What Teachers Need to Know to Teach Mathematics at the Elementary Grades

Sybilla Beckmann

Department of Mathematics
University of Georgia

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The Common Core K-5 domains that concern whole numbers

Counting and Cardinality: Kindergarten

Operations and Algebraic Thinking: K – 5

Numbers and Operations in Base Ten: K – 5

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Counting and Cardinality: Kindergarten

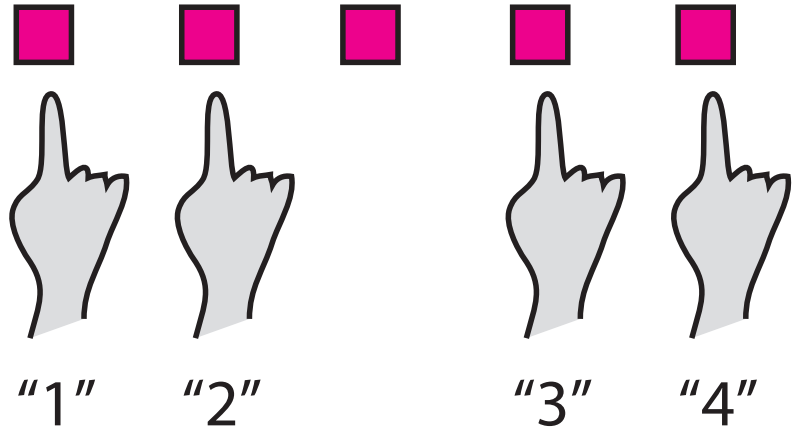
If a child can correctly say the first five counting numbers,

“one, two, three, four, five,”

will the child necessarily be able to determine how many blocks there are in this collection?

Counting and Cardinality: Kindergarten

Child 1:



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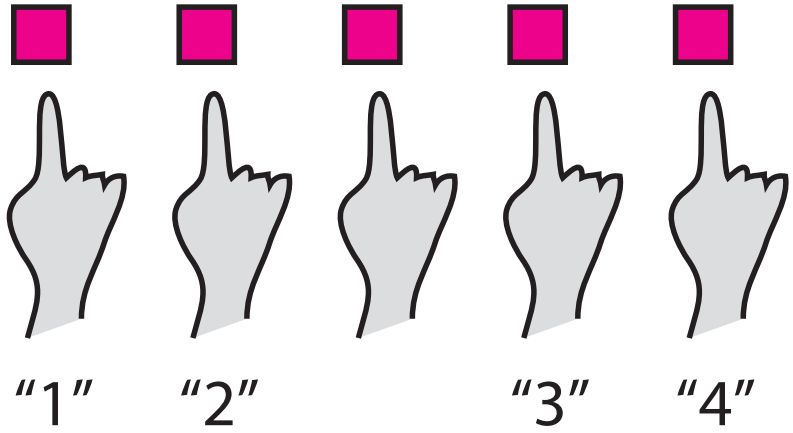

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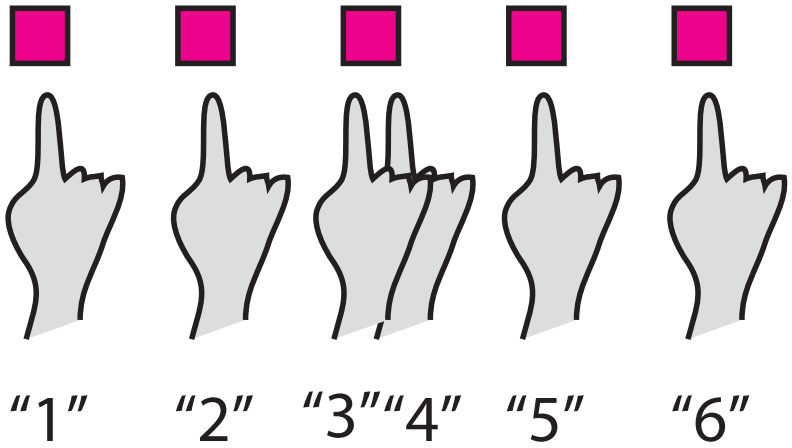

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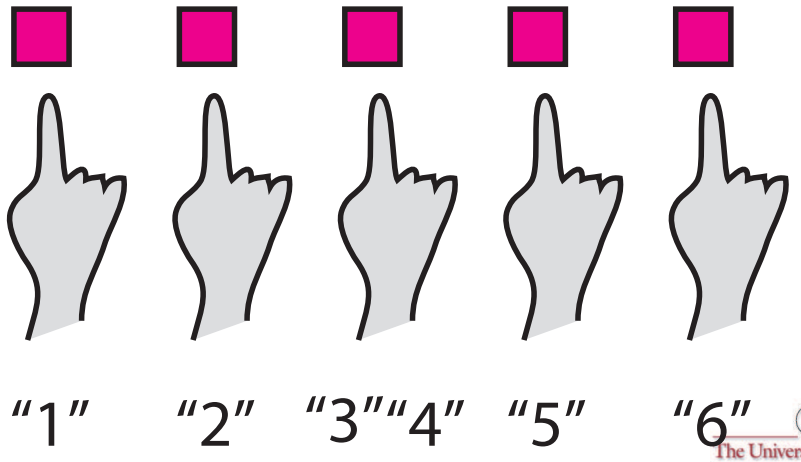

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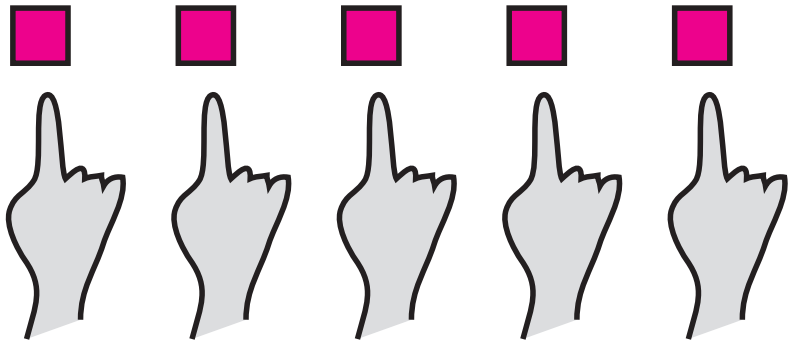
Counting and Cardinality

The last number word tells how many in all

Teacher: "How many blocks are there?"

Child 1:



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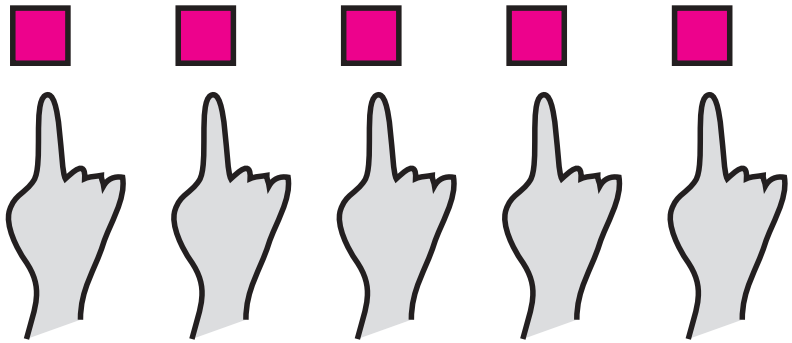
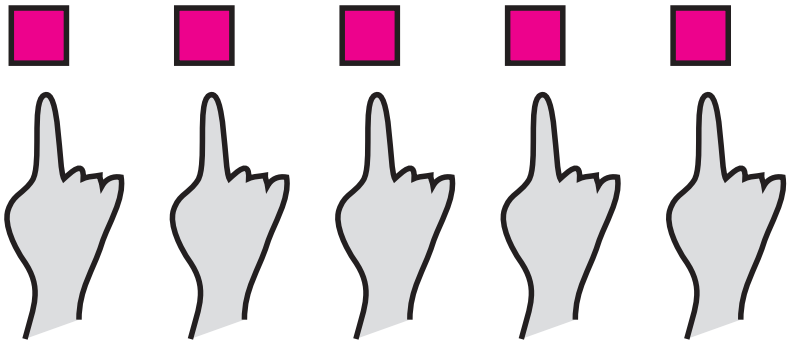
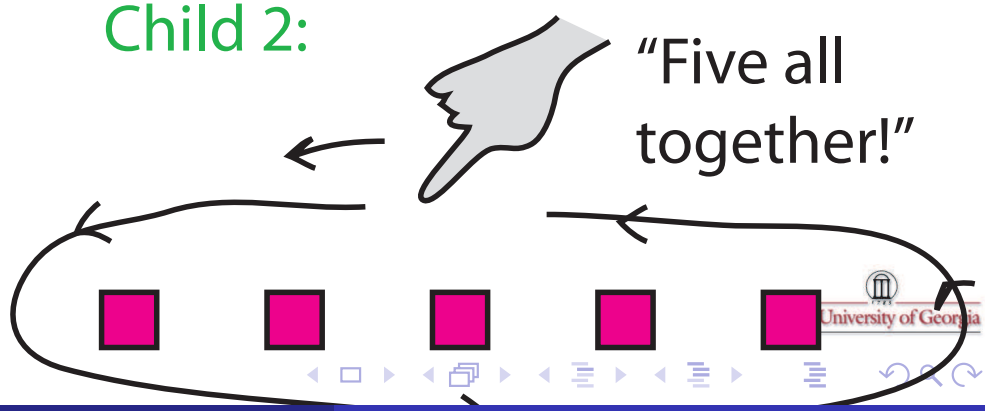


Teacher: "So how many blocks are there?"

Child 1:



Child 2:



Counting and Cardinality: Kindergarten

Kindergarteners coordinate two ways of thinking about what counting numbers are:

- they are a list
- they tell us how many are in a collection

Kindergarteners coordinate different ways of representing numbers:

- number words (names)
- number of objects
- number symbols

The Counting and Cardinality domain (Kindergarten)

Knowing the number names and the count sequence is the beginning of several intertwined progressions:

1. the count sequence
2. determining how many in all (leading to counting on)
3. determining how many in all in a combined set (subitizing, conceptual subitizing, leading to derived methods)
4. connecting number words with written base-ten numerals

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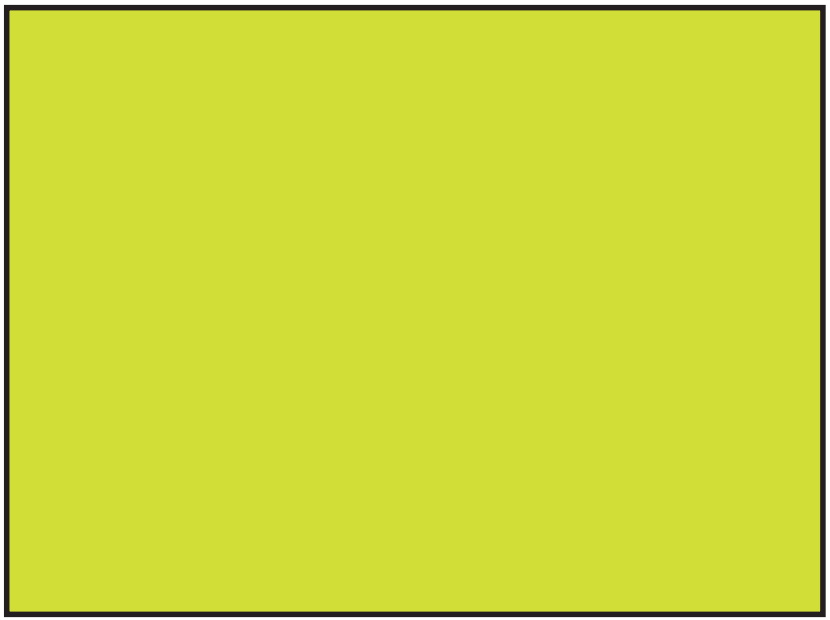
Counting and Cardinality

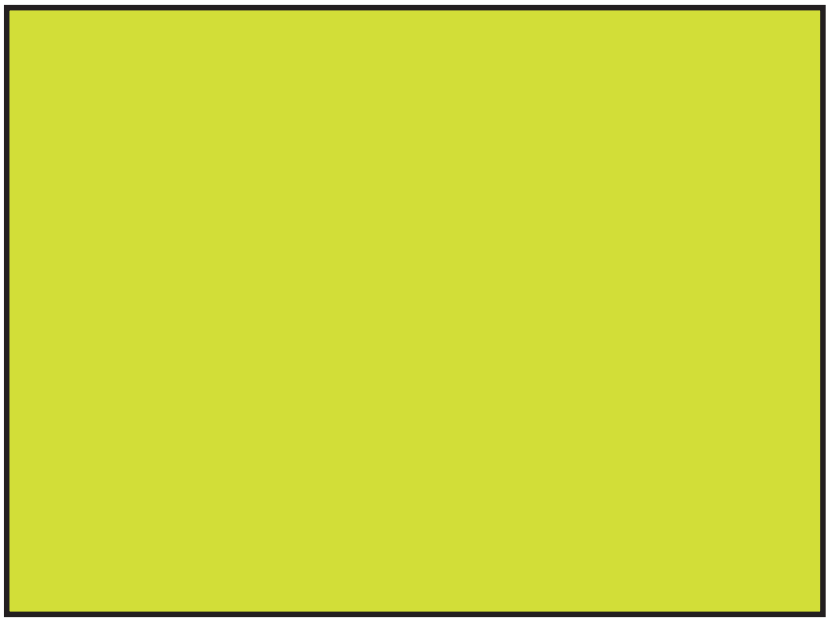
Shifting between the number word list and how many: working towards counting on



Hide them.

Counting and Cardinality

Shifting between the number word list and how many: working towards counting on



Ask: How many bugs are there altogether?

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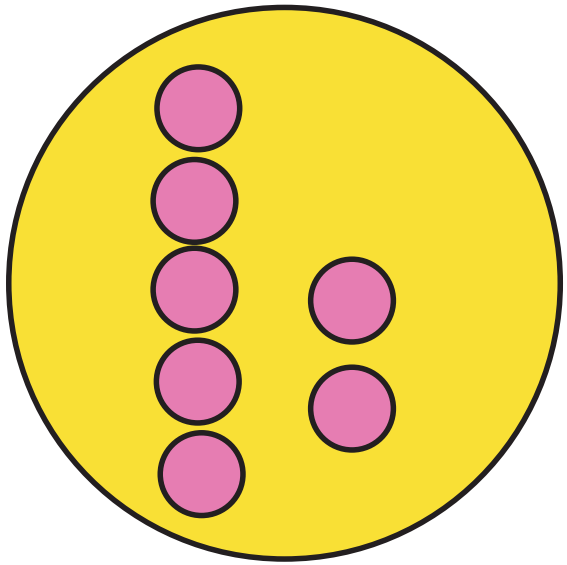
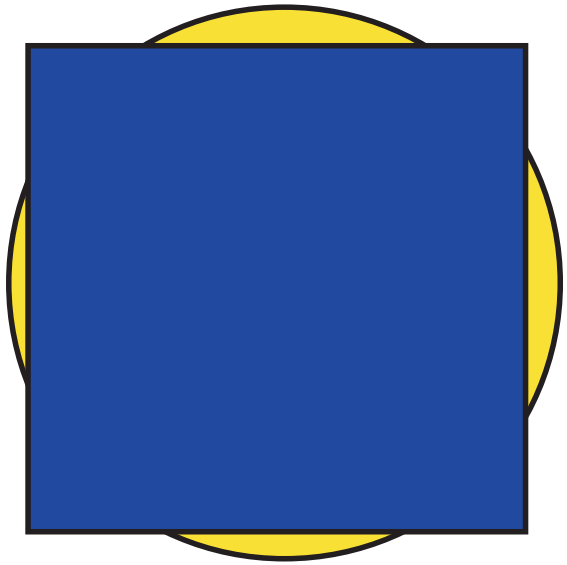
Show briefly:



Then hide:



Ask: How many are there?

