PROJECT GUTS
Growing Up Thinking Scientifically

Building Computational Thinkers in Science

Melody Hagaman
June 1, 2017 -Albuquerque, NM

Welcome NM STEM Symposium Attendees!

* If you have not already done so, please create your account on **slnova.org**

Introductions

- **Meet the facilitator:**

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Overview and Logistics

-3 hour hands-on introduction to Modeling and Simulation as a way to integrate CS in Science

-Set up accounts if you have not already done so

slnova.org

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Norms and Expectations:

-Maintain a positive learning environment

-Help one another

-Acknowledge that we are learning something new that is sometimes difficult

-Celebrate and be excited about all progress

-Model the dispositions we'd like to see in our students

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About Project GUTS

NM Adventures in Modeling (2003, NSF-ITEST)
Project GUTS afterschool (2007, NSF-AYS)
2014+ embedding Project GUTS during the school day!

Goals for the Workshop

- Gain understanding of using models to run experiments
- Gain understanding of how CS relates to modern scientific practice
- Gain understanding of **computational thinking** in the context of modeling and simulation.
- Learn how to create a simple Agent-based Model
- Apply the 3 As of **computational thinking** to the activities.
- Use and Identify Web 2.0 applications for lessons

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Workshop agenda

- Computational Thinking
- Mystery Model
- StarLogo Nova Introduction & Flower Turtles,
- Trailblazers & Bumper Turtles,
- Dice and Data & Colliding Turtles
- Epidemic model & experimentation/extensions
- Web 2.0 Resources
- Wrap-up and discussion

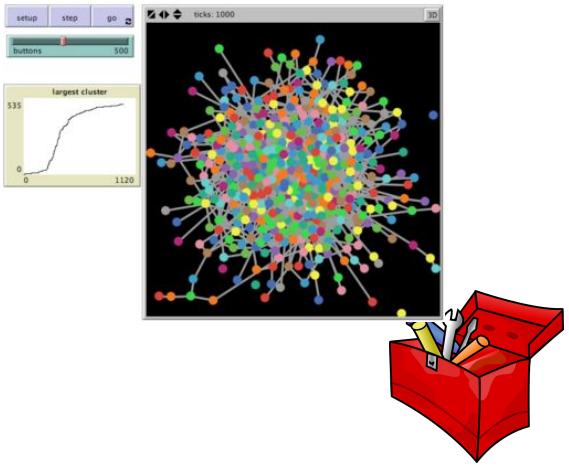
Computational Thinking

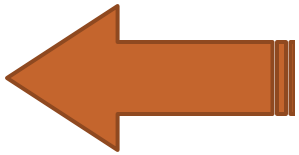
Skills, habits and approaches that are integral to solving problems using computers, developing models and performing simulations

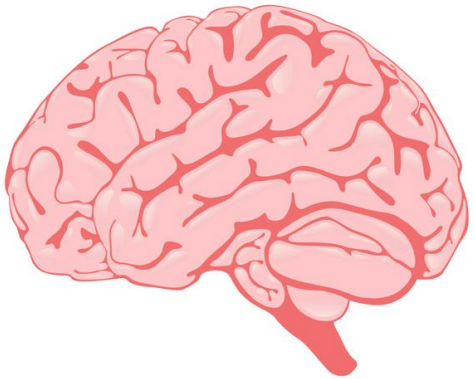
Three Pillars of Computational Thinking

- **Abstraction** – strip down a problem
- **Automation** – repetitive tasks
- **Analysis** – validate abstractions
- ***Decomposition**- break down into smaller parts

Computational Thinking







Computer Modeling and Simulation:

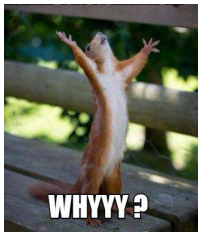
- Agent based modeling
- Stochastic modeling
- Monte Carlo simulation
- Systems dynamics modeling

Computational Thinking:

- Abstraction
- Automation
- Analysis
- Also, Decomposition

NGSS Framework's 8 Scientific practices

1. Asking questions and defining problems
2. Developing and using models
3. Planning and carrying out investigations
4. Analyzing and interpreting data
5. Using math and computational thinking
6. Constructing explanations / solutions
7. Engaging in argument from evidence
8. Obtaining, evaluating, and communicating info.



Web 2.0 GUTS

What's new?

A) Content and practice are intertwined.
(Greater emphasis on "learn and do", and learn by doing, rather than on rote memorization.)

B) Practice includes the use, creation and analysis of computer models and simulations in STEM inquiry and engineering design cycle.

C) Practice includes computational thinking

D) No prescribed ordering of practices

Framework concepts

- Mathematics and computational tools are central to science and engineering.
- Aspects of computational thinking and statistical thinking must be understood and applied in learning about the sciences.
- Students should learn to use mathematics, computational models and computational and statistical thinking for scientific inquiry and data analysis.

Goals relating to developing and using models (NRC Framework, p. 50)

By grade 12, students should be able to:

- Represent and explain phenomena with multiple types of models.
- Discuss the limitations and precision of a model …
- Refine a model ….
- Use computer simulations as a tool for understanding aspects of a system….
- Make and use a model to test a design and to compare the effectiveness of different design solutions.

Goals related to using computational and mathematical tools for data analysis (NRC Framework, p. 56)

By grade 12, students should be able to:

- Recognize that computer simulations are built on mathematical models that incorporate underlying assumptions about the phenomena or systems being studied.
- Use simple test cases of mathematical expressions, computer programs, or simulations—that is, compare their outcomes with what is known about the real world—to see if they "make sense."
- Use grade-level appropriate understanding of mathematics and statistics in analyzing data.

Web 2.0 and Computational Thinking

Creating something for an authentic audience improves:

- quality of the product
- critical thinking involved
- engagement

Should involve:

- Opportunity for authentic feedback
- Collaboration

Examples:

- Blogs
- Wikis
- Podcasts
- Animations
- Shared Docs
- Vlogs

Zawilinski, L. M. (2016).

Introduction to Computer Modeling and Simulation

-Mystery model

-www.slnova.org/GUTS/projects/310628/

- use model observation form
- also, give a quick tour of the interface.
- introduce setup and forever

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Introduction to Web 2.0

1. Share your observations verbally with a partner or group member
2. Add your name to the **Mystery Model Web 2.0 Mock Wiki**
3. Add your predictions and evidence
4. Add a question to at least 2 of your peer's "wikis"
5. Go back to your and answer the questions your peers left for you

Mystery Model Web 2.0 Mock Wiki

Student	Prediction about Mystery Model	3 Observations as Evidence	Peer Feedback Question
Example Student	I think the mystery model is of the effects of pollution on plants in the ocean.	1. The things on the bottom of the world get bigger smaller like they are growing and dying 2. The thing at the top is releasing something that is changing their growth 3. The graph shows that sometimes there are spikes	What do you think the spikes in the graph could mean? -Sally What do you think the thing at the top actually is? -Juan

Think Pair Share: What Computational Thinking Skills Did the Mystery Model Activity involve?

Three Pillars of Computational Thinking

- **Abstraction** – strip down a problem
- **Automation** – repetitive tasks
- **Analysis** – validate abstractions

- **Decomposition** -- Breaking down into smaller steps

Project GUTS resources

- Our website: projectguts.org
  - -top menu, click on **Resources**
  - -top menu, click on **Curriculum**

- All modules & resources are free

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CS in Science--The Big Picture

-Use-Modify-Create Approach
-Guide on the Side
-Building vs. Using Models
-Study real-world phenomena..
  -cheaply, more safely, more conveniently
  -in ways otherwise impossible

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Quick Demo!

