A Model for Integrating Elementary CS and Mathematics Instruction

Mimi Recker
Professor
Utah State University

Kaiann Womack
Computer Lab Specialist
Cache County School District
Utah

Grants #2031382/404

Outline

- Coding in Elementary Schools
- Collaborative Design of CS-Math lessons
- Integrated Model for CS-Math Instruction
- Example: Geometry + Scratch (overview)
- Example: Exponents + Scratch (in depth)
- Example: Fractions + Javascript blocks

Introductions

Why are you here?

What do you hope to learn?

Engaging Elementary Students in Computer Science Instruction

Strong push for CS instruction at elementary level

District lacks:

- Instructional minutes for CS
- 1:1 computing in classroom
- CS teaching expertise

Solution:

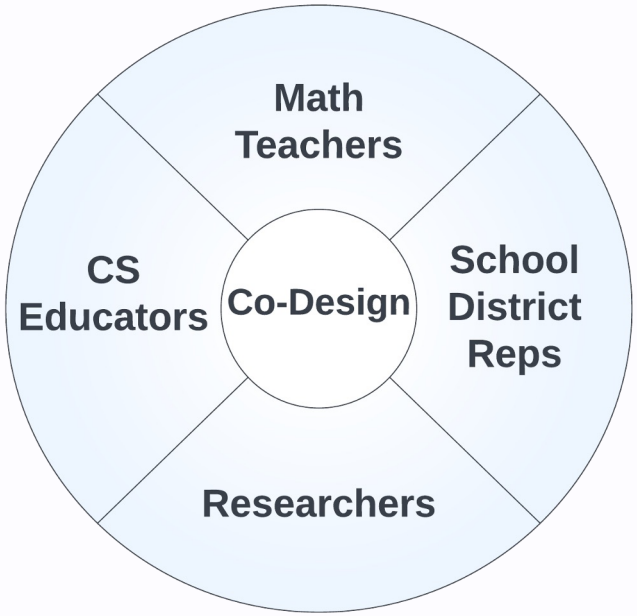
Offer CS instruction during weekly computer lab time using CodeHS

Taught by paraprofessional educators:

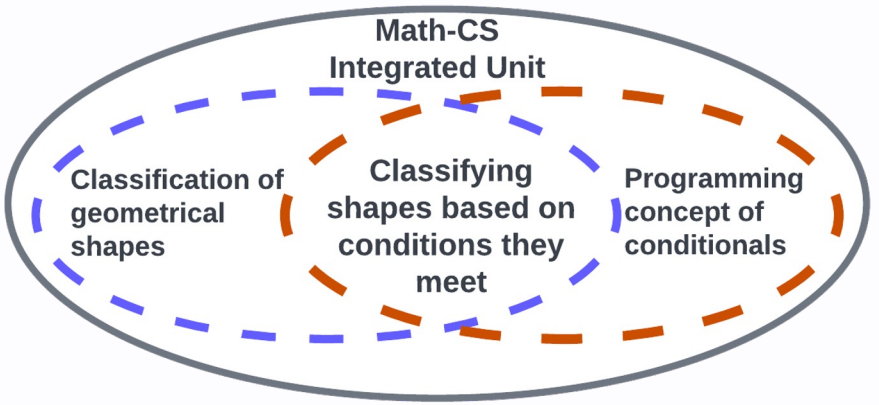
- Are part-time
- Often lack credentials
- Have high turnover

CS-Math Integration Model

Design Team Engaged in Collaborative Design of Instruction



***Expansively-framed* CS-math *integrated* lessons across computer lab and classroom**



Several fifth-grade units were co-designed:

- Exponents & Geometry(Scratch/CodeHS)
- Fractions (Javascript blocks/CodeHS)

Example 1: Geometry & Scratch

Connecting CS and Mathematics

Aligning Computer Science and Math Standards

FCR Focus:

Common Core State Standards

5.G.B.3 Understand that attributes belonging to a category of two-dimensional figures also belong to all subcategories of that category.

5.G.B.4 Classify two-dimensional figures in a hierarchy based on properties.