Operations and Algebraic Thinking, K – 5

Summary of the domain

- Meanings of addition and subtraction (K – 2), multiplication and division (3 – 5)
  types of problems these operations solve
  - MP1 Make sense of problems and persevere in solving them
  - MP2 Reason abstractly and quantitatively
  - MP4 Model with mathematics
- Algebraic properties of the operations; other patterns and rules
- Single-digit additions/related subtractions;
  single digit multiplications/related divisions;

  use of properties in *learning* them, *not rotely memorizing them*
  - MP7 Look for an make use of structure
  - MP8 Look for and express regularity in repeated reasoning

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Operations and Algebraic Thinking

"Add to" and "take from" word problems

Easier ones start in K, harder ones Grade 1 and up

	Result unknown	Change unknown	Start unknown
Add to	$2+3=?$	$2+?=3$	$?+3=5$
Take from	$5-2=?$	$5-?=3$	$?-2=3$

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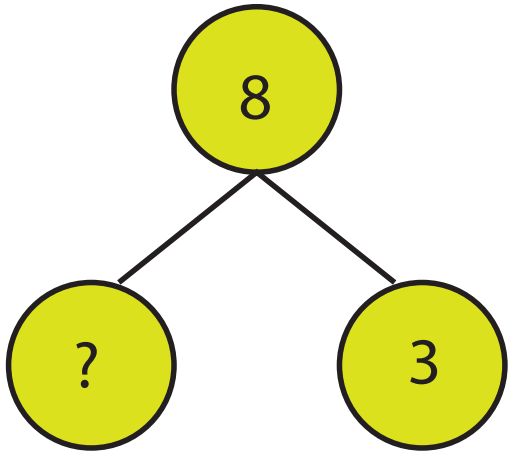
Operations and Algebraic Thinking

Add to, start unknown

Kwon has some cars. He gets 3 more cars. Now he has 8 cars in all. How many cars did Kwon have before he got more?

Note: students who rely only on keywords may mistakenly *add* 3 and 8.



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Operations and Algebraic Thinking

"Put together" and "take apart" word problems

Easier ones start in K, all types are Grade 1 and up

	Total unknown	Addend unknown	Both addends unknown
Put together/ Take apart	$3 + 2 = ?$	$3 + ? = 5$ $5 - 3 = ?$	$5 = 0 + 5$ $5 = 5 + 0$ $5 = 1 + 4$ $5 = 4 + 1$ $5 = 2 + 3$ $5 = 3 + 2$

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Operations and Algebraic Thinking

"Compare" word problems

Grade 1 and up

	Difference unknown	Bigger unknown	Smaller unknown
Compare	$2+?=5$ $5-2=?$	$2+3=?$ $3+2=?$	$5-3=?$ $?+3=5$

Grade 2 and up: two step problems

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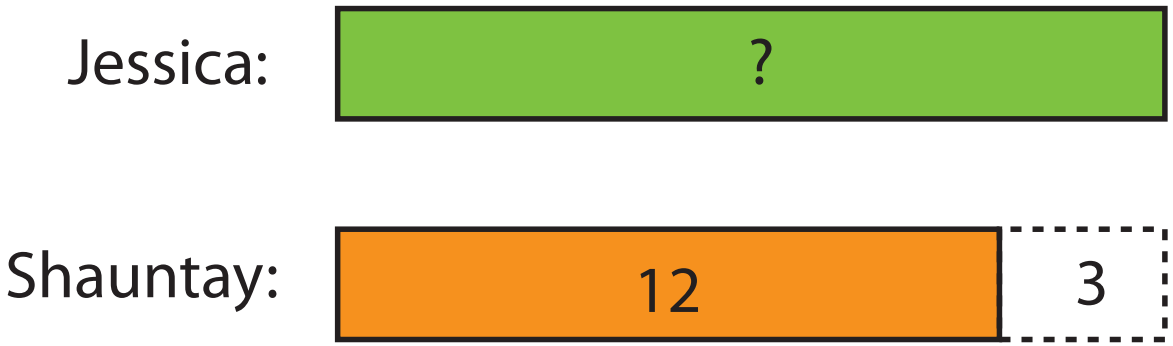
Jessica has some cards. Shauntay has 3 fewer cards than Jessica. Shauntay has 12 cards. How many cards does Jessica have?

Note: students who rely only on keywords may mistakenly *subtract* 3 from 12.



Operations and Algebraic Thinking

Links to later algebra

- "Start unknown" and "change unknown" "Add to" and "take from" problems are "algebra" problems (as are some other types).
- In "take apart" situations the equal sign can't be viewed as "calculate the answer."

$$5 = 2 + 3$$

- "Take apart" is necessary for level 3 addition strategies that use the associative property.

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Progression of numerical strategies in working toward fluency — *not rote memorization of the single-digit facts*:

- Level 1: count all (K)
- Level 2: count on, count on from larger, count on to subtract (Grade 1)
- Level 3: derived fact methods, especially make-a-ten methods (Grades 1, 2)

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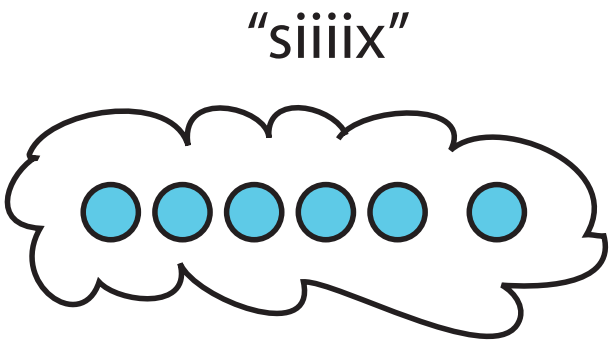
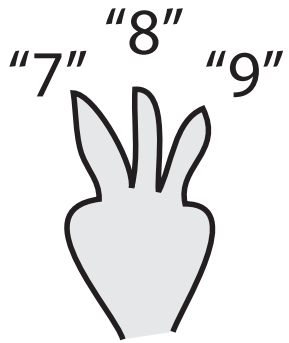
What is $6 + 3$?





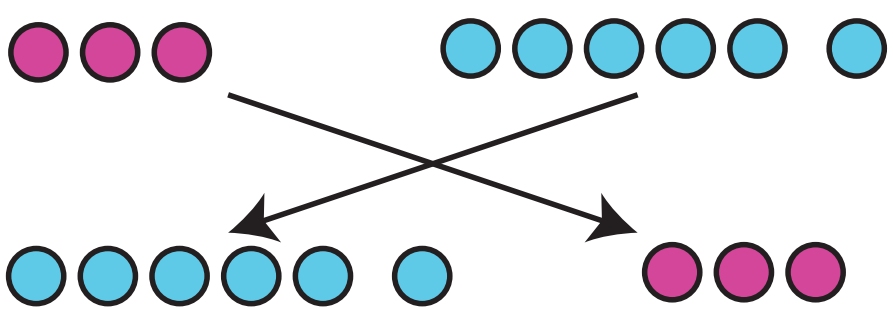
"so 6 + 3 = 9"

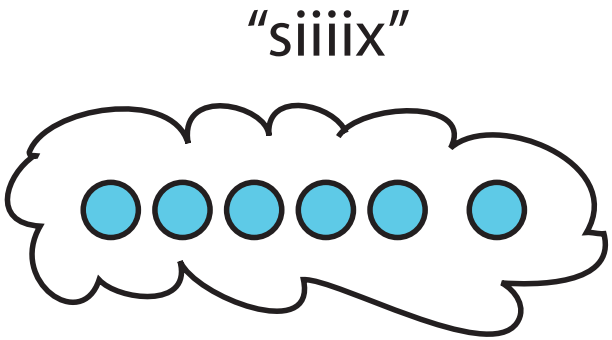
What is $3 + 6$?

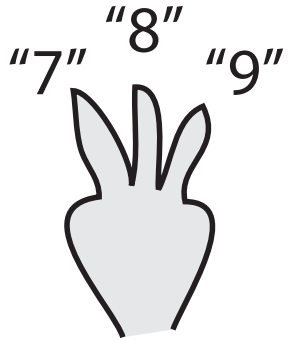
$3 + 6$

$=$

$6 + 3$





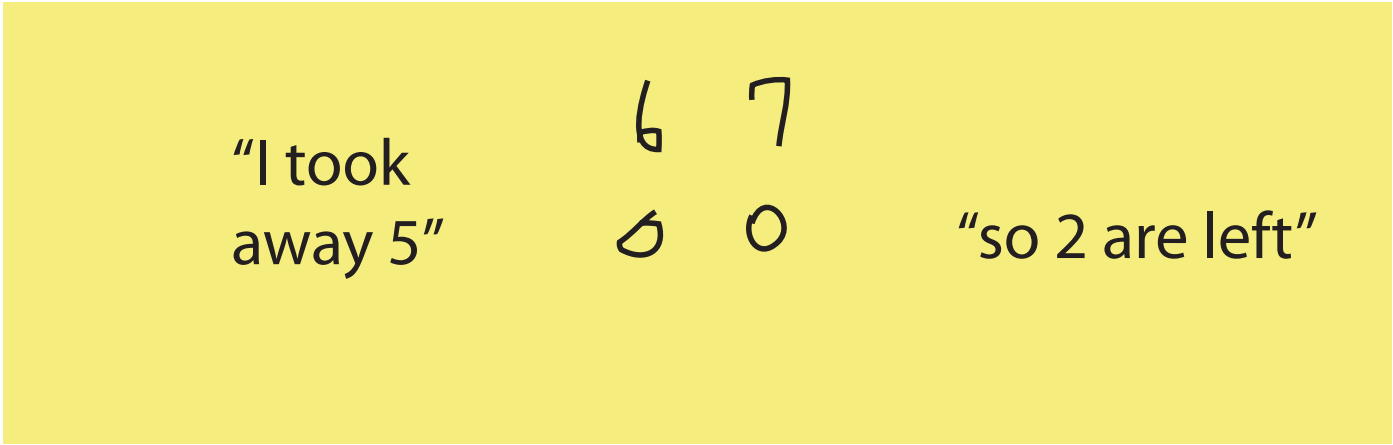


"so $6 + 3 = 9$
$3 + 6 = 9$"

Operations and Algebraic Thinking

Level 2: Counting on to subtract

A $7 - 5 = \square$ problem: There were 7 nuts. Then a mouse ate 5. How many nuts are left? Children can also solve this by counting on from 5:



This method links subtraction and addition:

$$7 - 5 = \square \quad \leftrightarrow \quad 5 + \square = 7$$

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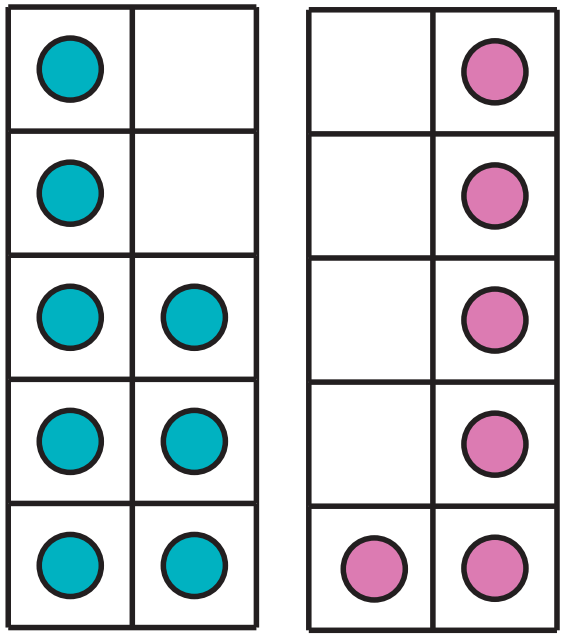
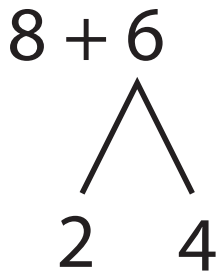
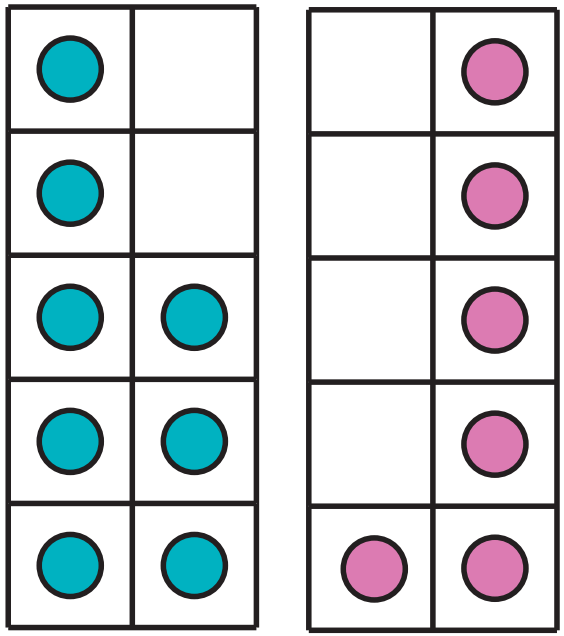
$8 + 6$

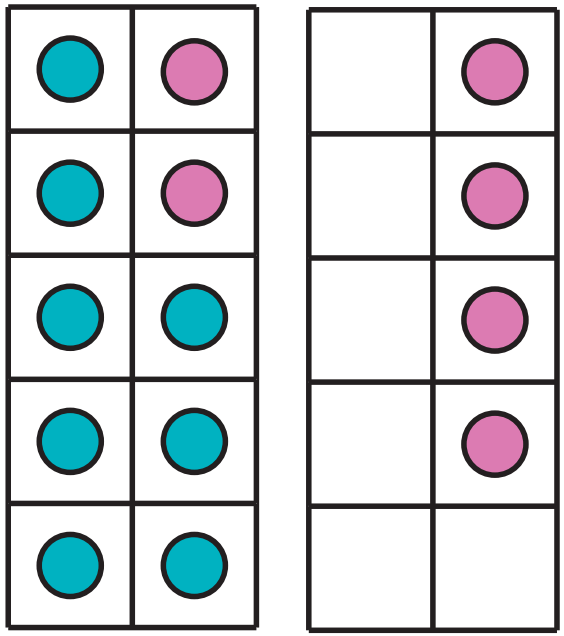



8 + 6
2
4

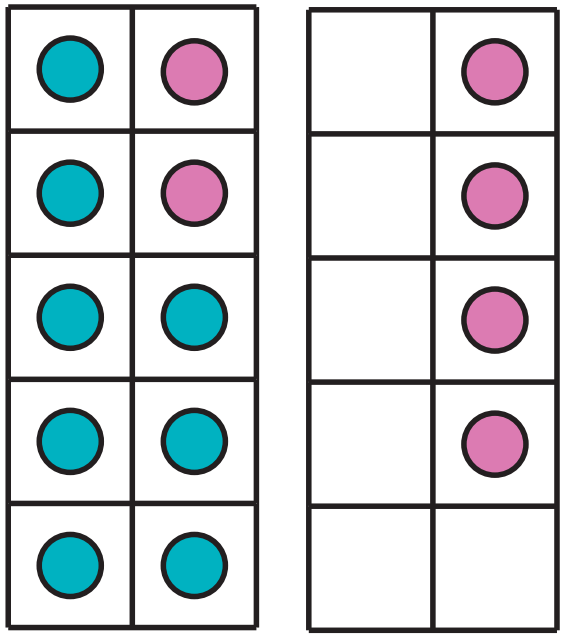


$$8 + 6 = 8 + (2 + 4)$$

2 4



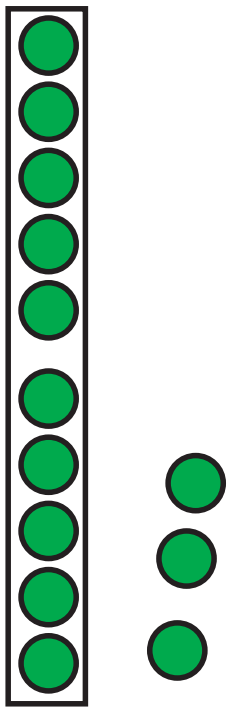
$$8 + 6 = 8 + (2 + 4) = (8 + 2) + 4 = 14$$