- **Completed Models:**
  - Epidemic with a twist (Zombies…)
  - Water Pump
  - Greenhouse Gases
  - Ecosystems
  - Chemical Reaction

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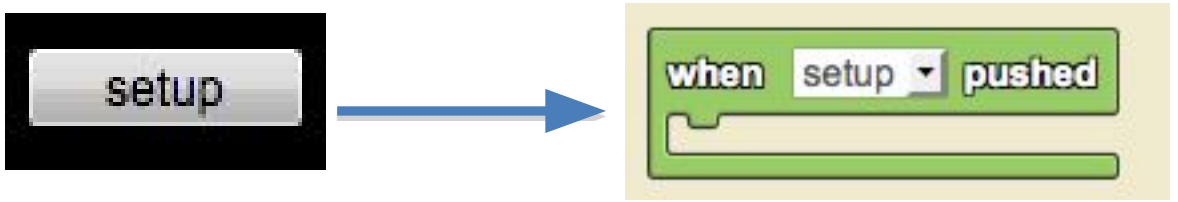
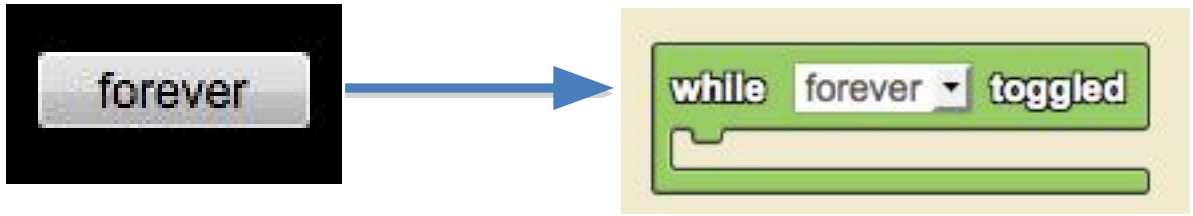
Setup and Forever blocks





Use!

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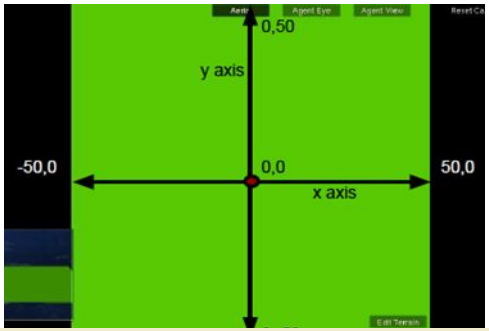
Modeling and Simulation

Introduction to StarLogo Nova
Flower Turtles

StarLogo Nova
A web-based software program

Create!



Computer Science Concepts

- Instructions
- Computer Program
- Looping
- Iterations
- Conditionals
- Variables
- Remixing

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StarLogo Nova Tour

-Three areas: Info, Interface, Code
-Remix, save, and run code.
-View code vs. Play mode
-Widgets and Spaceland
-Blocks area
    pages, drawers, blocks
    cut and paste, trash

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Flower Turtles

(instructing agents to impact their environment)

-Login to StarLogo Nova, go to the GUTS gallery
http://www.slnova.org/GUTS/

-Open and Remix the project called
"Lesson 2a- Flower Turtles- Tutorial Introduction Project"
http://www.slnova.org/GUTS/projects/4703/

-Some of the code will already be there...add what is missing and run your first model!

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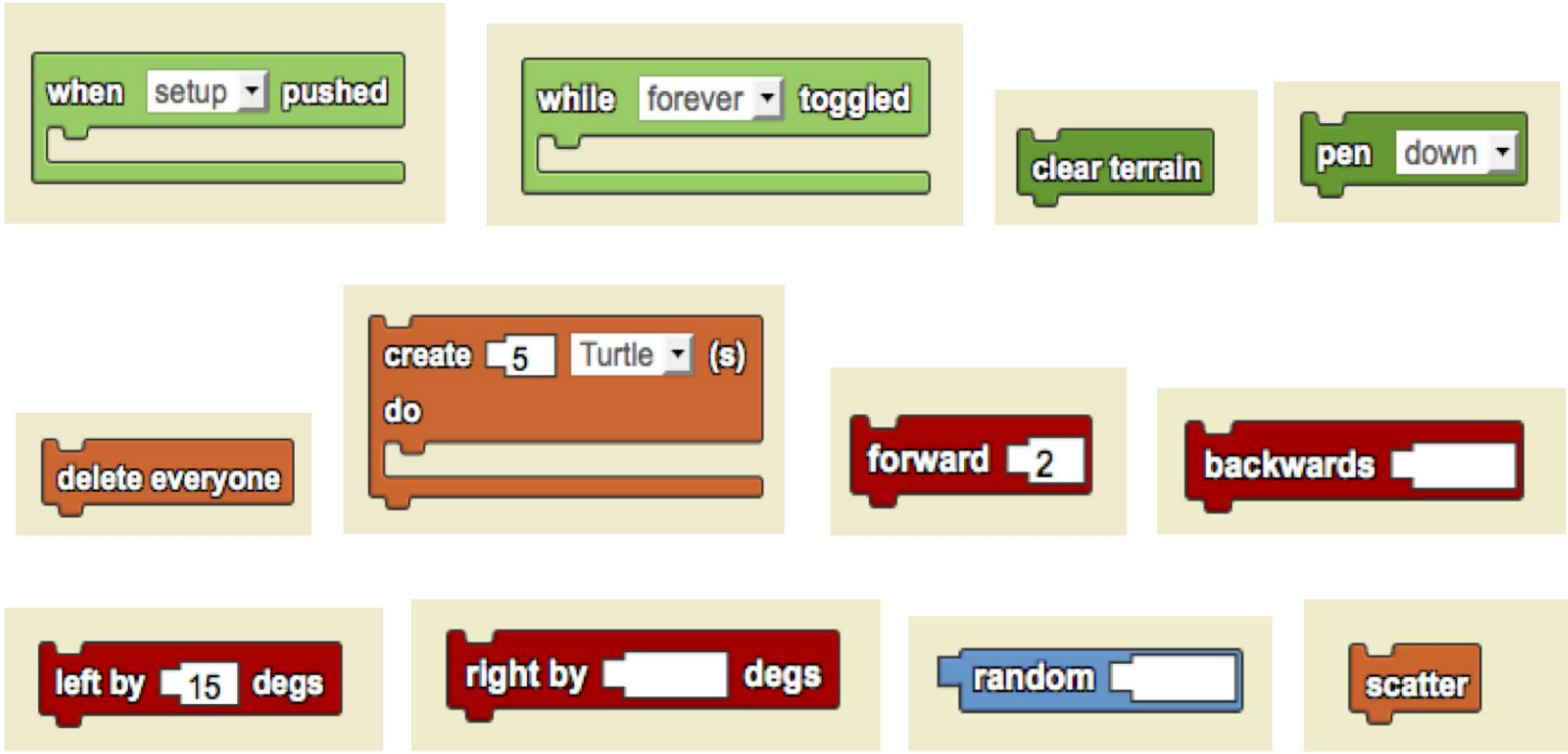
StarLogo Nova Blocks Review



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Pair Programming- a kid's perspective

- Driver & Navigator protocols
- Switching often
  - (every 7 to 10 minutes)

https://www.youtube.com/watch?v=vgkahOzFH2Q

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Pedagogy for Building Models

-Pair Programming

  -Drivers

  -Navigators

  -Why???

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http://mediad.publicbroadcasting.net/p/shared/npr/styles/placed_wide/nprshared/201310/208254582.jpg

Terms to Remember

- Agent
- Location
- Heading
- Steps
- Iteration
- Setup
- Runtime
- Random

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Modeling and Simulation

Conditionals and Boolean Logic
Trailblazer and Bumper Turtles

Review from Flower Turtles

- What commands enabled turtles to impact their environment?
- What could an agent leaving trails represent in a real world scenario?

