Performance Differences on Mathematics Vocabulary for English Learners and Non-English Learners

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Introductions

What is your name/job title?

What grade/subjects do you teach?

How many years have you been teaching math?

How do you teach mathematics vocabulary?

Which math vocabulary words are difficult for your students to understand?

Why is math vocabulary difficult for students?

Math Vocabulary Difficulties

- Shared meaning in math and English
- Different meanings in math and English
- Multiple meanings in mathematics
- Shared meaning with another content area
- Homonyms with other terms
- Different from terms in other languages

Math Vocabulary Difficulties

Language of Mathematics

numerator

denominator

least common multiple

Fraction

mixed number

proper fraction

multiple

decimal

simplest form

improper fraction

degree

Mathematics Vocabulary

COMMON CORE
STATE STANDARDS FOR
Mathematics

COMMON CORE
STATE STANDARDS INITIATIVE
PREPARING AMERICA'S STUDENTS FOR COLLEGE & CAREER

4. Analyze and compare two- and three-dimensional shapes, in different sizes and orientations, using informal language to describe their similarities, differences, parts (e.g., number of sides and vertices/"corners") and other attributes (e.g., having sides of equal length).

1. Understand the concept of a ratio and use ratio language to describe a ratio relationship between two quantities. *For example, "The ratio of wings to beaks in the bird house at the zoo was 2:1, because for every 2 wings there was 1 beak." "For every vote candidate A received, candidate C received nearly three votes."*

3. Partition circles and rectangles into two, three, or four equal shares, describe the shares using the words *halves*, *thirds*, *half of*, *a third of*, etc., and describe the whole as two halves, three thirds, four fourths. Recognize that equal shares of identical wholes need not have the same shape.

Mathematics Vocabulary

Kevin makes muffins.

- It takes 8 minutes to mix the batter.
- The muffins bake for 17 minutes.
- The muffins then cool for 5 minutes.

What is the total amount of time, in minutes, Kevin spe
baking, and cooling the muffins?

Select the expression equivalent to $(4x + 3) + (-2x + 4)$.

A $-2x + 12$

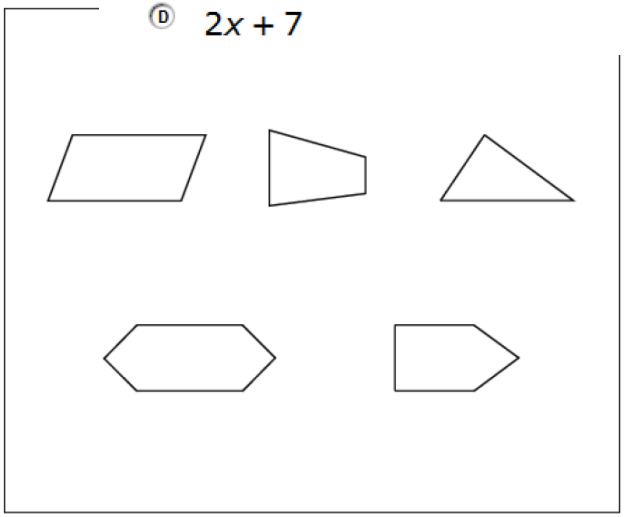
B $-8x + 12$

C $6x + 7$

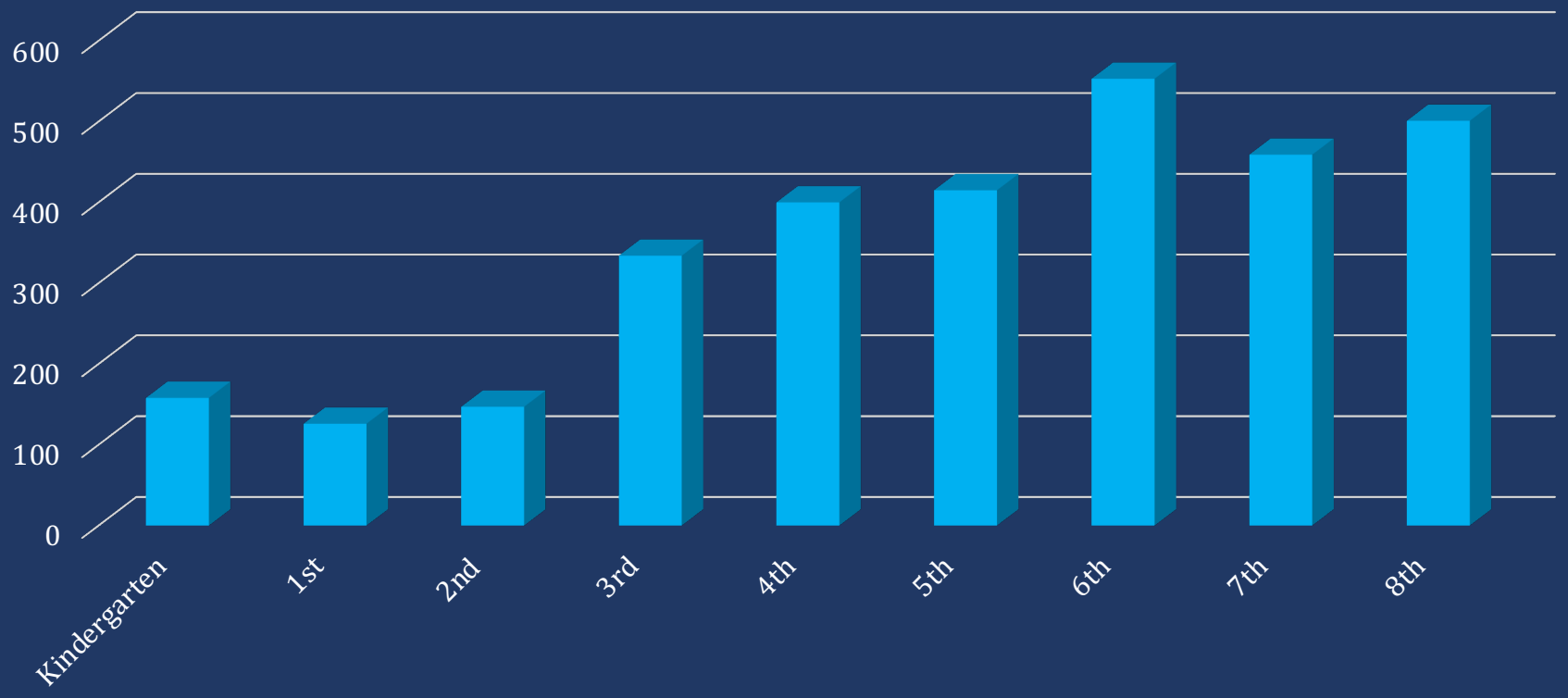
D $2x + 7$

2003

Click all of the shapes that are quadrilaterals.



