of "concreteness fading" for children's mathematical understanding.*

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Kaminsky, J.A., & Sloutsky, V.M. (2014)

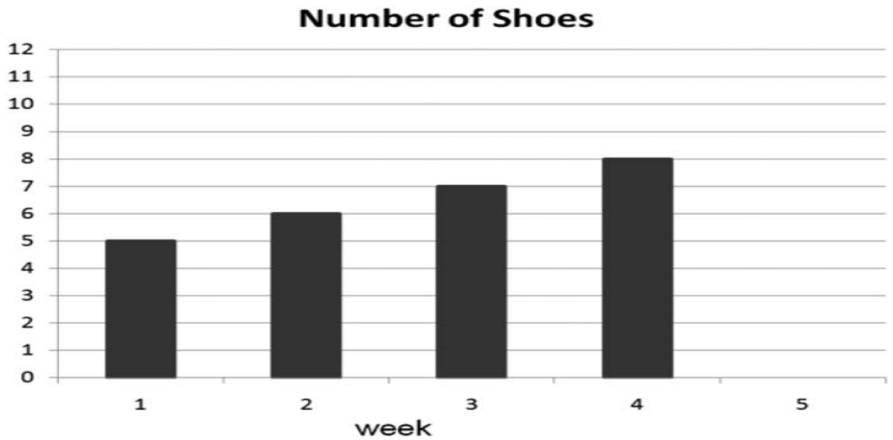
Extraneous perceptual information interferes with children's acquisition of mathematical knowledge.

Extraneous Information

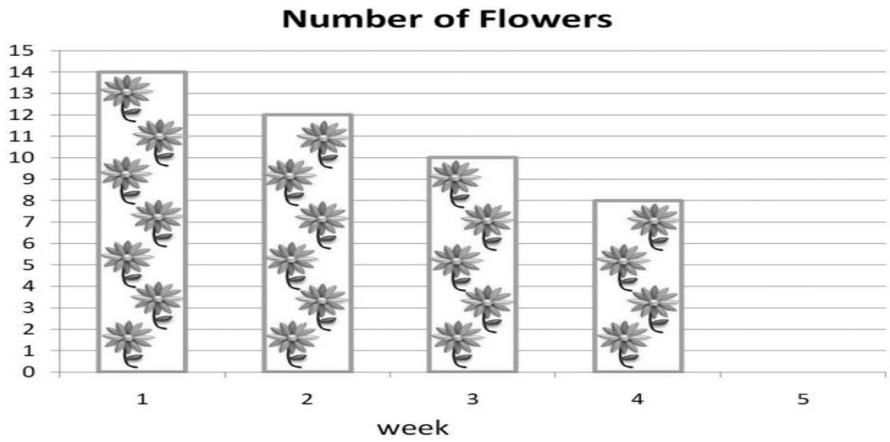
A

No Extraneous Information

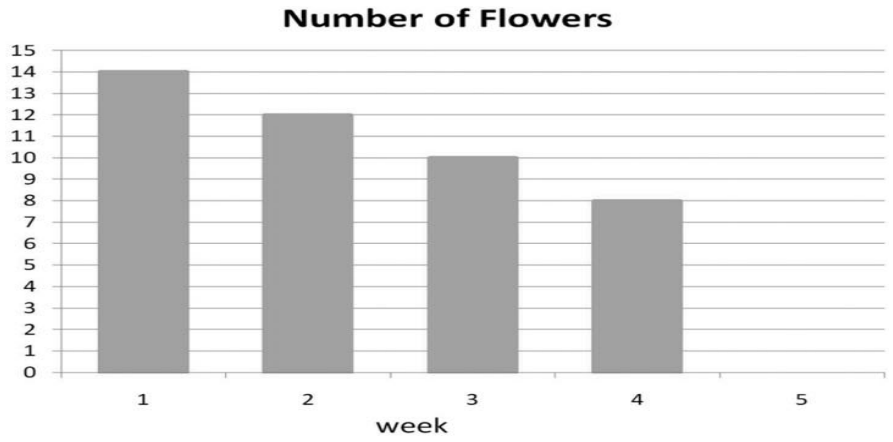
B



C

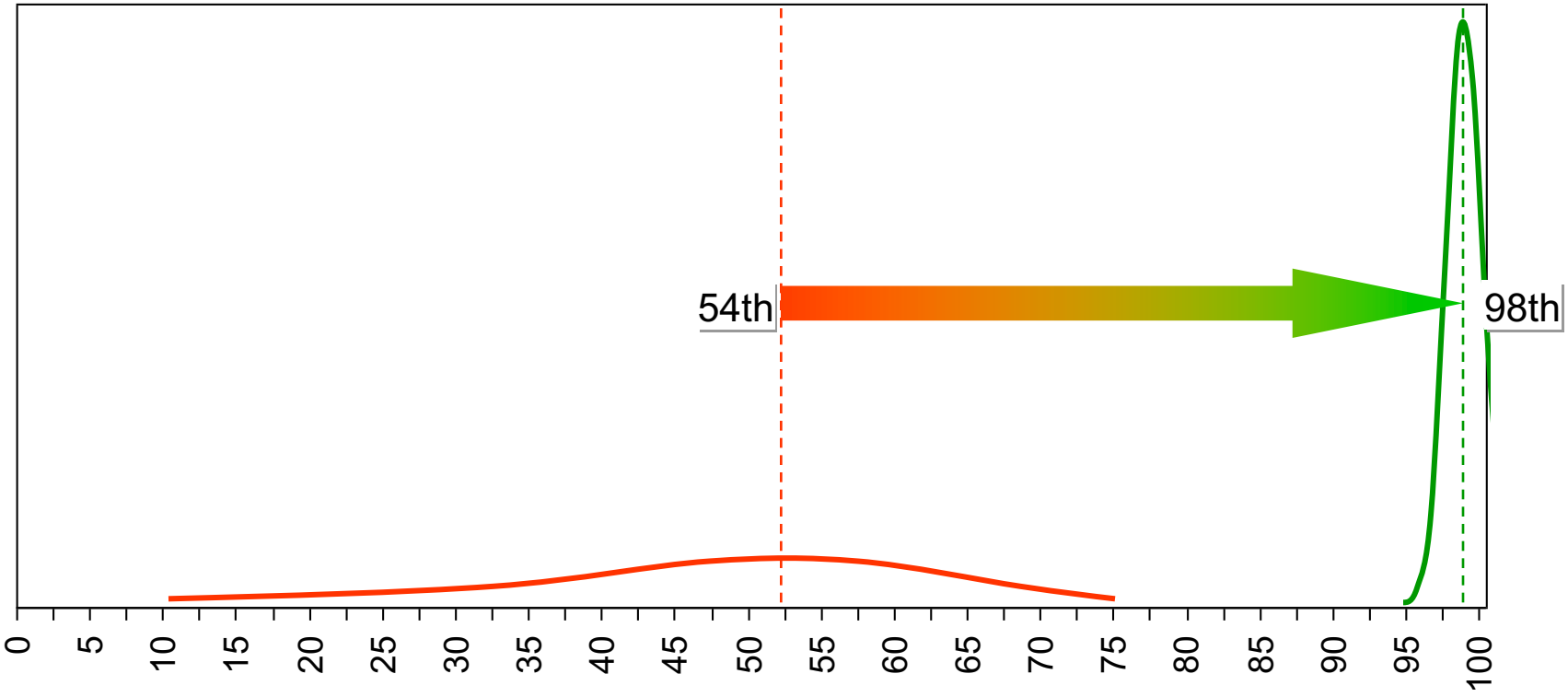


D



Case Study 1: Mabin School – Toronto, Ontario, Canada

Percentile Rankings*, Grade 5 (2008) vs Grade 6 (2009)



Notes: *Class percentile ranking based on results on the norm-referenced Test of Mathematical Abilities

