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Integrating Computer Science in Algebra

2017 STEM Education Conference

East Tennessee State University, Johnson City, TN

C O
D E

Hour of Code

CODE

Hour of Code

Derived from BOOTSTRAP
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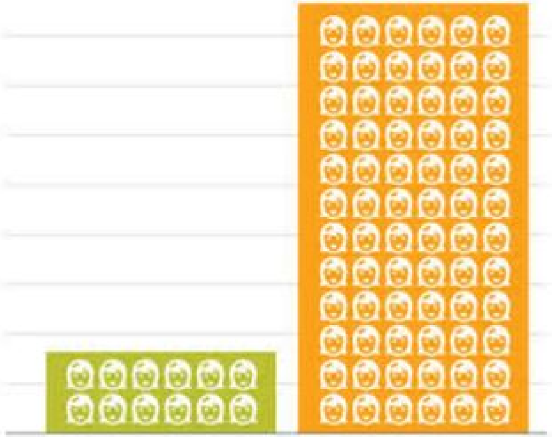
Hour of Code

Designed to demystify “code”, to show that anybody can learn the basics, and to broaden participation in the field of Computer Science

Students are learning in over 45 languages

Over 100M students have tried an Hour of Code

More girls tried computer science than in the last 70 years



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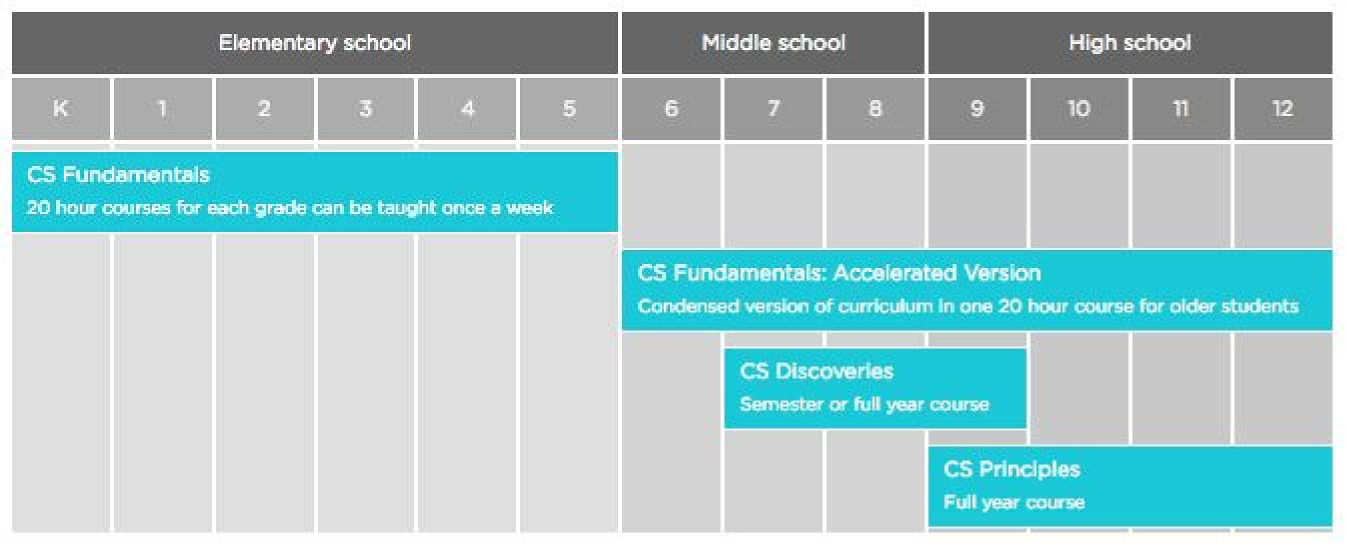
Beyond the Hour of Code



Elementary school						Middle school			High school			
K	1	2	3	4	5	6	7	8	9	10	11	12
CS Fundamentals 20 hour courses for each grade can be taught once a week												
						CS Fundamentals: Accelerated Version Condensed version of curriculum in one 20 hour course for older students						
							CS Discoveries Semester or full year course					
									CS Principles Full year course			

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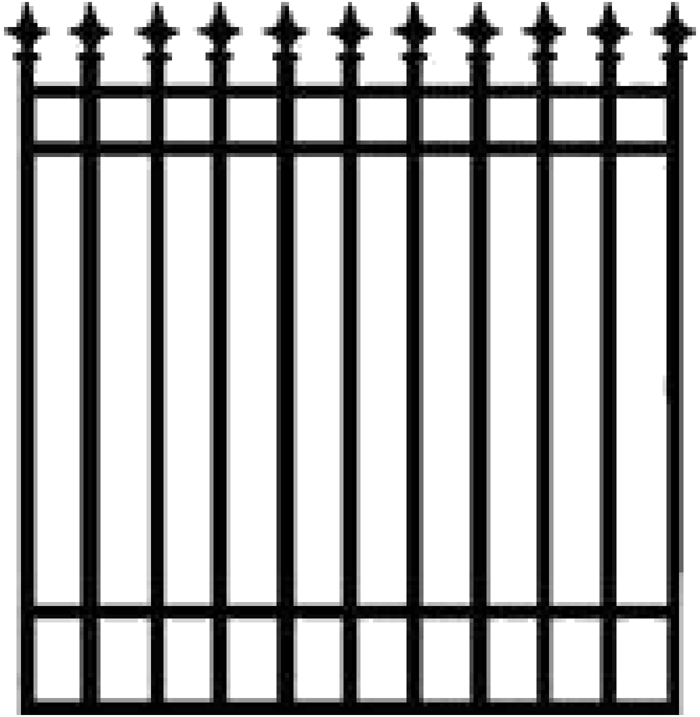
Let’s talk about Algebra...

Essential for abstract thinking, STEM fields, income and -for better or worse- standardized testing

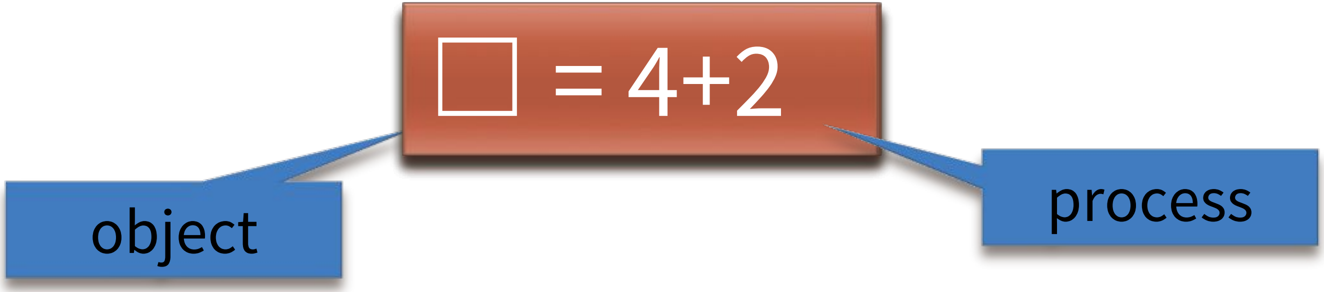
Fundamental leap from arithmetic

Algebra Matters



A train leaves Chicago...

Why is Algebra so Hard?