Operations and Algebraic Thinking

Level 3: Emphasizing grouping by tens

13 - 9



Operations and Algebraic Thinking

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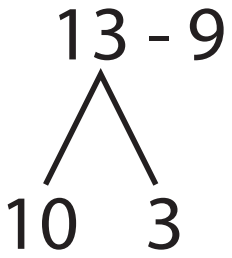
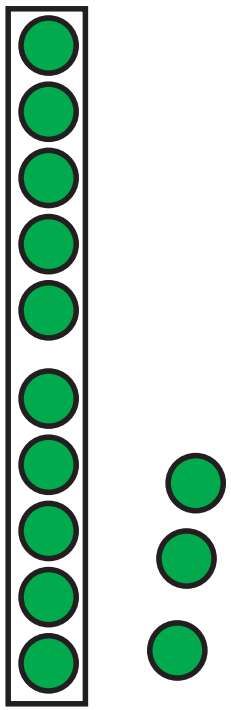
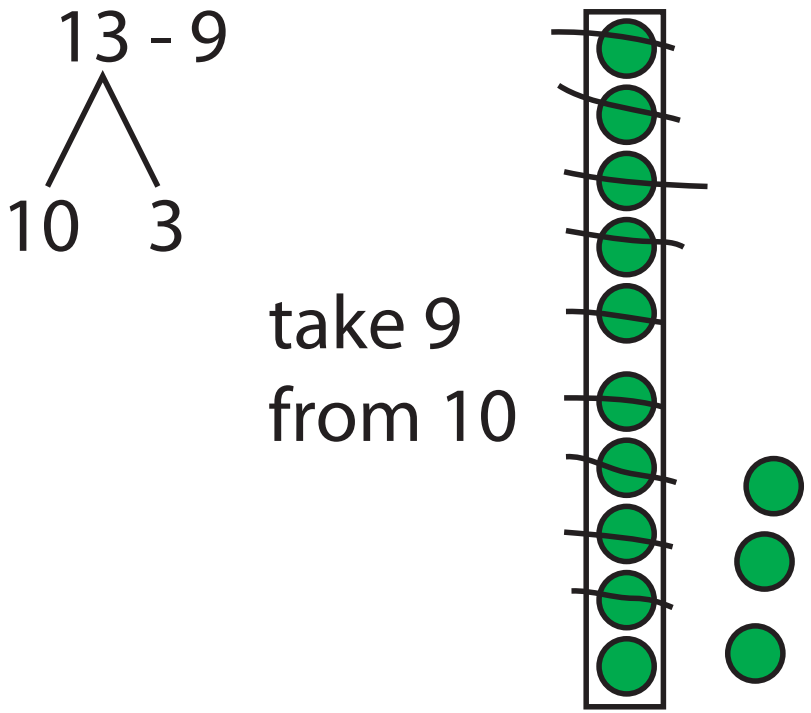
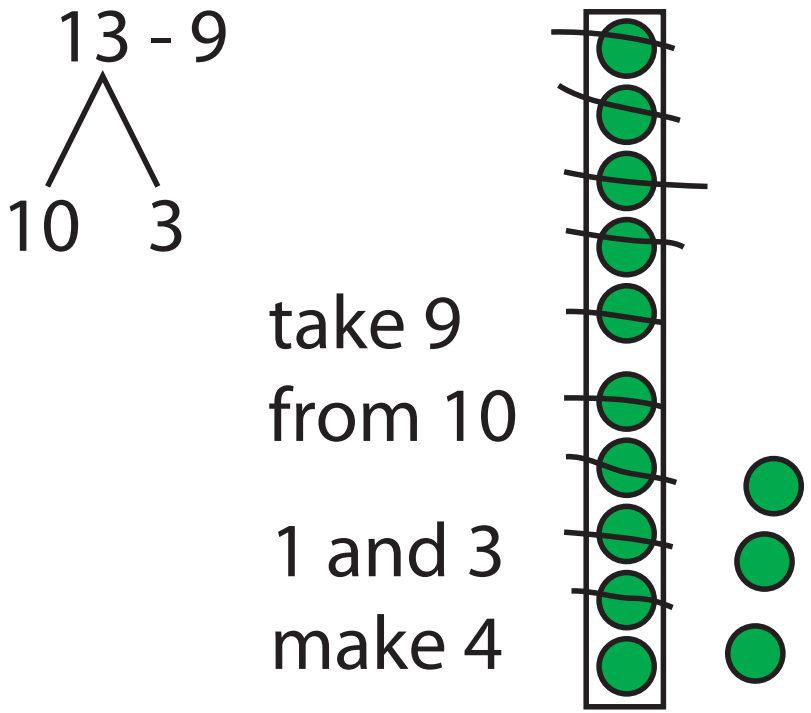


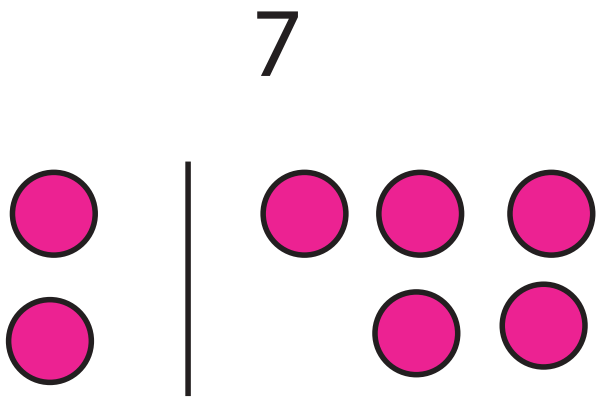


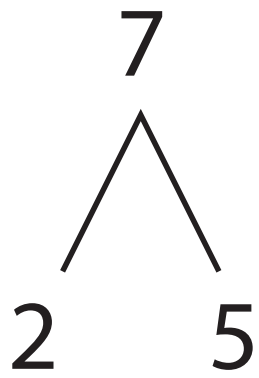

13 - 9
10
3
take 9
from 10


13 - 9
10
3
take 9
from 10
1 and 3
make 4

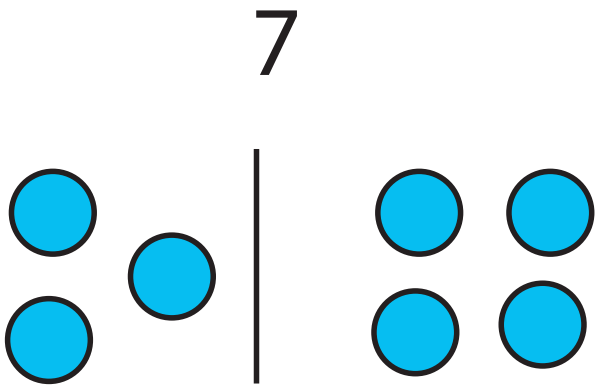
Operations and Algebraic Thinking

Level 3 requires breaking numbers apart into partners





$$7 = 2 + 5$$



$$7 = 3 + 4$$

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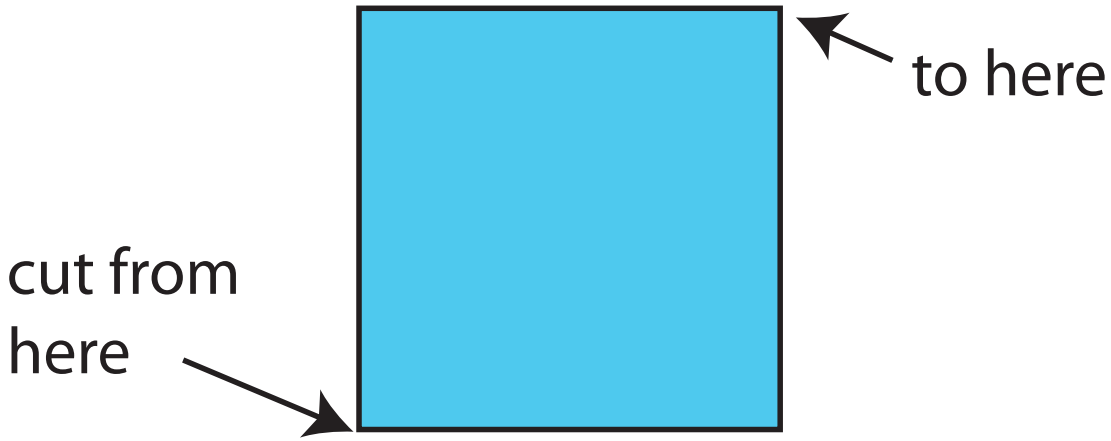
Operations and Algebraic Thinking Connection to Geometry

Decomposing a square and recomposing

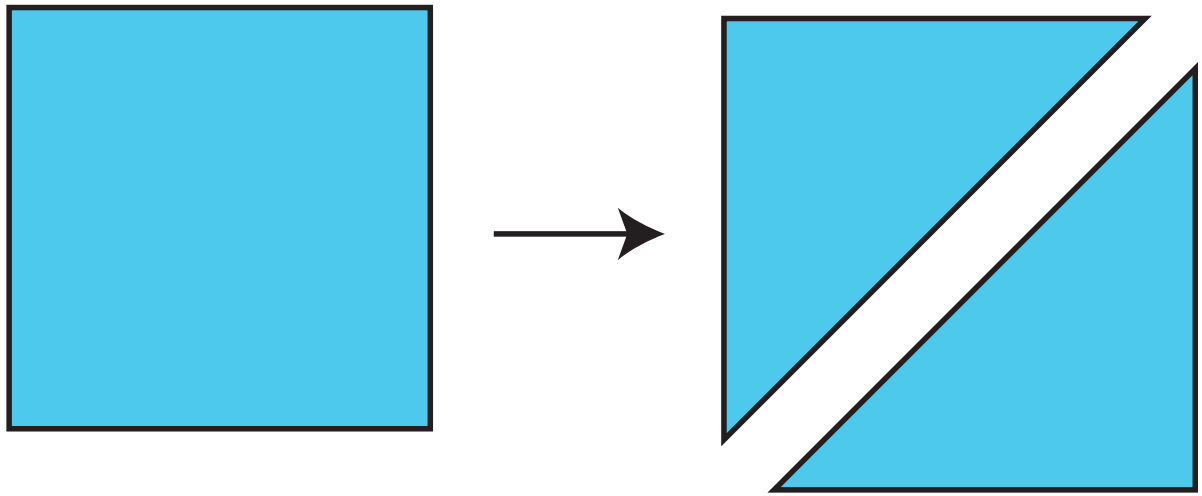
A 1st grade teacher might ask:
"What if we cut the square from one corner to the opposite corner? What shapes will we get?"



Operations and Algebraic Thinking Connection to Geometry

Decomposing a square and recomposing

"We get two triangles!"



Can we put the triangles together in other ways?

Operations and Algebraic Thinking Connection to Geometry

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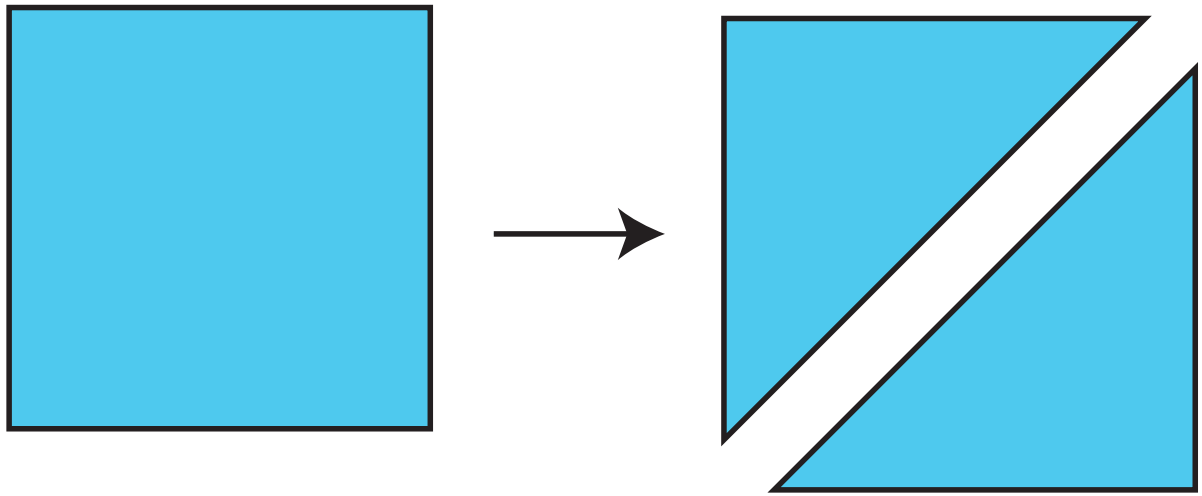

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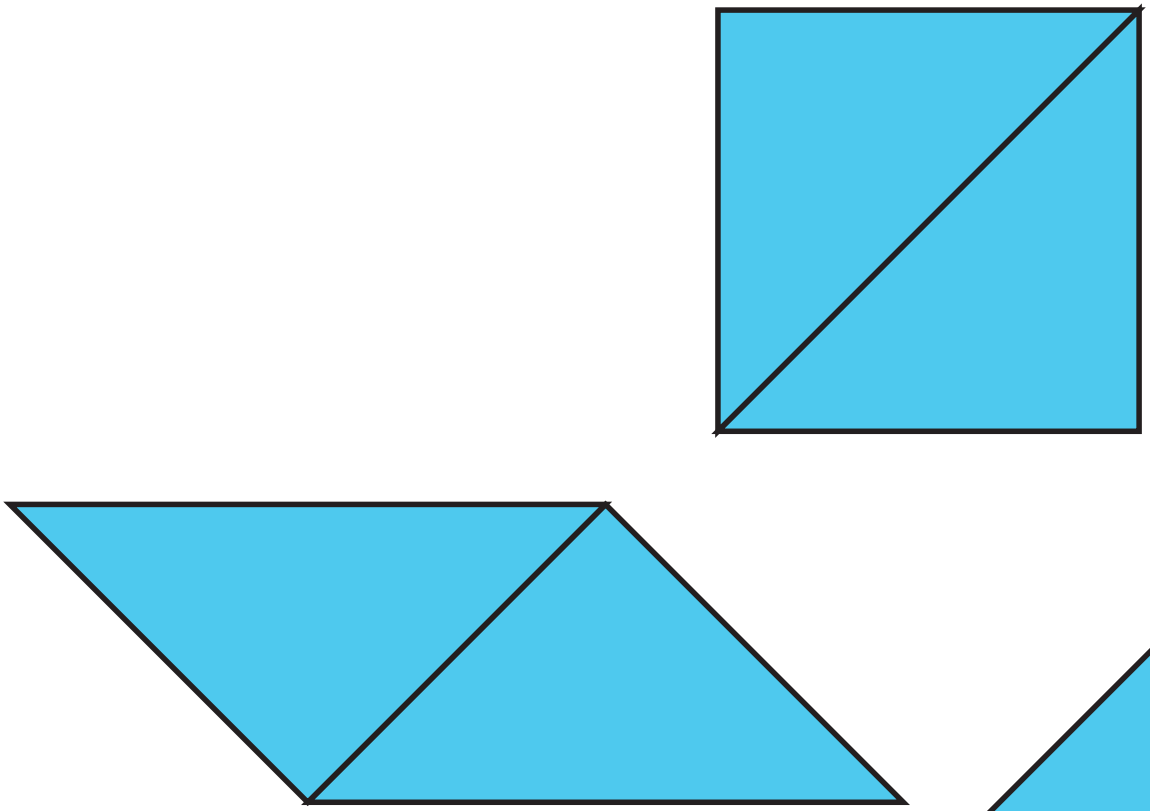