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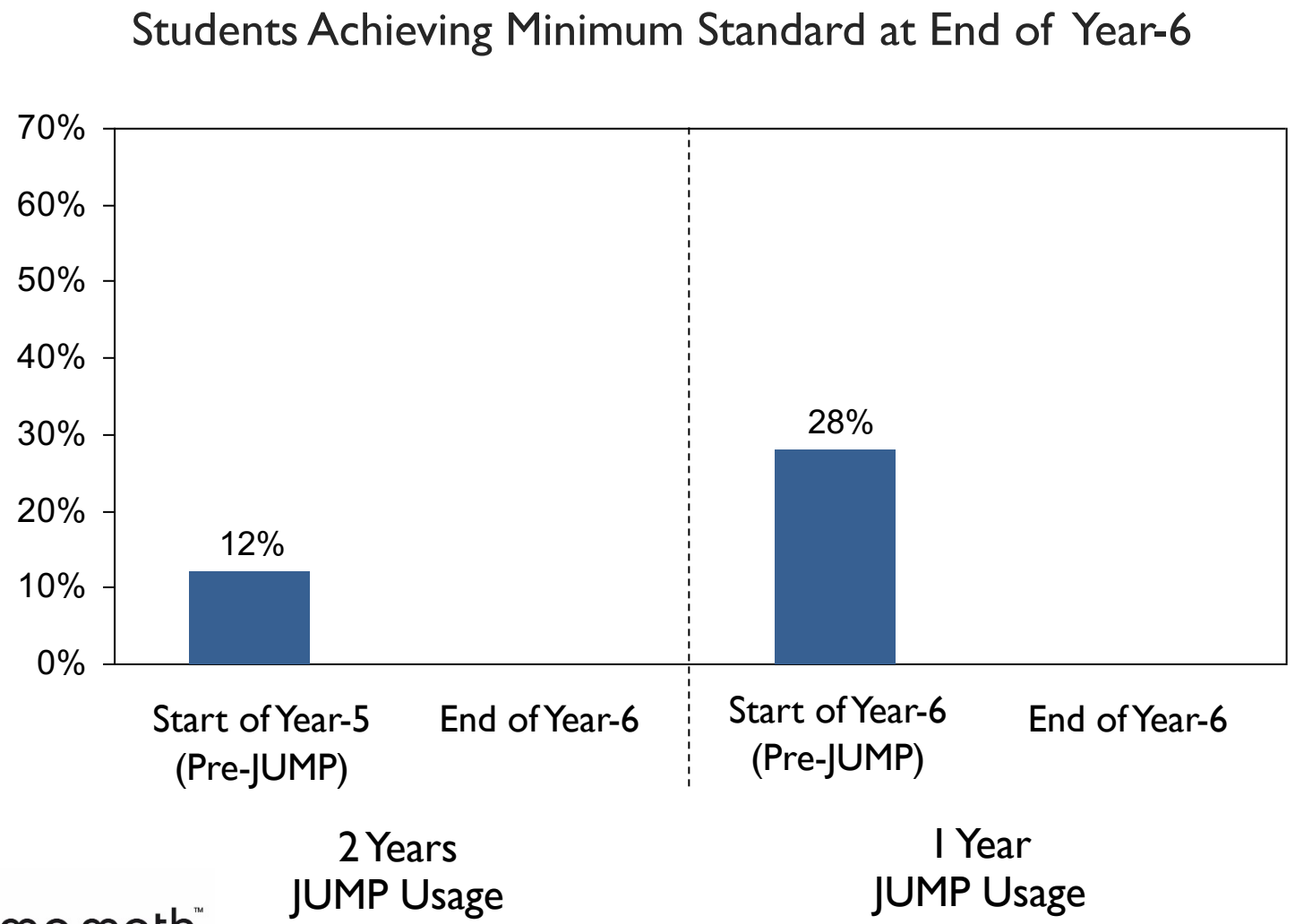
Evidence *Lambeth, United Kingdom*



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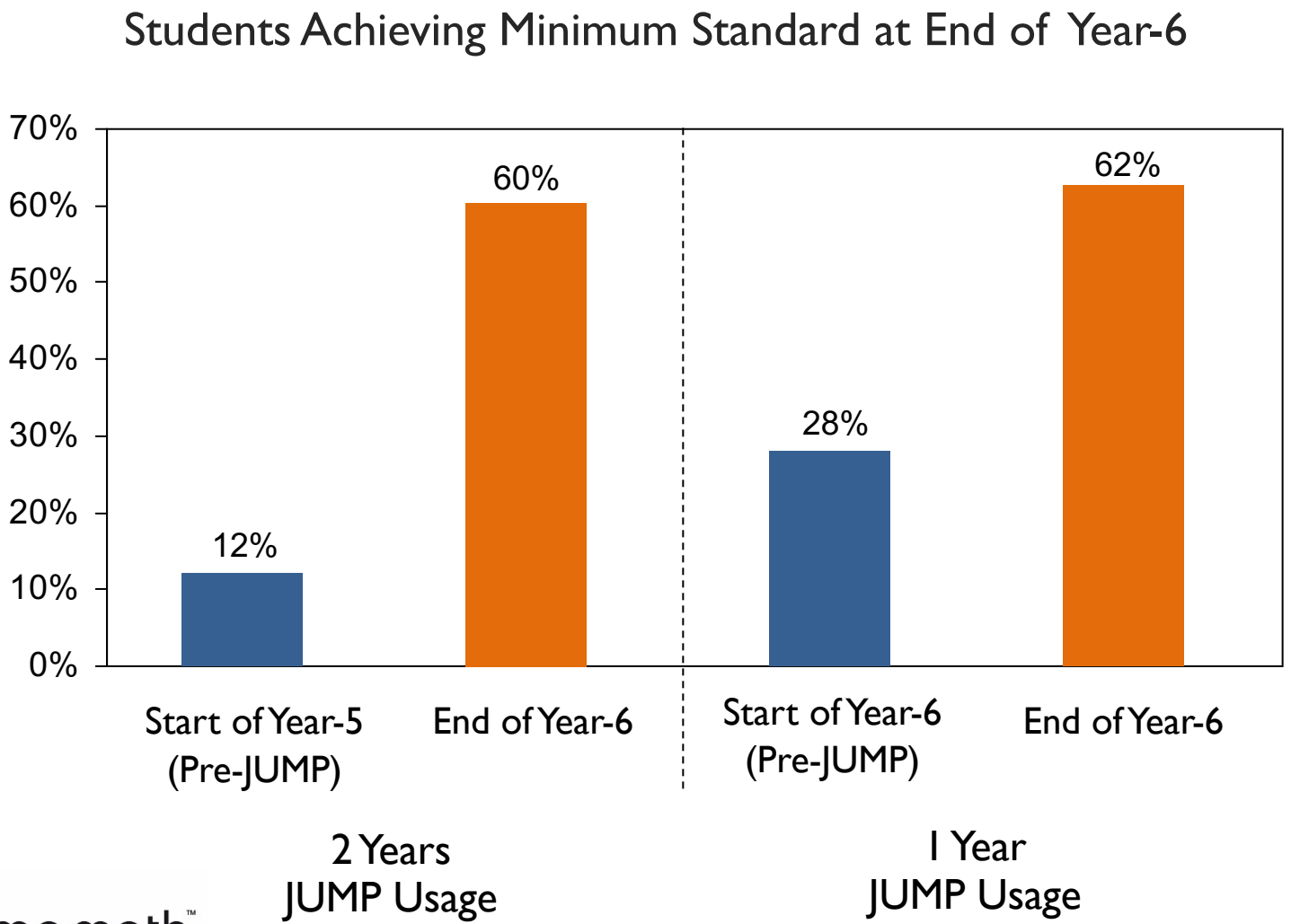
Evidence *Lambeth, United Kingdom*



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Mistaking the Ends for the Means

How do learners become engaged, expert problem solvers?

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Deliberate Practice

Deliberate Practice

Individual differences, even among elite performers, are closely related to assessed amounts of deliberate practice.

Many characteristics once believed to reflect innate talent are actually the result of intense practice extended for a minimum of 10 years.