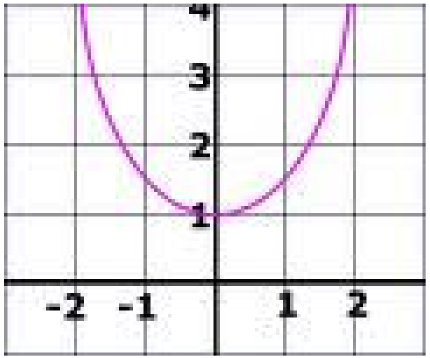


$\square = 4+2$

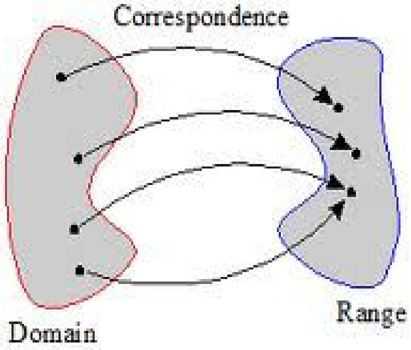
object

process

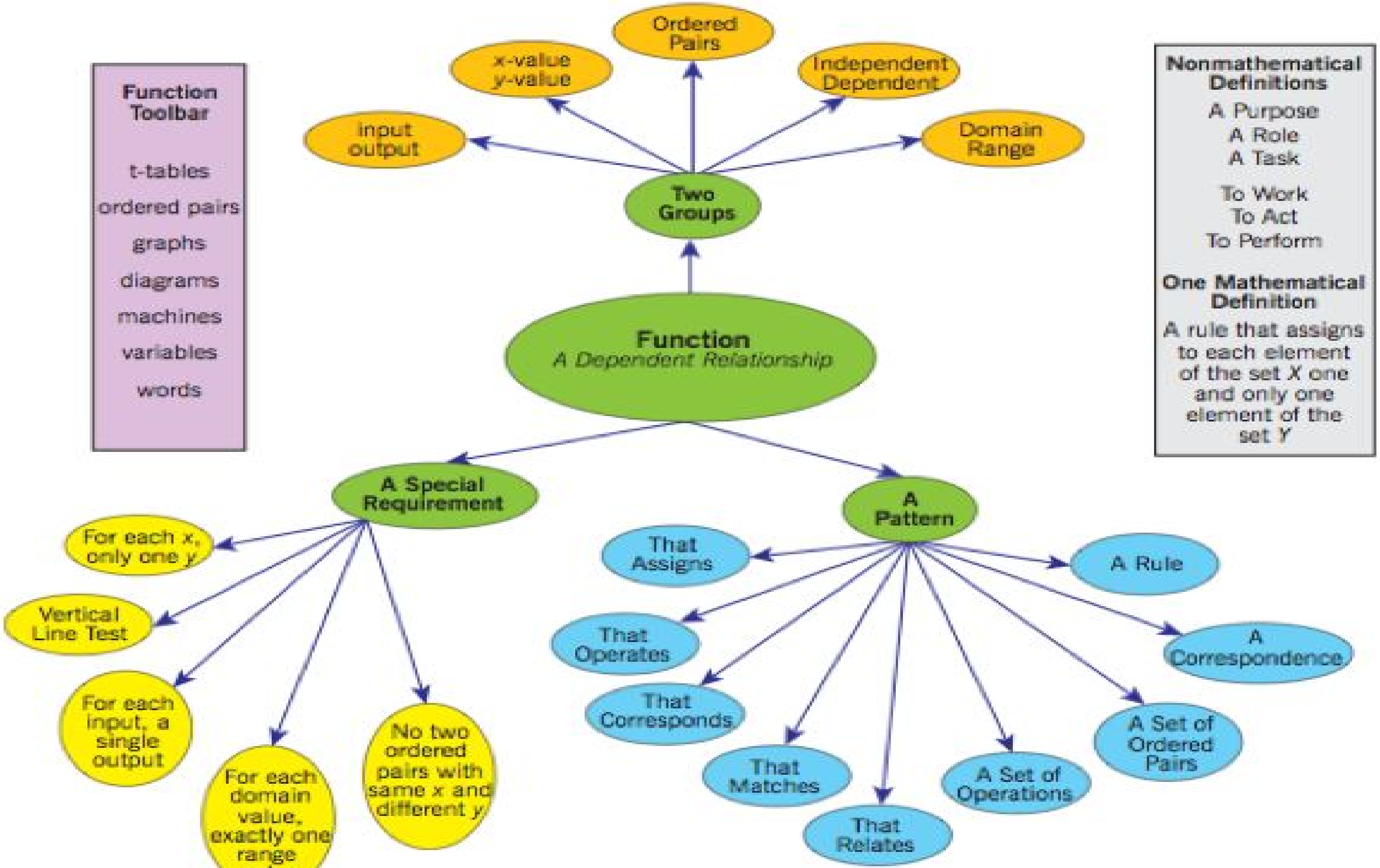
$$f(u,v)=u+\frac{v}{2}$$



x	F(x)
-5	24
-3	8
-2	3



THE CORE IDEAS THAT DEFINE FUNCTIONS



Function Toolbar

t-tables

ordered pairs

graphs

diagrams

machines

variables

words

Function
A Dependent Relationship

Two Groups

input output

x-value y-value

Ordered Pairs

Independent Dependent

Domain Range

A Special Requirement

For each x, only one y

Vertical Line Test

For each input, a single output

For each domain value, exactly one range

No two ordered pairs with same x and different y

A Pattern

That Assigns

That Operates

That Corresponds

That Matches

That Relates

A Set of Operations

A Set of Ordered Pairs

A Correspondence

A Rule

Nonmathematical Definitions

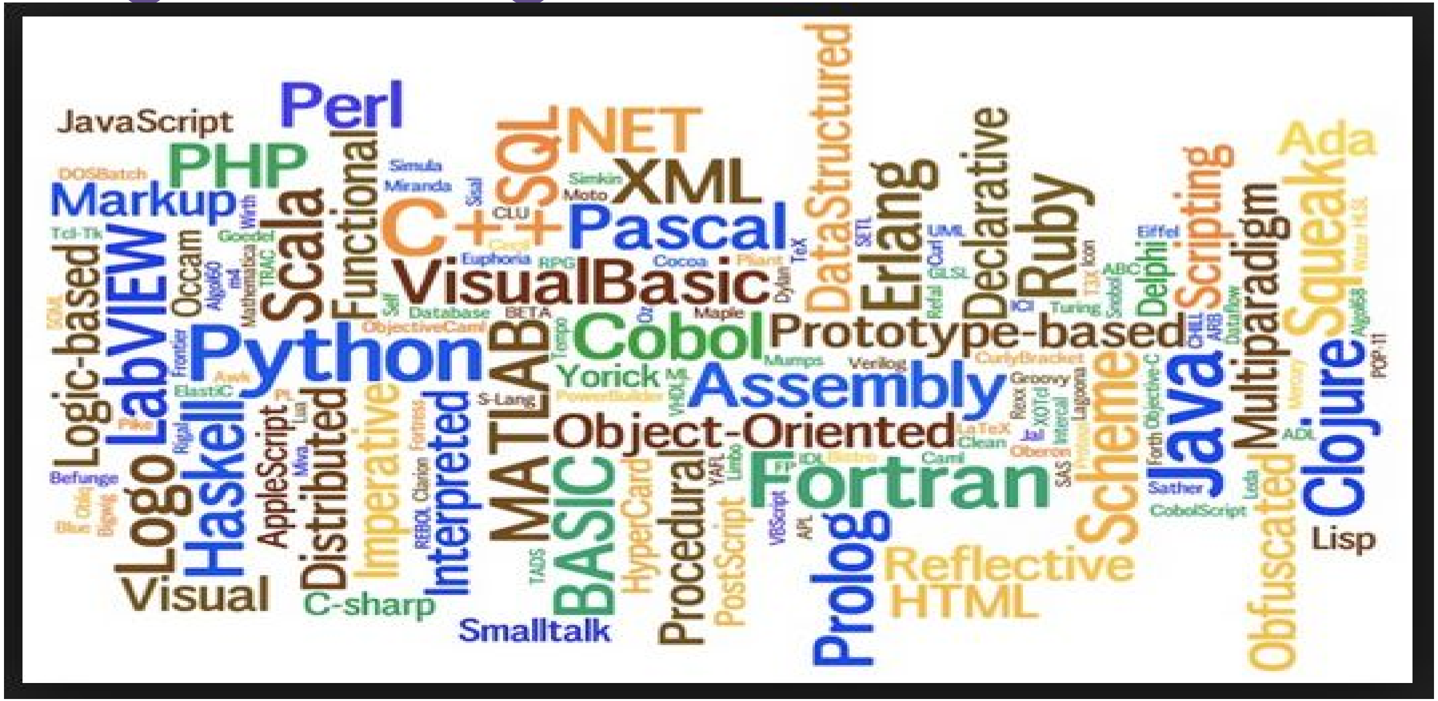
A Purpose
A Role
A Task

To Work
To Act
To Perform

One Mathematical Definition

A rule that assigns to each element of the set *X* one and only one element of the set *Y*

Programming has Functions!