Vocabulary Across Grades



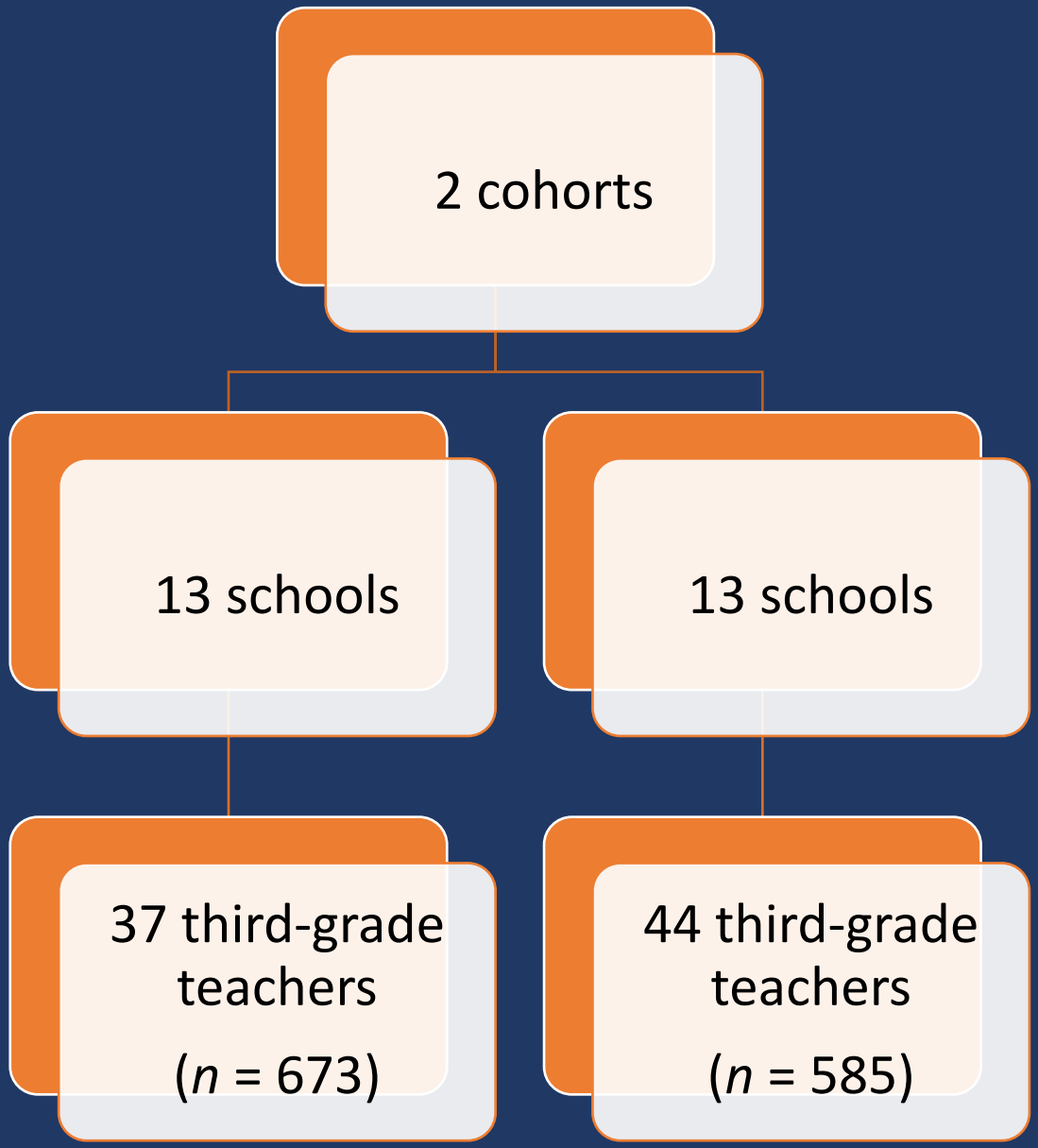
Purpose

ELs vs. Non-ELs

No difficulty vs. Equation difficulty vs. Word-problem difficulty vs. Word-problem + Equation difficulty

Most difficult vocabulary terms

Sample


2 cohorts
13 schools
13 schools
37 third-grade teachers
(n = 673)
44 third-grade teachers
(n = 585)

1. Identify English learners

English learners

Identified by classroom teacher as:

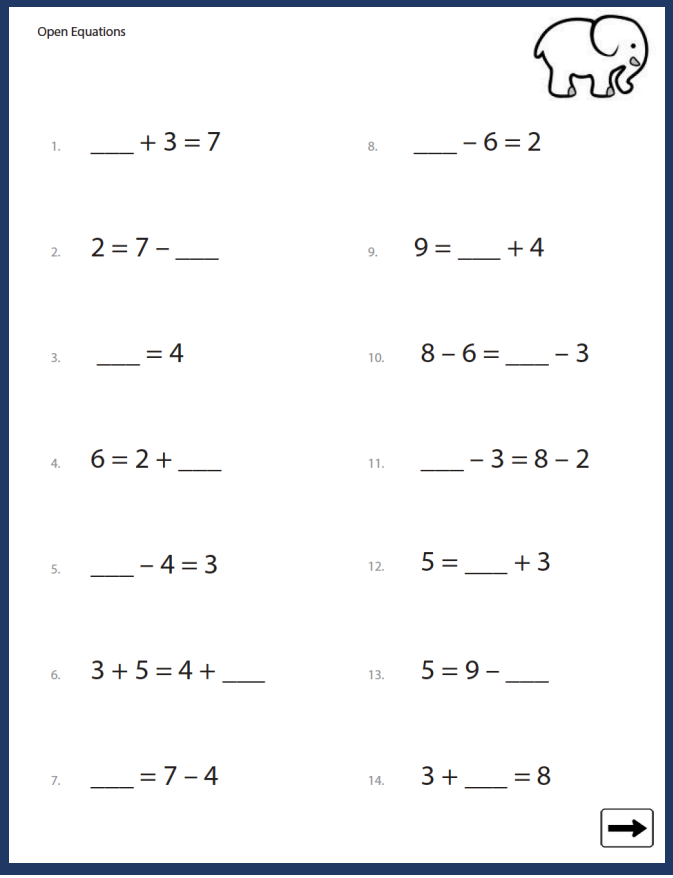
- English learner (EL)
- Non-English learner (non-EL)