How turtles can react to their environment

Trailblazer

Instructions

- Starting and ending in the same place.
- Using a pencil, draw the path in the CENTER of squares.
- Pick up ALL the gold while avoiding the hazards.
- Color the squares as necessary according to the following rules:
  - **Take a step forward.**
  - **If you are standing on a RED square, then turn right by 90 degrees**
  - **Else If you are standing on a BLUE square, then turn left by 90 degrees**
  - **Else If you are standing on a YELLOW or BLACK square, then turn right by 180 degrees**
  - **Repeat**
- Trade your map with your partner.

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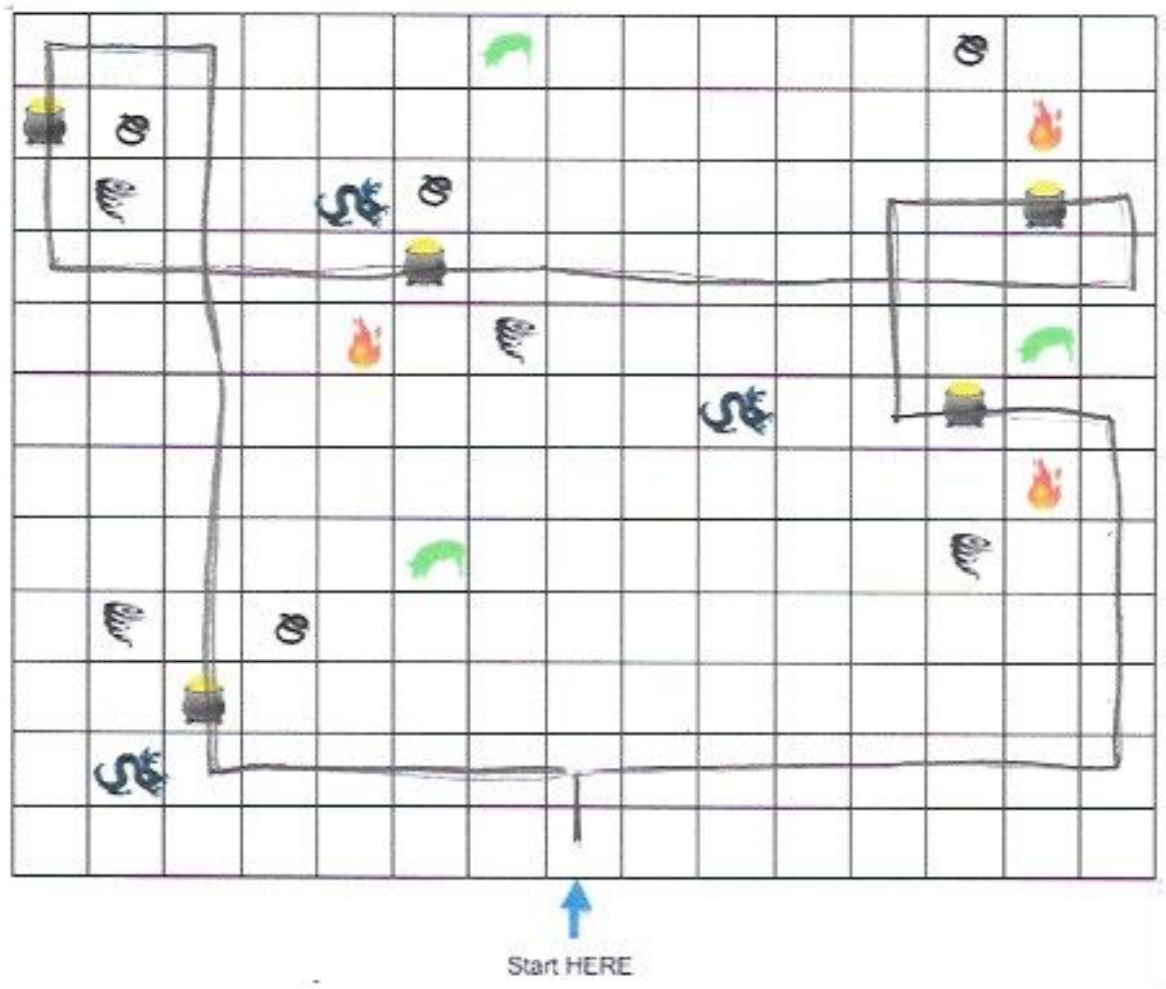
How turtles can react to their environment

Trailblazer



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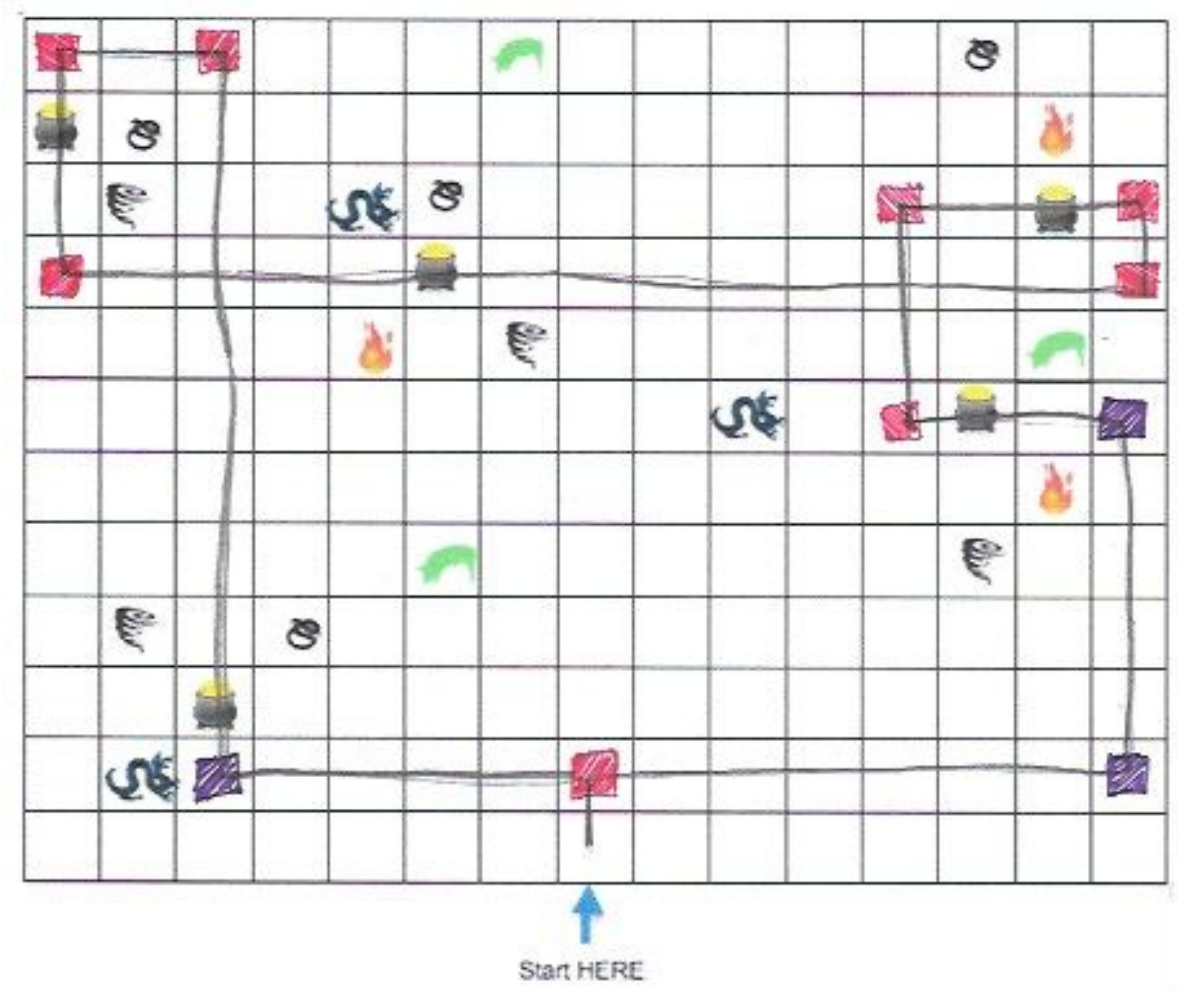
How turtles can react to their environment