But there’s a problem...
Programming != Math

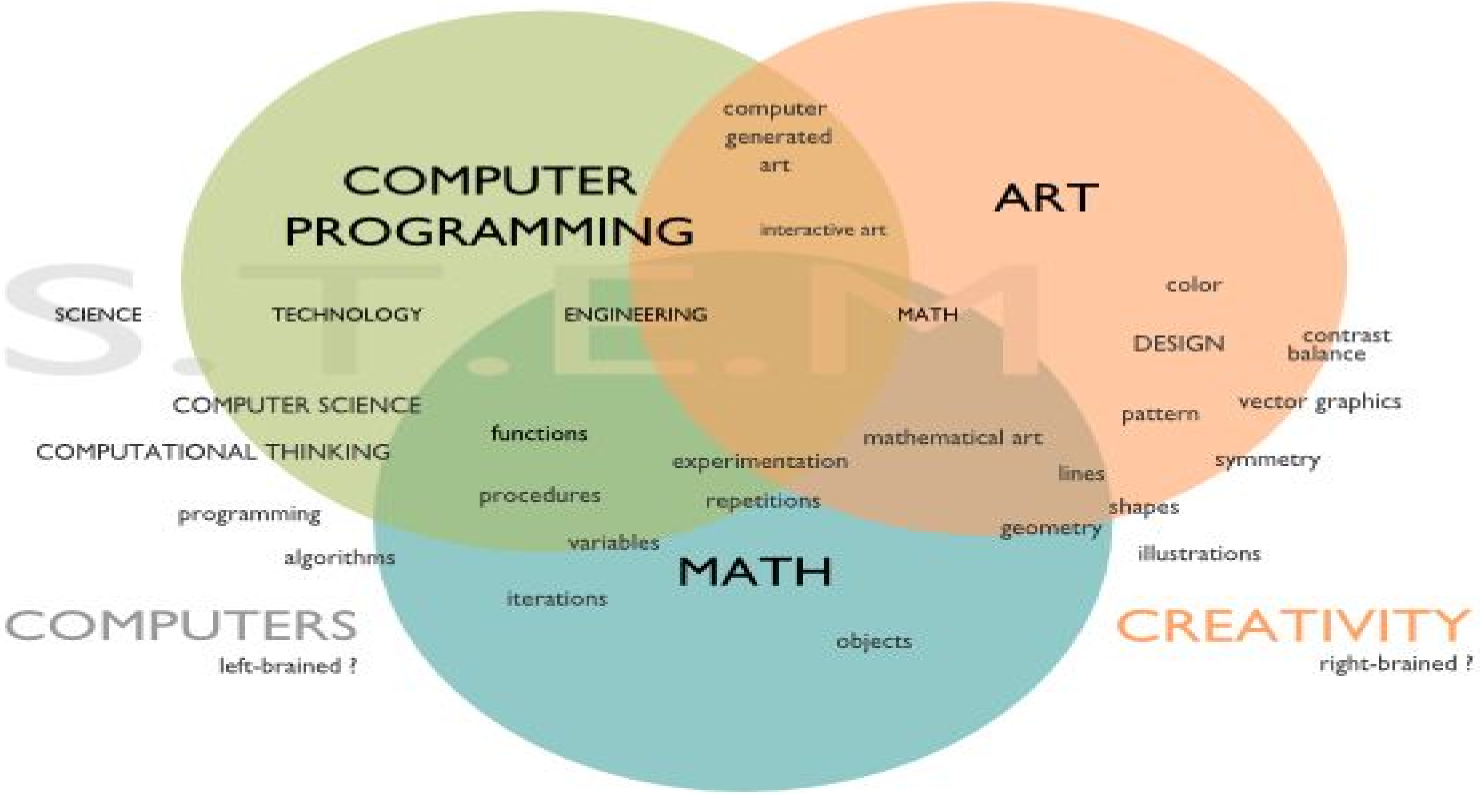
```
x = 10
x = x + 2
```

```
foo = 0
function f(x){
    return foo++
}
```

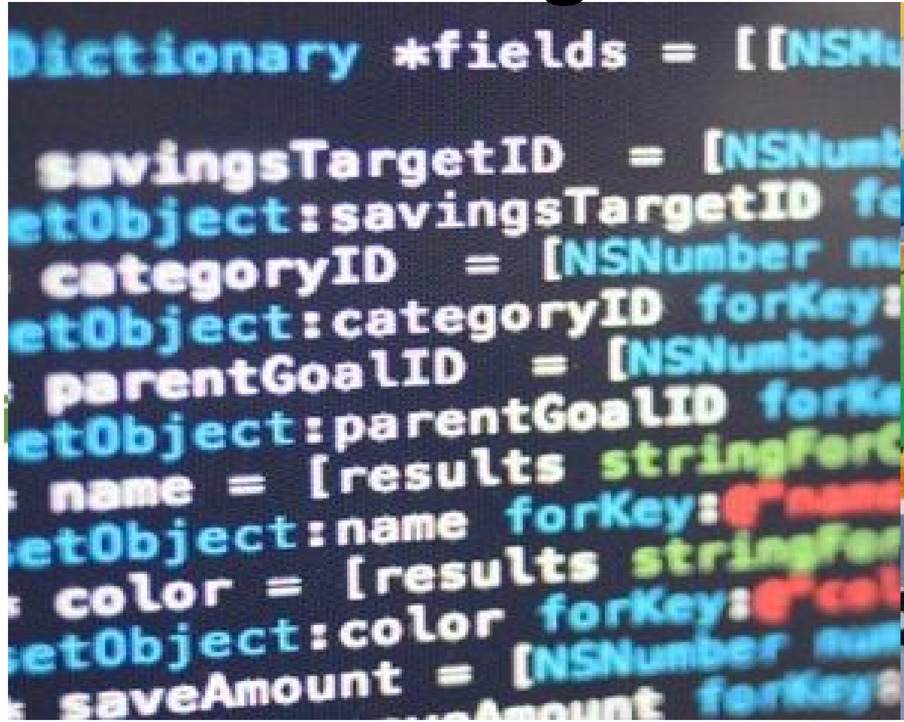
So if we want to help students...

Make representations of functions concrete

Make sure multiple representations are taught together


COMPUTER PROGRAMMING
computer generated art
interactive art
ART
S.T.E.M
SCIENCE
TECHNOLOGY
ENGINEERING
MATH
color
DESIGN
contrast
balance
COMPUTER SCIENCE
COMPUTATIONAL THINKING
functions
experimentation
mathematical art
pattern
vector graphics
lines
symmetry
procedures
repetitions
shapes
programming
geometry
variables
algorithms
illustrations
MATH
iterations
COMPUTERS
left-brained ?
objects
CREATIVITY
right-brained ?

Coding



```
Dictionary *fields = [[NSMu

 savingsTargetID  = [NSNumb
etObject:savingsTargetID fo
 categoryID  = [NSNumber nu
etObject:categoryID forKey:
 parentGoalID  = [NSNumber
etObject:parentGoalID forKe
 name = [results stringForC
etObject:name forKey:
 color = [results stringFor
etObject:color forKey:
etObject:color forKey:
 saveAmount = [NSNumber nu
             veAmount forKey:
```

Video Game Design

Bootstrap

+ computing creatively
thriving mathematically

Text-based Language

Open-ended projects

Lesson plans

Complete Student Workbook

Supporting Videos

Warm-up Activities

Exit Slips

Homework Assignments

Rubrics

Pedagogy

CODE

Block-based Language

Scaffolded projects

Lesson Plans

Student Workbook

Teacher Facing Videos

Student Facing Videos

Supplemental Resources

Teacher Dashboard

Pedagogy

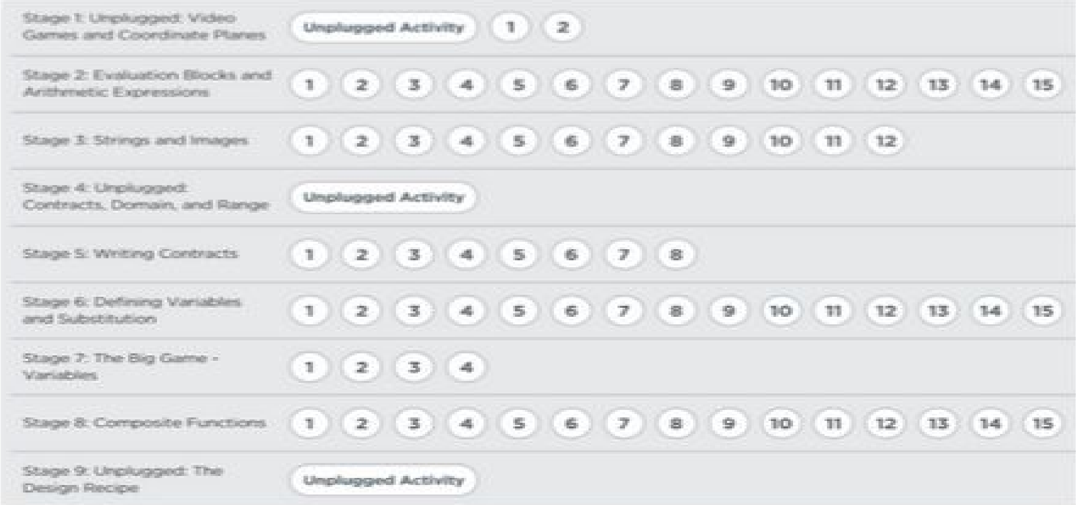
Computer Science in Algebra Overview

- Modules are integrated into an existing Algebra course
- Visual approach to function composition
- Programmatic method for solving word problems
- Making the learning concrete, relevant and engaging
- Programming language designed explicitly for Algebra