2. Identify mathematics difficulty

Equation-Solving Difficulty

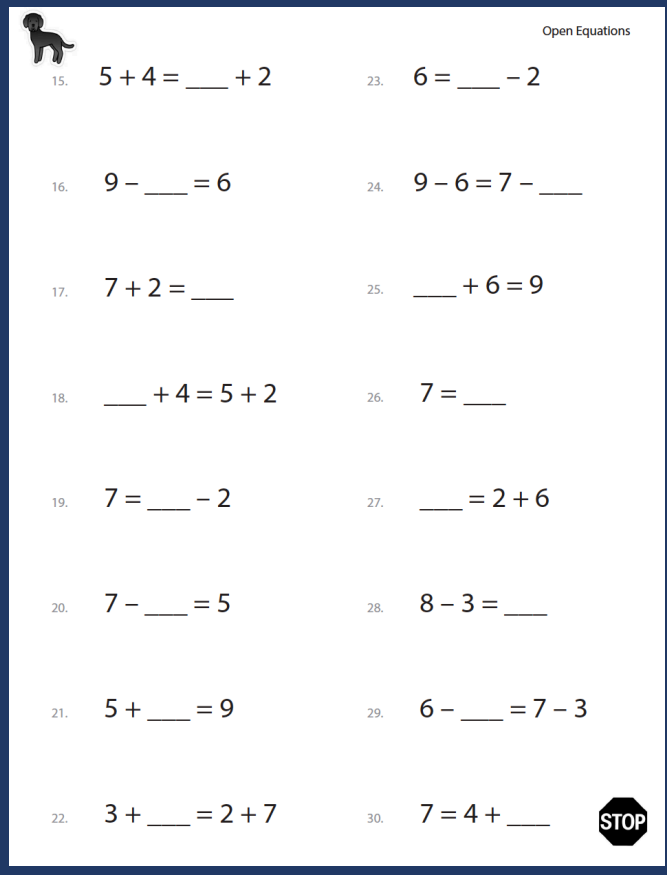
Open Equations (Powell, 2007)

Equations difficulty <27th percentile; α = .93



Open Equations

1. ___ + 3 = 7
2. 2 = 7 − ___
3. ___ = 4
4. 6 = 2 + ___
5. ___ − 4 = 3
6. 3 + 5 = 4 + ___
7. ___ = 7 − 4
8. ___ − 6 = 2
9. 9 = ___ + 4
10. 8 − 6 = ___ − 3
11. ___ − 3 = 8 − 2
12. 5 = ___ + 3
13. 5 = 9 − ___
14. 3 + ___ = 8



Open Equations

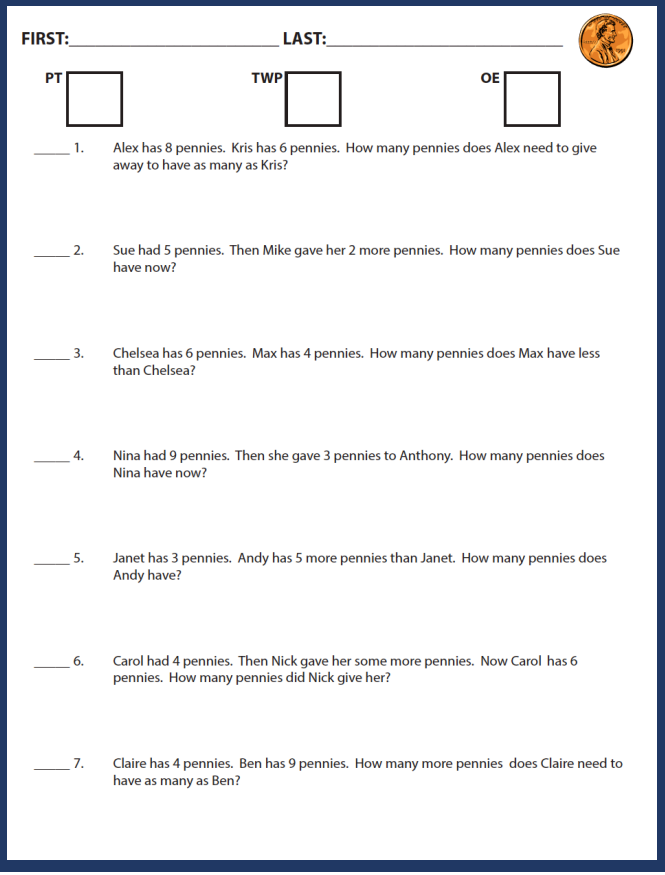
15. 5 + 4 = ___ + 2
16. 9 − ___ = 6
17. 7 + 2 = ___
18. ___ + 4 = 5 + 2
19. 7 = ___ − 2
20. 7 − ___ = 5
21. 5 + ___ = 9
22. 3 + ___ = 2 + 7
23. 6 = ___ − 2
24. 9 − 6 = 7 − ___
25. ___ + 6 = 9
26. 7 = ___
27. ___ = 2 + 6
28. 8 − 3 = ___
29. 6 − ___ = 7 − 3
30. 7 = 4 + ___

STOP

Word-Problem Difficulty

Single-Digit Word Problems (Jordan & Hanich, 2000)

Word-problem difficulty <28th percentile; α = .89



FIRST:_____ LAST:_____

PT ☐ TWP ☐ OE ☐

_____ 1. Alex has 8 pennies. Kris has 6 pennies. How many pennies does Alex need to give away to have as many as Kris?

_____ 2. Sue had 5 pennies. Then Mike gave her 2 more pennies. How many pennies does Sue have now?

_____ 3. Chelsea has 6 pennies. Max has 4 pennies. How many pennies does Max have less than Chelsea?

_____ 4. Nina had 9 pennies. Then she gave 3 pennies to Anthony. How many pennies does Nina have now?

_____ 5. Janet has 3 pennies. Andy has 5 more pennies than Janet. How many pennies does Andy have?

_____ 6. Carol had 4 pennies. Then Nick gave her some more pennies. Now Carol has 6 pennies. How many pennies did Nick give her?

_____ 7. Claire has 4 pennies. Ben has 9 pennies. How many more pennies does Claire need to have as many as Ben?

_____ 8. Jen had 7 pennies. Then she gave some pennies to Joe. Now Jen has 2 pennies. How many pennies did she give to Joe?

