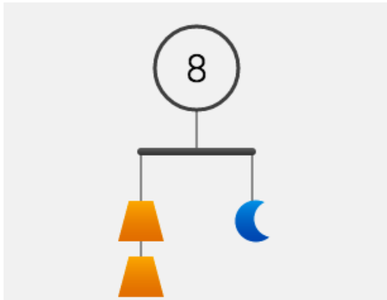
Using Mathematical Puzzles to Build Algebraic Habits of Mind

Mary K. Fries,
Education Development Center, Inc., MA

Why Puzzles?

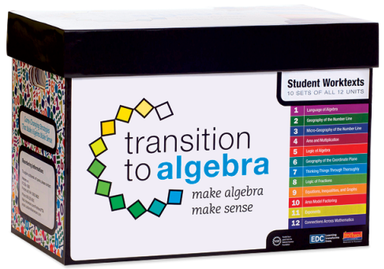
Mathematical Puzzles:

- (are fun and engaging)
- are genuine problems
- support number sense
- encourage logical reasoning
- help students develop strategy in problem solving
- promote constructive collaboration
- encourage perseverance and stamina



Our Research and Development

- Developed at the Education Development Center with support from the National Science Foundation



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EDC Learning transforms lives.

Transition to Algebra Curriculum

transition to algebra
make algebra make sense

- A coherent, full-year NSF-funded algebra support curriculum organized around five key ***algebraic habits of mind***

"…what is even more important is to give students the tools they will need in order to use, understand, and even make mathematics that does not yet exist. A curriculum organized around habits of mind tries to close the gap between what the users and makers of mathematics do."

Cuoco, Goldenberg, and Mark, 1996, p. 376

SolveMe Puzzle Apps

- Based on paper-based R&D with puzzles embedded in elementary and high school curricula

Habits of Mind Approach

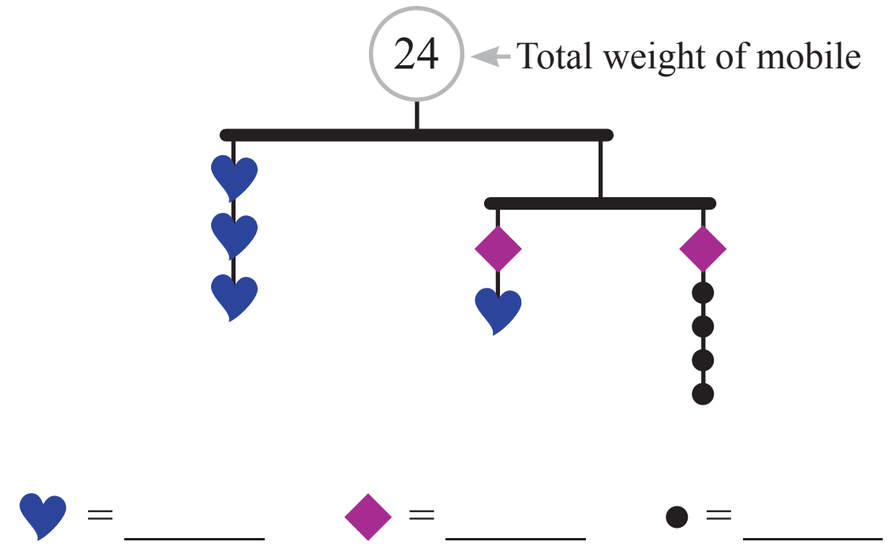
- Quickly giving students the mathematical knowledge, skill, and confidence to succeed in a first-year algebra class
- Focus on a few key mathematical ways of thinking or mathematical habits of mind
- Important algebra topics are used as contexts for fostering these mathematical practices

Algebraic Habits of Mind

Connected to the Common Core State Standards for Mathematical Practice:

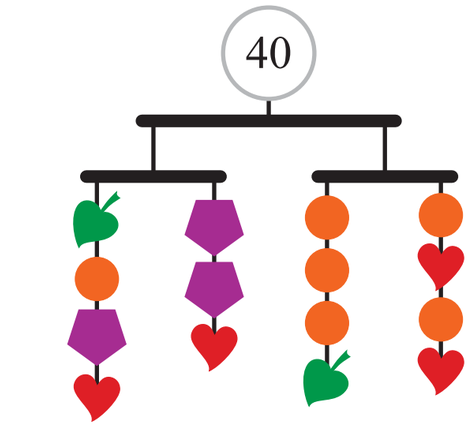
- Seeking and Using Structure (CCSS MP7)
- Puzzling and Persevering (CCSS MP1)
- Using Tools Strategically (CCSS MP2, MP4, MP5)
- Communicating with Precision (CCSS MP3, MP6)
- Describing Repeated Reasoning (CCSS MP8)