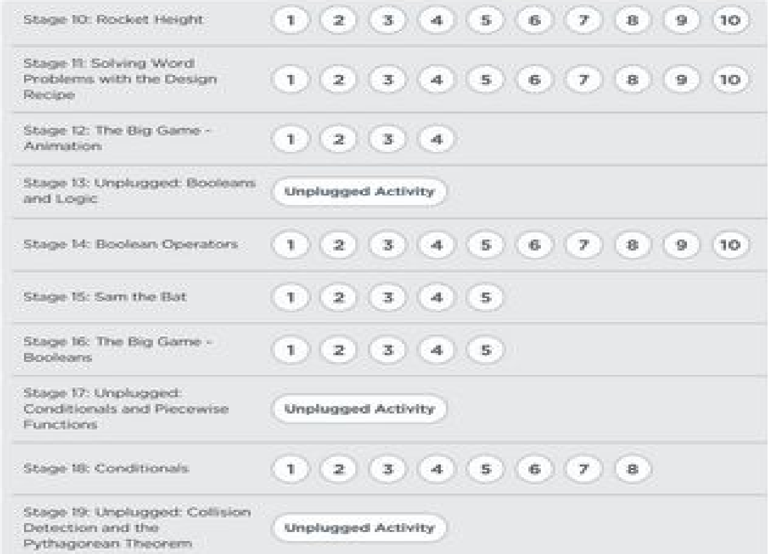
CODE STUDIO

Computer Science in Algebra

Learn Functional Programming through Algebra



Stage 1: Unplugged: Video Games and Coordinate Planes	Unplugged Activity 1 2
Stage 2: Evaluation Blocks and Arithmetic Expressions	1 2 3 4 5 6 7 8 9 10 11 12 13 14 15
Stage 3: Strings and Images	1 2 3 4 5 6 7 8 9 10 11 12
Stage 4: Unplugged: Contracts, Domain, and Range	Unplugged Activity
Stage 5: Writing Contracts	1 2 3 4 5 6 7 8
Stage 6: Defining Variables and Substitution	1 2 3 4 5 6 7 8 9 10 11 12 13 14 15
Stage 7: The Big Game - Variables	1 2 3 4
Stage 8: Composite Functions	1 2 3 4 5 6 7 8 9 10 11 12 13 14 15
Stage 9: Unplugged: The Design Recipe	Unplugged Activity



Stage 10: Rocket Height	1 2 3 4 5 6 7 8 9 10
Stage 11: Solving Word Problems with the Design Recipe	1 2 3 4 5 6 7 8 9 10
Stage 12: The Big Game - Animation	1 2 3 4
Stage 13: Unplugged: Booleans and Logic	Unplugged Activity
Stage 14: Boolean Operators	1 2 3 4 5 6 7 8 9 10
Stage 15: Sam the Bat	1 2 3 4 5
Stage 16: The Big Game - Booleans	1 2 3 4 5
Stage 17: Unplugged: Conditionals and Piecewise Functions	Unplugged Activity
Stage 18: Conditionals	1 2 3 4 5 6 7 8
Stage 19: Unplugged: Collision Detection and the Pythagorean Theorem	Unplugged Activity

Setting up your Classroom

- Physical Materials (workbooks, pens, etc)
- One computer for each pair of students
- Teacher Account at studio.code.org
- Class sections and student accounts in the Teacher Dashboard
- Students login and visit studio.code.org/s/algebra
- Lesson Plans available at code.org/curriculum/algebra

Derived from BOOTSTRAP
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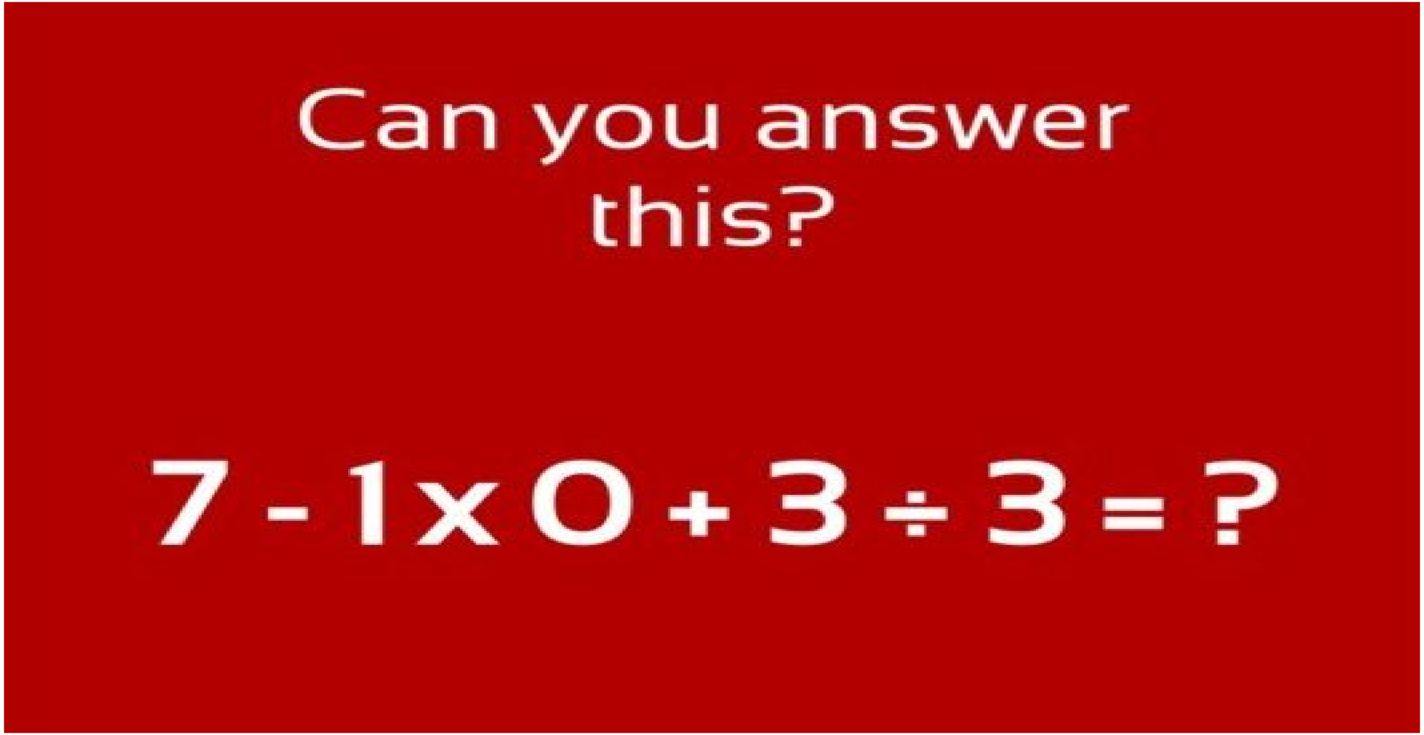
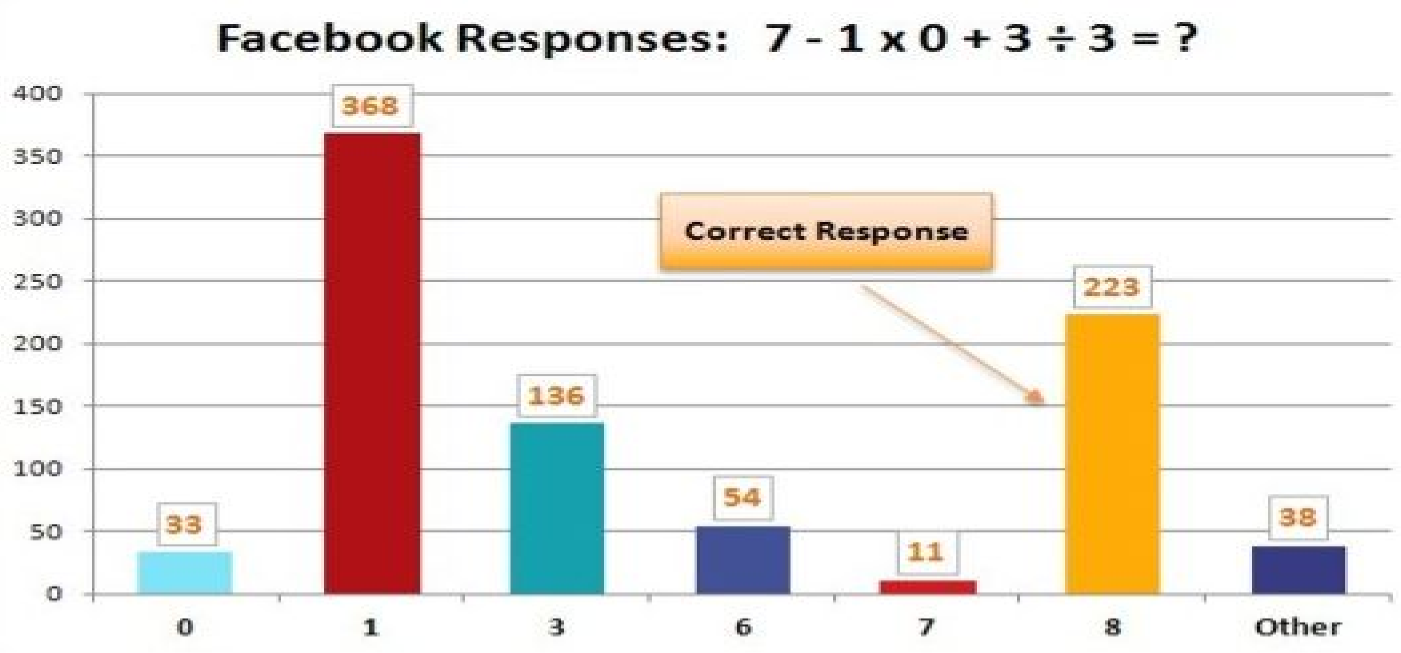
Task 1:
Make Representations of Functions Concrete