Trailblazer



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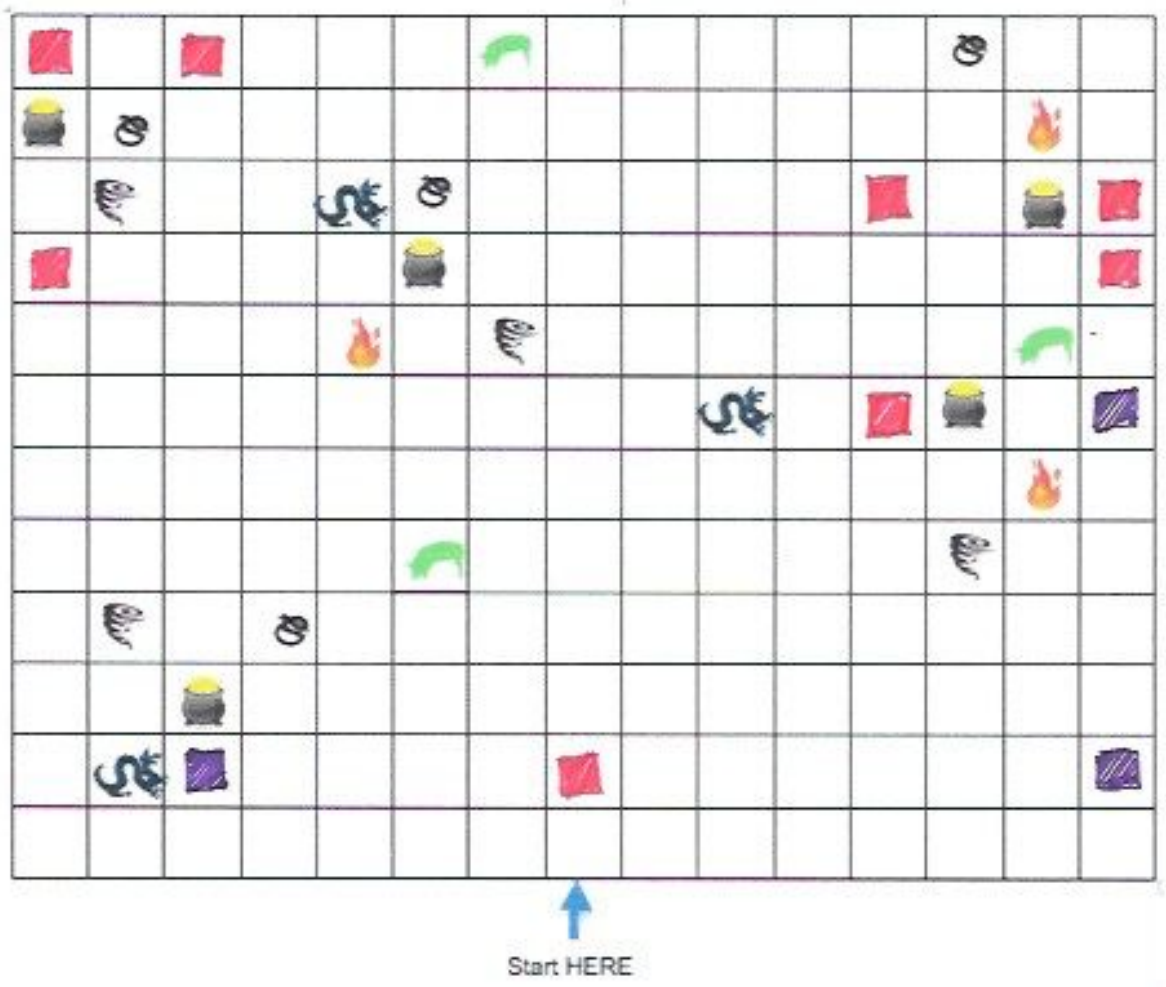
How turtles can react to their environment

Trailblazer



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Trailblazer Lifesize

- Plan a route to get to the front of the room for some chocolate and get back to your table following these rules:
  - Take a step forward
  - If on **Red**: Right 90
  - If on **Blue**: Left 90
  - If on **Yellow**: Right 180

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Trailblazer Learnings

- Different instructions can be followed based on conditions (what color square you are on).
- Algorithms are sequences of instructions that perform a task.
- Each different path we created can be thought of as a different algorithm.

Discussion-

- Are some better algorithms than others?
- Why or why not?

(see http://compass.ups.com/ups-drivers-avoid-left-turns/)

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Trailblazer Learnings

- What computational thinking skills did this activity involve?
- How could you use Web 2.0 to facilitate deeper learning for this activity?

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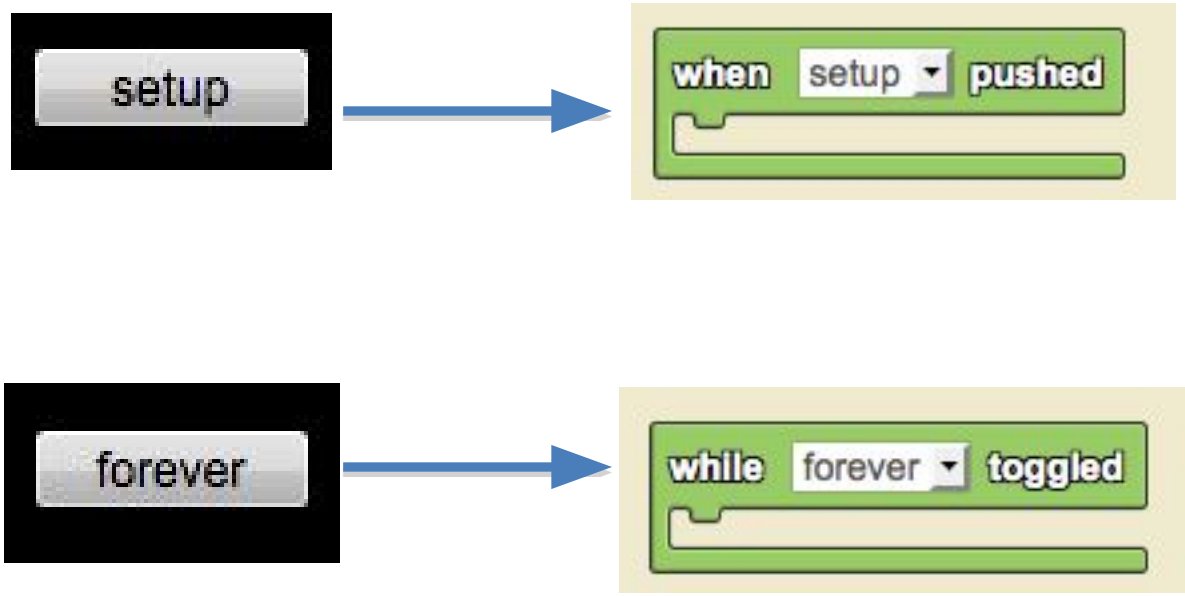
Bumper turtles

- Now we are going to instruct our turtles to follow different instructions based on conditions.

- Use the same rules as trailblazers:
  - **If you are standing on a RED square, then turn right by 90 degrees**
  - **Else If you are standing on a BLUE square, then turn left by 90 degrees**
  - **Else If you are standing on a BLACK square, then turn right by 180**

Setup and Forever blocks



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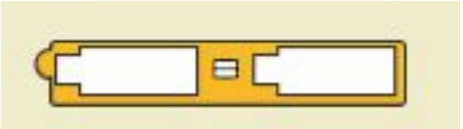
New StarLogo Nova Blocks



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Modify!

Bumper Turtles Challenge

- Start with the program called “Bumper Turtles starter” program

  http://slnova.org/GUTS/projects/9383/

- Click on the “Paint Landmarks” push button and see the program execute the code provided.
- **Remix the project**
- Your challenge is to make the turtles react to the landmarks created by the “Paint Landmarks”

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Bumper Turtles Progress Monitor

Goals!