MATHEMATICAL PRACTICES (See *Mathematical Practices in GO Math!* in the *Planning Guide* for full text.) **MP1** Make sense of problems and persevere in solving them. **MP7** Look for and make use of structure. **MP8** Look for and express regularity in repeated reasoning.

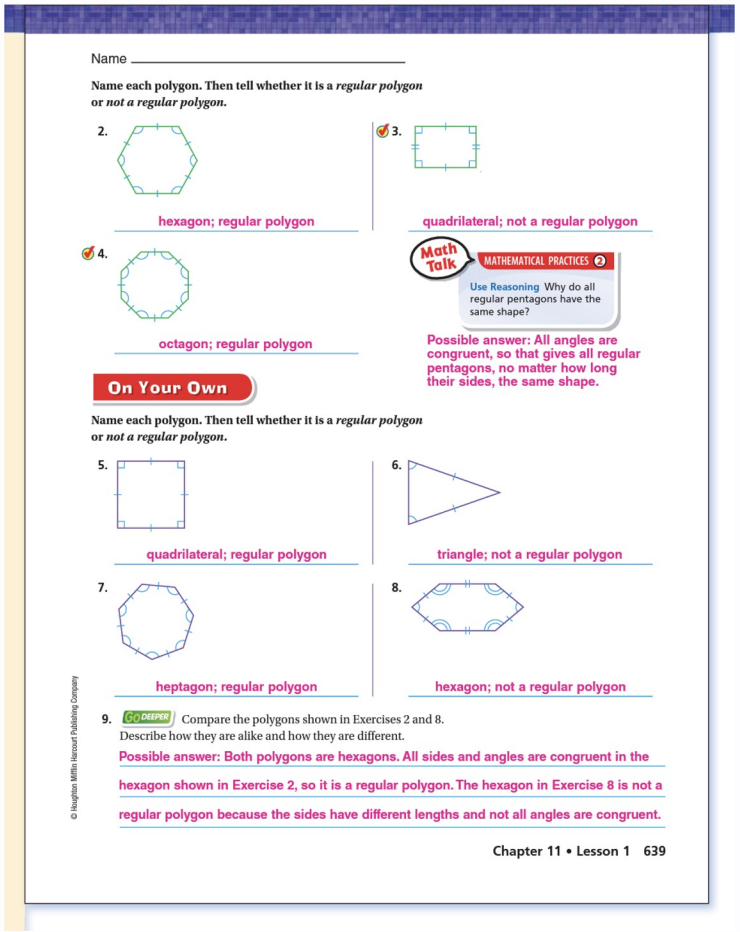
Algorithms and Programming (AP):

An algorithm is a sequence of steps designed to accomplish a specific task. Algorithms are translated into programs, or code, to provide instructions for computing devices. Algorithms and programming control all computing systems, empowering people to communicate with the world in new ways and efficien it, breaking analyzing d

Utah K-5 Computer Science Standards Writing Draft: March 15, 2019

Standard 4.AP.2 - Create **programs** that include **events**, **loops**, and **conditionals**. *(Practice 5: Creating Computational Artifacts)*

Students will develop a set of instructions (a program) that include events, loops, and conditionals to facilitate and manage tasks. Event examples include mouse clicks, typing on the keyboard, and collisions between objects. Conditional statements are sets of commands that are tied to specific actions based on whether the condition evaluates to TRUE or FALSE. Other terms that can be used to specify the appropriate groups of instructions to execute under various conditions include AND, OR, and NOT.



Name _____

Name each polygon. Then tell whether it is a *regular polygon* or *not a regular polygon*.

2. hexagon; regular polygon

3. quadrilateral; not a regular polygon

4. octagon; regular polygon

Math Talk — MATHEMATICAL PRACTICES 2

Use Reasoning Why do all regular pentagons have the same shape?

Possible answer: All angles are congruent, so that gives all regular pentagons, no matter how long their sides, the same shape.

On Your Own

Name each polygon. Then tell whether it is a *regular polygon* or *not a regular polygon*.