Can you answer this?

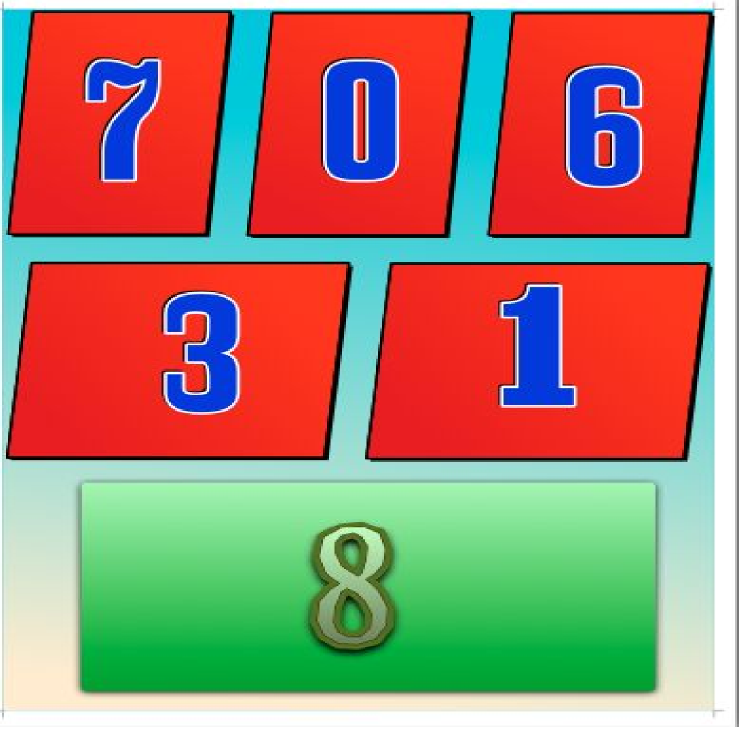
7 - 1 x 0 + 3 ÷ 3 = ?


Facebook Responses: 7 - 1 x 0 + 3 ÷ 3 = ?
400
350
300
250
200
150
100
50
0
33
368
136
54
11
223
38
0
1
3
6
7
8
Other
Correct Response

Student

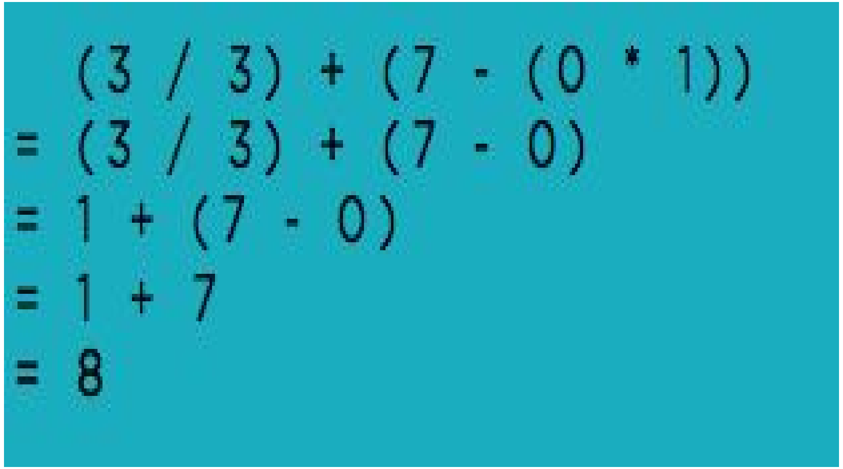
Teacher

7 - 1 x 0 + 3 ÷ 3 = ?

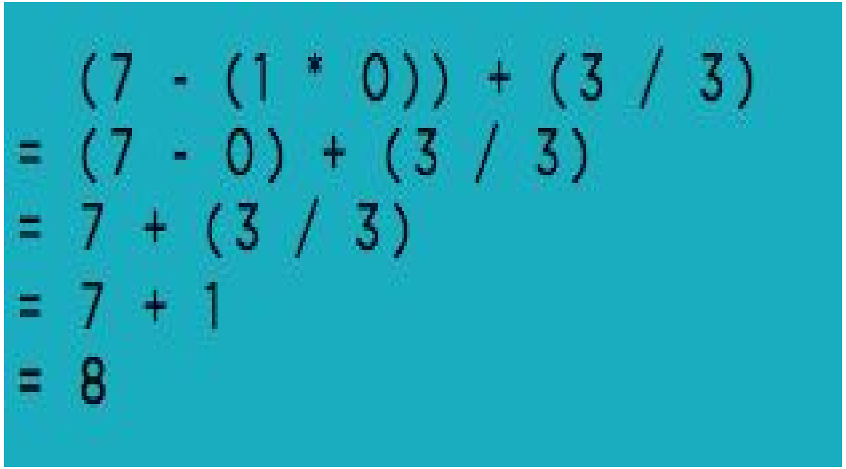


7 - 1 x 0 + 3 ÷ 3 = ?