- ❑ Add logic so turtles react to red squares by turning right by 90°
- ❑ Add logic so turtles react to blue squares by turning left by 90°
- ❑ Add logic so turtles react to black squares by turning around 180°

Bonus!

- ❑ Change the number of landmarks drawn in the “Paint Landmarks” procedure
- ❑ Make the turtles change color, shape, or size when they bump into landmarks

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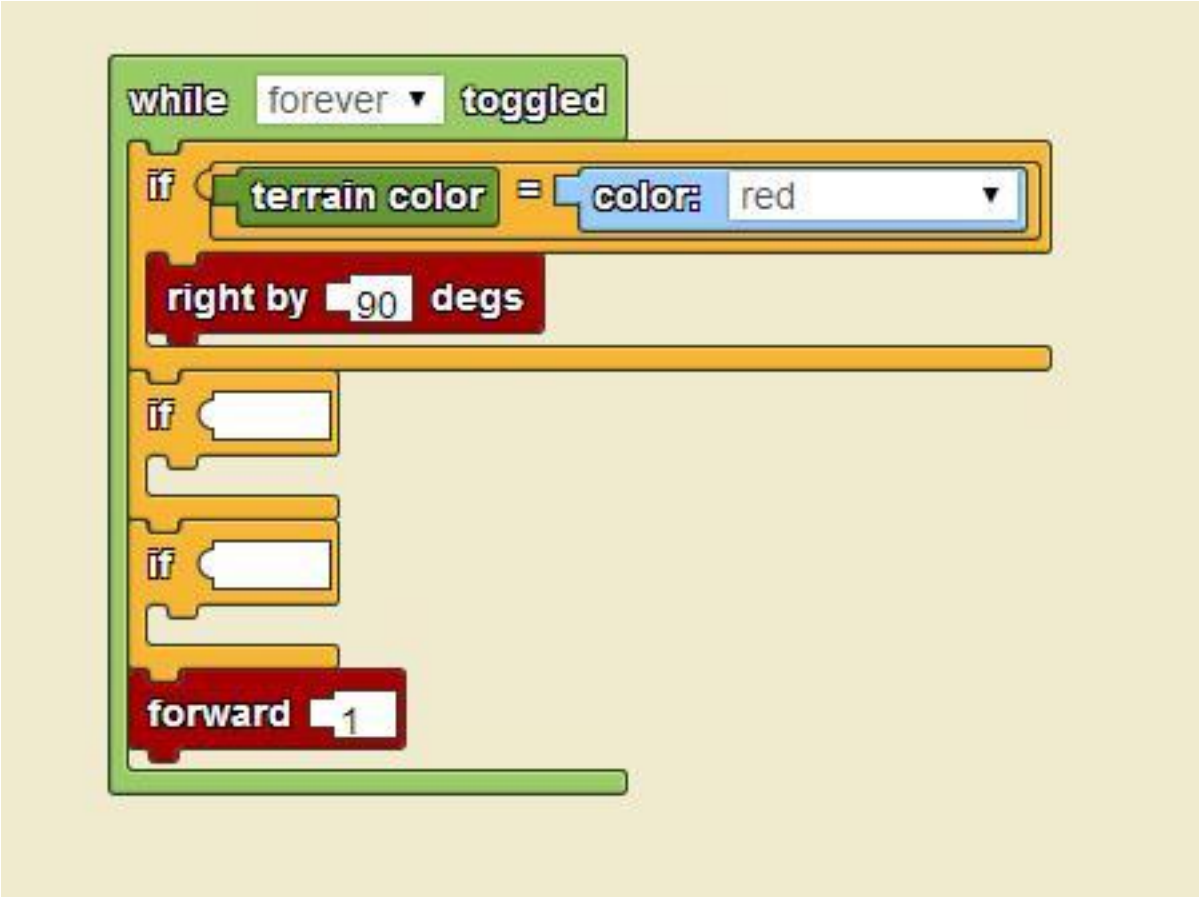
Modify!

Partial Solution



Discussion

- What could these trails and bumpers represent in Bumper Turtles model?
- What computational thinking skills did we use?

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Modeling and Simulation

Probability with Dice and Data, Wiggle Walk, and Colliding Turtles

Use!

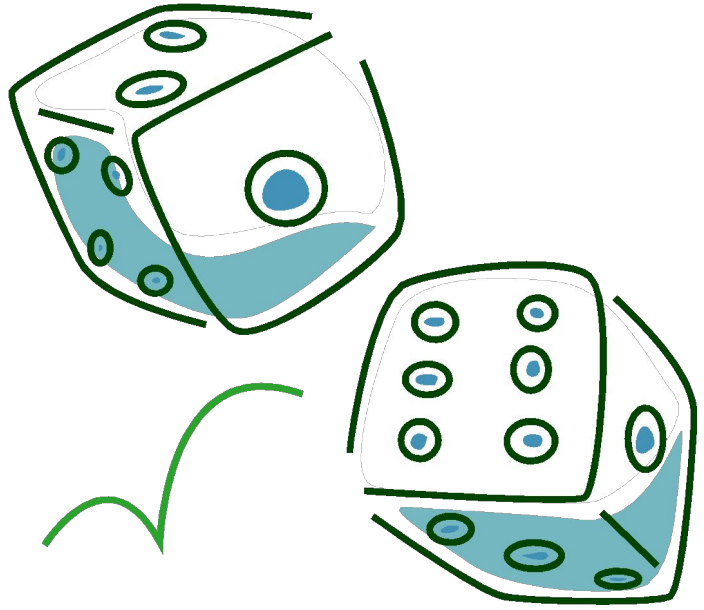
Using Probability

- Next, we are going to learn about probability (or the likelihood of something happening).
- Then we are going to use probability to make turtles do a “wiggle” walk.

Dice and Data

-Gain understanding through hands-on exercise

-Materials used



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Roll one die

- Record the result using a hatch mark.
- https://www.geogebra.org/m/UsoH4eNl

1		Sum:
2		Sum:
3		Sum:
4		Sum:
5		Sum:
6		Sum:

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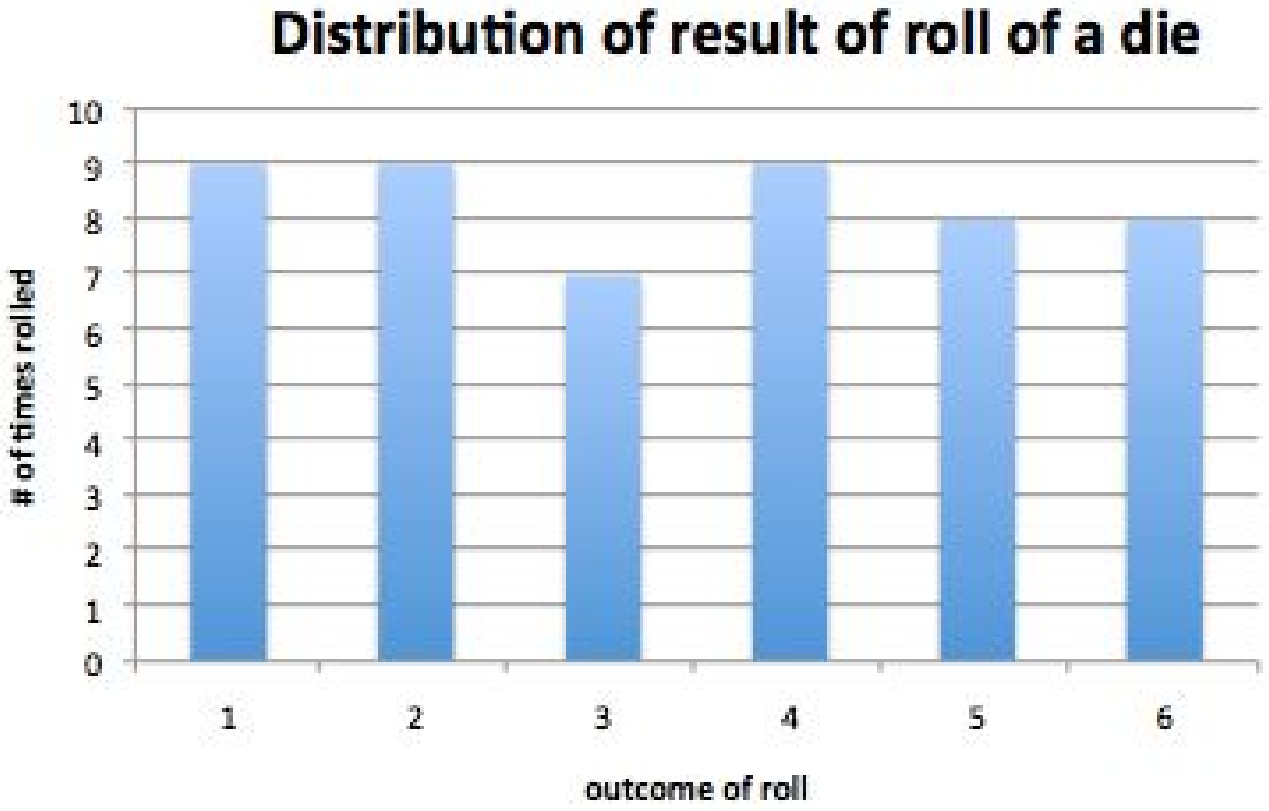
Roll one die