_____ 9. Emily has 3 pennies. John has 6 pennies. How many pennies do they have altogether?

_____ 10. Maria and Kevin have 8 pennies together. Maria has 3 pennies. How many pennies does Kevin have?

_____ 11. Ashley has 7 pennies. Jason has 4 pennies less than Ashley. How many pennies does Jason have?

_____ 12. Dennis has 7 pennies. Molly has 5 pennies. How many pennies does Dennis have more than Molly?

_____ 13. Karen had some pennies. Then Matt gave her 4 more pennies. Now Karen has 6 pennies. How many pennies did she have to start with?

_____ 14. Lisa had some pennies. Then she gave 3 pennies to Bill. Now Lisa has 5 pennies. How many pennies did Lisa have to start with?

Demographics by Difficulty Status and English Learner Status

	No difficulty (*n* = 788)				Equation difficulty (*n* = 125)				Word problem difficulty (*n* = 135)				Word problem + Equation difficulty (*n* = 211)			
	EL (*n* = 242)		Non-EL (*n* = 546)		EL (*n* = 36)		Non-EL (*n* = 89)		EL (*n* = 101)		Non-EL (*n* = 34)		EL (*n* = 136)		Non-EL (*n* = 75)	
Variable	*n*	%	*n*	%	*n*	%	*n*	%	*n*	%	*n*	%	*n*	%	*n*	%
Female	117	48.3	262	48.0	25	69.4	45	50.6	39	38.6	23	67.7	76	55.9	44	58.7
Race																
African American	5	2.1	62	11.3	1	2.8	18	20.2	1	1.0	4	11.8	4	2.9	26	34.7
Asian American	13	5.4	27	4.9	1	2.8	3	3.4	2	2.0	1	2.9	6	4.4	1	1.3
Caucasian	7	2.9	307	56.2	1	2.8	43	48.3	2	2.0	6	17.6	1	0.7	9	12.0
Hispanic	207	85.5	86	15.8	29	80.6	14	15.7	95	94.1	18	52.9	114	83.8	34	45.3
Multi-racial	5	2.1	54	9.9	4	11.1	9	10.1	1	1.0	4	11.7	5	3.7	3	4.0
Other	5	2.1	10	1.8	0	0.0	2	2.2	0	0.0	1	2.9	6	4.4	2	1.3
School-identified disability	3	1.2	21	3.8	1	2.8	7	7.9	5	5.0	5	14.7	17	12.5	22	29.3
English learner	242	100.0	0	0.0	36	100.0	0	0.0	101	100.0	0	0.0	136	100.0	0	0.0
Retained	8	3.3	11	2.0	2	5.6	1	1.1	10	9.9	4	11.7	16	6.3	6	8.0

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Note. EL = English Learner.

Texas English Language Proficiency Assessment System (TELPAS) Scores for English Learners

	No difficulty (n = 242)		Equation difficulty (n = 36)		Word problem difficulty (n = 101)		Word problem + Equation difficulty (n = 136)	
Variable	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*
Listening	3.16	0.76	3.03	0.80	2.50	0.97	2.30	0.93
Speaking	2.86	0.86	2.68	0.95	2.19	0.95	2.05	0.83
Reading	2.65	0.94	2.29	0.87	1.67	0.70	1.55	0.67
Writing	2.45	0.89	2.18	0.90	1.69	0.75	1.68	0.77
Composite	2.68	0.76	2.47	0.75	1.87	0.67	1.73	0.62

4 = advanced high
3 = advanced
2 = intermediate
1 = beginning

Mathematics Vocabulary

Third-Grade Mathematics Vocabulary (Powell & Tran, 2016)

$\alpha = .92$

NUMBER AND OPERATIONS	NUMBER AND OPERATIONS - FRACTIONS	GEOMETRY	MEASUREMENT

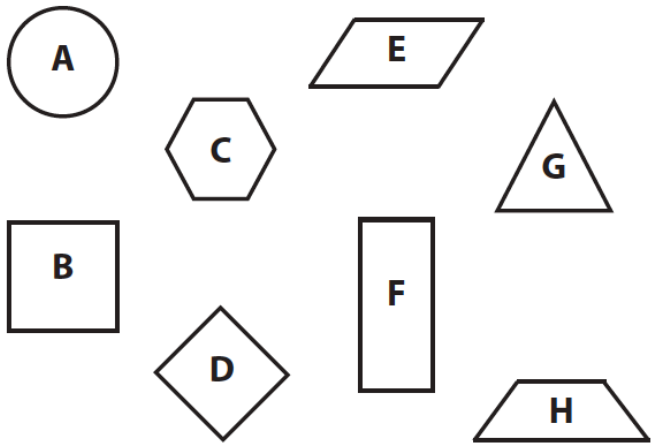
Fall 2016

Mathematics Vocabulary - Grade 3

Answer the questions. Try the easy problems first, then go back and try the harder problems.

1. Match the letter of each shape with the name.

circle ☐
triangle ☐
rectangle ☐
parallelogram ☐
rhombus ☐
square ☐
trapezoid ☐



2. Write an **odd** number. ☐

Write an **even** number. ☐

3. Write a **fraction** for the picture.

 ☐

4. In the box, draw a **line**. ☐

In the box, draw a **line segment**. ☐

circle
triangle
rectangle
parallelogram
rhombus
square
trapezoid

odd
even

fraction

line
line segment

5. Write 537 in **expanded form**.

6. Write a **unit fraction**.

7. Draw an **array** for 4 times 2.

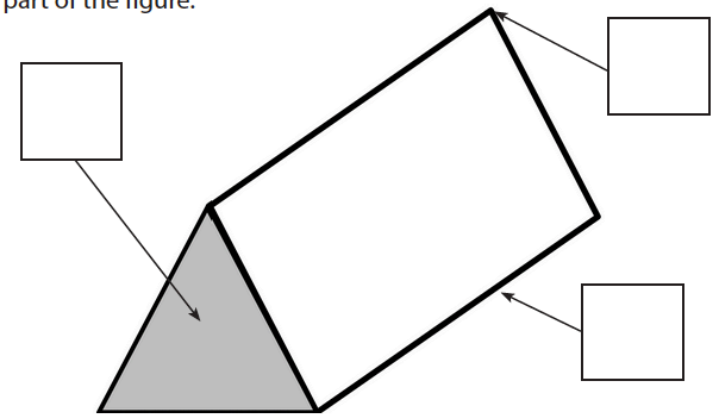
8. Match the letter with each part of the figure.

A edge

B face

C side

D vertex



9. Draw a **polygon**.

expanded form

unit fraction

array

edge
face
vertex

polygon

11. Draw a **right angle**.

12. Write an **equation**.

13. Write *three-hundred, twenty-five* in **standard form**.

14. Mark the **perimeter** of the shape.

Mark the **area** of the shape.