Operations and Algebraic Thinking

Grade 3

Multiplication and division are a priority in Grade 3

Addition and subtraction are maintained at Grade 3

- through multi-step problems
- maintaining or developing fluency within 1000

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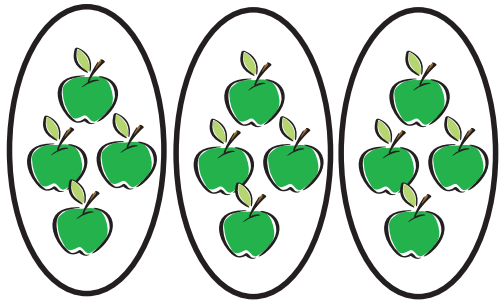
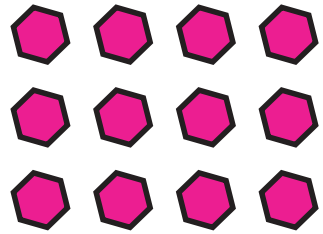
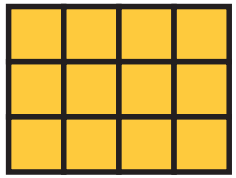
Operations and Algebraic Thinking

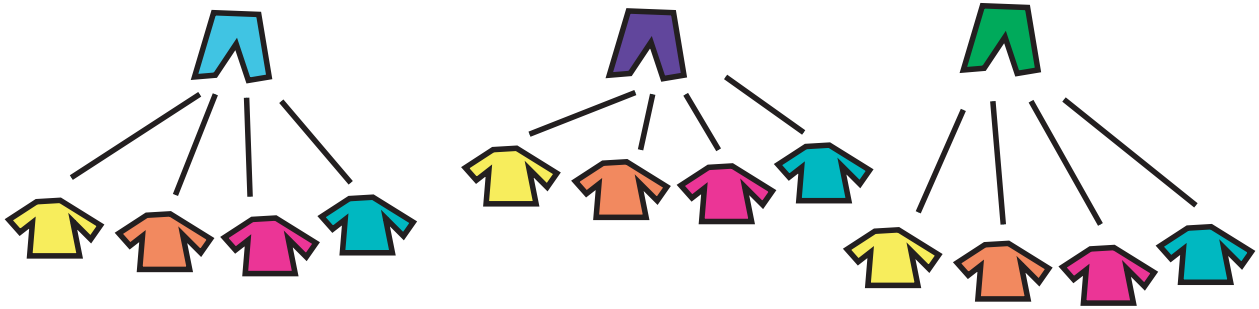
Types of multiplication and division problems (some beyond Grade 3)







3×4



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$$\underset{\uparrow}{A} \times \underset{\uparrow}{B} = \underset{\uparrow}{C}$$

A: # of groups

B: amount in one whole group

C: resulting amount

Unknown product	$3 \times 4 = ?$
Group size unknown "How many in each group?" division	$3 \times ? = 12$ $\quad$ $12 \div 3 = ?$
Number of groups unknown "How many groups?" division	$? \times 4 = 12$ $\quad$ $12 \div 4 = ?$

Progression of numerical strategies in working toward fluency — *not rote memorization of the single-digit facts*:

- Level 1: Make and count all (Grade 2)
- Level 2: "Skip counting"
  8×3 count by 3s eight times
  $24 \div 3$ count by 3s until 24 is reached, keeping track of how many counts
- Level 3: Make use of properties (perhaps implicitly)
  I know 6×5 is 30, so 7×5 is 5 more, 35.

Supported by examining patterns in the multiplication table

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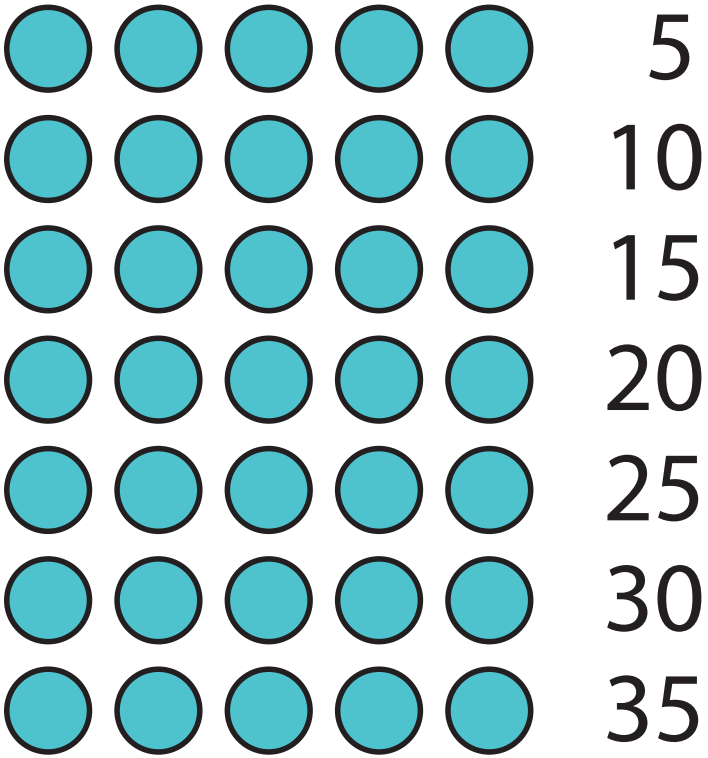
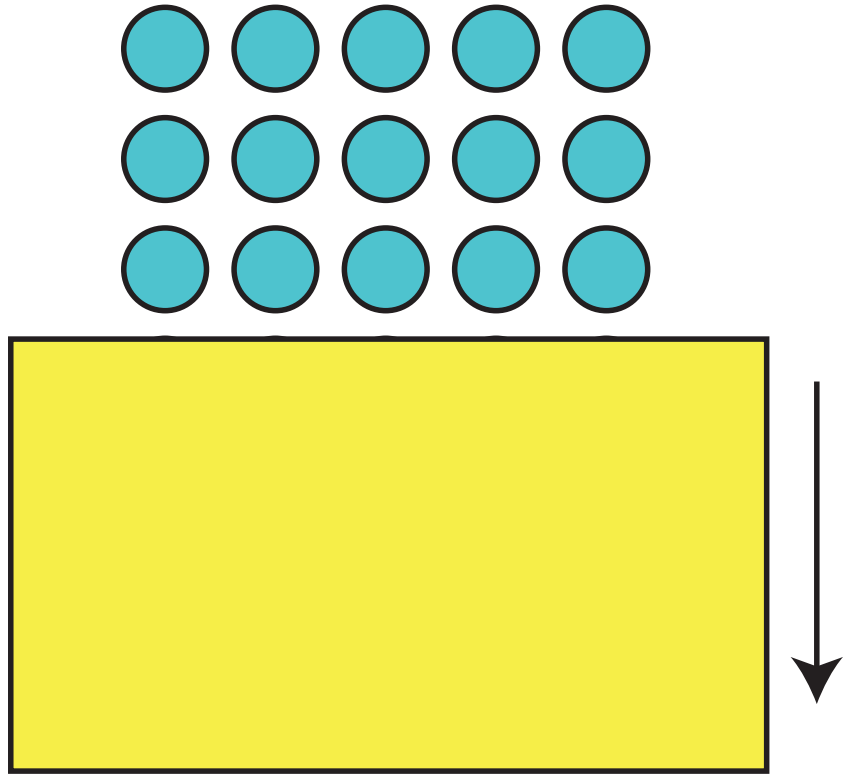
Supported by examining patterns in the multiplication table

Operations and Algebraic Thinking

Level 2: Count by list supported with an array





slide paper down
to uncover rows
while skip counting

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Operations and Algebraic Thinking

Level 3 makes use of properties of multiplication (sometimes implicit).

Is the commutative property of multiplication obvious?

$$A \times B = B \times A$$

for all numbers A, B

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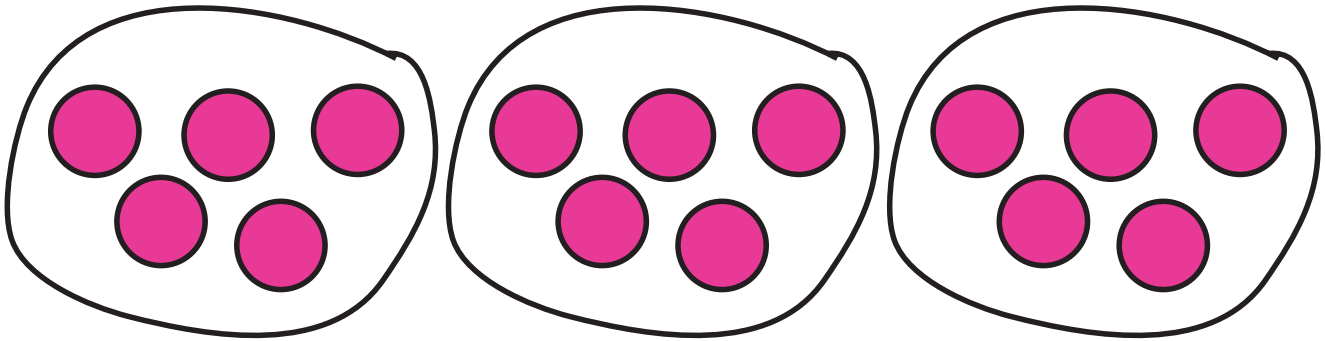
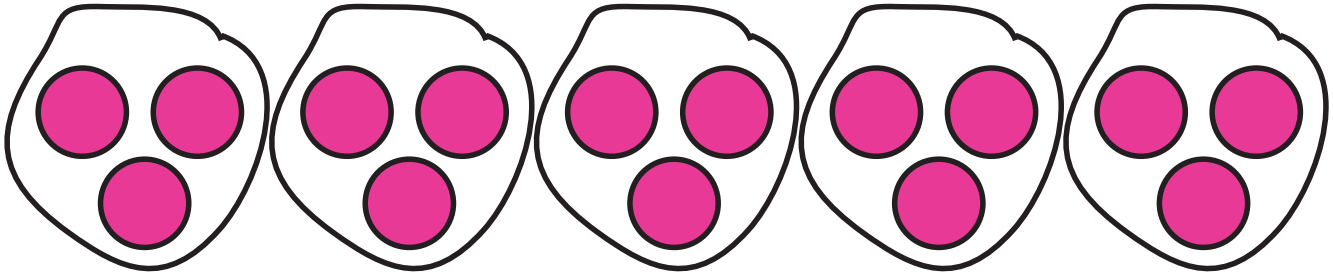
A 3rd grade perspective on why the commutative property of multiplication is not obvious:

3×5

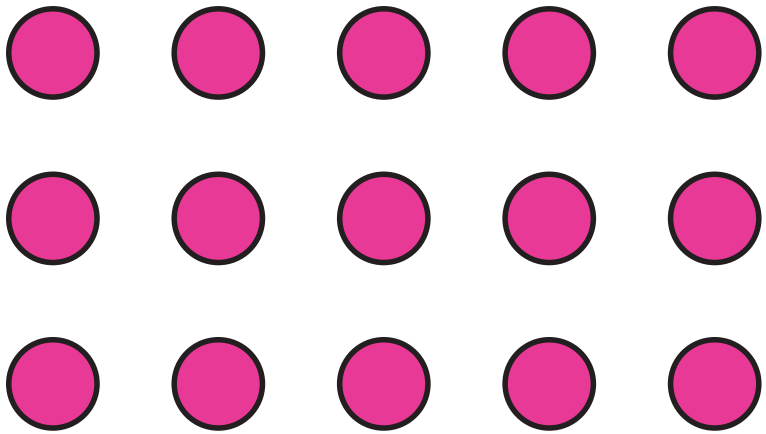


5×3



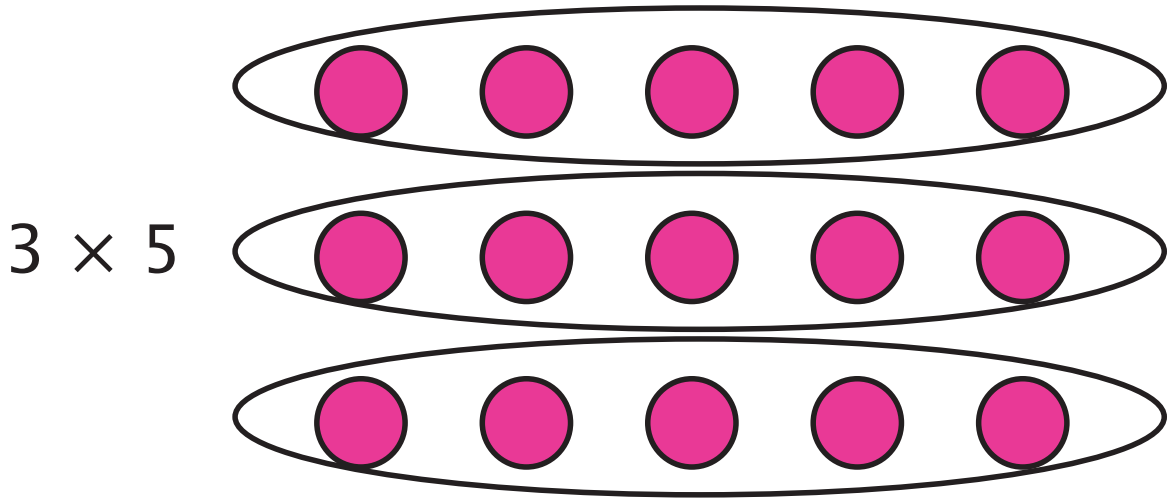
Operations and Algebraic Thinking

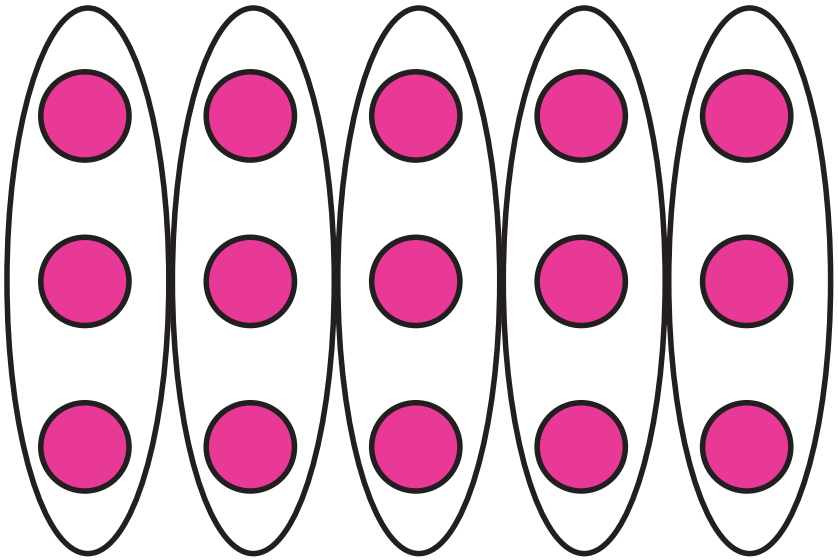
The commutative property of multiplication



Operations and Algebraic Thinking

The commutative property of multiplication





5×3

Operations and Algebraic Thinking

Level 3: Using relationships to derive new facts from other facts

$6 \times 7 = 5 \times 7 + 1 \times 7$

$6 \times 7 = 2 \times (3 \times 7)$

$6 \times 7 = 6 \times 5 + 6 \times 2$

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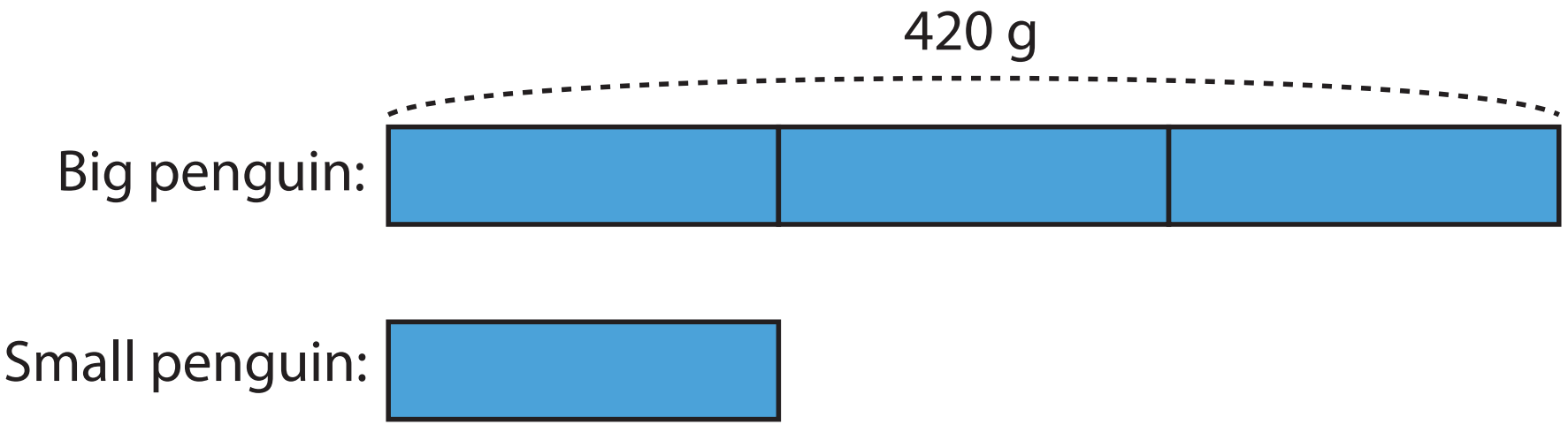
A big penguin will eat 3 times as much fish as a small penguin. The big penguin will eat 420 grams of fish. All together, how much will the two penguins eat?