8

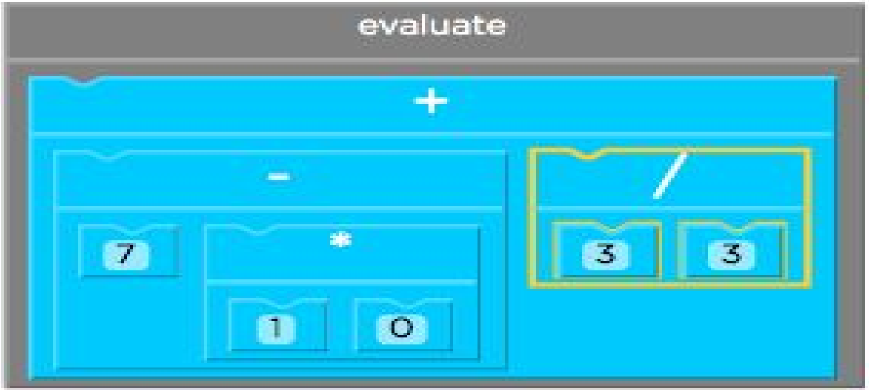


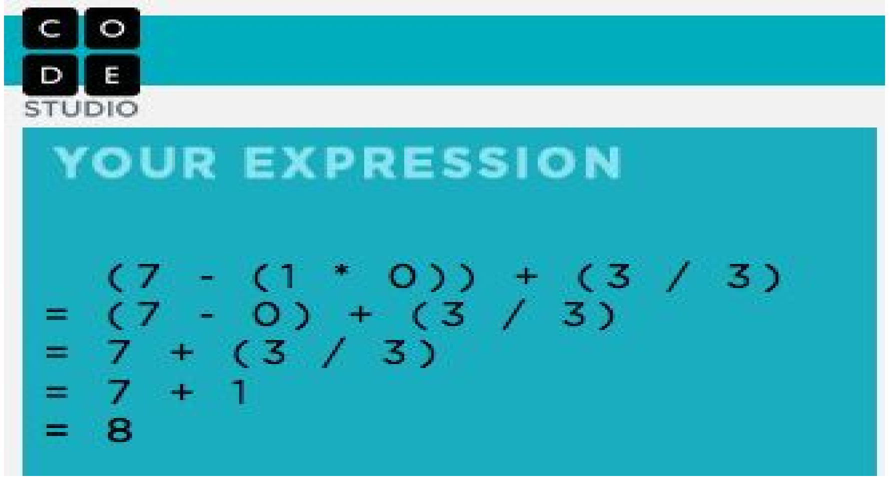
```
  (3 / 3) + (7 - (0 * 1))
= (3 / 3) + (7 - 0)
= 1 + (7 - 0)
= 1 + 7
= 8
```



```
  (7 - (1 * 0)) + (3 / 3)
= (7 - 0) + (3 / 3)
= 7 + (3 / 3)
= 7 + 1
= 8
```

7 - 1 x 0 + 3 ÷ 3 = ?



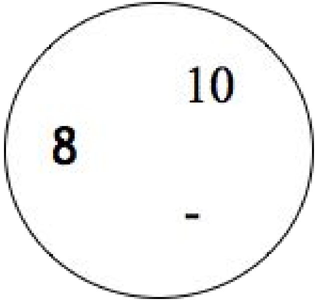


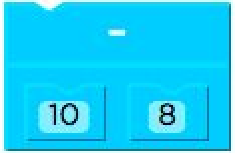
YOUR EXPRESSION

```
   (7 - (1 * 0)) + (3 / 3)
=  (7 - 0) + (3 / 3)
=  7 + (3 / 3)
=  7 + 1
=  8
```

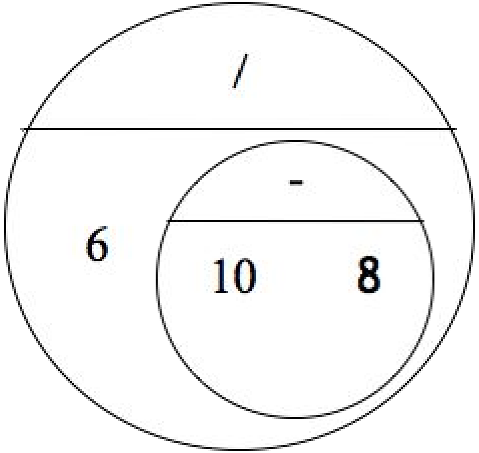
Circles of Evaluation

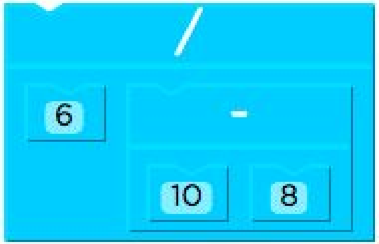
$10 - 8$





$$\frac{6}{10 - 8}$$





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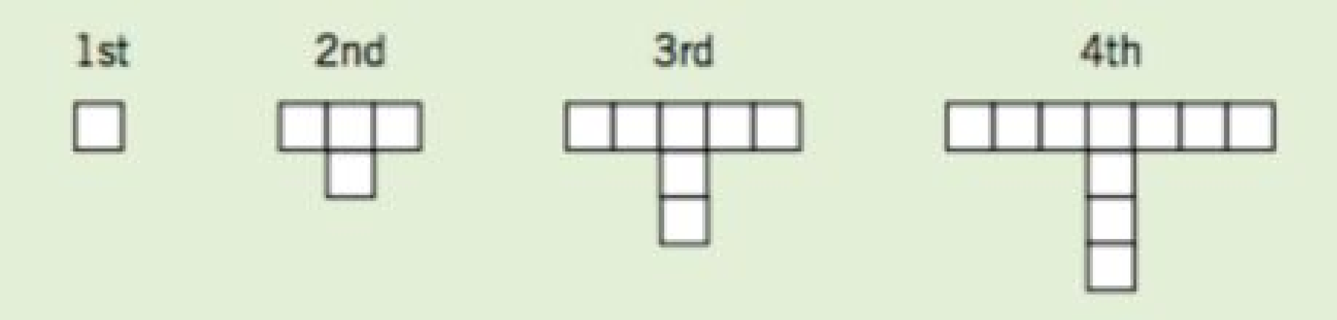
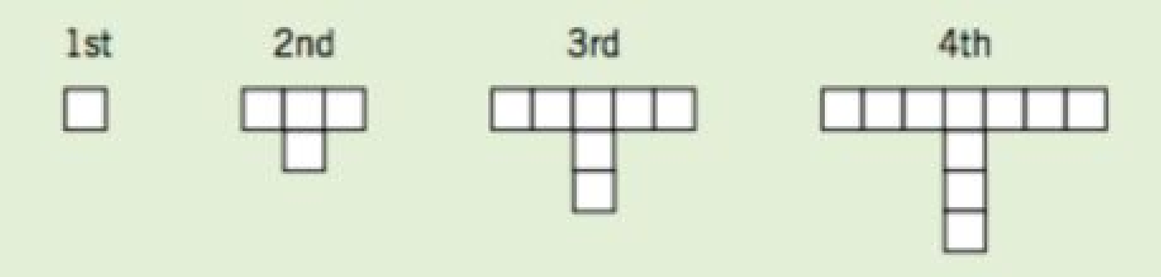
Task 2

Make sure multiple representations are taught together



Find the number of tiles on the...

- 5th stage
- 8th Stage
- 50th Stage



x	y
1	1
2	4
3	7
4	10
...	...
8	?