- Ericsson, Krampe, Tesch-Romer

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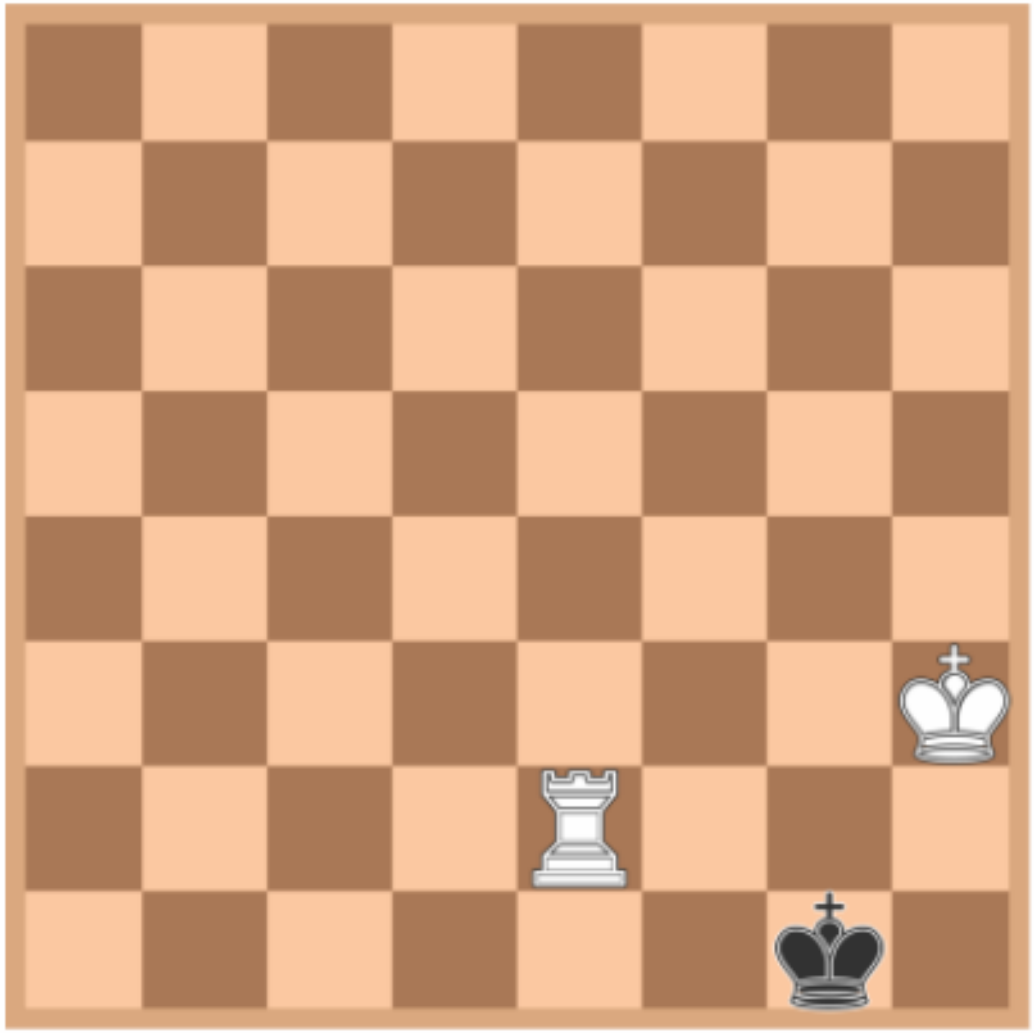
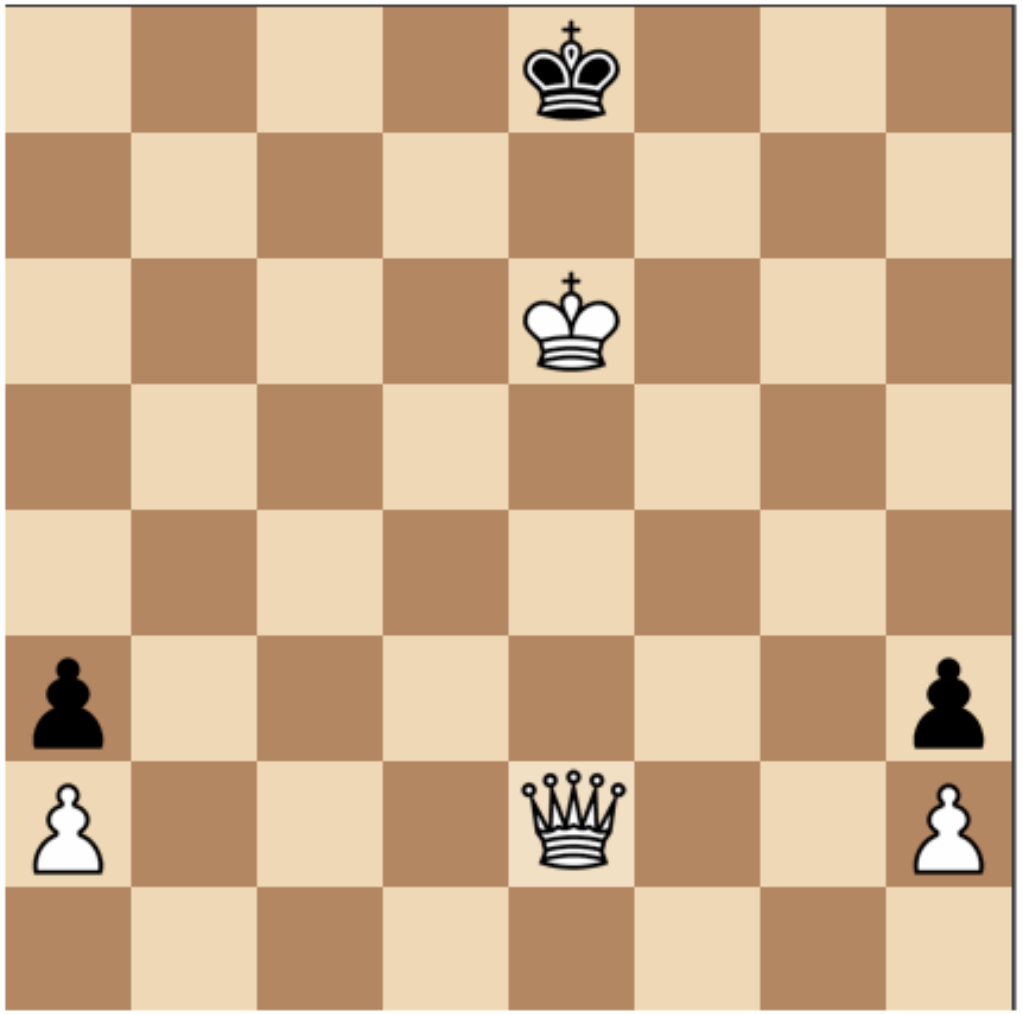
Deliberate Practice





Cognitive Overload

People are naturally curious, but we are not naturally good thinkers: unless the cognitive conditions are right, we will avoid thinking.

Daniel Willingham, *Why Don't Students Like School?*

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"Unassisted learning does not benefit learners, whereas feedback, worked examples, scaffolding and elicited explanations do."

L. Alfieri (et al), "Does discovery-based instruction enhance learning?" Journal of Educational Psychology (2011)

Research shows that children only become good at things through practice. Calling practice "drill and kill" obscures this fact. The real question we need to ask is:

How do we make practice interesting?

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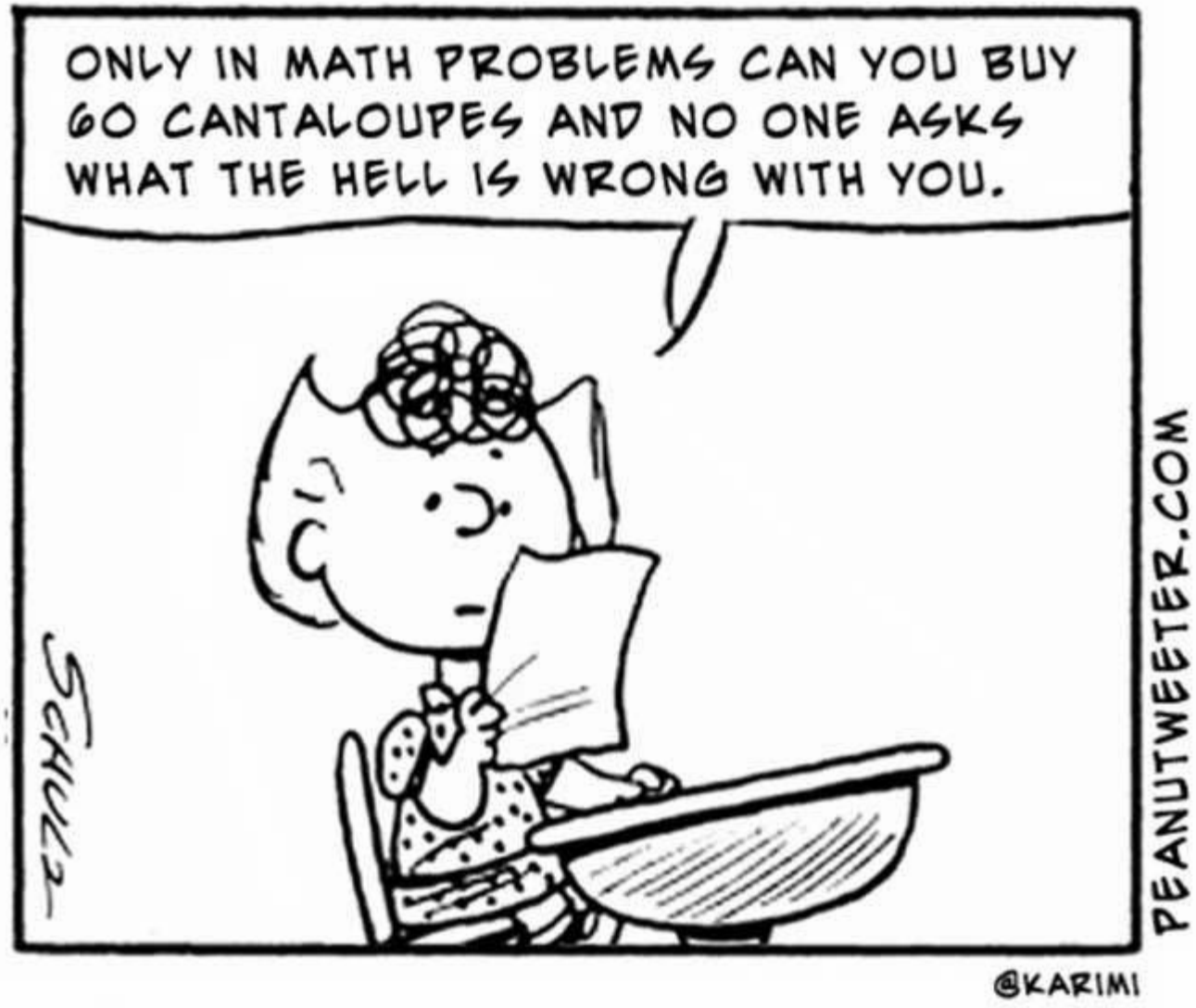