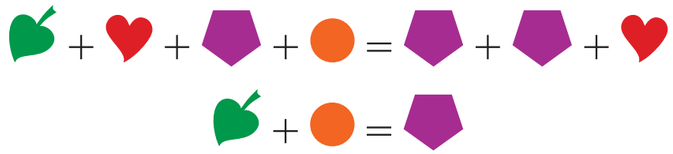
Mobile Puzzles

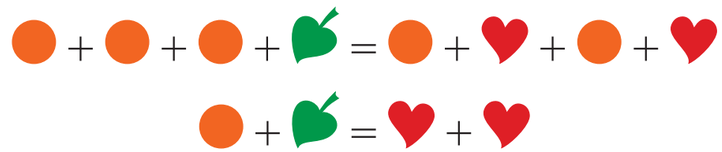


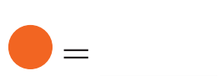
♥ = _____ ◆ = _____ ● = _____

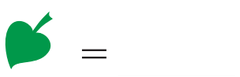
Mobile Puzzles

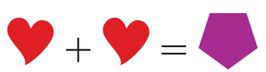












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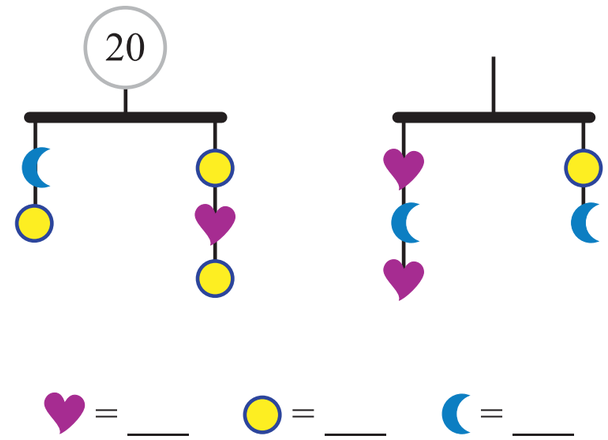
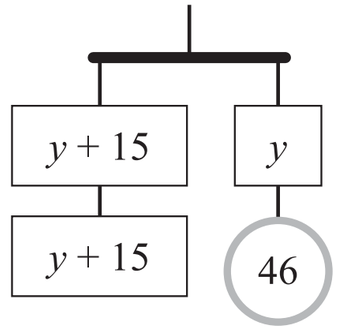


♥ = ___ ● = ___ ☾ = ___



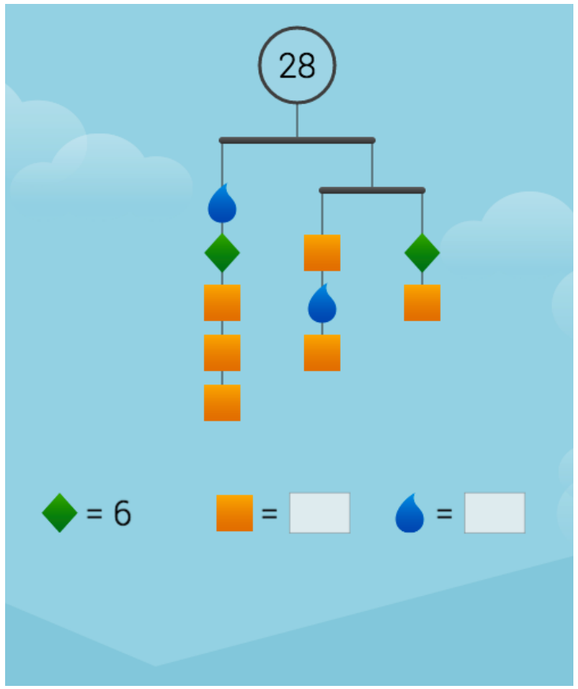
y = ____

SolveMe Mobiles App

solveme.edc.org

for iPads and Laptops

Choose **Play** for now.