+3

+3

+3

$$\boxed{a_n = a + (n-1)d}$$

5th

= 1 + (5-1)3
= 1 + (4)3
= 1 + 12
= 13

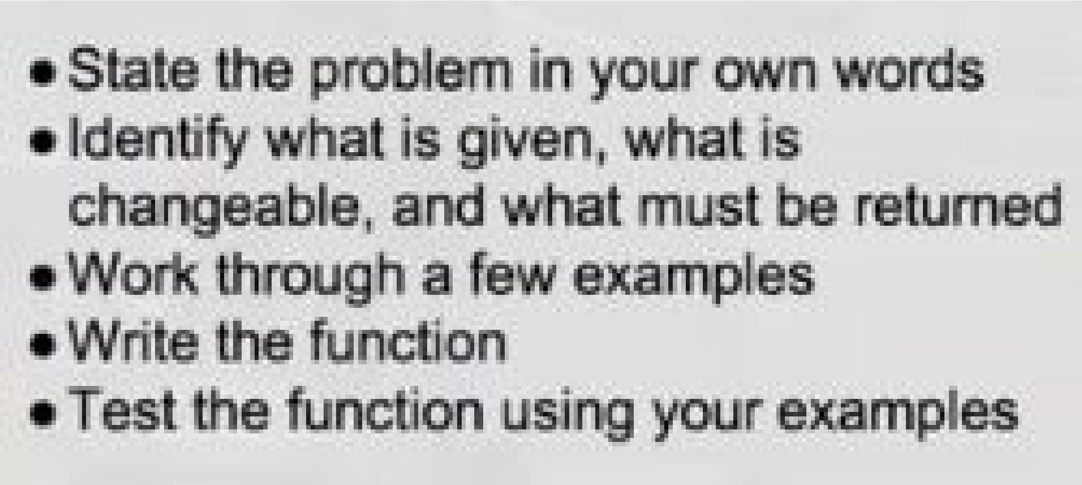
8th

= 1 + (8-1)3
= 1 + (7)3
= 1 + 21
= 22

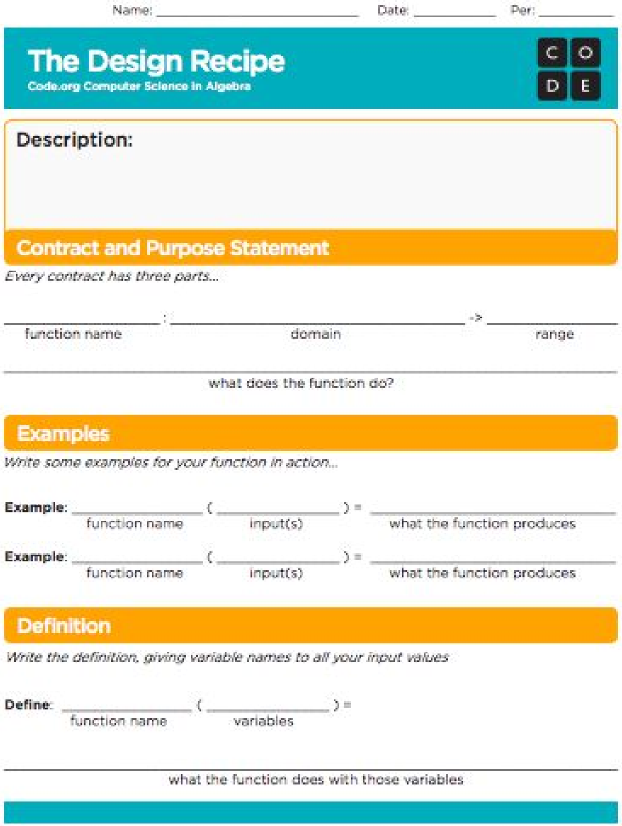
50th

= 1 + (50-1)3
= 1 + (49)3
= 1 + 147
= 148

The Design recipe



- State the problem in your own words
- Identify what is given, what is changeable, and what must be returned
- Work through a few examples
- Write the function
- Test the function using your examples



Name: ______________________ Date: __________ Per: ________

The Design Recipe

Code.org Computer Science in Algebra

Description:

Contract and Purpose Statement

Every contract has three parts...

______________ : ______________________________ -> ______________
function name domain range

____
what does the function do?

Examples

Write some examples for your function in action...

Example: ______________ (______________) = ______________________
function name input(s) what the function produces

Example: ______________ (______________) = ______________________
function name input(s) what the function produces

Definition

Write the definition, giving variable names to all your input values

Define: ______________ (______________) =
function name variables

____
what the function does with those variables

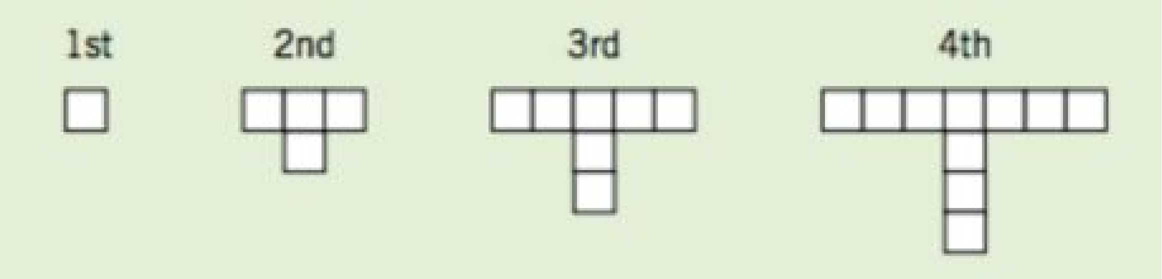
Function Design Recipe

Derived from BOOTSTRAP www.bootstrapworld.org

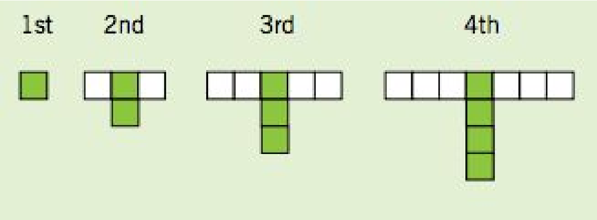
1 CONTRACT

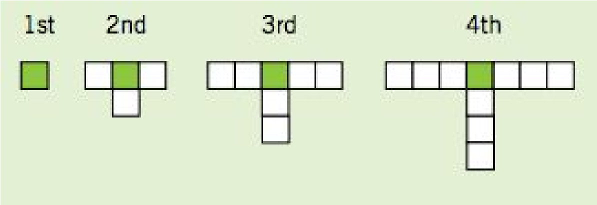
Describes what data **Types** your function takes as its **Domain** and returns as its **Range**.

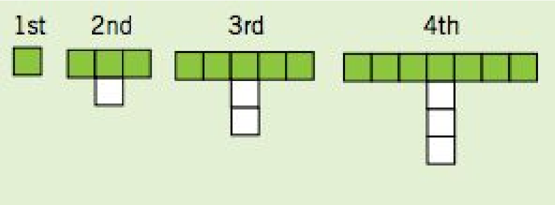
Name: green-triangle
Domain: Number
Range: Image



What is the same? / What is different?

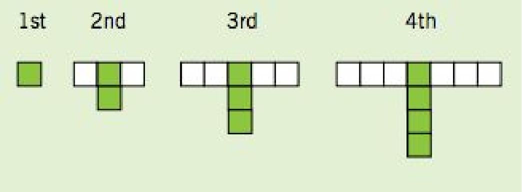






Fast Functions

Write a function `findNew`*, which takes in a number and produces a number that following the pattern*



	findNew	:	Number	→ Number
	name		domain	range
			n	n
Example:	findNew	(	$\boxed{4}$	) = $\boxed{4}$ + ($\boxed{4}$ - 1) + ($\boxed{4}$ - 1) or $\boxed{4}$ + 2($\boxed{4}$ - 1)
			n	
Example:	findNew	(	$\boxed{3}$	) = $\boxed{3}$ + ($\boxed{3}$ - 1) + ($\boxed{3}$ - 1) or $\boxed{3}$ + 2($\boxed{3}$ - 1)
Define:	findNew	(	n	) = n + (n - 1) + (n - 1)) or n + 2(n - 1)

Fast Functions

Write a function `green-triangle`*, which takes in a size and produces a solid, green triangle of that size.*

green-triangle : Number → Image

name domain range

size size

Example: green-triangle (15) = triangle(15, "solid" , "green")

Example: green-triangle (100) = triangle(100, "solid" , "green")

Define: green-triangle (**size**) = triangle(**size** , "solid" , "green")

A batch of cookies will feed 12 hungry students. Write a function `feed`, which takes in the number of batches of cookies and produces the number of students we can feed.