JUMPMath 6.2
Teacher Resources
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JUMPMath 4.1
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JUMPMath 1.2
Assessment & Practice
JUMPMath 1.1
Assessment & Practice
Unit 1 Operations and Algebraic Thinking:
Counting and Comparing

Resources

Teacher Resource
(Part 1 + Part 2)

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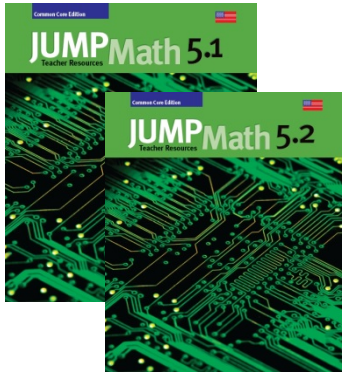
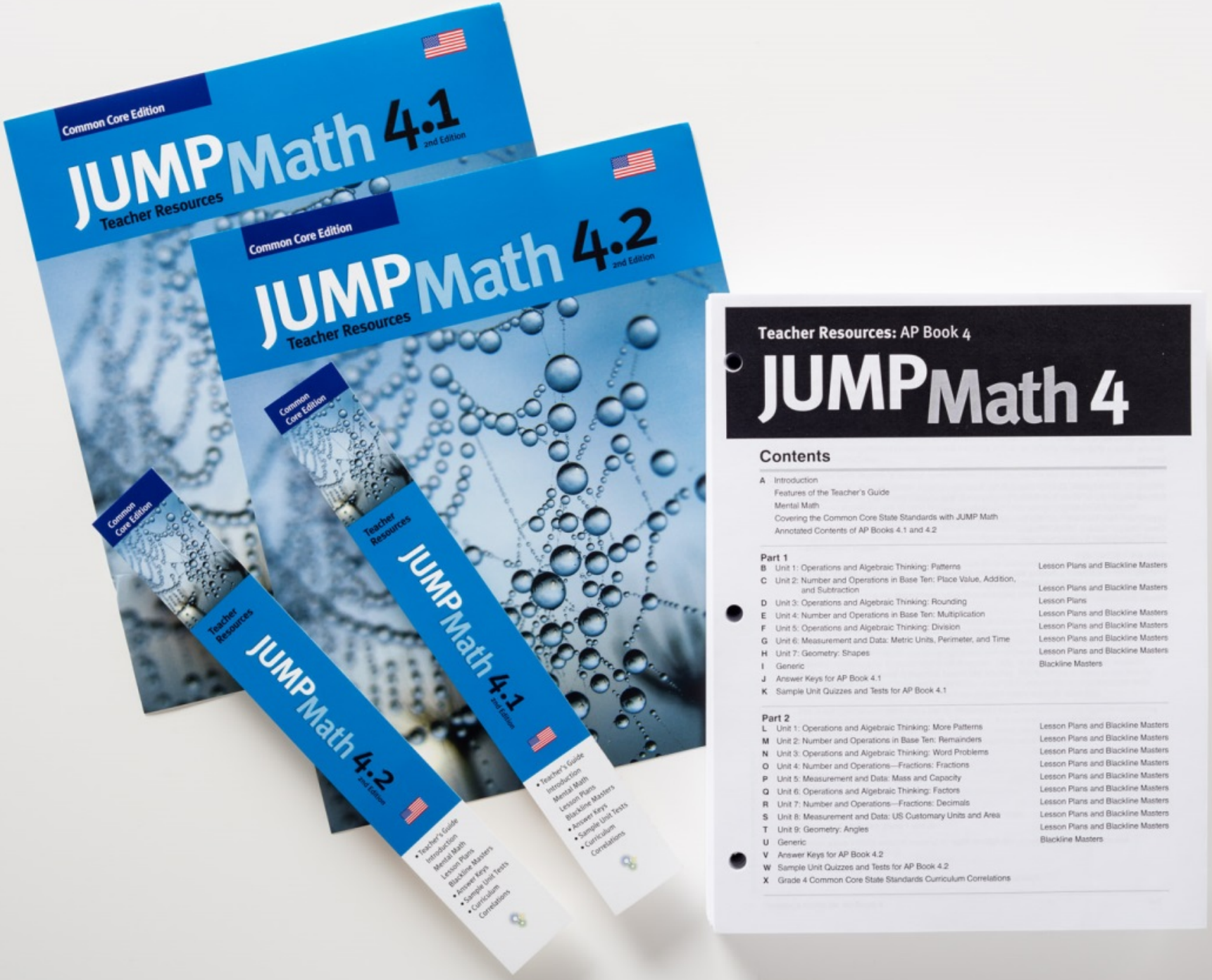


Student Assessment & Practice Books
(Part 1 + Part 2)

Confidence Building Units

SMART Interactive Lessons


Common Core Edition
JUMPMath 4.1
2nd Edition
Teacher Resources
Common Core Edition
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Common Core Edition
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Teacher Resources: AP Book 4
JUMPMath 4
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Covering the Common Core State Standards with JUMP Math
Annotated Contents of AP Books 4.1 and 4.2
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C Unit 2: Number and Operations in Base Ten: Place Value, Addition, and Subtraction — Lesson Plans and Blackline Masters
D Unit 3: Operations and Algebraic Thinking: Rounding — Lesson Plans
E Unit 4: Number and Operations in Base Ten: Multiplication — Lesson Plans and Blackline Masters
F Unit 5: Operations and Algebraic Thinking: Division — Lesson Plans and Blackline Masters
G Unit 6: Measurement and Data: Metric Units, Perimeter, and Time — Lesson Plans and Blackline Masters
H Unit 7: Geometry: Shapes — Lesson Plans and Blackline Masters
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J Answer Keys for AP Book 4.1
K Sample Unit Quizzes and Tests for AP Book 4.1
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N Unit 3: Operations and Algebraic Thinking: Word Problems — Lesson Plans and Blackline Masters
O Unit 4: Number and Operations—Fractions: Fractions — Lesson Plans and Blackline Masters
P Unit 5: Measurement and Data: Mass and Capacity — Lesson Plans and Blackline Masters
Q Unit 6: Operations and Algebraic Thinking: Factors — Lesson Plans and Blackline Masters
R Unit 7: Number and Operations—Fractions: Decimals — Lesson Plans and Blackline Masters
S Unit 8: Measurement and Data: US Customary Units and Area — Lesson Plans and Blackline Masters
T Unit 9: Geometry: Angles — Lesson Plans and Blackline Masters
U Generic — Blackline Masters
V Answer Keys for AP Book 4.2
W Sample Unit Quizzes and Tests for AP Book 4.2
X Grade 4 Common Core State Standards Curriculum Correlations

Mental Math
Checklist #3

Student Name	Can Mentally Make Change from a Dollar. SEE: AP Book Pages on Money.	Can Mentally Add Any Pair of 1-Digit Numbers.	Can Mentally Subtract Any Pair of 1-Digit Numbers.	Student Can Multiply and Count by: 2	3	4	5	6	7	8	9

Book 6

Workbook Contents

PART 1
Number Sense

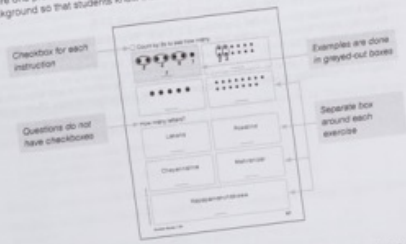
Table of Content

Features of the Teacher's Guide for Workbook 2

Features of Worksheets

We provide checkboxes for the instructions on worksheets. This teaches students to keep track of what they've done by checking the boxes as they complete their work. Many students enjoy using these checkboxes. Both checkboxes and question marks are prompts telling students that a task needs to be done. When several instructions refer to the same set of problems, students can perform each instruction separately and check off the checkbox for it. Sometimes it makes sense to photocopy the page of this type and have students do all the tasks again together.