15. Draw a **quadrilateral**.

16. Circle the set of **equivalent fractions**.

A. $\frac{3}{4} = \frac{3}{8}$

B. $\frac{3}{4} = \frac{8}{12}$

C. $\frac{3}{4} = \frac{6}{8}$

right angle

equation

standard form

perimeter
area

quadrilateral

equivalent
fractions

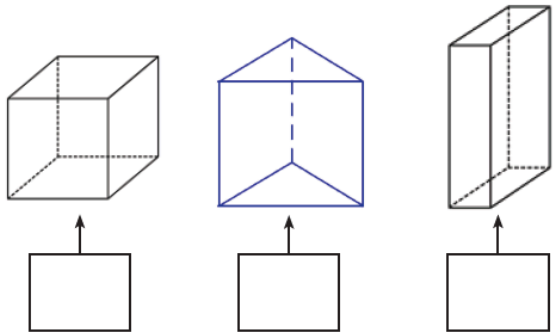
17. Write the letter of each shape.

A cube

B rectangular pyramid

C rectangular prism

D triangular prism



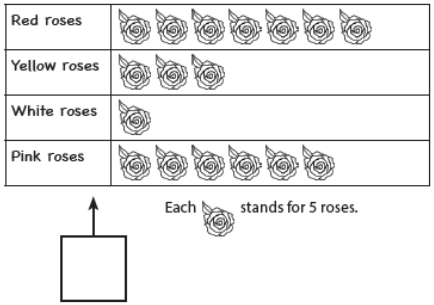
18. Write the letter that matches each graph.

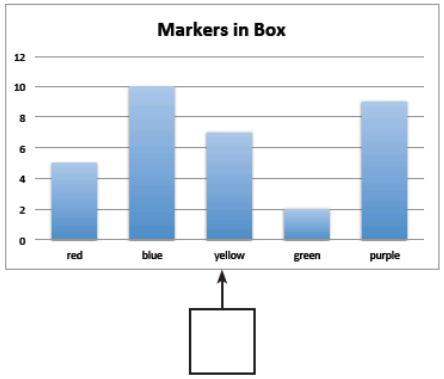
A bar graph

B dot plot

C pictograph

D tally chart





Fruit	Total Number
Apple	𝍸 𝍸 ||
Banana	𝍸 |
Orange	𝍸 ||||
Mango	𝍸 𝍸

19. Draw an **angle**.

cube
rectangular pyramid
rectangular prism
triangular prism

bar graph
dot plot
pictograph
tally chart

angle

20. Write the letter for each part of a number sentence.

A addend
B difference
C dividend
D divisor
E factor
F minuend
G product
H quotient
J sum

$5 + 6 = 11$ ☐ ☐

$24 \div 4 = 6$ ☐ ☐ ☐

$3 \times 9 = 27$ ☐ ☐

$14 - 5 = 9$ ☐

21. What is the name of this?

$6\overline{)125}$ 20 R5 ☐

22. Write the **numerator**.

$\frac{3}{8}$ ☐

Write the **denominator**.

$\frac{6}{9}$ ☐

23. Draw a shape with three **sides**.

☐

addend
difference
dividend
divisor
factor
minuend
product
quotient
sum

remainder

numerator
denominator

sides

STOP

For non-English learners

Means and Standard Deviations by Difficulty Status and English Learner Status

	No difficulty (n = 787)				Equation difficulty (n = 125)				Word problem difficulty (n = 135)				Word problem + Equation difficulty (n = 211)			
	EL (n = 242)		Non-EL (n = 545)		EL (n = 36)		Non-EL (n = 89)		EL (n = 101)		Non-EL (n = 34)		EL (n = 136)		Non-EL (n = 75)	
Variable	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*
Word problems	11.43	1.96	12.71	1.57	10.44	1.99	11.27	2.02	5.05	1.72	5.18	2.05	4.12	1.99	4.41	1.97
Open equations	13.29	5.59	15.49	7.31	3.97	1.13	3.35	1.35	9.85	4.04	9.38	4.13	2.82	1.55	2.57	1.54
Math vocabulary	15.02	6.41	20.49	7.90	11.06	5.79	14.52	6.78	9.31	4.89	10.74	3.85	7.22	4.51	8.19	4.80

Note. EL = English learner.

For English learners

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Variable	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*
Word problems	11.43	1.96	12.71	1.57	10.44	1.99	11.27	2.02	5.05	1.72	5.18	2.05	4.12	1.99	4.41	1.97
Open equations	13.29	5.59	15.49	7.31	3.97	1.13	3.35	1.35	9.85	4.04	9.38	4.13	2.82	1.55	2.57	1.54
Math vocabulary	15.02	6.41	20.49	7.90	11.06	5.79	14.52	6.78	9.31	4.89	10.74	3.85	7.22	4.51	8.19	4.80

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Means and Standard Deviations by Difficulty Status and English Learner Status

	No difficulty (n = 787)				Equation difficulty (n = 125)				Word problem difficulty (n = 135)				Word problem + Equation difficulty (n = 211)			
	EL (n = 242)		Non-EL (n = 545)		EL (n = 36)		Non-EL (n = 89)		EL (n = 101)		Non-EL (n = 34)		EL (n = 136)		Non-EL (n = 75)	
Variable	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*
Word problems	11.43	1.96	12.71	1.57	10.44	1.99	11.27	2.02	5.05	1.72	5.18	2.05	4.12	1.99	4.41	1.97
Open equations	13.29	5.59	15.49	7.31	3.97	1.13	3.35	1.35	9.85	4.04	9.38	4.13	2.82	1.55	2.57	1.54
Math vocabulary	15.02	6.41	20.49	7.90	11.06	5.79	14.52	6.78	9.31	4.89	10.74	3.85	7.22	4.51	8.19	4.80

Note. EL = English learner.

$F = 89.85, p < .001$

Means and Standard Deviations by Difficulty Status and English Learner Status

	No difficulty (n = 787)				Equation difficulty (n = 125)				Word problem difficulty (n = 135)				Word problem + Equation difficulty (n = 211)			
	EL (n = 242)		Non-EL (n = 545)		EL (n = 36)		Non-EL (n = 89)		EL (n = 101)		Non-EL (n = 34)		EL (n = 136)		Non-EL (n = 75)	
Variable	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*
Word problems	11.43	1.96	12.71	1.57	10.44	1.99	11.27	2.02	5.05	1.72	5.18	2.05	4.12	1.99	4.41	1.97
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Math vocabulary	15.02	6.41	20.49	7.90	11.06	5.79	14.52	6.78	9.31	4.89	10.74	3.85	7.22	4.51	8.19	4.80

Note. EL = English learner.