5. quadrilateral; regular polygon

6. triangle; not a regular polygon

7. heptagon; regular polygon

8. hexagon; not a regular polygon

9. GO DEEPER Compare the polygons shown in Exercises 2 and 8. Describe how they are alike and how they are different.

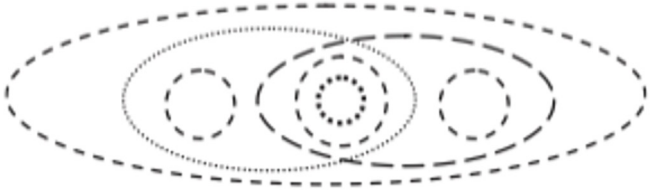
Possible answer: Both polygons are hexagons. All sides and angles are congruent in the hexagon shown in Exercise 2, so it is a regular polygon. The hexagon in Exercise 8 is not a regular polygon because the sides have different lengths and not all angles are congruent.

Chapter 11 • Lesson 1 639

Image credit: Go Math! 5th grade teacher's edition

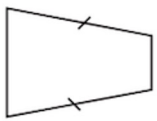
Bounded Framing

Expansive Framing



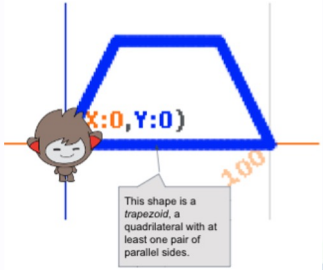
Classify the quadrilateral in as many ways as possible.
Write *quadrilateral, trapezoid, parallelogram, rectangle, rhombus,* or *square.*

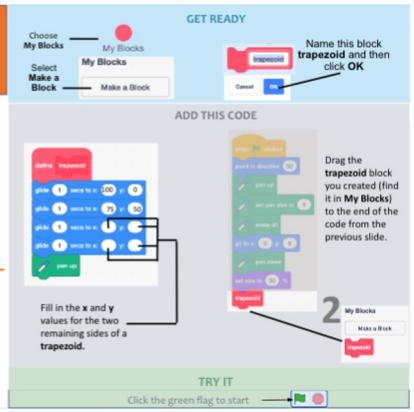
5.



quadrilateral, trapezoid

Challenge Task:
Change the code so that nano draws a trapezoid.





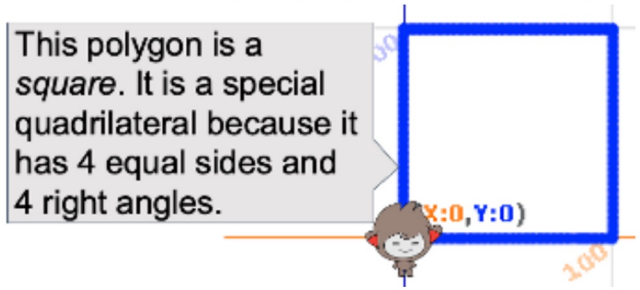
A cross-contextual expansively-framed unit

Context 1: Computer lab

Computer lab specialists lead coding activities that generate geometrical shapes

Computer lab example

Educative elements contain math content

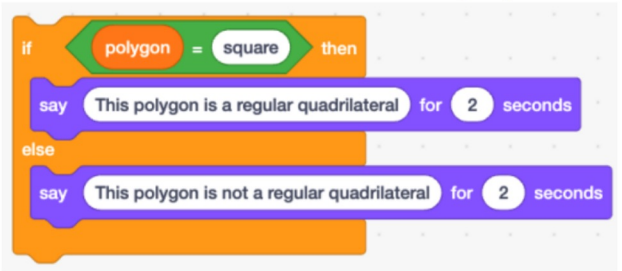


Context 2: Math in classroom

Teachers run code that demonstrate math concepts

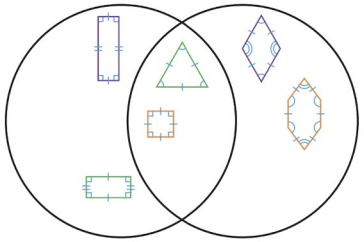
Math class example

Code uses conditionals to classify quadrilaterals



Content creates connections between math and CS

Math Big Ideas

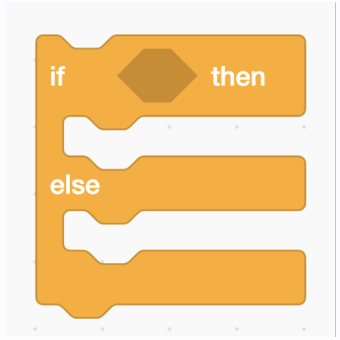


1. What do the polygons in the left circle have in common with each other?
2. What do the polygons in the right circle have in common with each other?
3. What do the polygons in the center section have in common with both groups?