Mystery Number Puzzles

③ What could ☆, 💧, and ⬢ be if all the variables represent different numbers?

💧 • ⬢ = ☆

⬢ + ⬢ = ☆

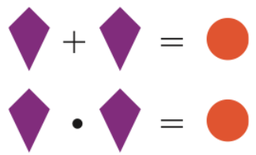
💧 + 💧 + 💧 = ☆

☆ = _____

💧 = _____

⬢ = _____

Mystery Number Puzzles

	Only one solution
	Two solutions
	For some value of  ,  can have any value. For some value of  ,  can have any value.
	Two solutions (assuming different variables can have the same value)

Who Am I? Puzzles:
I am a 4-digit number…

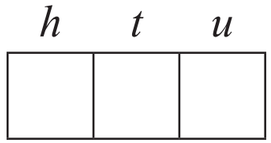
Who Am I?

- The product of my digits is not 0.
- $tu = h$
- k is my only odd digit.
- $t + 1 = k$
- t is a square number.
- None of my digits are the same.
- I'm greater than 5000.

k	h	t	u

Who Am I? Puzzles:
I am a 3-digit number…

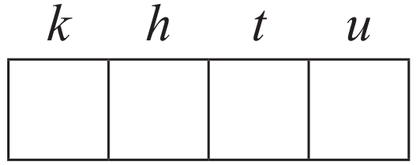
Who Am I?



- I am even.
- My digits are all different.
- I am greater than 319.
- My hundreds digit is less than 7.
- $u = 1 + h$
- My tens digit is my largest digit.
- My hundreds digit is my only odd digit.
- My units digit is one more than my hundreds digit.
- The sum of all three of my digits is 19.
- My units digit is not 4.

Who Am I? Puzzles:
I am a 4-digit number…

Who Am I?



- $h + t = k + 2u$
- At least one of my digits is prime.
- No two of my digits are the same.
- Three of my digits are powers of 2.
- The sum of my digits is a perfect square.
- Three of my digits are perfect squares.
- The difference between t and u is 5.
- $9h = t$

Adapting Who Am I? Puzzles

Choose or build puzzles with relevant content:

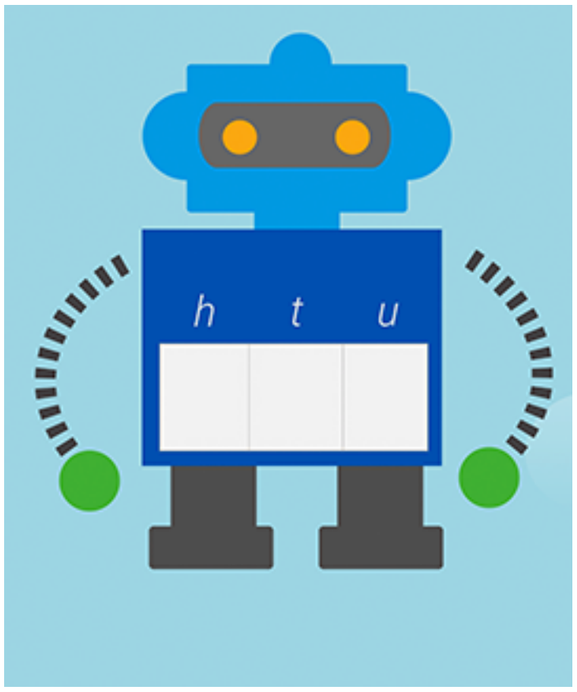
- place value
- parity: evens and odds
- inequalities
- squares and roots
- multiples
- primes
- divisibility
- factors
- GCD & LCM
- algebraic expressions
- factoring (ex: $t + u = 12$ and $tu = 36$)

SolveMe Who Am I? Sneak Preview

solveme.edc.org/whoami

-- Beta version --

for iPads and Laptops



MysteryGrid – Latin Square Puzzle

- Use the clues to fill in the grid so that every row and every column contains one of each element.