$F = 7.23$, $p = .008$

Means and Standard Deviations by Difficulty Status and English Learner Status

	No difficulty (n = 787)				Equation difficulty (n = 125)				Word problem difficulty (n = 135)				Word problem + Equation difficulty (n = 211)			
	EL (n = 242)		Non-EL (n = 545)		EL (n = 36)		Non-EL (n = 89)		EL (n = 101)		Non-EL (n = 34)		EL (n = 136)		Non-EL (n = 75)	
Variable	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*
Word problems	11.43	1.96	12.71	1.57	10.44	1.99	11.27	2.02	5.05	1.72	5.18	2.05	4.12	1.99	4.41	1.97
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Math vocabulary	15.02	6.41	20.49	7.90	11.06	5.79	14.52	6.78	9.31	4.89	10.74	3.85	7.22	4.51	8.19	4.80

Note. EL = English learner.

$F = 2.39$, $p = .124$

Means and Standard Deviations by Difficulty Status and English Learner Status

	No difficulty (n = 787)				Equation difficulty (n = 125)				Word problem difficulty (n = 135)				Word problem + Equation difficulty (n = 211)			
	EL (n = 242)		Non-EL (n = 545)		EL (n = 36)		Non-EL (n = 89)		EL (n = 101)		Non-EL (n = 34)		EL (n = 136)		Non-EL (n = 75)	
Variable	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*
Word problems	11.43	1.96	12.71	1.57	10.44	1.99	11.27	2.02	5.05	1.72	5.18	2.05	4.12	1.99	4.41	1.97
Open equations	13.29	5.59	15.49	7.31	3.97	1.13	3.35	1.35	9.85	4.04	9.38	4.13	2.82	1.55	2.57	1.54
Math vocabulary	15.02	6.41	20.49	7.90	11.06	5.79	14.52	6.78	9.31	4.89	10.74	3.85	7.22	4.51	8.19	4.80

Note. EL = English learner.

$F = 2.21$, $p = .147$

NUMBER AND OPERATIONS

NUMBER AND OPERATIONS - FRACTIONS

GEOMETRY

MEASUREMENT

Easier Terms for ELs and non-ELs

even expanded form odd		circle cube edge face rectangle square triangle triangular prism vertex	perimeter

Difficult Terms for ELs and Non-ELs with MD

array difference dividend divisor factor product quotient remainder sum	denominator numerator unit fraction	line line segment	angle right angle

Difficult Terms for ELs and Non-ELs with EQD + WPD

addend
array
difference
dividend
divisor
equation
factor
product
quotient
remainder
sum

denominator
equivalent
fraction
fraction
numerator
unit fraction

line
line segment

angle
area
bar graph
pictograph
right angle
tally chart

Implications for Practice

Use formal math language

Use explicit instruction

Formal Math Language

Use terms specifically

Use terms precisely

- Technical terms

trapezoid	rhombus	numerator	addend	subtract

- Subtechnical terms

base	degrees	cube	plane	arc

- Symbolic terms

plus	zero	twelve	dollars	and

- General terms

above	measure	answer	longest	outside

Instead of…	Say…
“And the last one is 10.”	“8, 9, 10. We’ll stop counting there but we could count more.”
“What number is in the tens place?”	“What digit is in the tens place?”
“Six hundred and forty-eight”	“Six hundred forty-eight”
“Bigger number and smaller number”	“Number that is greater and the number that is less”

Hughes et al. (2016)

Instead of…	Say…
“Numbers in the fraction”	“This fraction is one number.”
“Top number and bottom number”	“Numerator and denominator”
“Reduce”	“Find an equivalent fraction”
“One point two nine”	“One and twenty-nine hundredths”

Hughes et al. (2016)

Instead of…	Say…
“Corner”	“Angle”
“Flips, slides, and turns”	“Reflections, translations, and rotations”
“Box or ball”	“Cube or sphere”
“Long hand and short hand”	“Minute hand and hour hand”

Hughes et al. (2016)

Mathematical Language

Instead of that...	Say this...

Explicit Instruction

Modeling	Practice
Clear Explanation	Guided Practice
Planned Examples	Independent Practice

Supporting Practices

- Asking the right questions
- Eliciting frequent responses
- Providing immediate specific feedback
- Maintaining a brisk pace

Modeling

Clear Explanation

Planned Examples

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

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

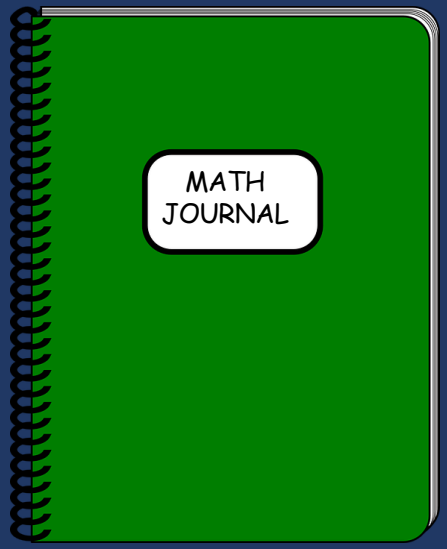
"20 **plus** 70 is 90. I write 90 right here under the **equal line**."