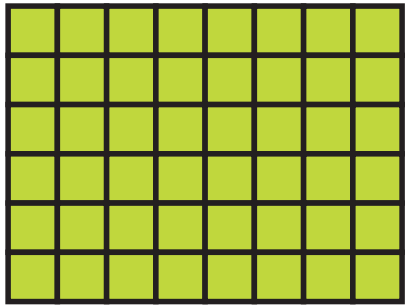


Connection to Geometric Measurement

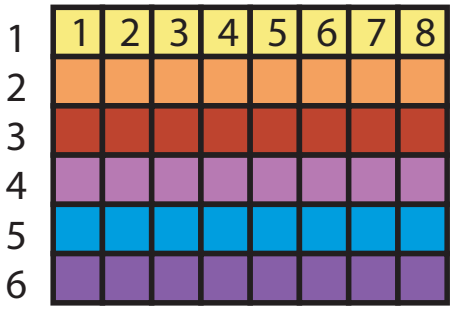
1 square unit

What is the area of this rectangle in square units?

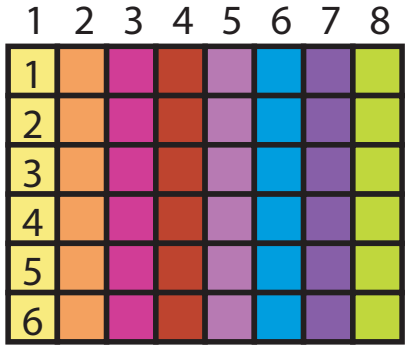
Cover the rectangle with squares. How many squares?



Is there a quicker way to find the area than counting all the squares one by one?



View as 6 groups of 8 squares.
$6 \times 8 = 48$ square units



View as 8 groups of 6 squares.
$8 \times 6 = 48$ square units

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Number and Operations in Base Ten, K – 5

Summary of the domain

Representing, comparing, and calculating with numbers in base ten.

- Use strategies based on place value and properties of operations
- Illustrate and explain calculations with representations such as mathematical drawings
  - MP2 Reason abstractly and quantitatively
  - MP3 Construct viable arguments and critique the reasoning of others
  - MP5 Use appropriate tools strategically
  - MP6 Attend to precision
  - MP7 Look for and make use of structure
  - MP8 Look for and express regularity in repeated reasoning
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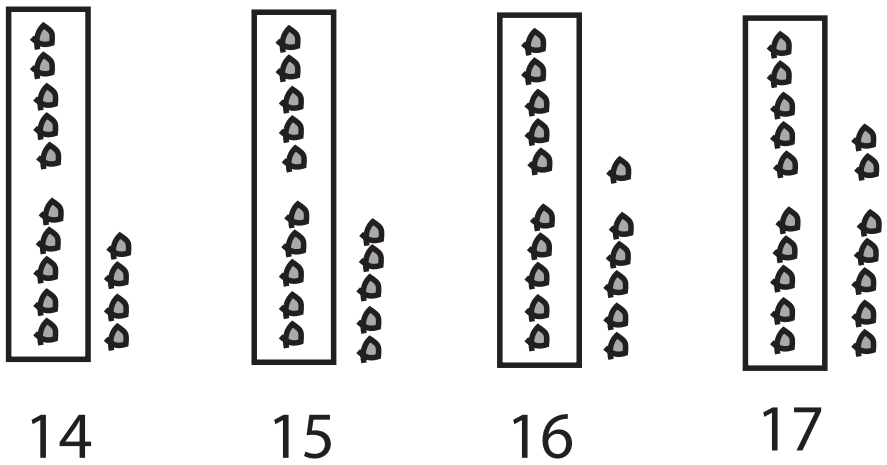
Kindergarten: Numbers 11 through 19 are ten ones and some more ones

Grade 1: Ten ones form a unit of ten



Number and Operations in Base Ten

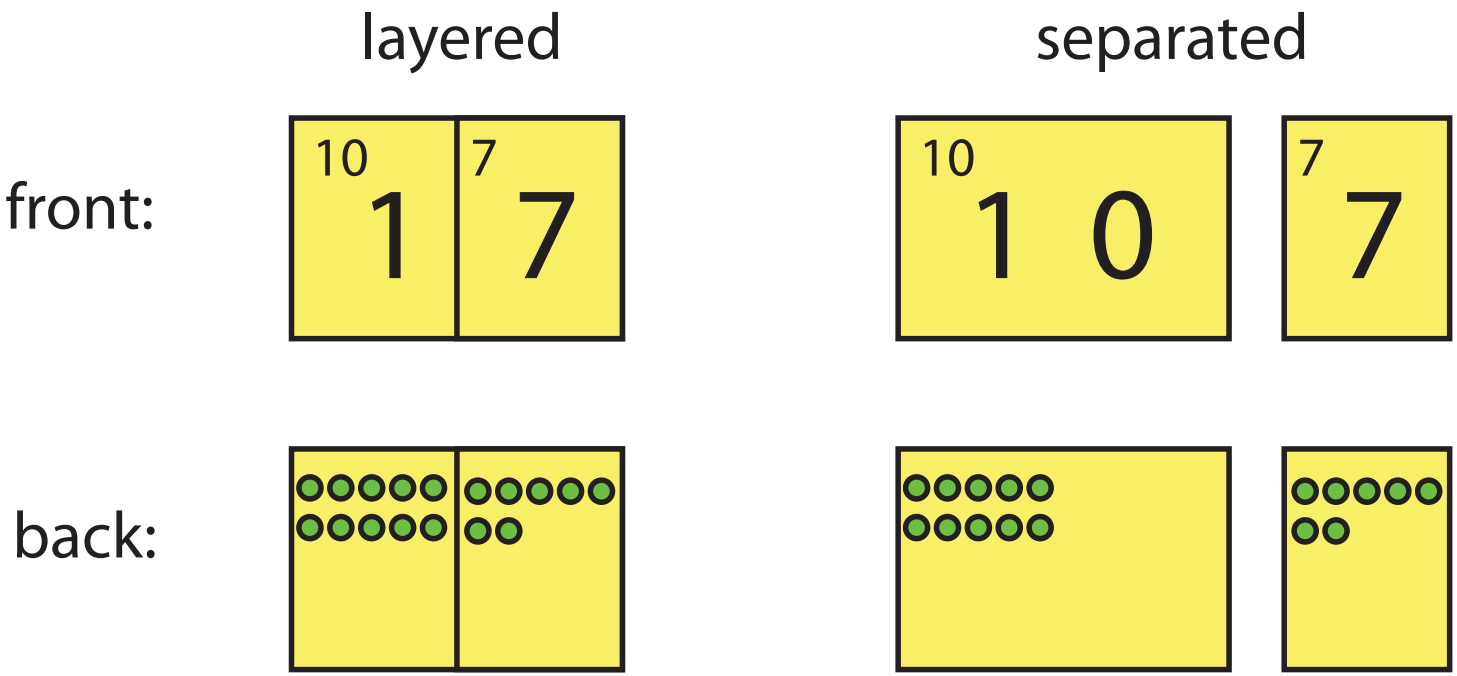
Difficulties with spoken number words in English:

- “eleven,” “twelve” do not sound like ten and one, ten and two
- “thirteen,” “fourteen,” etc. reverse the ones and tens
- teen words often sound like decade words: sixteen versus sixty
- “teen” may not be recognized as meaning ten

Difficulties with written numerals:

- 16 looks like “one six” and not like 1 ten and 6.

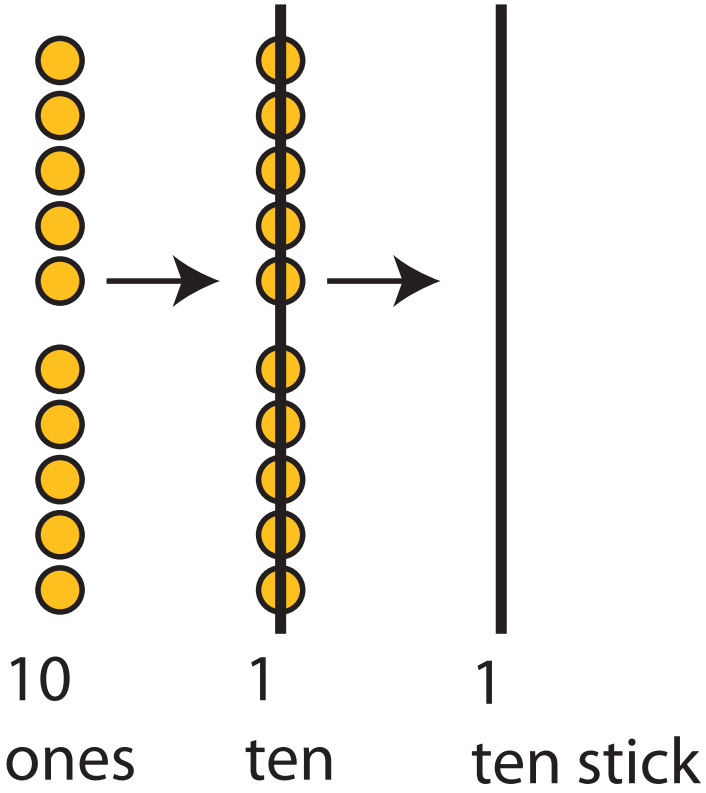
Layered place value cards



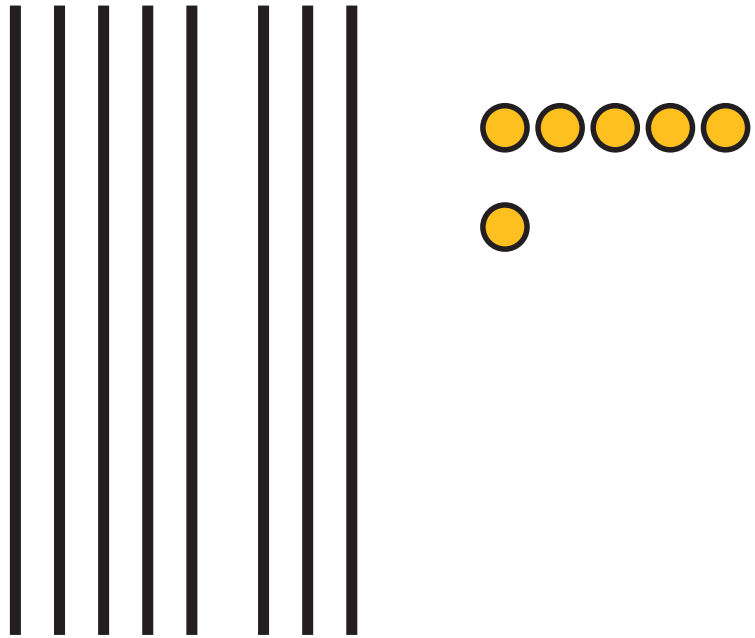
Number and Operations in Base Ten

Mathematical drawings to show base ten structure

drawings to support
seeing 10 ones as 1 ten



86



8 tens and 6 ones

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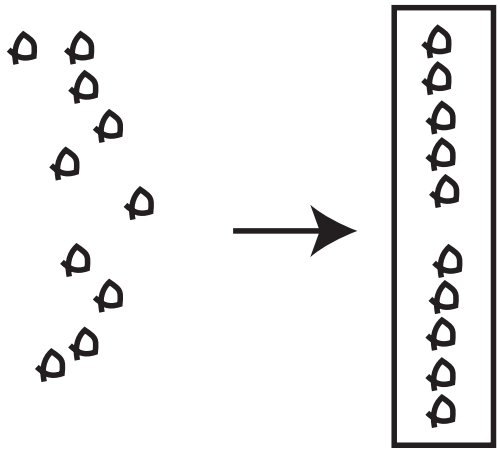
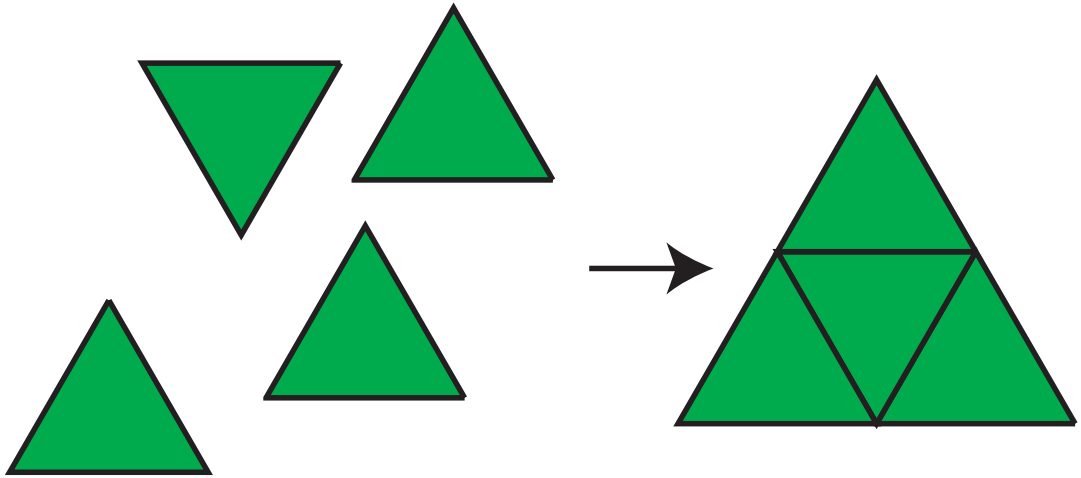
Unitizing