a*, *b*, *c Latin Square

c		a
	c	

MysteryGrid Puzzles

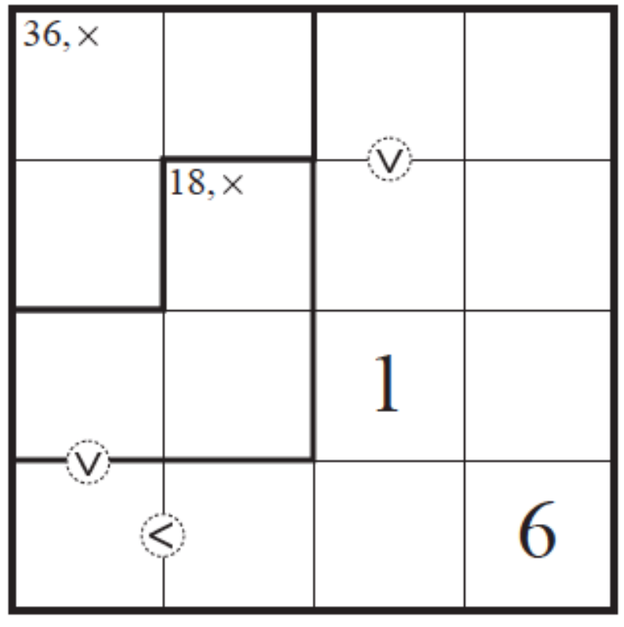
- In MysteryGrid puzzles, the numbers in each "cage" should reach the target number using the given operation.
- For example, a 3-cell, "20, ×" cage means you need to fill that cage with 3 numbers that multiply to 20.

MysteryGrid **1, 3, 4, 5**

4, +		4, ÷	1, −
20, x	12, +		
			2, −
	15, x		

MysteryGrid Puzzles

MysteryGrid 1, 2, 3, 6



MysteryGrid Puzzles

MysteryGrid a, a^2, a^3, a^4

a^6, •			$2a^4+a^3$,+
a^7, •	a^4, •		
		a^5, •	
	a^7, •		

SolveMe MysteryGrid Sneak Preview

solveme.edc.org/mysterygrid

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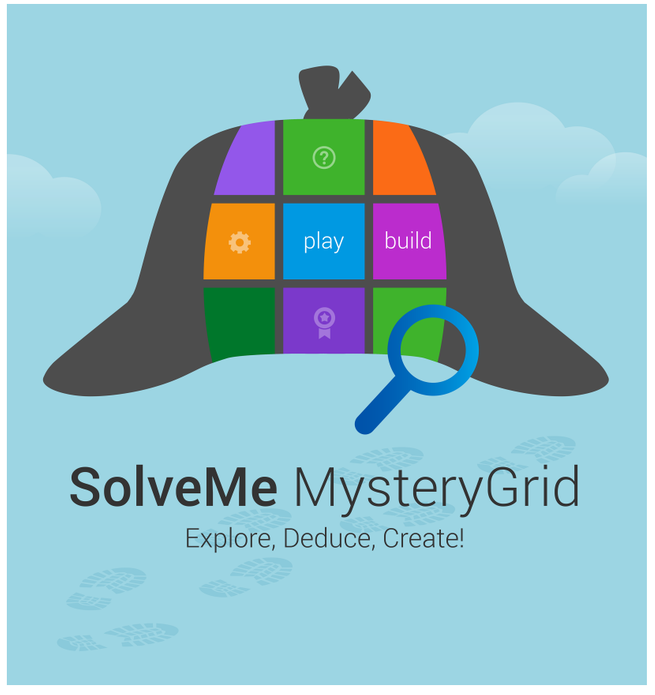


Why Have Students Create Puzzles?