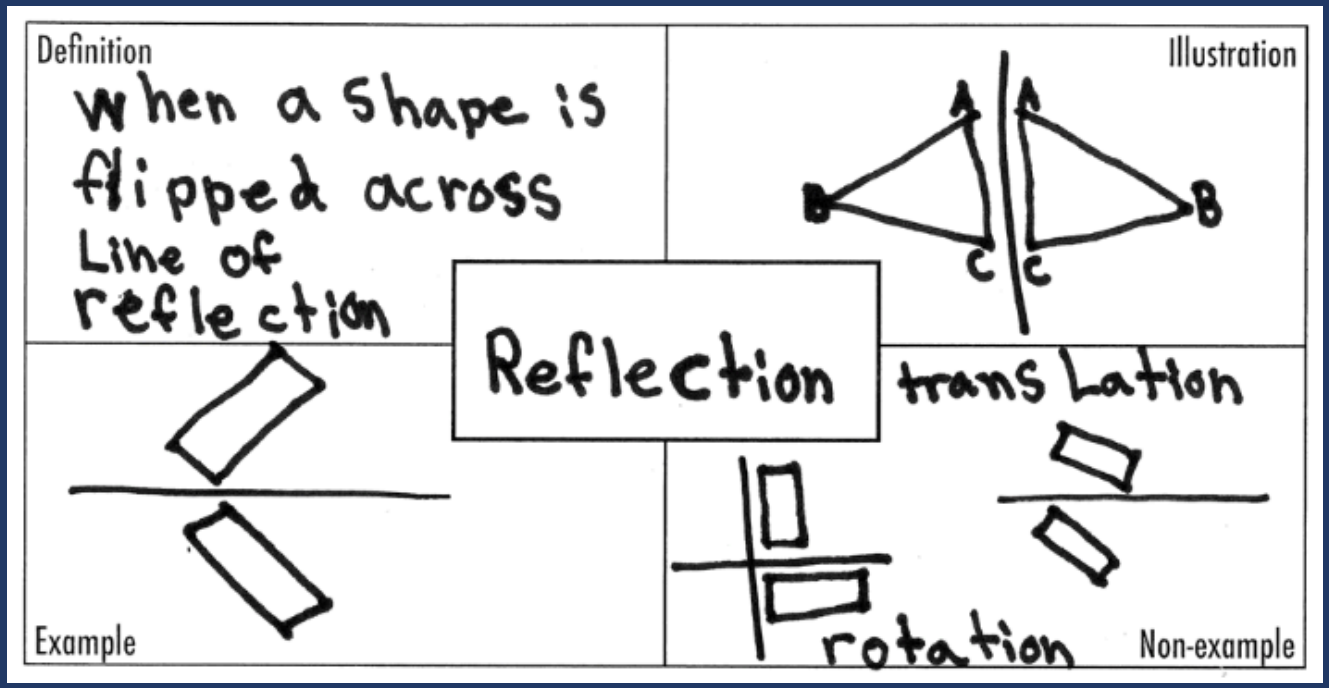
"Then I **add** 6 **plus** 9. What's 6 **plus** 9?"

"6 **plus** 9 is 15. So, I write 15 here."

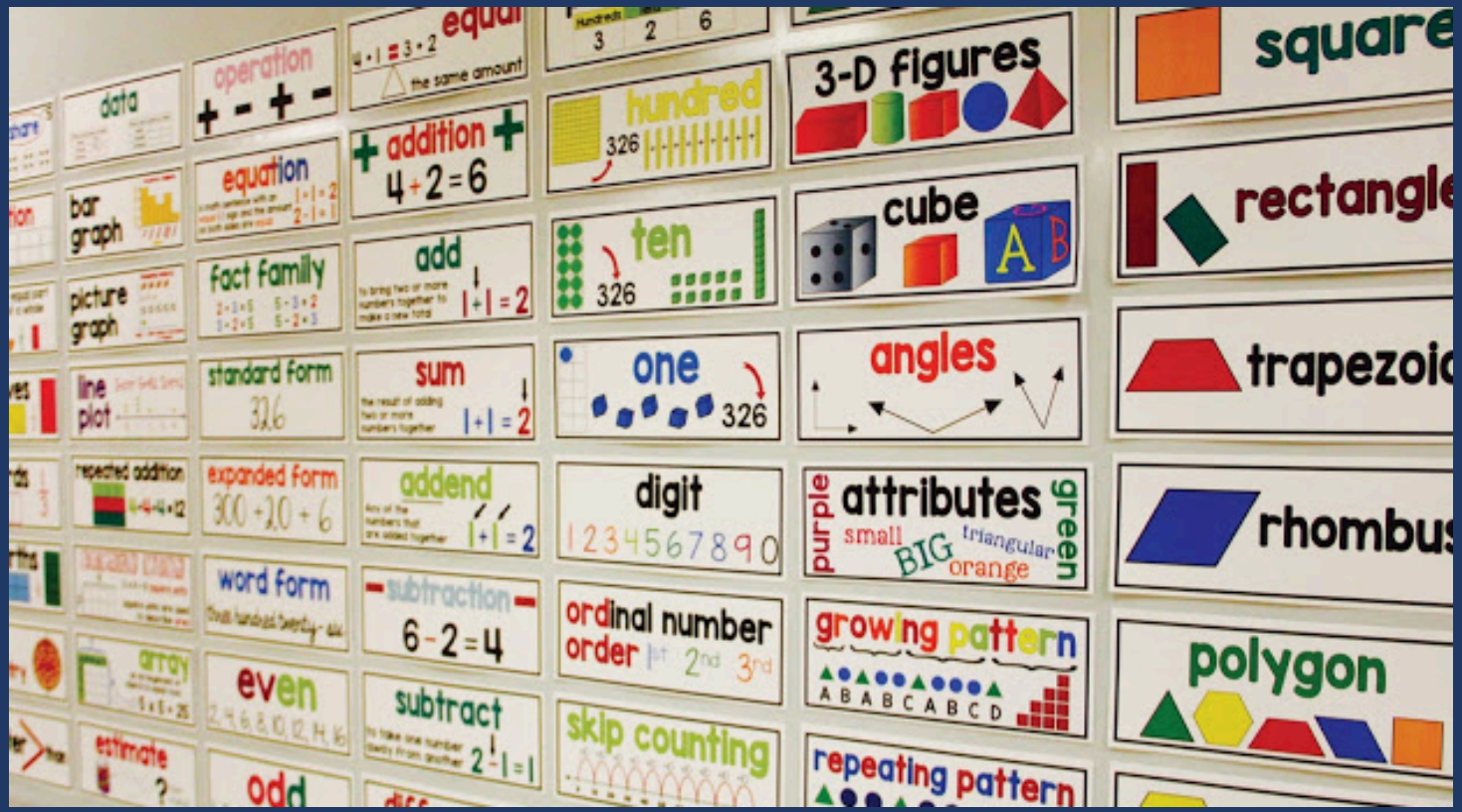
"Finally, we **add** the **partial sums**: 90 and 15. 90 **plus** 15 is 105. So, 26 **plus** 79 **equals** 105."