Reasoning with polygons

+

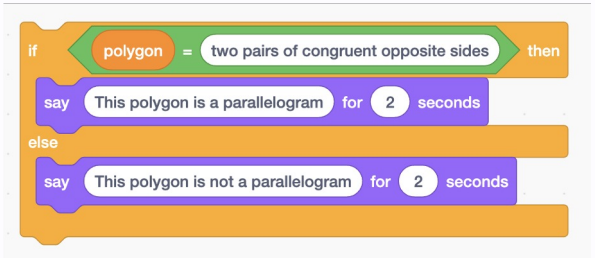
Computing Big Ideas



Conditionals, variables, abstraction

=

CS-Math Connections



Using conditionals to reason about polygons and attributes

Cross-Context, Expansively Framed Math + CS Geometry Unit

Math Topics	Math Big Ideas	Computing Big Ideas	CS-Math Connections
Quadrilaterals	• Reasoning with polygons • Classifying shapes	Conditionals, variables, abstraction	Use conditionals to reason about polygons and attributes
Triangles	Classifying triangle types	Conditionals, variables, loops	Program shapes

Front Matter: Aligning CS and Math Instruction

Cache Code Math: CS-Math Unit on Geometry for March
Chapter 11 (and review Chapter 9, Lesson 9.2) in *Go Math!* + Scratch Cards

Lesson	Computer Lab	Mathematics Class	Notes	Suggested Timing/Pacing
#1 Math Routine		Math Routine: Which One Doesn't Belong? (reasoning about shapes using attributes in Chapter 11 lessons)	Teach **prior to** Computer Lab lessons *Supports a math content and language review. Supports reasoning with attributes.*	7-10 minutes Week of March 14, before or during Lesson 11.1
Computer Lab Scratch Card: Introduction to My Block	The typical Scratch Card (Scratch card 9: Jumping Game Cards) New jumping card (Monkey jump)		Teach **prior to** the Computer Lab Quadrilateral activity. *Supports students' learning of the My Block procedure in Scratch in order to focus on the mathematics in subsequent Computer Lab lessons.*	5-10 minutes Week of March 14 **Exit Ticket**
#2 Math Minilesson		Math Minilesson: Visualizing the Shape – What Shape Will It Be? (extends Lesson 9.2 on order pairs and accesses background knowledge for Lessons 11.1-11.3)	Teach **prior to** Computer Lab Quadrilateral activity in Scratch to explain the use of coordinate grid and ordered pairs in Scratch. *Supports the use of ordered pairs in Scratch.*	10-15 minutes Week of March 14
#3 Math Minilesson		Math Minilesson: Conditionals and Regular/Non-Regular Polygons (goes with Lesson 11.1 on polygons)	Teach **prior to** Computer Lab lesson Scratch Quadrilateral Quiz to explain the use of conditional statements with shapes. *Supports math content for Lesson 11.1. Supports use of conditionals in upcoming Computer Lab lesson.*	10 minutes Week of March 21, extends Lesson 11.1
Computer Lab Scratch Card: Scratch Quadrilaterals Quiz	Scratch Quadrilaterals Quiz card		Teach **after** #4 Math Minilesson on conditionals and quadrilaterals	20-30 minutes Week of March 21 **Exit Ticket**
	Create a shapes quiz on polygons using conditionals and My Blocks		*Supports the math content in Lesson 11.2 and introduces conditionals and procedures (My Blocks).*	
#4 Math Minilesson		Math Minilesson: Conditionals and Quadrilaterals (goes with Lesson 11.3 on quadrilaterals or after Lesson 11.3)	Teach **after** Computer Lab Quadrilateral activity in Scratch *Supports math content for Lesson 11.3 Supports use of conditionals in Computer Lab lessons.*	10 minutes Week of March 21, supports Lesson 11.3 **Exit Ticket**
Computer Lab Scratch Card: Triangle Quiz	Scratch Triangle Quiz card Create a triangle quiz on equilateral, isosceles, and right triangle types using conditionals		Teach **after** students learn lesson 11.2 on triangles and after #2 Math Minilesson on conditionals *Supports the math content in Lesson 11.2 and uses conditionals and procedures (My Blocks).*	20-30 minutes Week of March 28 **Exit Ticket**
#5 Math		Math Minilesson: Interior/Exterior Angles of Acute, Obtuse, and Right Triangles	Teach **after** Computer Lab "Triangle Quiz" to explain the interior/exterior angles in My Blocks	10 minutes Week of March 28, extends Lesson 11.2