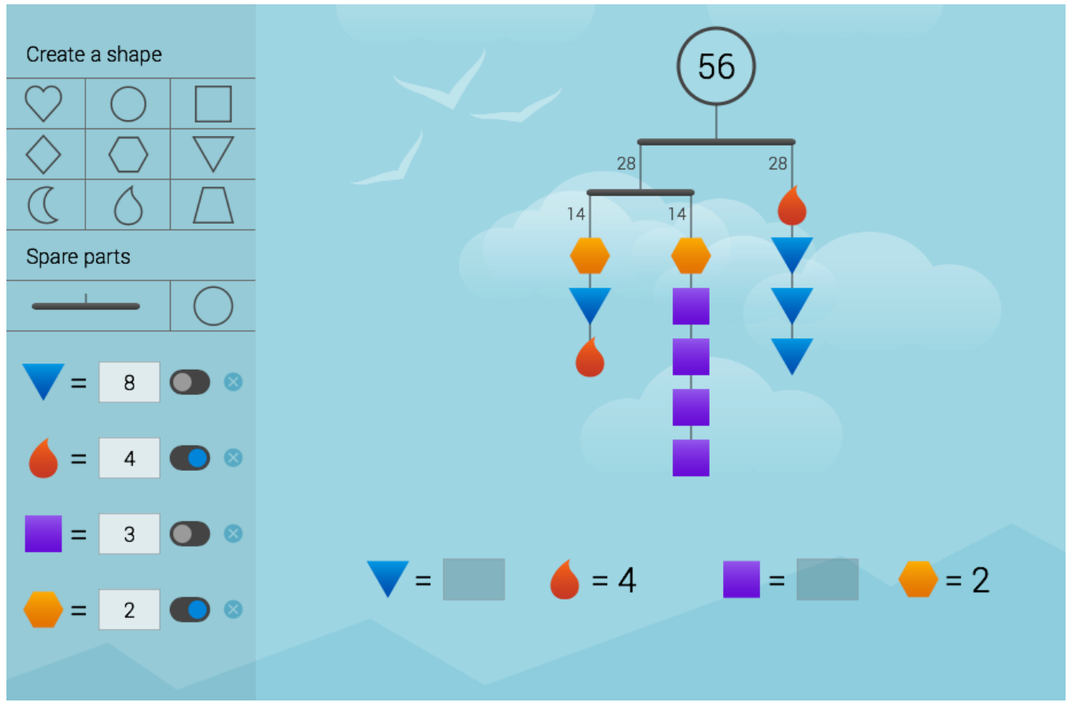
Creating Puzzles:

- supports deeper understanding the of the logic and mathematics of the puzzles
- helps students develop sense of agency as producers not just consumers of mathematics
- focuses on creative element of doing mathematics
- offers a social mathematics activity

Steps for Creating Puzzles

1. Design the solution first
   a. Who Am I?: Choose number
   b. Mobiles: Choose shapes and values
   c. MysteryGrid: Choose elements and build Latin square
2. Create clues
   a. Who Am I?: Write clues with English and/or algebra
   b. Mobiles: Build Mobiles
   c. MysteryGrid: Build cages, create target expressions with operations, and place inequalities
3. Check that the clues lead to a unique solution