MP7 Look for and make use of structure

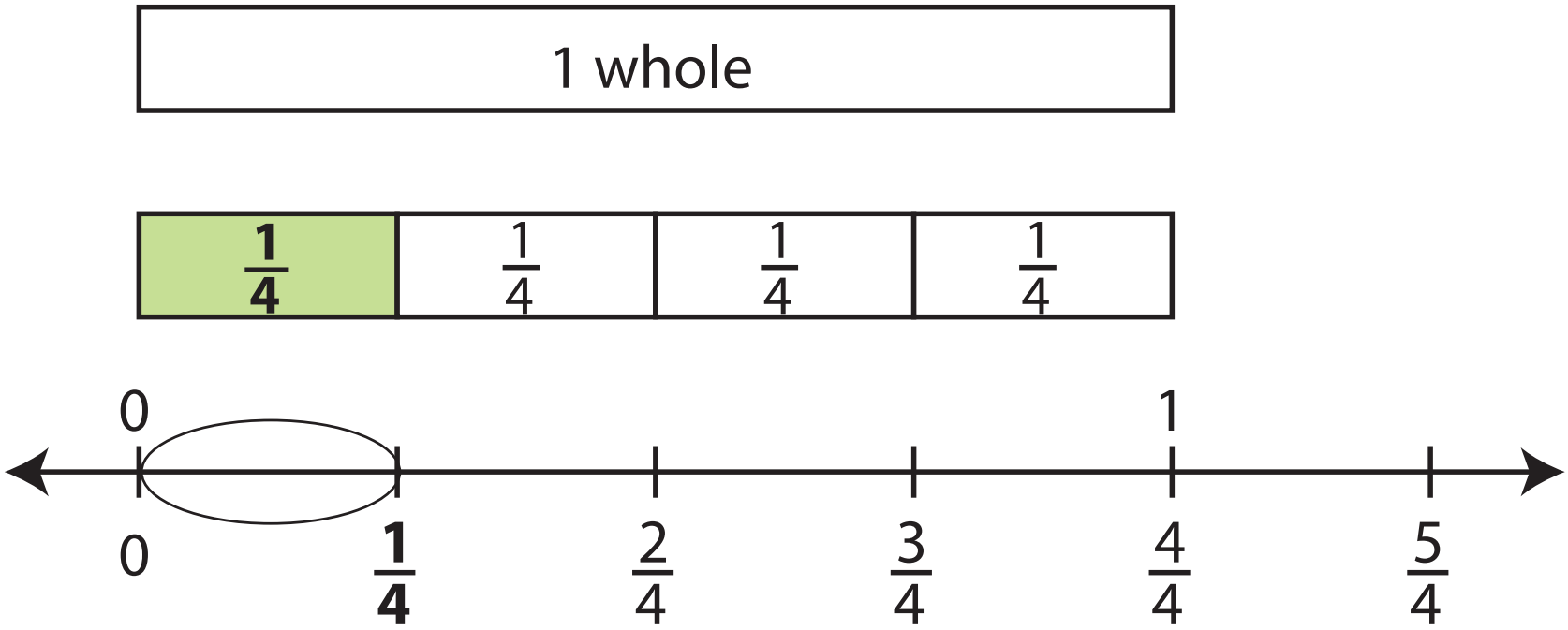




10 ones are grouped
to form one ten

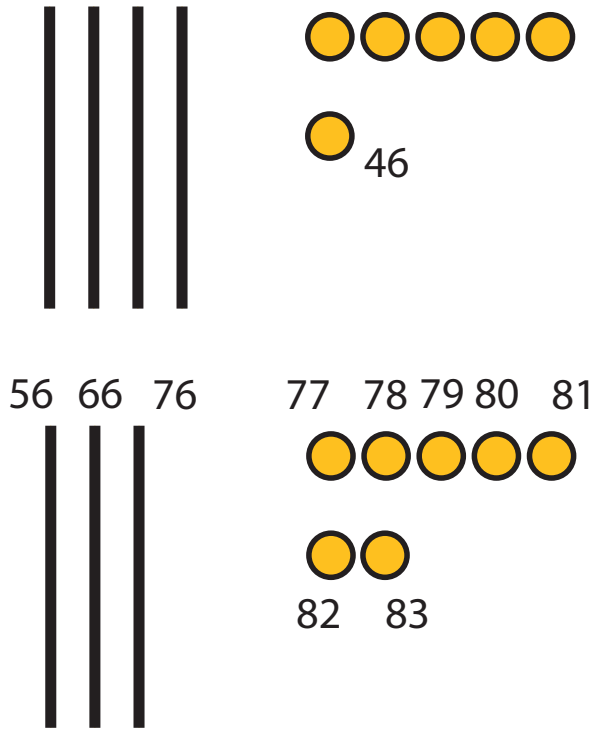
Unitizing

MP7 Look for and make use of structure



Grade 1 numerical work side by side with mathematical drawing

$$\begin{array}{r} 46 \\ +37 \\ \hline 83 \end{array}$$



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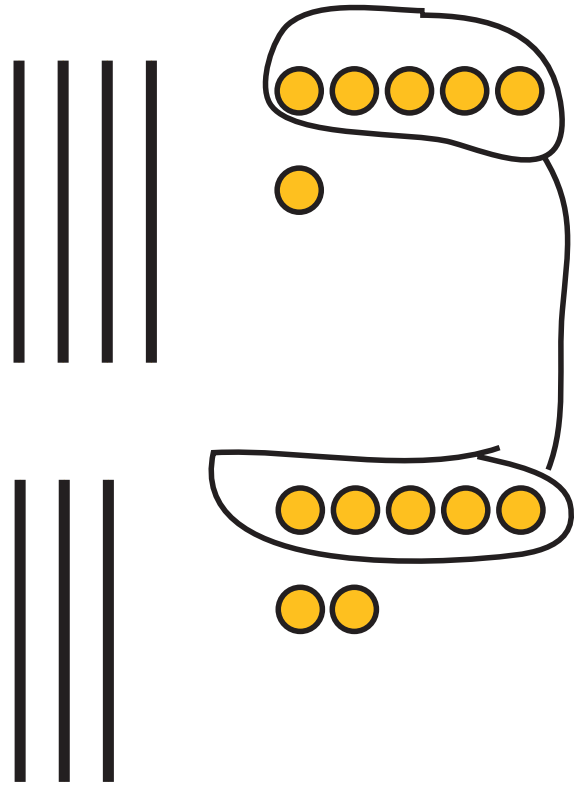
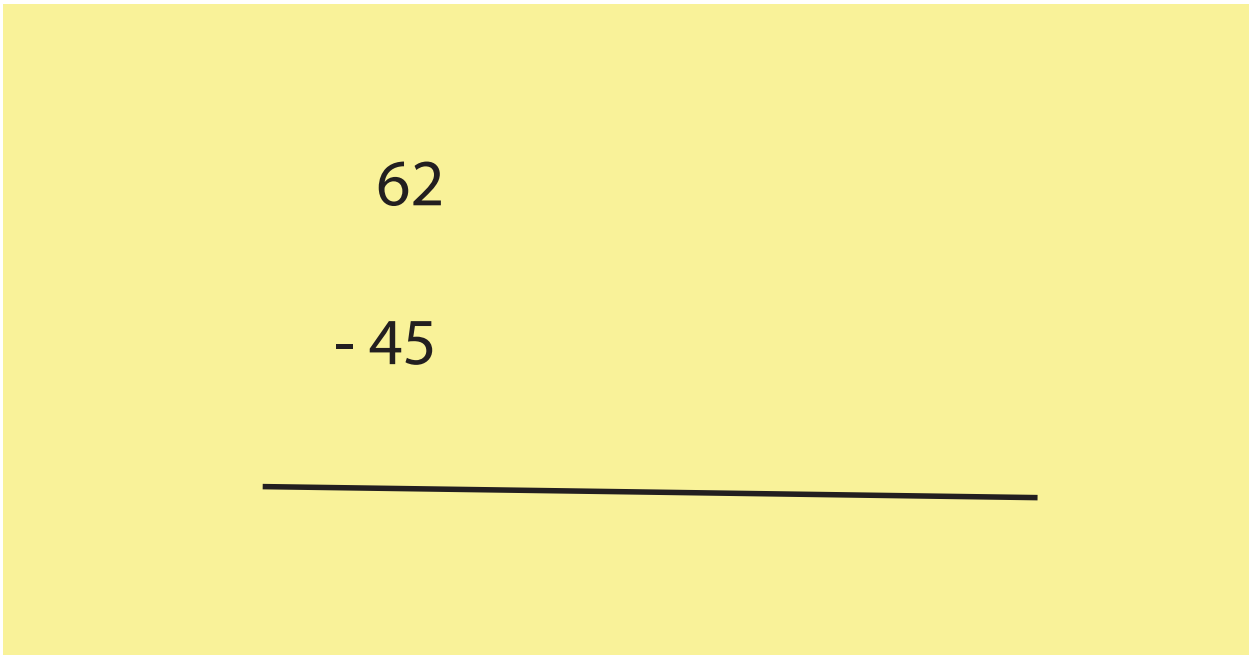


Important: no two-digit subtraction involving both tens and ones until it is done *with regrouping*.

This is so that the error of always subtracting the smaller digit from the larger digit does not take hold.

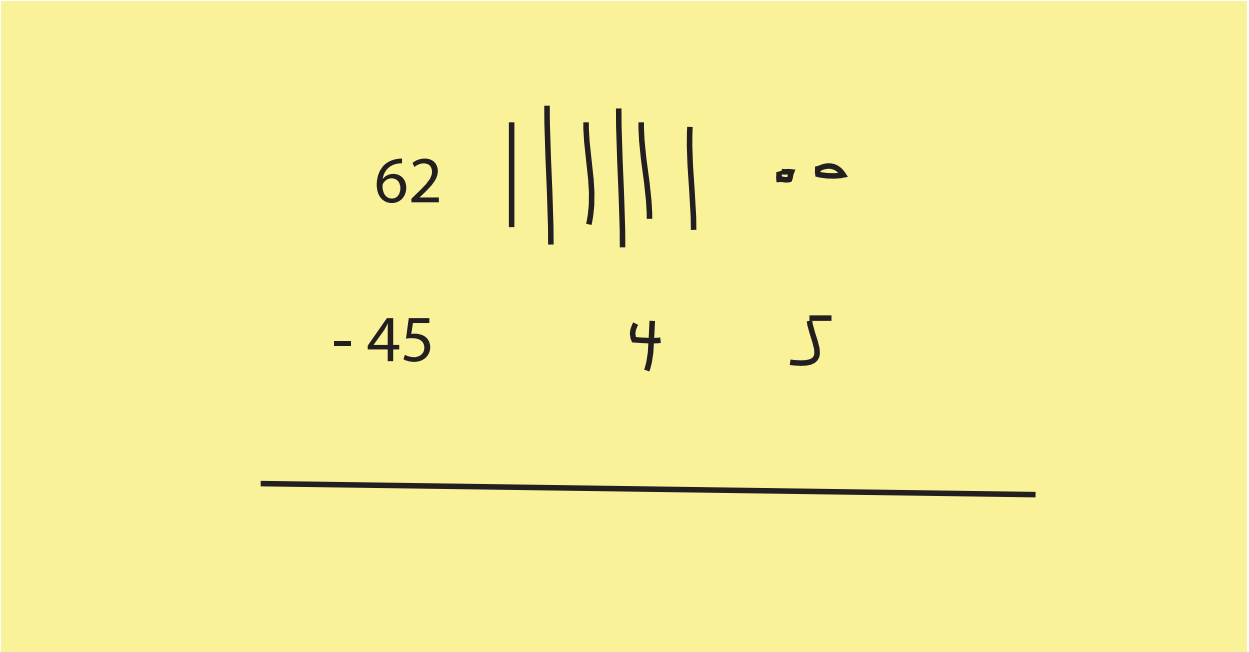
Understanding and explaining subtraction

Grade 2



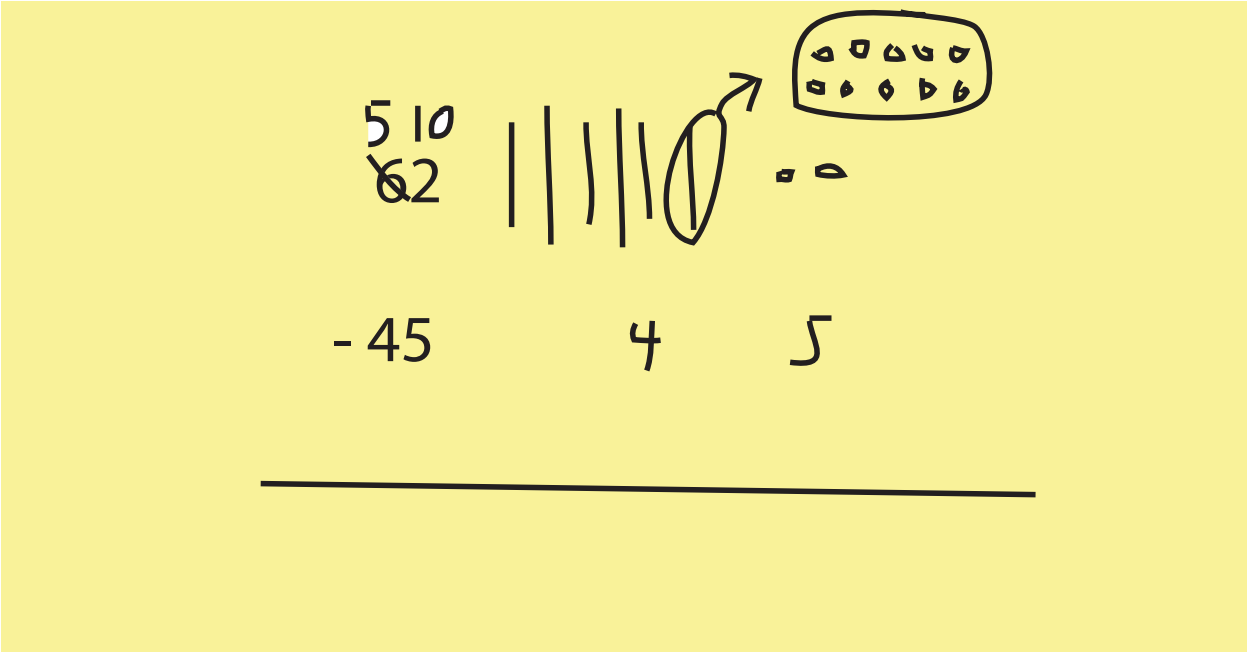
Understanding and explaining subtraction

Grade 2



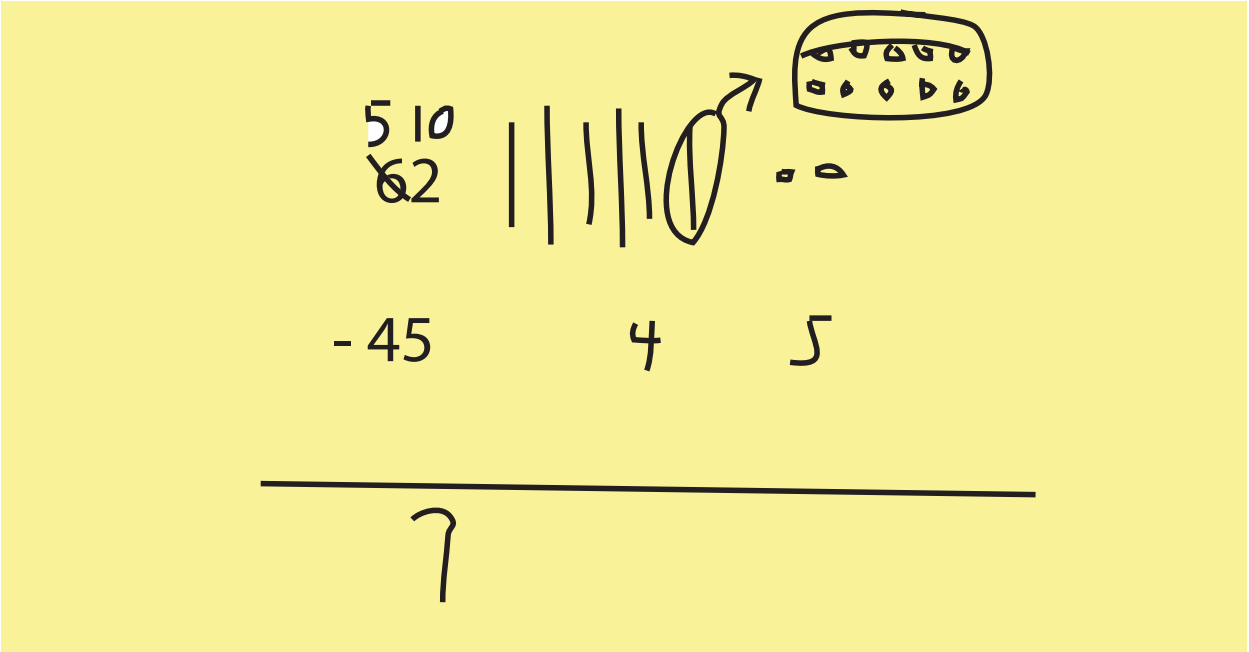
Understanding and explaining subtraction