- Possible result of 50 rolls.



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Roll two dice

https://www.geogebra.org/m/Uso

- Record the result with a hatch mark

2 dice (subtraction)	# of occurrences	Sum of tally
5		
4		
3		
2		
1		
0		
-1		
-2		
-3		
-4		
-5		

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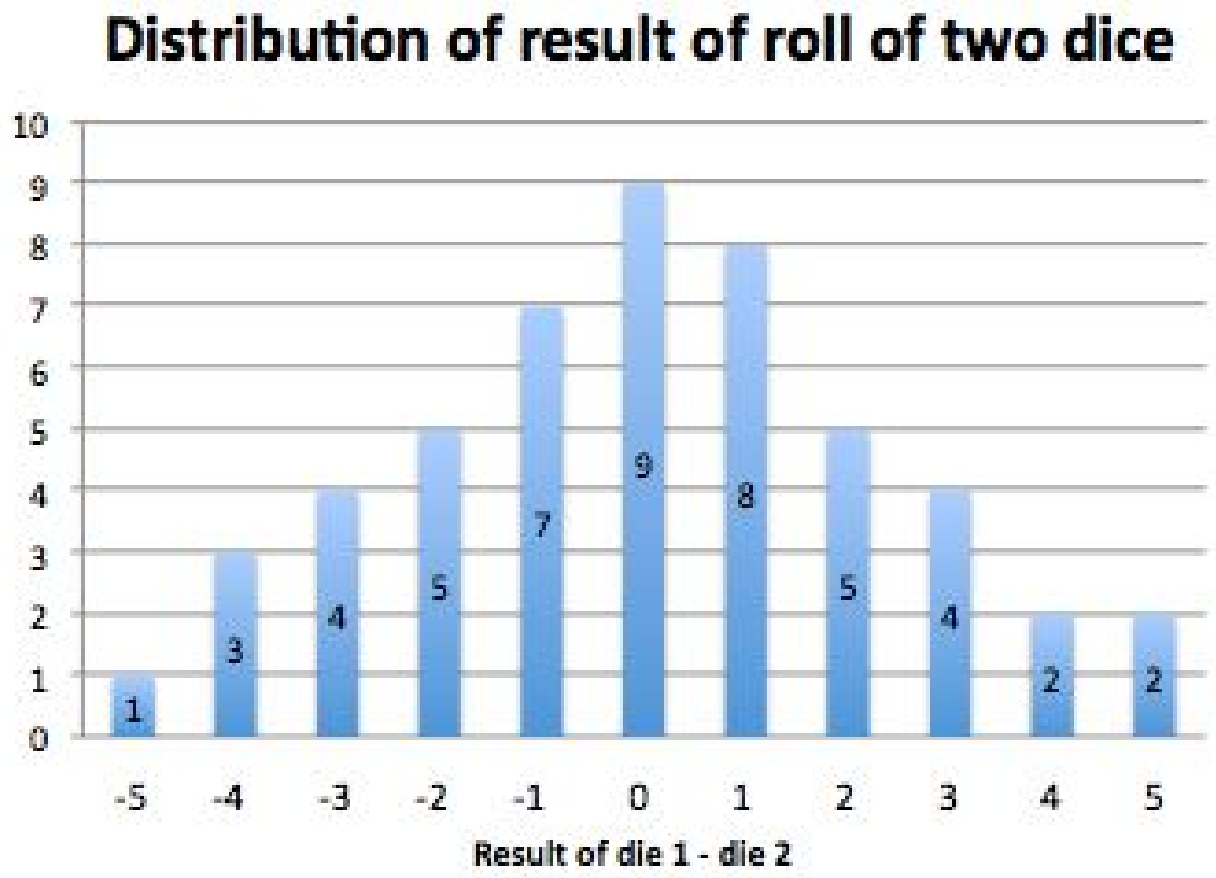
Roll two dice

- Possible result of 50 rolls.



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What does this have to do with a modeling and simulation?

- One die represents right turn amount, the other represents left turn amount.
- Most common outcome is ?

Left turn \ Right turn	1	2	3	4	5	6
1	0	1	2	3	4	5
2	-1	0	1	2	3	4
3	-2	- 1	0	1	2	3
4	-3	-2	-1	0	1	2
5	-4	-3	-2	-1	0	1
6	-5	-4	-3	-2	-1	0

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Use!

Random function

- We can mimic a roll of a die in StarLogo Nova using the random command.
- Random 6 will return a number between 0 and 5.

In StarLogo Nova

- We use a single random function like a single die.

In StarLogo Nova

- We use two randoms to represent rolling two dice.

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Modify!

Wiggle Walk

- What kind of motion does this produce when run repeatedly?

What's really going on?

1. Agent has an initial heading.

2. Agent turns left by some random number of degrees between 1 and 6. In this case, it is 2 degrees. (Image not to scale)

3. Agent turns right by some random number of degrees between 0 and 5. In this case, it is 5 degrees, so the final heading is 3 degrees to the right of the original heading. (Image not to scale)

4. Agent takes one step forward at new heading. (Image not to scale)

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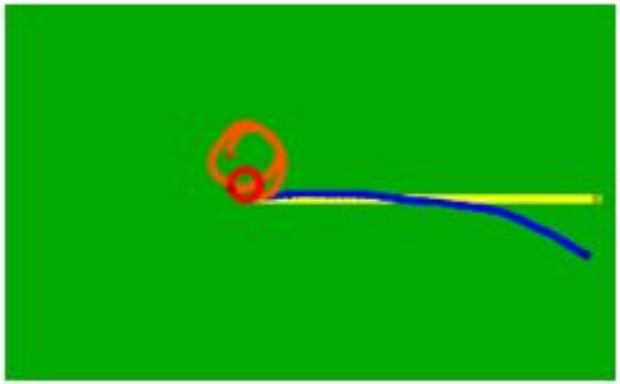
Self-test of understanding



Match the command blocks a, b, c, and d with the path created by an agent following those blocks.

a.

color: _____

c.

color: _____

b.

color: _____

d.

color: _____

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Modeling and Simulation

Colliding Turtles

Modify!