Example 2: Exponents & Scratch

Connecting CS and Mathematics

Connecting CS and Mathematics

Multiplication as repeated addition:

Repeated addition of addends can be represented by a **multiplication** equation:

5 + 5 = 10

5 x 2 = 10

Exponents as repeated multiplication:

Repeated multiplication of factors can be efficiently represented by **exponent** notation:

$\mathbf{2^5 = 32}$

2 x 2 x 2 x 2 x 2 = 32

Exponents and Scratch Coding

Lesson Example

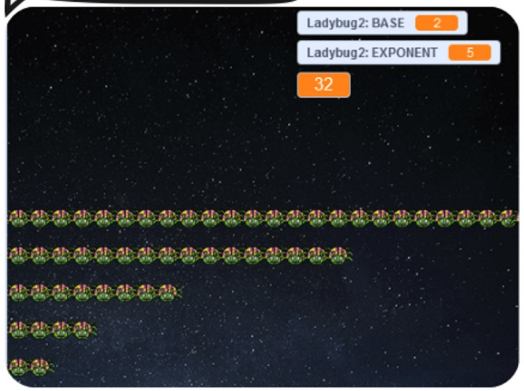
Math

Repeated multiplication of factors can be efficiently represented by exponent notation.

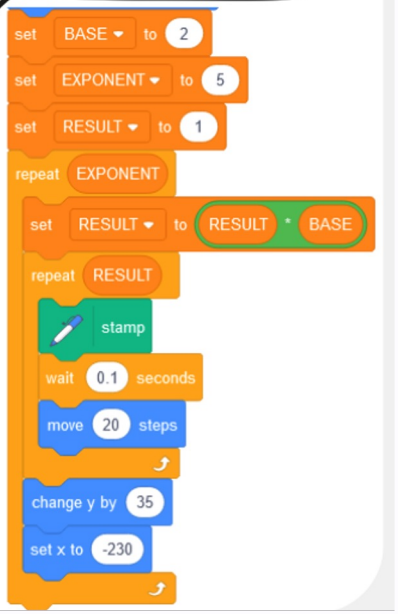
$2^5 = 32$

$2 \times 2 \times 2 \times 2 \times 2 = 32$

Classroom connections



Computer Science



Multiplication: Repeated Addition
Exponents: Repeated Multiplication

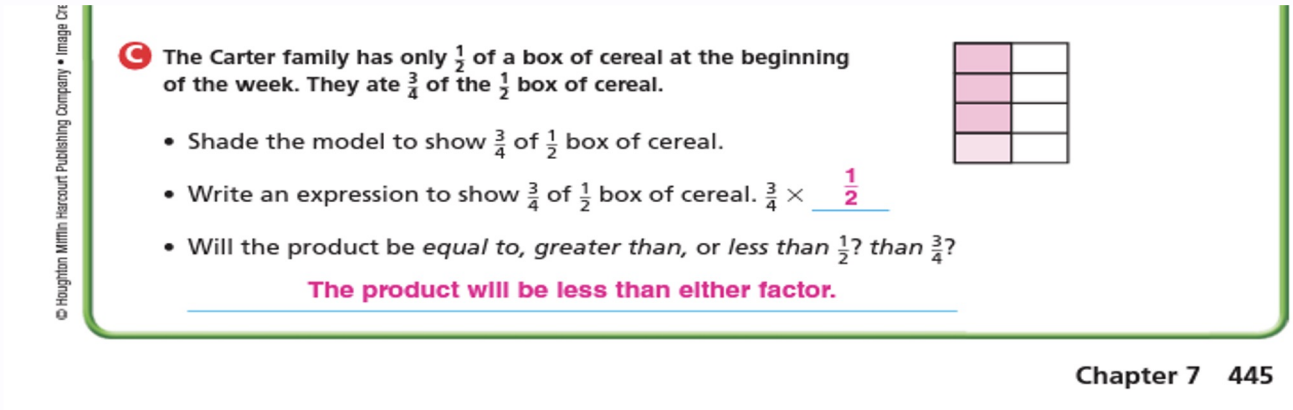
Front Matter and math routines
Computer Lab Teaching slides
Classroom math lessons