Grade 2



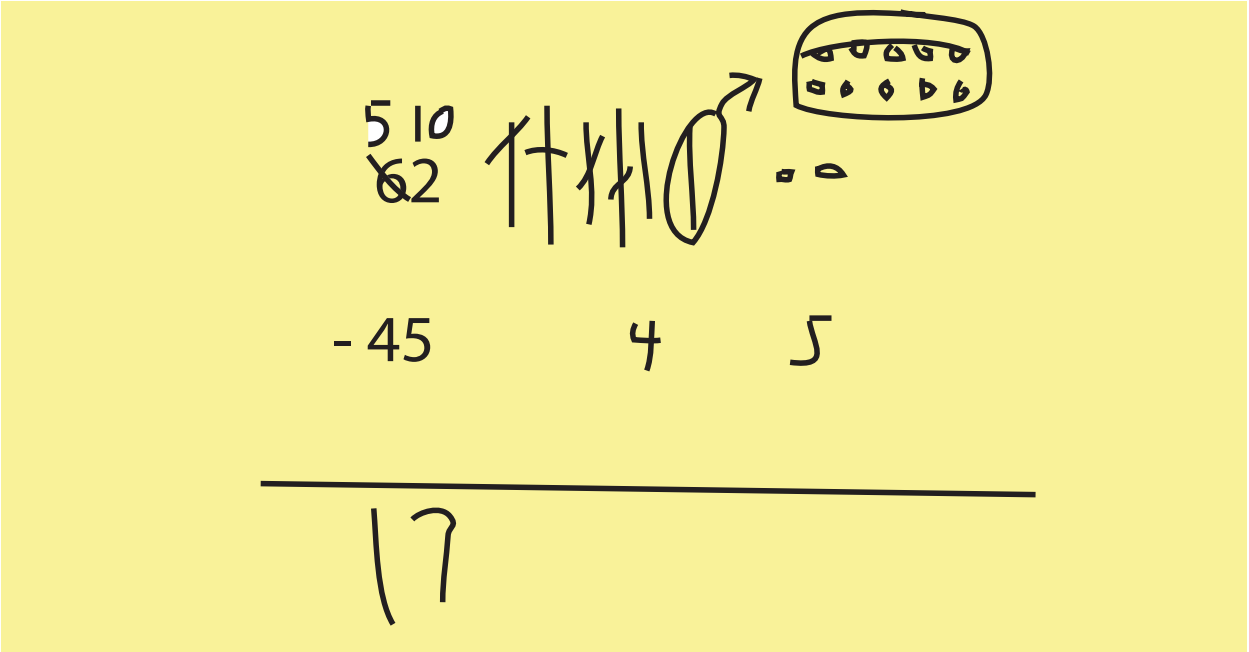
Understanding and explaining subtraction

Grade 2



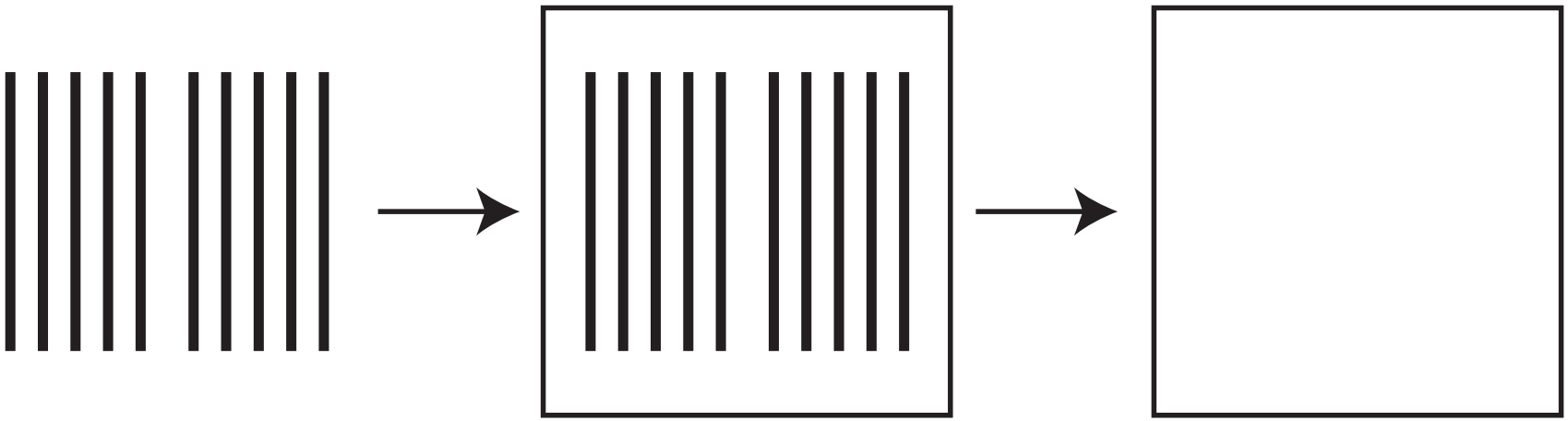
Understanding and explaining subtraction

Grade 2



Number and Operations in Base Ten

Grade 2: Mathematical drawing to represent 1 hundred as 10 tens



10 tens

1 hundred

1 hundred box (quick drawing to show 1 hundred)

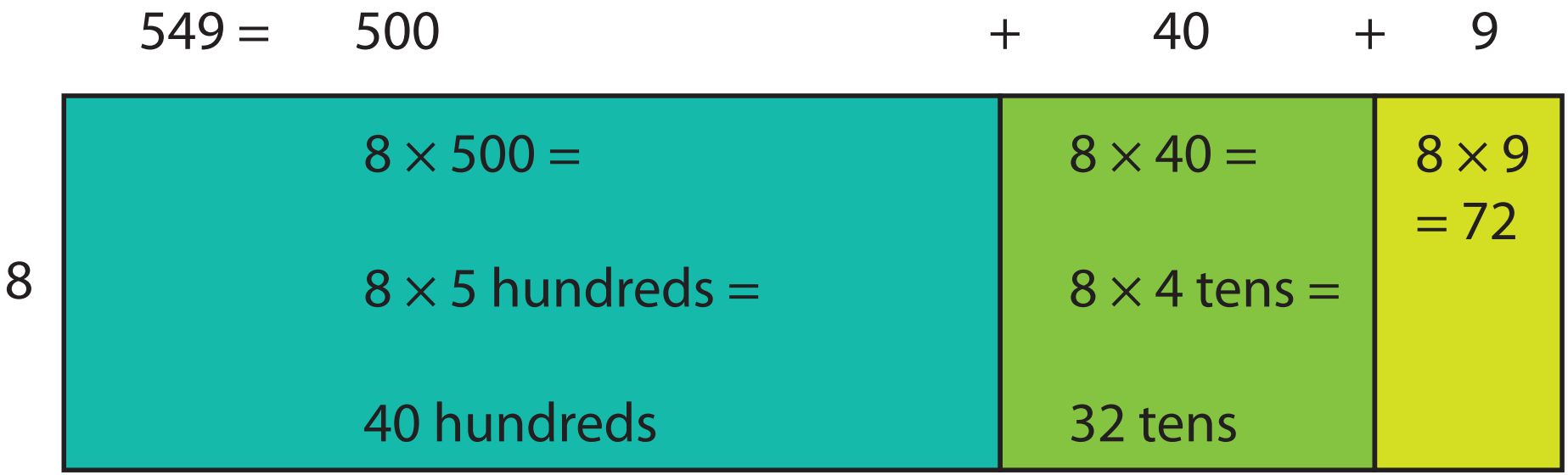
$$3 \times 50$$

3 times (5 tens)
(3 times 5) tens

$$\begin{aligned} 3 \times 50 &= 3 \times (5 \times 10) \\ &= (3 \times 5) \times 10 \\ &= 15 \times 10 = 150 \end{aligned}$$

Uses the associative property of multiplication

Simplified array/area drawing for 8×549



Three accessible ways to record the standard algorithm:

Left to right showing the partial products

$$\begin{array}{r} 549 \\ \times\ 8 \\ \hline 4000 \\ 320 \\ 72 \\ \hline 4392 \end{array}$$

thinking:

- 8×5 hundreds
- 8×4 tens
- 8×9

Right to left showing the partial products

$$\begin{array}{r} 549 \\ \times\ 8 \\ \hline 72 \\ 320 \\ 4000 \\ \hline 4392 \end{array}$$

thinking:

- 8×9
- 8×4 tens
- 8×5 hundreds

Right to left recording the carries below

$$\begin{array}{r} 549 \\ \times\ 8 \\ \hline {\scriptstyle 3\ 7} \\ 4022 \\ \hline 4392 \end{array}$$

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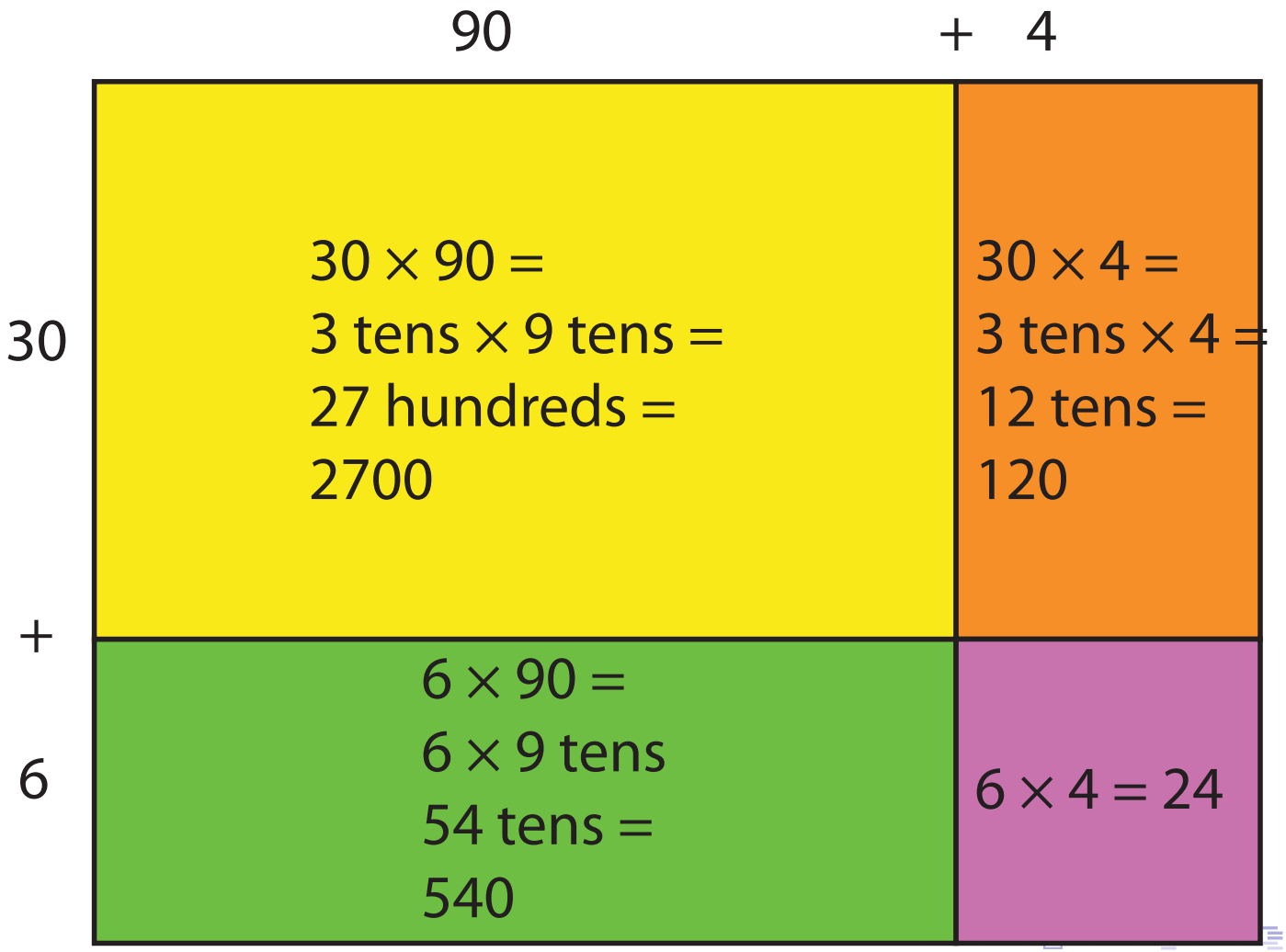
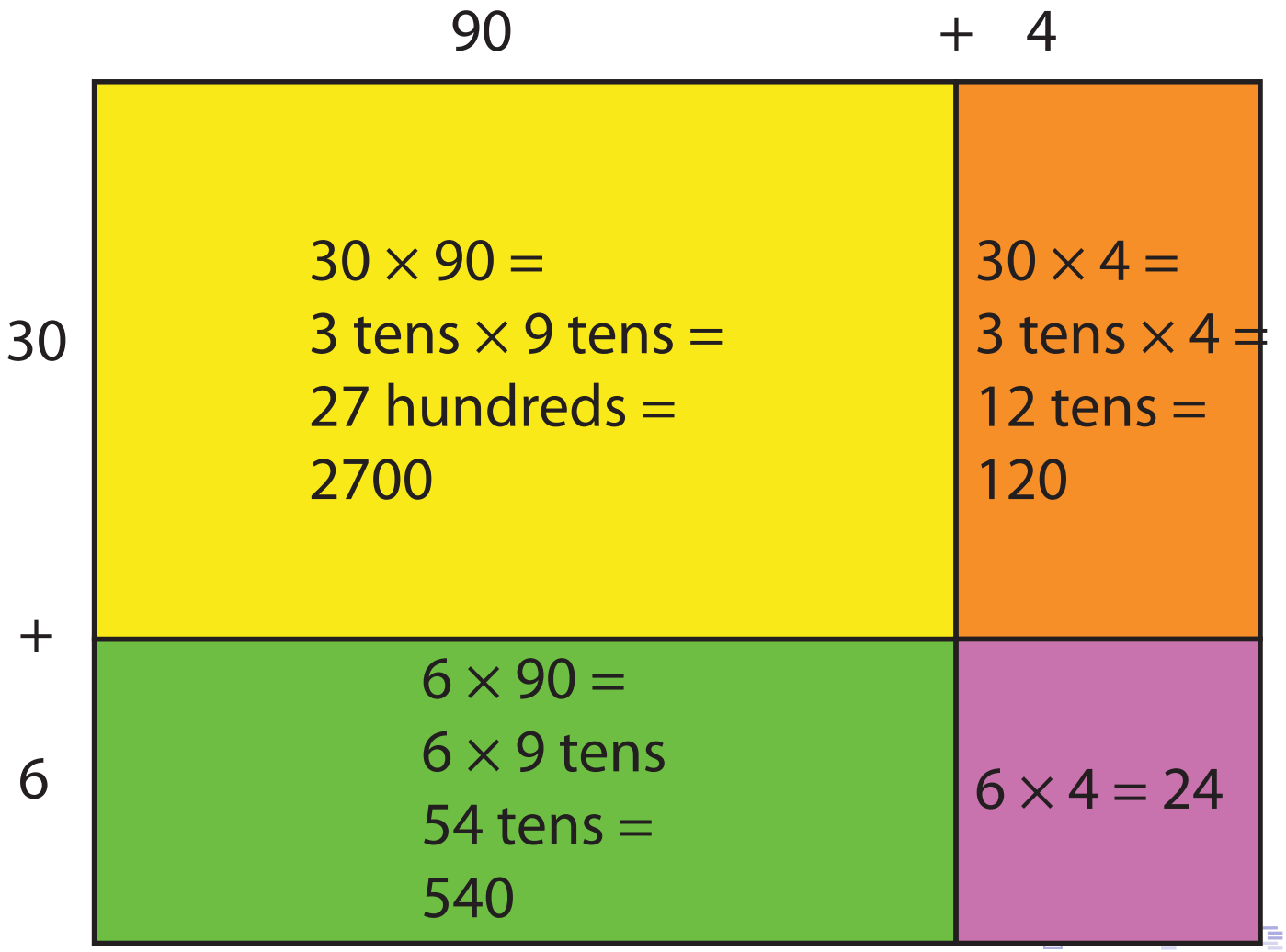
Simplified array/area drawing for 36×94