Collisions

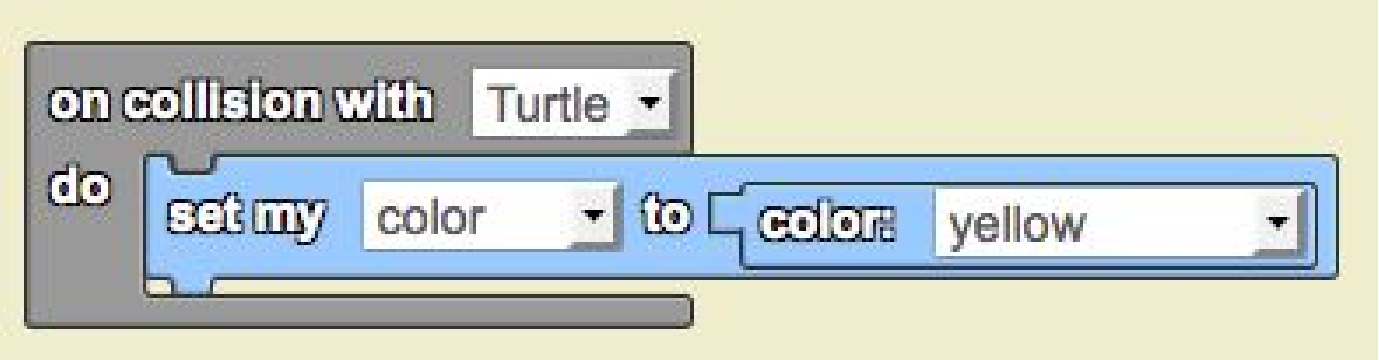
New Command: Collision

- Collisions occur when two agents bump into one another. (They do not need to be centered on the same patch.)

Colliding Turtles

Modify!

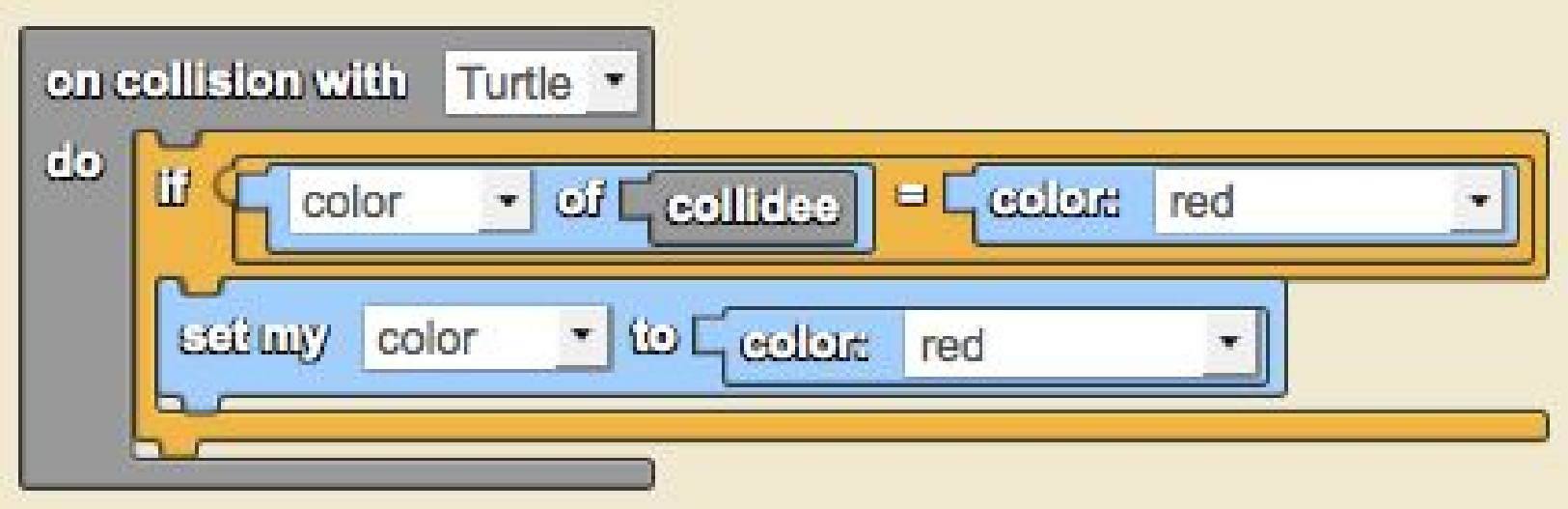
New Command: Collision



Colliding Turtles

Modify!

New Command: Collision with a condition



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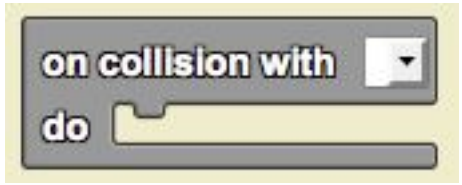
New StarLogo Nova Blocks

Modify!



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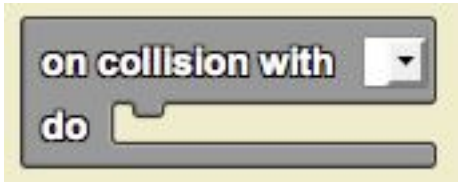
Agent-Agent Interactions

Modify!

Your Challenge: Colliding Turtles

Goals!

- ❑ slnova.org/GUTS/projects/73800/ and REMIX it.
- ❑ Have the turtles move forward with a little wiggle in their walk.
- ❑ Add detection block (collision) so turtles react to each other
- ❑ Change a turtle's trait after a collision [size, color, shape, ?]



Bonus!

- ❑ Upon colliding with a red turtle, have blue turtles react by changing their color to red.

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Review from Colliding Turtles

- What could collisions represent in the real world?
- Why do we use probability in models?
- What computational thinking skills did we use in this activity?

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Modify!

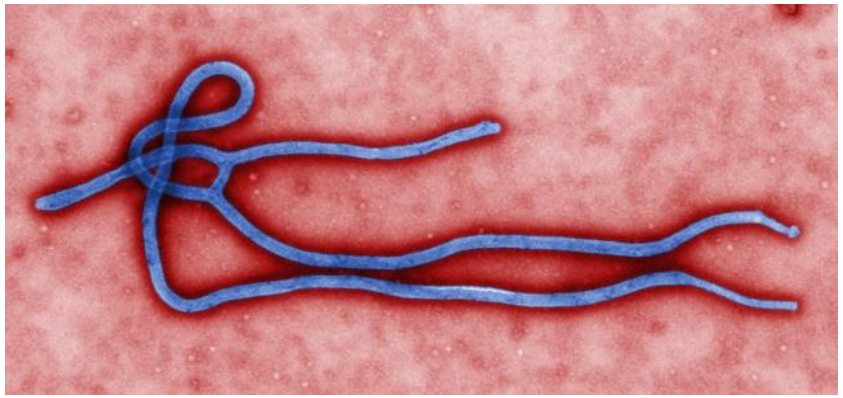
Modeling and Simulation

Modeling the Spread of Disease

Designing and Running Experiments

An Example:

- Ebola virus disease (EVD)
- Transmitted to humans from wild animals and then via human-human contact
- Colorized transmission electron micrograph (TEM) of ebola virus virion



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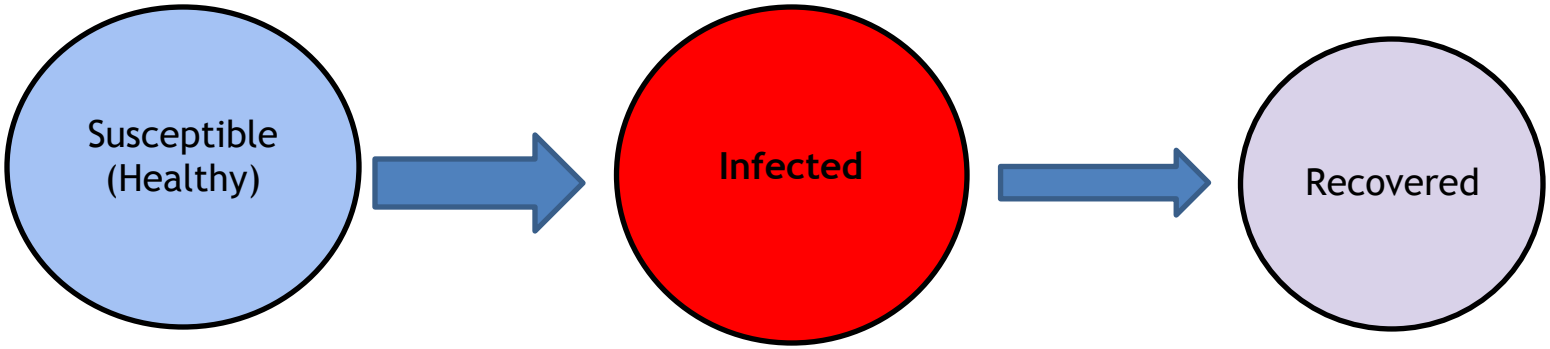
Transmission Cycle

- Ebola



CT for the Epidemic Model

- We are going to turn our colliding turtles model to make it into an epidemic model.
- What do we need? (agents and behavior)
- How do we formulate the task/problem so it can be solved using a computer as a information processing agent?