The boxes around each problem allow students to easily distinguish between them; they show where one problem ends and the other begins. Example solutions are given in boxes with a grey background so that students know that they don't have to write in that box.



Features of Each Unit

Recurring activities. Some activities are repeated throughout the lessons, with variations depending on the concepts being learned. For example, a matching game like Memory can be used in Geometry, to match shapes with the same name, or in Number Sense, to match addition sentences with their answers. One advantage of using activities repeatedly is that students become so familiar with the activity that they can focus all their attention on the mathematical task instead of learning new rules or following new instructions. Recurring activities are described in detail at the beginning of the strand where they first occur, and are described only insofar as they need to be modified for a specific use when they occur in a lesson.

Games. We have tried to ensure that all of the games provided require individual work (working alone) or co-operation (working with a partner) instead of competition (working against an opponent). This is important because we want students to begin developing empathy—the ability to understand how others feel and to act on that understanding. To do their best in a competitive game, students have to distance themselves from what other players want, and distancing yourself from your classmates' feelings is the opposite of showing empathy.

Teacher's Guide for Workbook 2

A-16

Part 1 Number Sense

In this unit, students will explore numbers up to 100; they will count (match numbers with their corresponding quantities and numerals), order numbers using different materials (hundreds charts, number lines, place value), represent numbers in different ways (pictures, numerals, tens and ones blocks, number words, and lengths) and compare quantities (more, less, fewer, as many as). They will also learn to add and subtract using different strategies (pictures, number lines, hundreds charts, counting on, counting back, using addition to subtract, and using 10). Students will also begin solving and creating word problems.

Materials

Number Cards (0–20) and Number Word Cards (zero–twenty). Write each numeral from 0 through 20 and each number word from zero through twenty on an index card or piece of construction paper. Each student will also need a set of these cards, and you can use **BLM Numbers Template** (p G-1) to make them. You will use these cards throughout the unit for demonstrations; students will use them as manipulatives (e.g., for sorting and ordering activities, to play Memory). The same numbers, in both forms, should be posted or displayed in the classroom for student reference.

Hundreds Charts and Base Ten Materials. Make a copy of **BLM Hundreds Chart** (p G-2) for each student, and laminate it if possible. Use additional photocopies of this BLM as required. Students will often use this hundreds chart with 1 cm connecting cubes and tens and ones blocks. If you do not have such cubes or blocks, or if your students need larger manipulatives, they can use **BLM Hundreds Chart—Five Rows** (p G-3) with paper ones and tens blocks from **BLM Base Ten Materials** (p G-4). Copy and laminate as many tens and ones blocks as required. Also available: a slightly larger hundreds chart on **BLM A Larger Hundreds Chart** (p G-5).

A Hundreds Chart for Whole-Class Teaching. For whole-class discussions and demonstrations, use a pocket hundreds chart, a hundreds chart poster, or an overhead projector. You could also create a large hundreds chart on the board or on chart paper.

Paper Sticks. Glue 1 cm grid paper (you can use **BLM 1-cm Grid Paper** (p G-6)) to Bristol board or thin cardboard (e.g., a cereal box). Make paper sticks 1 cm wide of lengths 2 cm, 3 cm, . . . , 10 cm. As an alternative, if you have Cuisenaire rods, simply add grid markings at each 1 cm mark on one side of the rods. You could do this using a sharp tool, such as scissors, if using Cuisenaire rods, however, be careful not to create false associations between numbers and colours. Students will use these sticks/rods in several lessons, both in Part 1 and Part 2. You will need many copies of these sticks: for some activities, you will need only two of each length per student; for others, you will need six or seven of each length per student (in which case, you might choose to have students work at stations instead), both of which will be useful in different situations.

Dice. Have students make their own "dice." There are two ways to do this.

Teacher's Guide for Workbook 2.1

B-1

Page E-37 of the 4.1 Teacher Resource

NBT4-38 Multiplying 2-Digit Numbers by 2-Digit Numbers

Pages 109–111

STANDARDS
4.NBT.B.5

VOCABULARY
double
multiple

Goals

Students will multiply 2-digit numbers by 2-digit numbers.

PRIOR KNOWLEDGE REQUIRED

Can multiply a 2-digit number by a 1-digit number
Can multiply a 2-digit number by a 2-digit multiple of 10

MATERIALS

grid paper

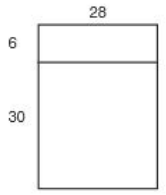
Introduce the lesson topic. Write on the board 28×36. ASK: How is this multiplication different from any we have done so far? (We have never multiplied a 2-digit number by a 2-digit number of which neither is a multiple of 10—we have only estimated the product in such cases.)

(MP.3) **Splitting a problem into easier problems.** Tell students that you would like to think of a way to split the problem into two easier problems, both of which they already know how to do. Have students list all the types of problems they know how to do that might be helpful:

- Multiply a 1-digit number by a 1-digit number.
- Multiply a 2-digit number by a 1-digit number.
- Multiply a 2-digit number by a 2-digit multiple of 10.

Allow students time to think of a way to split the problem into two easier products that they already know how to do. Possibilities include:

$28 \times 36 = (20 \times 36) + (8 \times 36)$ OR $28 \times 36 = (28 \times 30) + (28 \times 6)$



Read these out loud as "20 thirty-sixes plus 8 thirty-sixes" or "30 twenty-eights plus 6 twenty-eights."

Write the equations out with blanks if students need a prompt. Example:

$28 \times 36 = 28 \times \_\_\_\_\_ + 28 \times \_\_\_\_\_$

SAY: 28 is a 2-digit number. How can we split 36 into 2 numbers so that we know how to do both products? Draw the picture in the margin on the board.

(MP.2) Remind students that the area of the whole rectangle is the sum of the two smaller rectangles. Write on the board: $28 \times 36 = (28 \times 30) + (28 \times 6)$, and SAY: 36 twenty-eights is 30 twenty-eights plus 6 twenty-eights.

Also remind students that we write brackets to show what operations we do first. SAY: We first find the areas of the two smaller rectangles (point to the two products as you say this), and then we add them together to get the area of the whole rectangle (point to the addition as you say this).

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From page D-33 in 5.1 Teacher Resource

Extensions

(MP.1) 1. Using only the digits 2, 3, 4, and 6, find the greatest product that can be made by multiplying a 3-digit number by a 1-digit number.

Answer: 2,592

(MP.1) 4. Try the following number trick with a friend.

a) Pick a number from 1 to 9.
b) Multiply your number by 100.
c) Add 3 to your answer.
d) Multiply your answer by 6.
e) Subtract 18.
f) Ask for the answer.

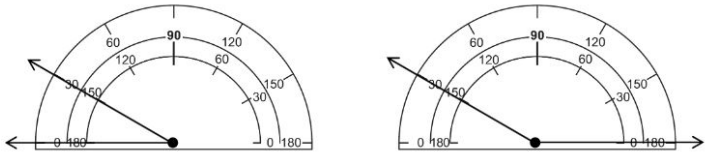
To guess the number, remove the zeros at the end of the number, then divide by 6. That will be the number your friend started with.

Try it with your friend, then have your friend try it with you. Can you figure out why it works?