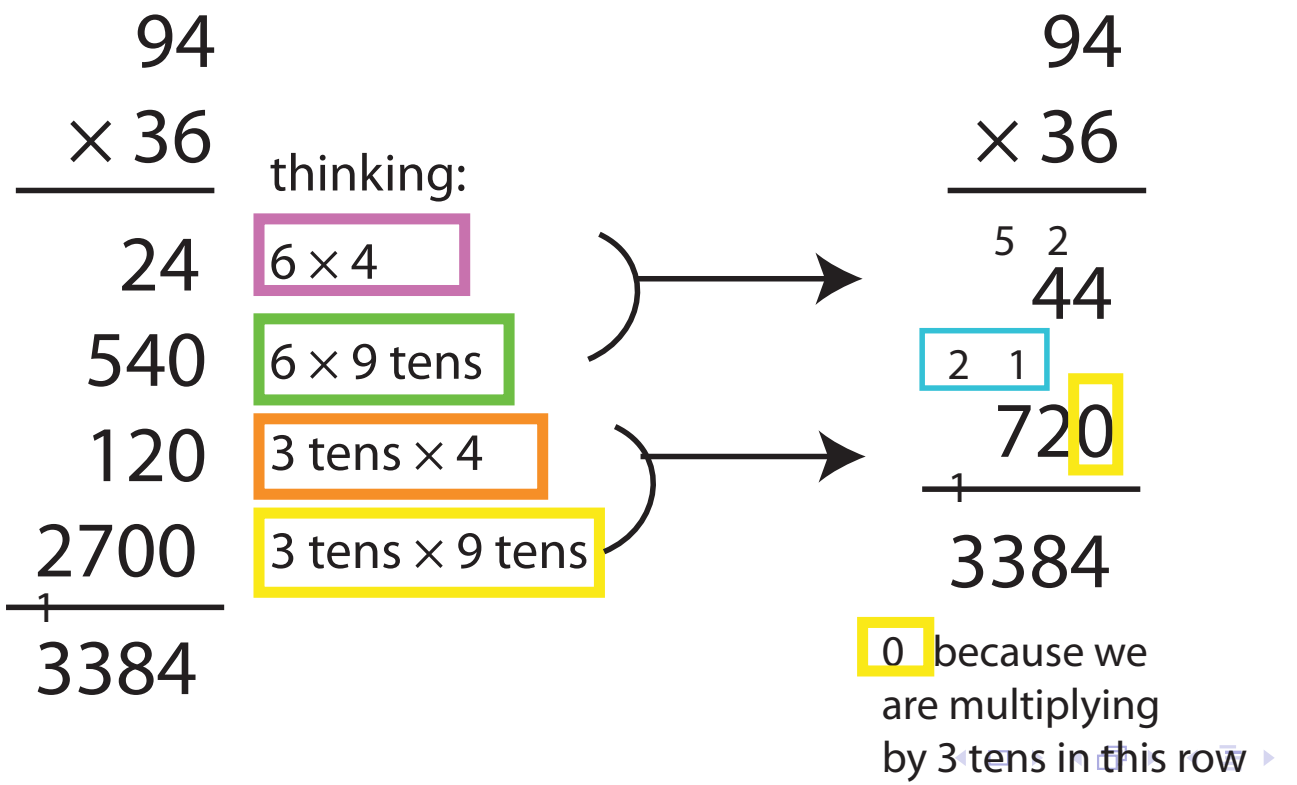
Simplified array/area drawing for 36×94



Two accessible, right to left ways to record the standard algorithm:

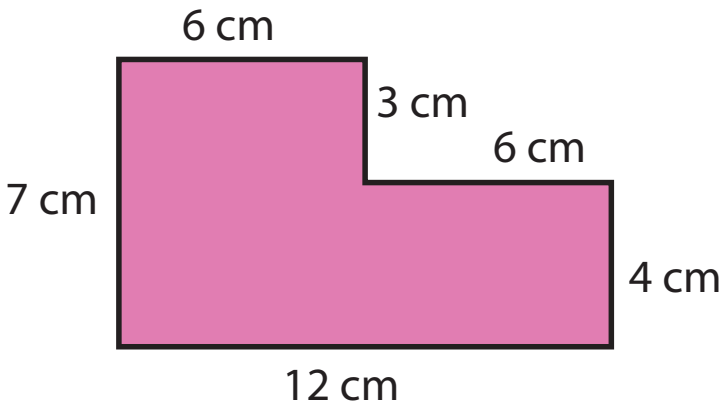
Showing the partial products

Recording the carries below for correct place value placement

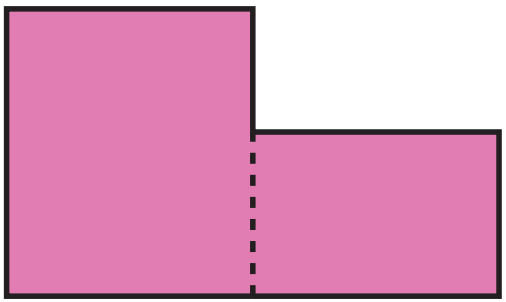


Connection to geometric measurement

What is the area of the shaded shape?

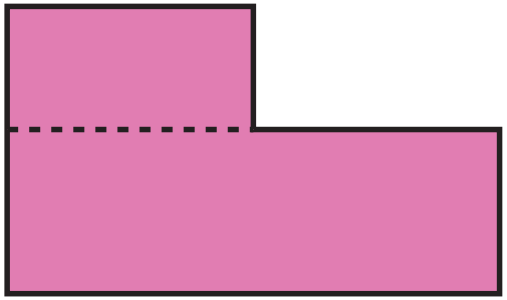


Method 1



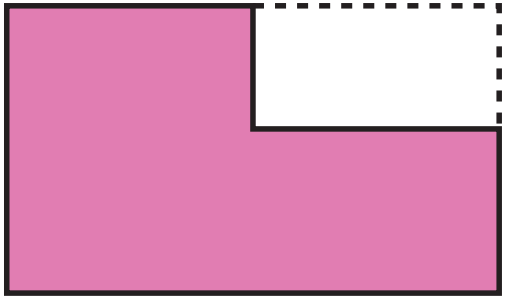
7×6 + 4×6

Method 2



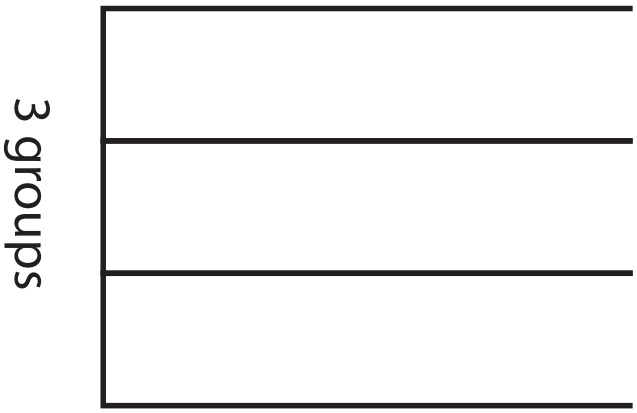
3×6 + 4×12

Method 3



7×12 - 3×6

$$745 \div 3 = ?$$

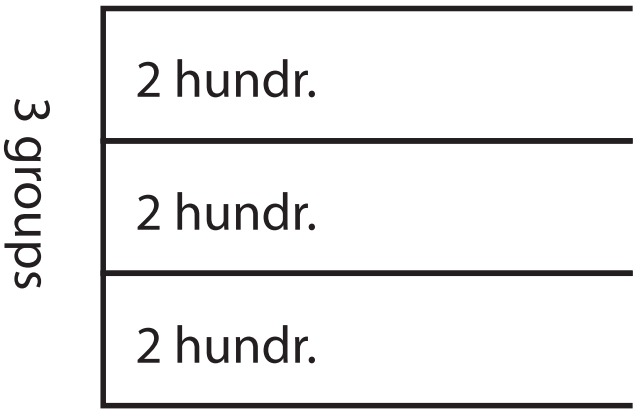


$$3\overline{)745}$$

Thinking:

Divide
7 hundreds, 4 tens, 5 ones
equally among 3 groups,
starting with hundreds.

$$745 \div 3 = ?$$

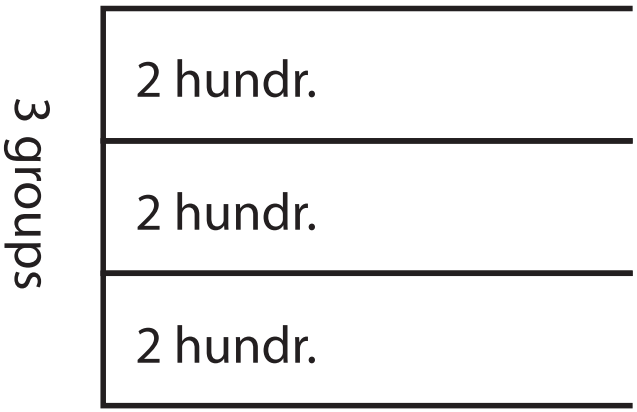


$$\begin{array}{r} 2 \\ 3\overline{)745} \\ -\,6 \\ \hline 1 \end{array}$$

Thinking:

7 hundreds ÷ 3
each group gets
2 hundreds;
1 hundred is left.

$$745 \div 3 = ?$$

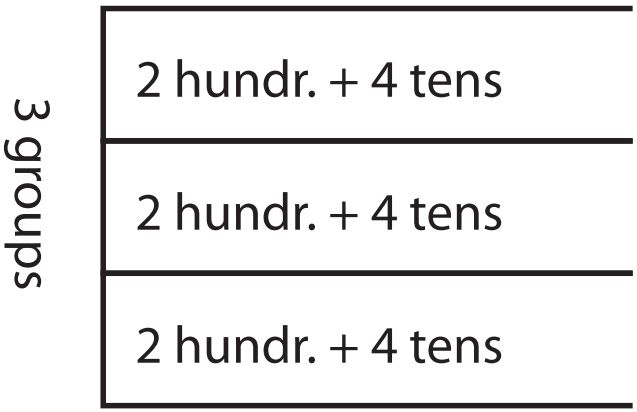


$$\begin{array}{r} 2 \\ 3\overline{)745} \\ -\,6 \\ \hline 14 \end{array}$$

Thinking:

Unbundle 1 hundred.
Now I have
10 tens + 4 tens
= 14 tens.

$$745 \div 3 = ?$$

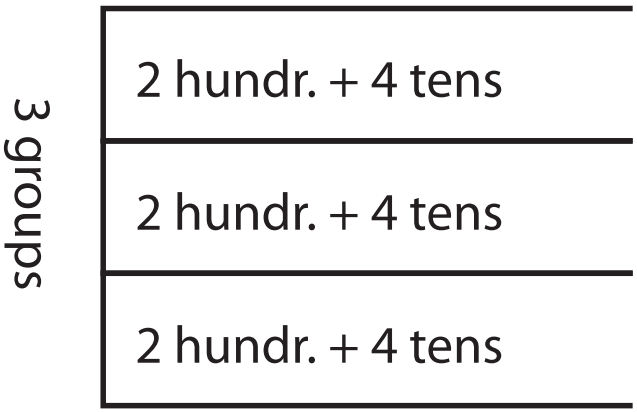


$$\begin{array}{r} 24 \\ 3\overline{)745} \\ -\,6 \\ \hline 14 \\ -\,12 \\ \hline 2 \end{array}$$

Thinking:

14 tens ÷ 3
each group gets
4 tens;
2 tens are left.

$$745 \div 3 = ?$$



$$\begin{array}{r} 24 \\ 3\overline{)745} \\ -\,6 \\ \hline 14 \\ -\,12 \\ \hline 25 \end{array}$$

Thinking:

Unbundle 2 tens.
Now I have
20 + 5 = 25 left.

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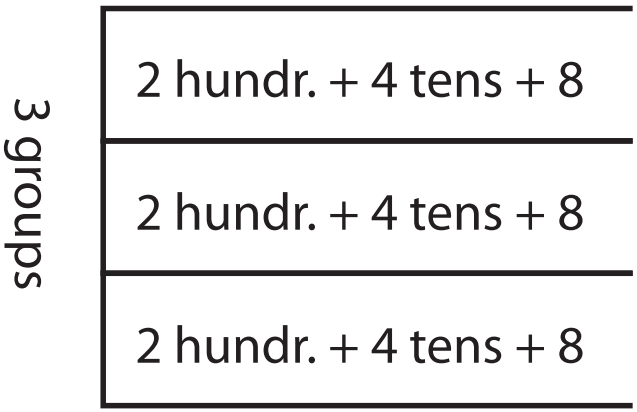
$$745 \div 3 = ?$$



Thinking:

25 ÷ 3
each group gets 8;
1 is left.

$$\begin{array}{r} 248 \\ 3\overline{)745} \\ -\,6 \\ \hline 14 \\ -\,12 \\ \hline 25 \\ -\,24 \\ \hline 1 \end{array}$$

Each group got 248
and 1 is left.

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Case A:

$$\begin{array}{r} 2 \\ 3\,)\overline{805} \\ \underline{6} \\ 2 \end{array}$$

What to do about the 0?

2 hundreds = 20 tens

Case B:

$$\begin{array}{r} 2 \\ 3\,)\overline{65} \\ \underline{6} \\ 0 \end{array}$$

Stop now because of the 0?

No, there are still 5 ones left.

Case C:

$$\begin{array}{r} 3 \\ 14\,)\overline{4314} \\ \underline{42} \\ 11 \end{array}$$

Stop now because 11 is less than 14?

No, it is 11 tens, so there are still $110 + 4 = 114$ left.

1. Ignore the remainder
2. Add 1 to the quotient
3. The remainder is the answer
4. Mixed number answer
5. Decimal answer
6. Use two units in the answer: A 14 foot long piece of rope is divided into 3 equal pieces. How long is each piece? 4 feet, 8 inches

Number and Operations in Base Ten

Division: what to do with the remainder?

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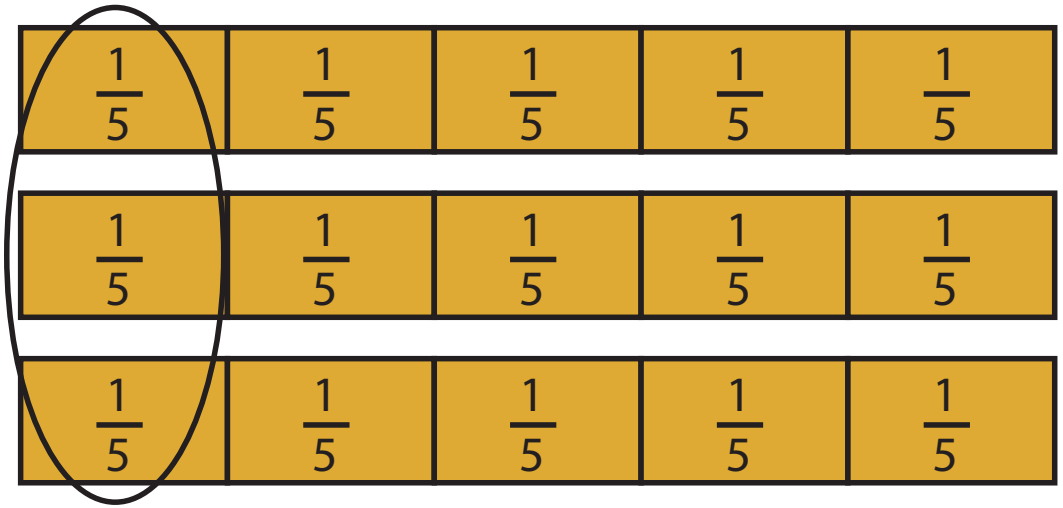
Number and Operations in Base Ten

Also in the Number and Operations in Base Ten progression:
Decimals and operations with decimals

Number and Operations Base Ten Connection to Fractions

3 subs divided equally among 5 people



$3 \div 5 = \frac{3}{5}$

$\frac{1}{5} + \frac{1}{5} + \frac{1}{5} = \frac{3}{5}$

1 person's share is 3/5 of a sub

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