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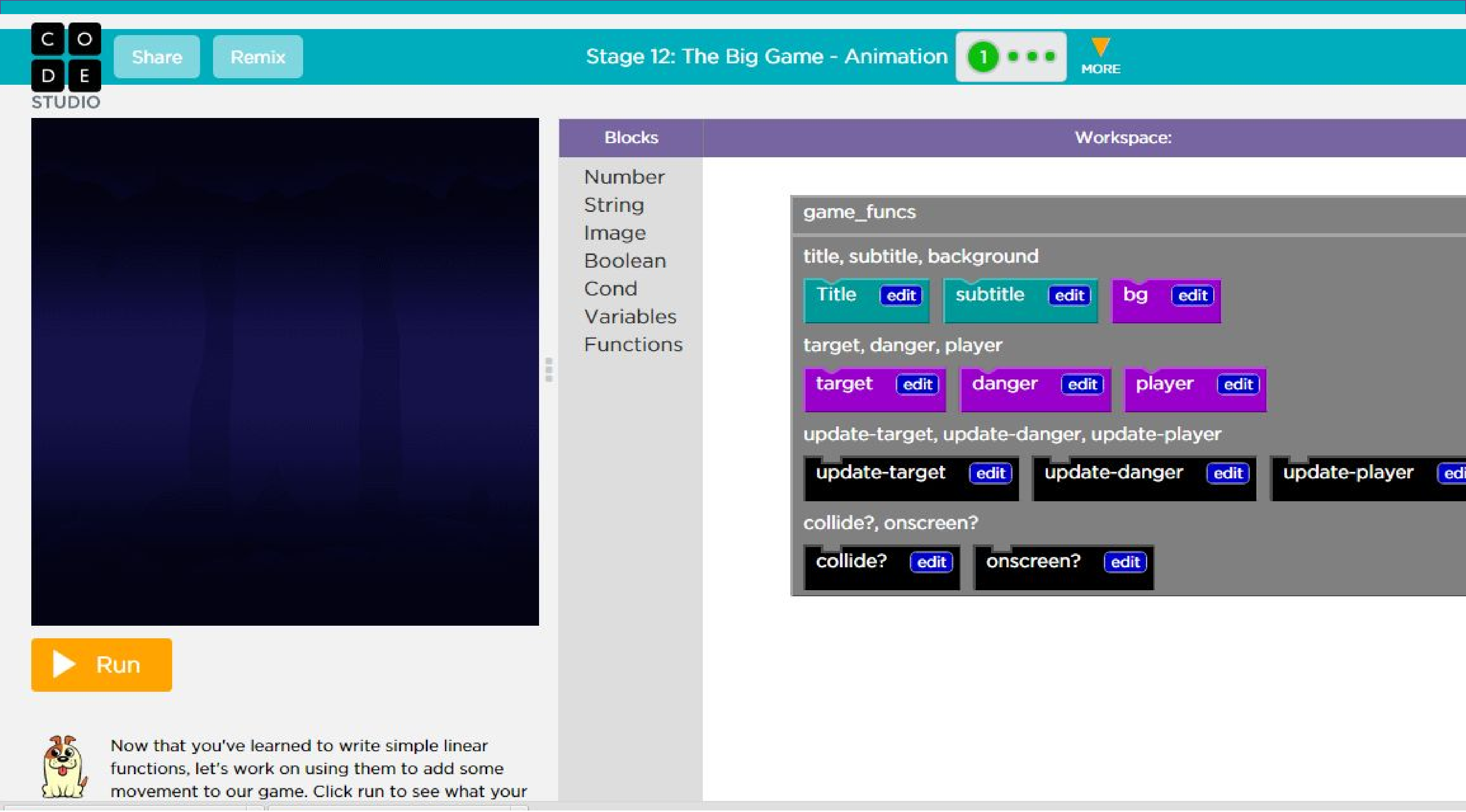
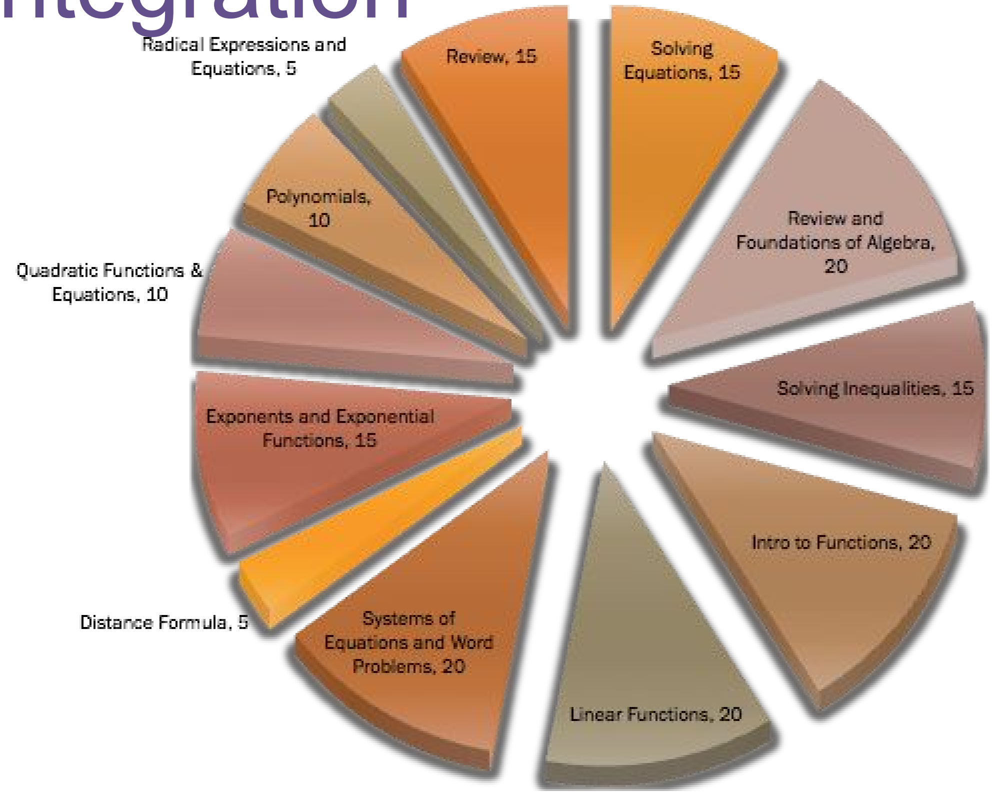
C O D E

Multiple Representations



Now that you've learned to write simple linear functions, let's work on using them to add some movement to our game. Click run to see what your

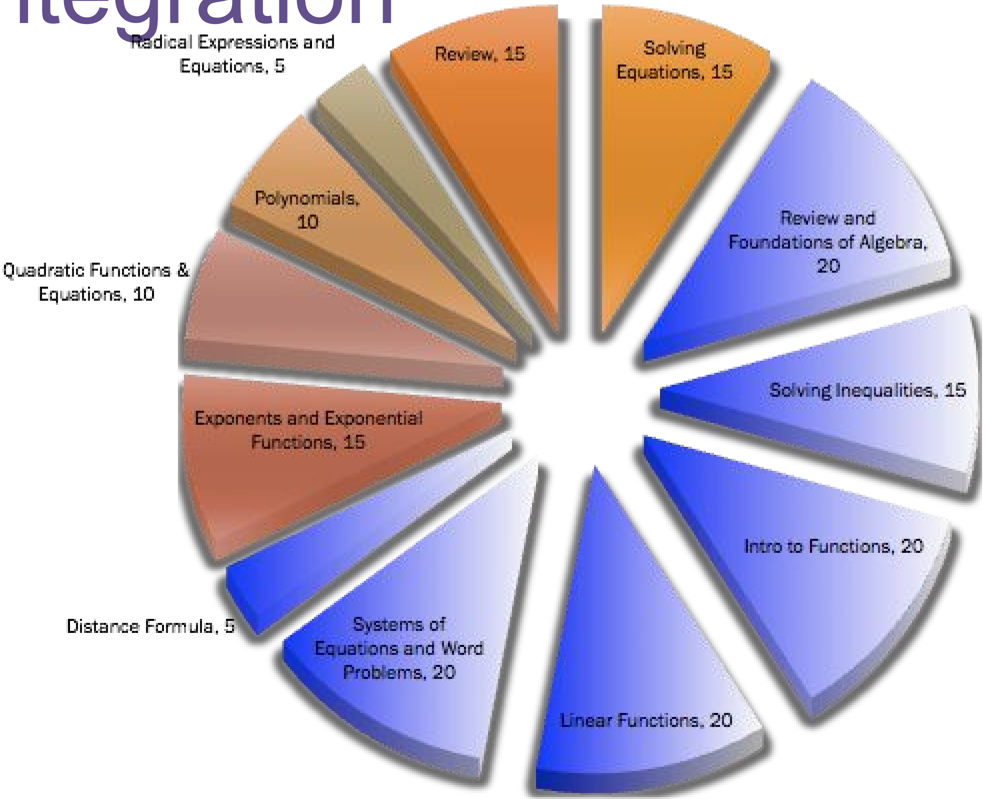
Integration



- Evaluation Blocks
- Design Recipe
- Rocket-Height
- Target/Danger Motion
- Sam the Bat
- Player Motion
- Collision Detection

Derived from BOOTSTRAP www.bootstrapworld.org

Integration



- Evaluation Blocks
- Design Recipe
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QUESTIONS
ANSWERS