SMART Lessons

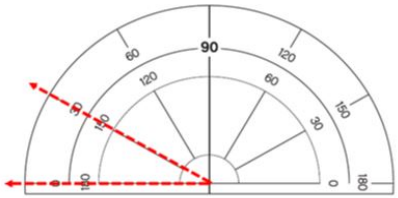
Introduce protractors. Give each student a protractor and SAY: This is a *protractor*. Have students examine their protractors and compare them to rulers. Remind students that when they measure with a ruler, they have to line up one end of the object with the zero mark. Have students find the zero mark on their protractors (There are two of them, one at each end!) Point out that a protractor has two scales, both with the same unit, but in opposite directions. A ruler can have two scales, too, but the two scales would use different units. Explain that having two identical scales going in different directions allows you to measure the angles from both sides, but this also means that you need to decide which scale you will use each time.

Project **BLM Simple Protractors** onto the board. Explain that the protractors on the BLM are simplified pictures of a protractor, without all the tiny markings in between the larger angles. Draw the angles below on the board:



Pointing at the first picture, ASK: Is this angle an acute angle or an obtuse angle? (acute) Circle the numbers 30 and 150 that the arm of the angle passes through. ASK: Which one is the

Is this an acute angle or an obtuse angle?



What angle does it show?

Hint: Read from the scale that has a "0" on the arm of the angle.

STANDARDS
3.OA.D.8, **preparation for 4.OA.A.3**

VOCABULARY
altogether
difference
how many more than
total

Goals

Students will use pictures and tables to solve word problems.

PRIOR KNOWLEDGE REQUIRED

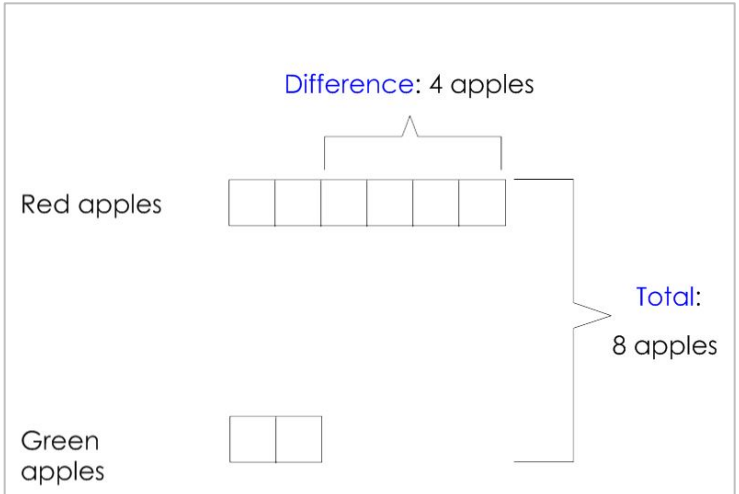
Equivalent addition and subtraction equations
Subtraction as take away
Subtraction as comparison
(how much more than, how much shorter than, and so on)
Addition as how much altogether, or how many altogether, or how long altogether

Using bars on grid paper to represent quantities. Write on the board:

Red apples ☐☐☐☐☐☐

Green apples ☐☐

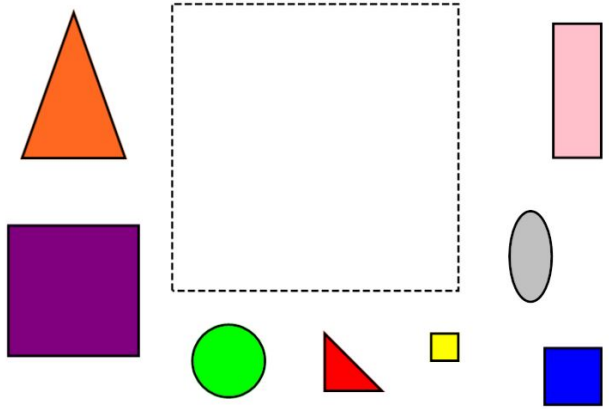
Tell students that each square represents one apple and ASK: How many red apples are there? How many green apples? Are there more red apples or green apples? How many more? (PROMPT: If we pair up red apples with green apples, how many apples are left over?) How many apples are there altogether?

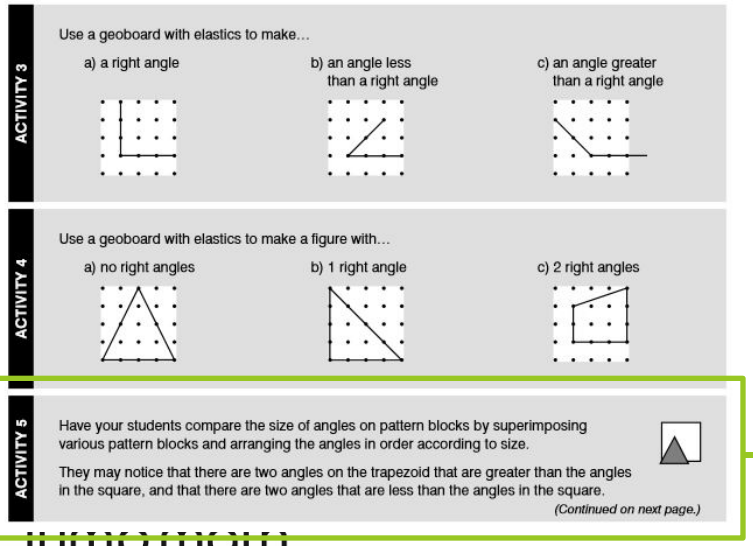


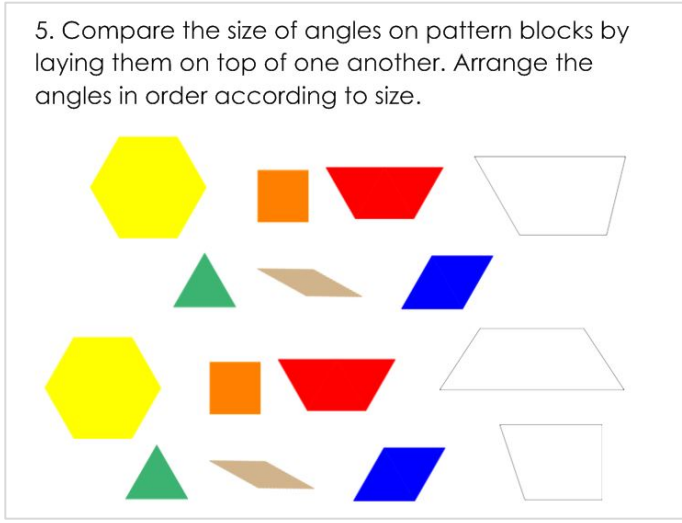
Interactivity

Sort geometric shapes into one group. Review the names of various geometric shapes, sides and corners, and curved and straight sides. Give each student the same 7–8 attribute blocks (2 or 3 squares, a rectangle, a circle, 2 triangles, and an oval would be a good set) and a sorting box. Ask students to place all the squares in the box. Point out that the shapes left outside the box could be called "not squares." Repeat with triangles. Then have students place all the shapes with straight sides in the box. **ASK:** What is left outside? (a circle and an oval) Why? (They do not have straight sides.) What kind of sides do they have? (curved)

Sort and trace. Give students a large sorting circle on paper and have them label the group "4 sides." Ask students to sort their attribute blocks using this sorting circle. They should trace the shapes without overlapping them. Then show students a parallelogram and **ASK:** Does this go inside or outside the circle? Repeat with a pentagon and a four-sided shape that has some curved sides. Then give each student a different shape to place inside or outside the circle. Ask partners to swap sorting circles and check each other's work.







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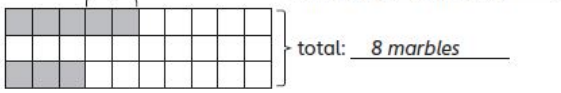
SCAFFOLDING FLUENCY AND CONCEPTUAL UNDERSTANDING

Pages 67 and 68 of the 3.1 Assessment & Practice book

OA3-I2 Parts and Totals

1. Shade boxes to show the number of marbles. Then find the total and the difference.

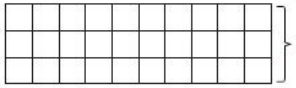
a) 5 green marbles
3 blue marbles



difference: *2 marbles*

total: *8 marbles*

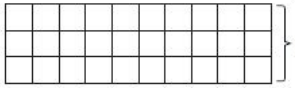
b) 4 green marbles
6 blue marbles



difference: _____

total: _____

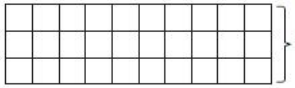
c) 8 green marbles
4 blue marbles



difference: _____

total: _____

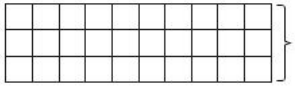
d) 9 green marbles
4 blue marbles



difference: _____

total: _____

e) 3 green marbles
8 blue marbles



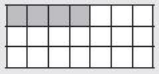
difference: _____

total: _____

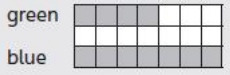
4 green marbles
3 more blue marbles than green

To draw the diagram:

Step 1: Shade the amount you know.