Math Journals



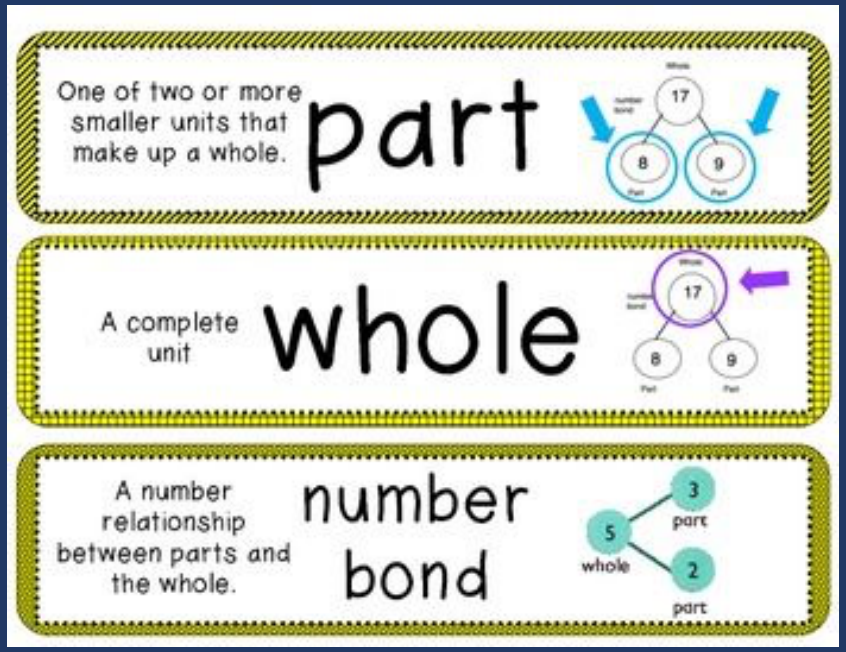


Word Walls

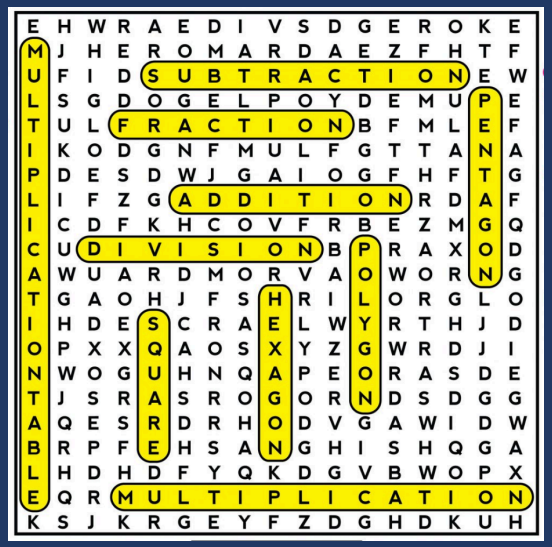


http://www.starrspangledplanner.com/math-word-walls/

Vocabulary Cards



Math Games


E H W R A E D I V S D G E R O K E
M J H E R O M A R D A E Z F H T F
U F I D S U B T R A C T I O N E W
L S G D O G E L P O Y D E M U P E
T U L F R A C T I O N B F M L E F
I K O D G N F M U L F G T T A N A
P D E S D W J G A I O G F H F T G
L I F Z G A D D I T I O N R D A F
I C D F K H C O V F R B E Z M G Q
C U D I V I S I O N B P R A X O D
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T G A O H J F S H R I L O R G L O
I H D E S C R A E L W Y R T H J D
O P X X Q A O S X Y Z G W R D J I
N W O G U H N Q A P E O R A S D E
S J S R A S R O G O R N D S D G G
Q E S R D R H O D V G A W I D W
B R P F E H S A N G H I S H Q G A
L H D H D F Y Q K D G V B W O P X
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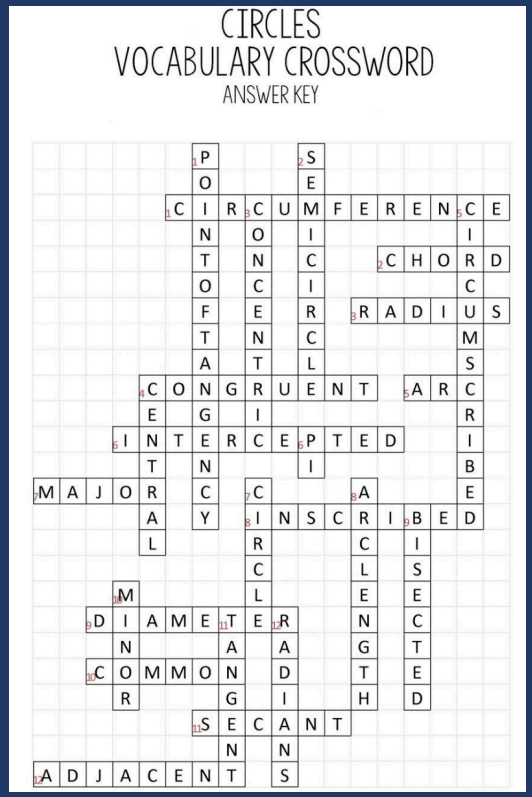
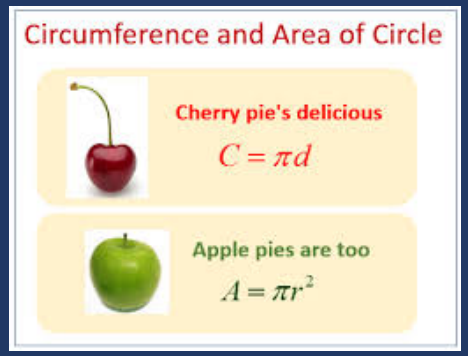
K S J K R G E Y F Z D G H D K U H

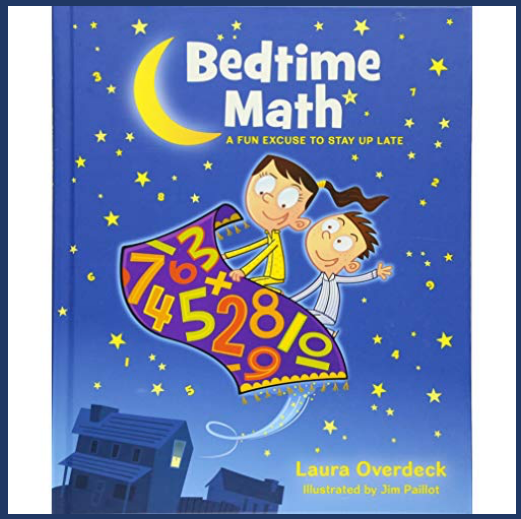

CIRCLES
VOCABULARY CROSSWORD
ANSWER KEY


Houghton Mifflin Math
Grade 2
eGames
How to Play
New Game
Math Lingo
ALL
UNIT
60 minutes = 1 ____.
change
minute hand
hour hand
hour
equal amounts
second
quarter-hour
half-hour
minute


MATH
BINGO

Other Ideas





Problem type	Definition	Examples			Equation	Graphic organizer
Total		Total unknown	Part unknown			

Thanks

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Exit Slip

1. What was most valuable part of today's session?

2. What questions do you still have about the topics or the discussion?

3. Is there anything else you want me to know?