Example 3: Fractions & Javascript blocks

Connecting CS and Mathematics

Expansively Framing Multiplication of Fractions and Code HS

Unpacking a Fraction Equation: Karel Shows the Product!



C The Carter family has only $\frac{1}{2}$ of a box of cereal at the beginning of the week. They ate $\frac{3}{4}$ of the $\frac{1}{2}$ box of cereal.

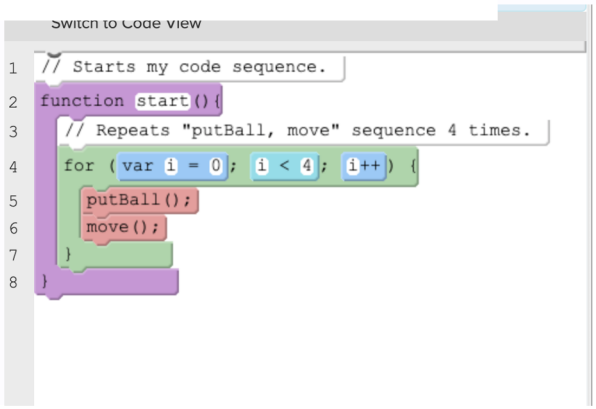
- Shade the model to show $\frac{3}{4}$ of $\frac{1}{2}$ box of cereal.
- Write an expression to show $\frac{3}{4}$ of $\frac{1}{2}$ box of cereal. $\frac{3}{4} \times \frac{1}{2}$
- Will the product be *equal to, greater than,* or *less than* $\frac{1}{2}$? *than* $\frac{3}{4}$?

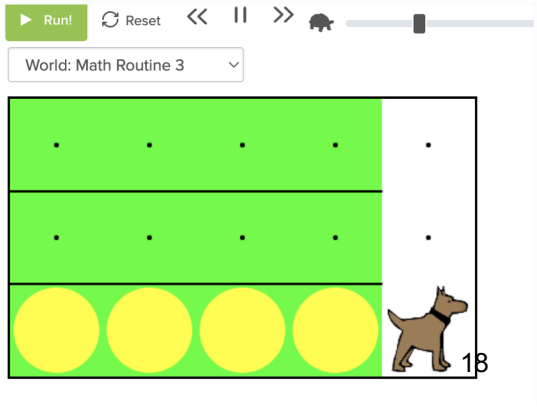
The product will be less than either factor.

Chapter 7 445

Why is the Product Getting Smaller?

1/3 x 4/5 = 4/15





Fractions lessons

Two computer lab activities: Instructional guide

1. Karel Cleans Up
   - Karel Cleans Up Video-Specialists (11 mins)
   - Karel Cleans Up Video-Students (7 mins)
2. Karel at the Dog Park
   - Karel At the Dog Park Video-Specialists (6 mins)
   - Karel at the Dog Park Video-Students (3:45 mins)

Classroom math instruction: Math Routines instruction

Thank you!

Jessica Shumway, Jody Clarke-Midura, Victor Lee
Umar Shehzad, Aubrey Rogowski, Sina Zandi, Kimberly Beck
Stacie Gomm, Beverly Sanders
Jim Buist, Brittani Dewart, Jeannie Astle
Brittany Wall, Debi Alexander, Rachel Holmgren, Allysa Wilson, Sally Bair

All the specialists and 5th grade students in the district

http://digitalcommons.usu.edu/eled_support

Grants #2031382/404