Step 2: Find the other amount.



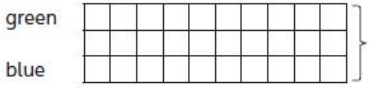
2. Draw the diagram. Then fill in the blanks.

a) 5 green marbles
2 more blue marbles than green marbles

difference: _____

total: _____

b) 4 blue marbles
3 more green marbles than blue marbles

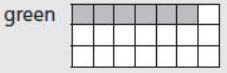


difference: _____

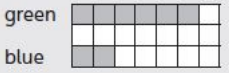
total: _____

Sometimes you know the larger amount.

6 green marbles

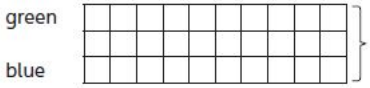


4 more green marbles than blue marbles



3. Draw the diagram. Then fill in the blanks.

7 green marbles
3 more green marbles than blue marbles



difference: _____

total: _____

Scaffolding Fluency

OA3-13 More Parts and Totals

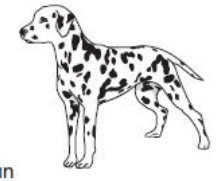
1. Fill in the table.

	Green Marbles	Blue Marbles	Total	Difference
a)	3	5	8	*2 more blue marbles than green*
b)	2	9		
c)	4		6	
d)		2	7	
e)	6		10	
f)	3			1 more blue marble than green
g)		2		1 more green marble than blue
h)		4		1 more blue marble than green
i)	7	2		5 more green marbles than blue
j)		5		4 more green marbles than blue
k)		12		6 more blue marbles than green
l)	12	35		
m)	35			20 more green marbles than blue

3. Fill in the table. Circle the number in the table that answers the question.

		Red	Green	Total	Difference
a)	Kate has 3 green fish and 4 red fish. How many fish does she have altogether?	*4*	*3*	(7)	*1*
b)	Bill has 4 green fish and 6 red fish. How many fish does he have altogether?				
c)	Mary has 8 green fish and 2 more green fish than red fish. How many fish does she have?				
d)	Peter has 19 fish. He has 15 green fish. How many red fish does he have?				
e)	Hanna has 8 green fish and 3 fewer red fish than green fish. How many fish does she have?				
f)	Ken has 22 red fish and 33 green fish. How many more green fish does he have?				

4. Alice has 3 science books and 4 art books. How many books does she have?



5. Marco has 5 pets. 3 are cats. The rest are dogs. How many dogs does he have?

6. Ed has 25 red apples. He has 14 more green apples than red apples. How many apples does he have?

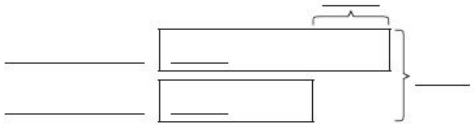
7. There are 25 students in a class. 16 of the students are girls.
   a) How many students are boys?
   b) How many more girls are there than boys?

SCAFFOLDING FLUENCY AND CONCEPTUAL UNDERSTANDING

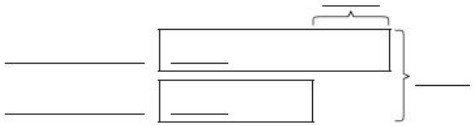
Pages 78 and 79 of the 3.2 Assessment & Practice book

3. Fill in the blanks.

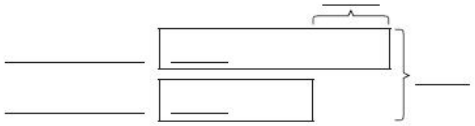
a) 9 lions and 7 tigers



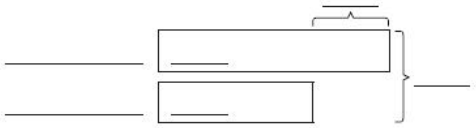
b) 9 more girls than boys
13 girls



c) 6 more boys than girls
5 girls

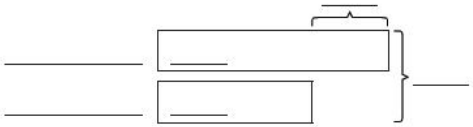


BONUS ▶ Karen has 12 apples in total.
8 are green. The others are red.



4. There are 24 students in a class. 14 are boys.

a) Fill in the blanks.

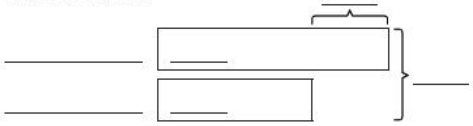


b) How many girls are in the class? _____

c) How many more boys than girls are there? _____

5. Alan has 5 more US stamps than Canadian stamps.
He has 12 Canadian stamps.

a) Fill in the blanks.



b) How many stamps does he have in total? _____

6. Sally rode her bike 252 miles to raise money for charity.
Kevin rode his bike 57 miles.

a) Draw a tape diagram to show this information.

b) How much farther did Sally ride?

c) How many miles did they ride altogether?

BONUS ▶ Hint: Use a tape diagram with 3 bars.

a) A store sold 8 books on Friday.
They sold 5 fewer books on Thursday than on Friday.
They sold 4 more books on Saturday than on Friday.
How many books did the store sell on the three days?

b) Ivan has 12 green apples.
He has 7 more red apples than green apples.
He has 3 fewer yellow apples than red apples.
How many apples does he have altogether?

STRUCTURED INQUIRY

- Adequate review and practice
- Rigorous scaffolding
- Continuous assessment
- Challenges in steps
- Differentiated instruction (without differentiated outcomes)

Teach

$$3\overline{)72}$$

Teach

$3\overline{)72}$

3 friends

7 dimes

2 pennies

How many friends, dimes, and pennies are there?

$4\overline{)96}$ $2\overline{)74}$ $3\overline{)75}$

Practice

Draw a picture to show how you would divide the dimes.

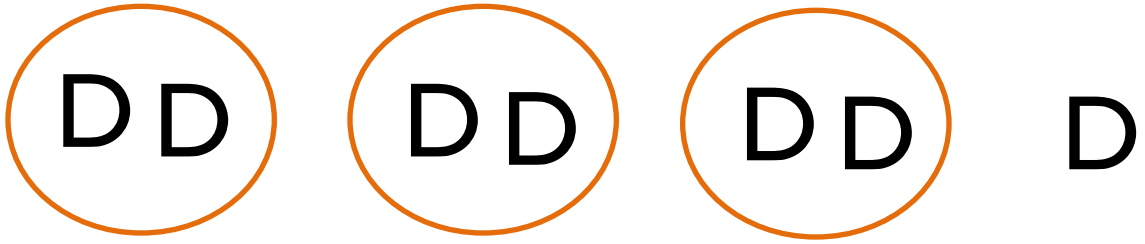
$3\overline{)72}$ $2\overline{)74}$ $3\overline{)75}$

Assess

$3\overline{)72}$

Assess

$$
\begin{array}{r}
2 \\
3\overline{)72} \\
-\,6 \\
\hline
1
\end{array}
$$



Assess

$$\begin{array}{r} 2 \\ 3\overline{)72} \\ -\,6 \\ \hline 1 \end{array}$$

- Where do you see the 2 in the picture?

Assess

$$\begin{array}{r} 2 \\ 3\overline{)72} \\ -\,6 \\ \hline 1 \end{array}$$

- Where do you see the 2 in the picture?
- Where do you see the 6 in the picture?