Building SolveMe Mobiles Puzzles



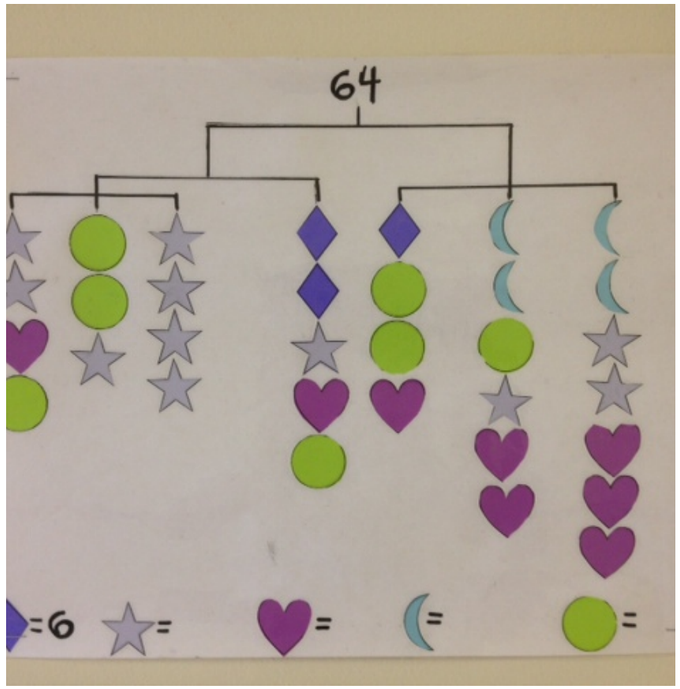
Using Mathematics Apps Effectively

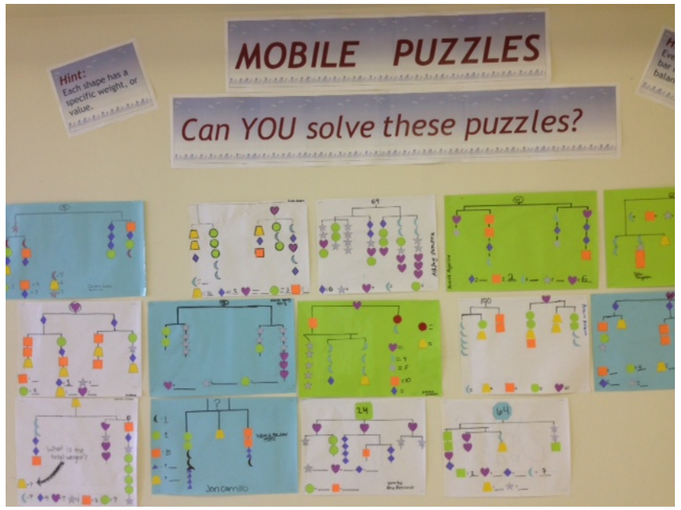
- Get to know the app well first (use help pages)
- Introduce apps *briefly*—allow for exploration
- Have students "play" before "building"
- Assign benchmarks (in class or as HW)
  - solving specific puzzles (easy to differentiate)
  - earning certain badges or trophies (e.g. "solve 5")
  - building puzzles with particular characteristics

Other Tips for Success

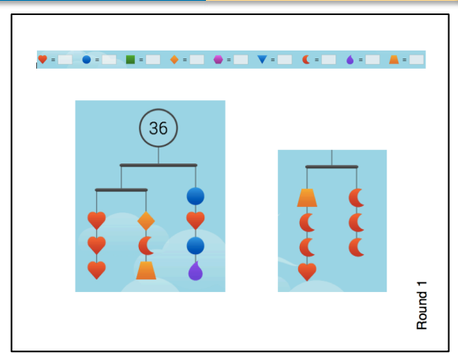
- Use a projector or an interactive white board
- Have students demonstrate solving
- Ask for "good next steps" (no "right way")
- Ask for "another way" to solve same puzzle
- Focus on students' logic over algebra at first
- Turn off devices during group discussions

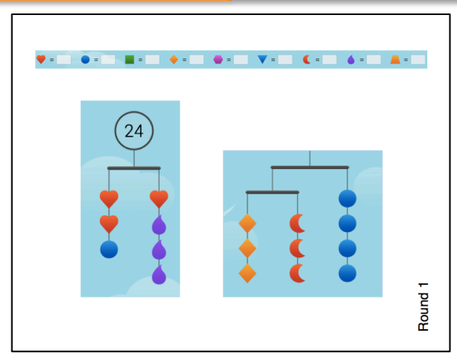
In the Classroom

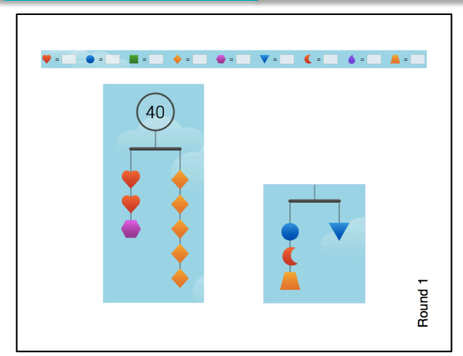


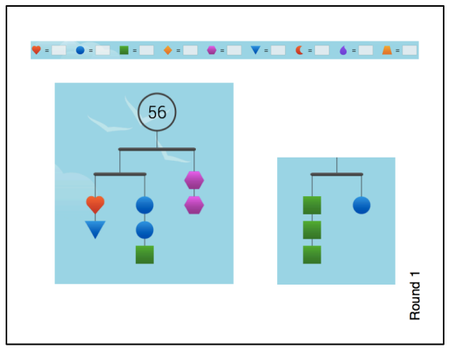


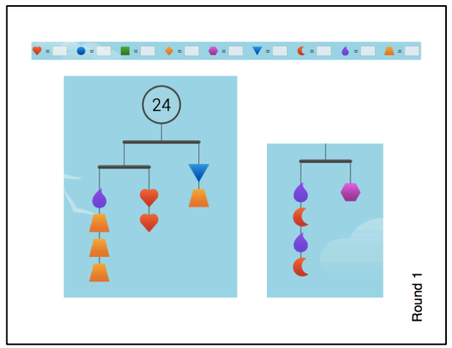
Collaborative Game











Puzzle Links

- Transition to Algebra Curriculum: **transitiontoalgebra.com**
- Puzzle Apps: **solveme.edc.org**
- Prototypes (in progress—may change):
  - solveme.edc.org/whoami
  - solveme.edc.org/mysterygrid
- Presenter email: mfries@edc.org

Thank you for coming!