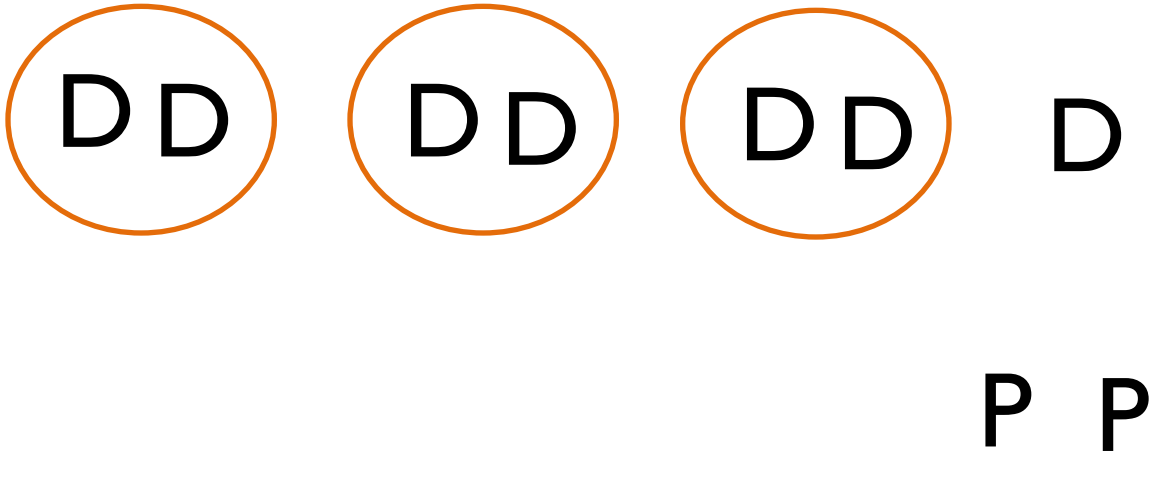
Assess

$$\begin{array}{r} 2 \\ 3\overline{)7\,2} \\ -\,6 \\ \hline 1 \end{array}$$

- Where do you see the 2 in the picture?
- Where do you see the 6 in the picture?
- Where do you see the 1 in the picture?

Assess

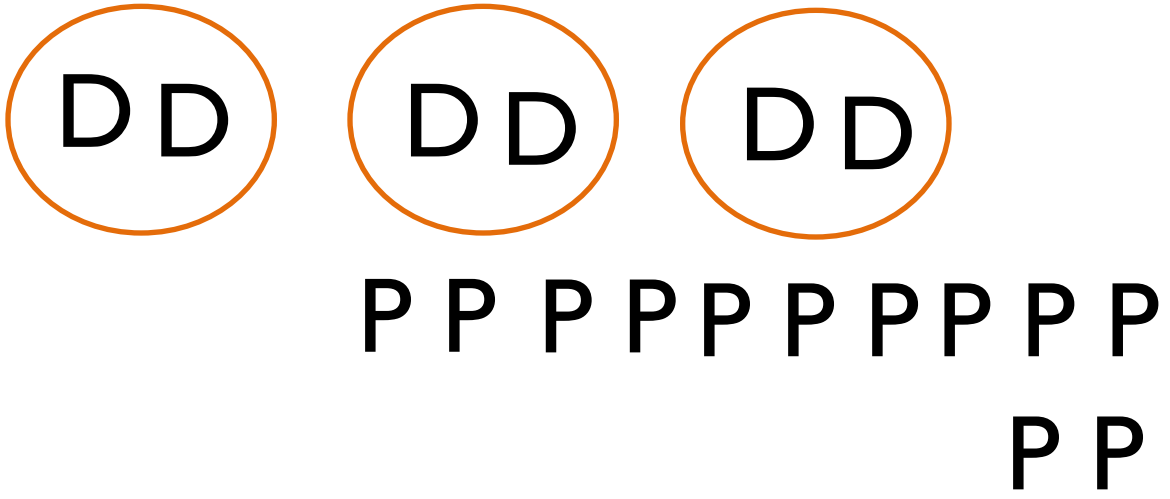
$$\begin{array}{r} 2 \\ 3\overline{)7\,2} \\ -\,6 \\ \hline 1 \end{array}$$



- Where do you see the 2 in the picture?
- Where do you see the 6 in the picture?
- Where do you see the 1 in the picture?

Assess

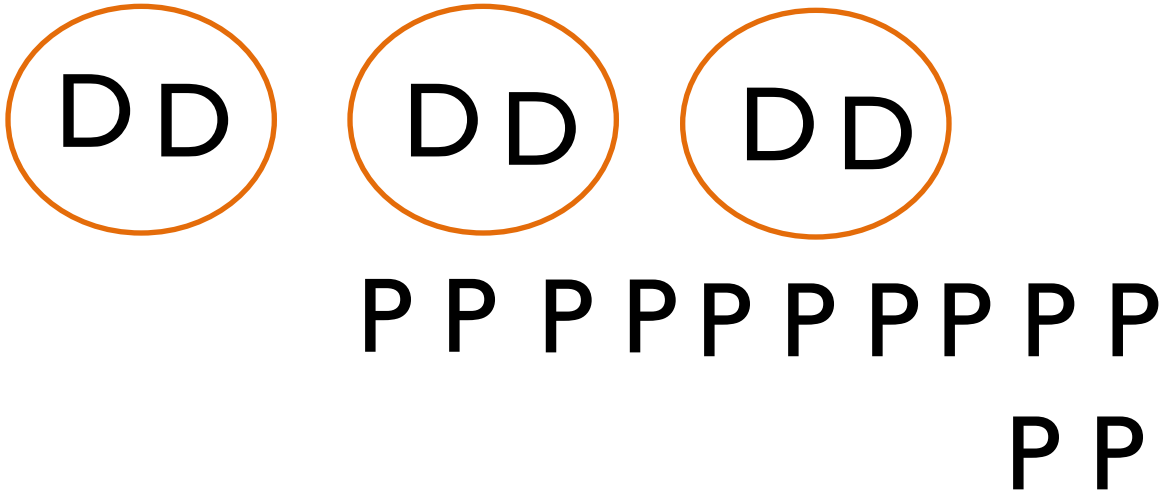
$$
\begin{array}{r}
2 \\
3\overline{)7\,2} \\
-\,6 \\
\hline
1
\end{array}
$$



- Where do you see the 2 in the picture?
- Where do you see the 6 in the picture?
- Where do you see the 1 in the picture?

Assess

$$\begin{array}{r} 2 \\ 3\overline{)72} \\ -6\downarrow \\ \hline 12 \end{array}$$



- Where do you see the 2 in the picture?
- Where do you see the 6 in the picture?
- Where do you see the 1 in the picture?

HOST
+ HOST
THEME

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MULTIPLYING POTENTIAL.

$$\begin{array}{r} BB \\ +\ \ B \\ \hline A4 \end{array} \qquad \begin{array}{r} AB \\ +\ \ B \\ \hline A8 \end{array} \qquad \begin{array}{r} AA \\ +\ \ A \\ \hline A6 \end{array} \qquad \begin{array}{r} AA \\ +\ \ A \\ \hline B6 \end{array}$$

$$\begin{array}{r} AA \\ +\ \ A \\ \hline B0 \end{array} \qquad \begin{array}{r} AB \\ +\ AB \\ \hline 78 \end{array} \qquad \begin{array}{r} AB \\ +\ AB \\ \hline 42 \end{array}$$

Bonus Questions:

$$\begin{array}{r} AAB \\ +\ AB \\ \hline A78 \end{array} \qquad \begin{array}{r} AAB \\ +\ AB \\ \hline B78 \end{array} \qquad \begin{array}{r} AAB \\ +\ AB \\ \hline C46 \end{array} \qquad \begin{array}{r} AB \\ +\ AB \\ \hline BBC \end{array} \qquad \begin{array}{r} AB \\ +\ AB \\ \hline BCC \end{array}$$

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Differentiated Instruction -- without differentiated outcomes

Children are more alike than different in terms of how they think and learn.

- Daniel Willingham

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The Science of Motivation

- Purpose
- Mastery
- Autonomy

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Building Confidence

JUMP Math demonstrates growth mindset readily. Kids are moving at an exciting pace - it feels that it should be hard but it's not hard for them, the way you're teaching it.

They all have a feeling of progress, and they all get the feeling, "I can be good at this. I can learn."

- Carol Dweck, author of *Mindset*

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The Impact

STRUCTURED INQUIRY

- Adequate review and practice
- Rigorous scaffolding
- Continuous assessment
- Challenges in steps
- Differentiated instruction (without differentiated outcomes)

Features that help struggling students

- Resources contain 20 review lessons, so students can start on an equal footing
- Fluency is reinforced using patterns and games
- Lessons are built on small conceptual variations
- Language is minimized at first and only gradually increases in complexity, so the mathematical structure is not obscured
- JUMP provides confidence building exercises so all students can engage in math without anxiety

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- jumpmath.org
- John Mighton, For the Love of Math, Scientific American Mind, September 2013

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