Epidemic Model

Modify!

Create a 10-30 second podcast on Vocaroo.com to answer: *How would an epidemic model need to be different from our Colliding Turtles model*?

Think about:

- Agents:
- Environment:
- Behaviors:

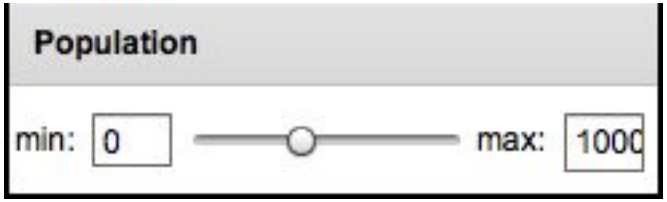
- CS concepts: Variables and Traits

Post your finished podcast on Google Doc n give peer feedback. Example

CS Concept
Traits & Variables

Modify!

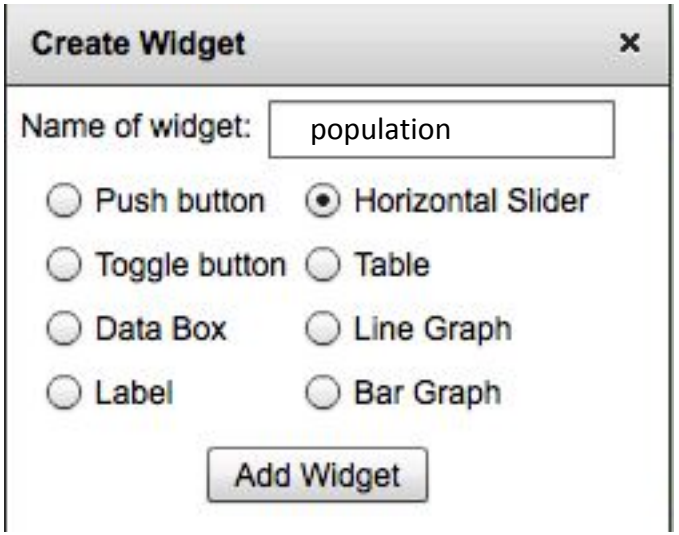
- Traits & variables are containers for holding values.
- Think of a variable as a box with a label.
- In StarLogo Nova, sliders can be used to hold values and set values as inputs to the model.



Modify!

Create a New StarLogo Nova widget

- Name the widget
- Select “Horizontal Slider”



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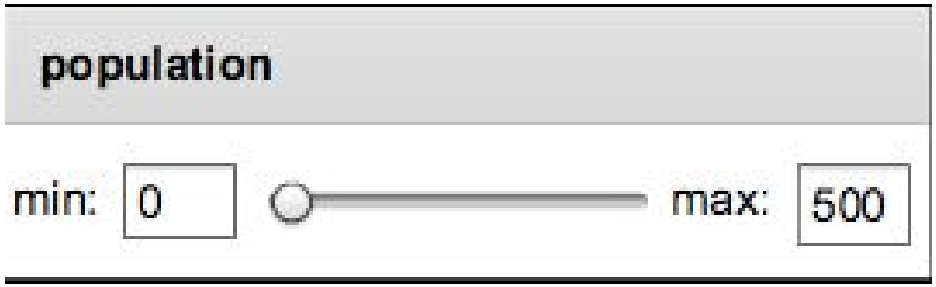
Modify!

New StarLogo Nova widget



- Make a new slider to control the initial number of turtles.
- Change the max value to 500 by typing in 500 next to max and **hitting the return key**.
- Click on “Edit Widgets” again to get out into editing mode and back into play mode.

Modify!

Use the New Widget

- We now have a way to set the number of turtles through the user interface with a slider.
- We can get the value of population in code.
- Replace the # in create do block with population slider value.

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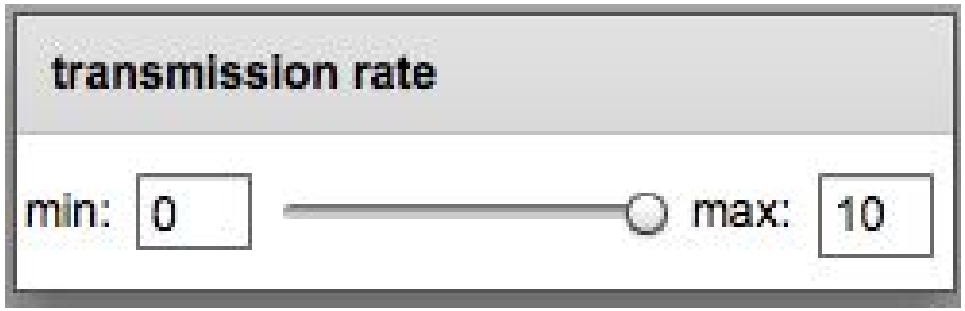
Epidemic Model

Modify!

- Now let's add a new slider to hold a value called the transmission rate.
- This rate is the percentage of time a disease gets passed from one person to another upon collision.

Modify!

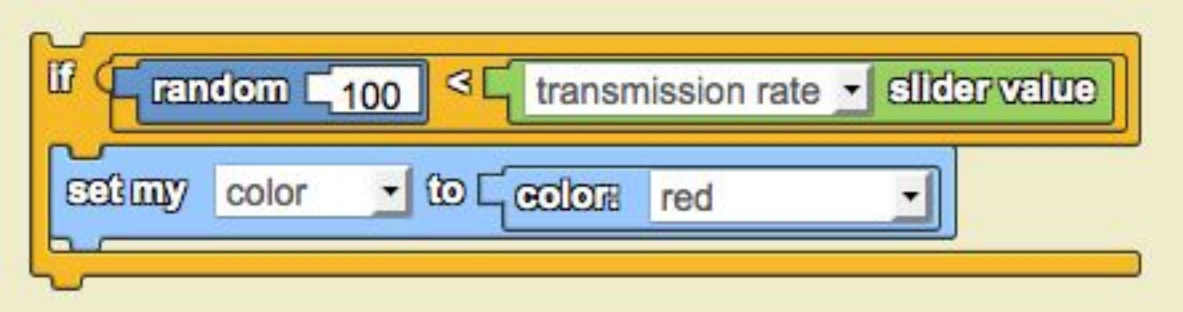
2nd slider- Transmission Rate



- Add a second slider for transmission

Modify!

Use the Transmission Rate Widget



- We are rolling a 100-sided die. If the result is less than the transmission rate, pass the disease on.
- How often should we roll less than the transmission rate?
- What kind of distribution does the roll of a single die give us?

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Probability in Transmission Rate

- We are rolling a 100-sided die. If the result is less than the transmission rate, pass the disease on.

All possible outcomes of the roll can be seen as a number line.

*If you roll between 1 and 20, you pass the disease on. This should happen only 20% of the time because there is an equal chance of rolling any # between 0-100.

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Epidemic Model Progress Monitor

Goals!

- ❑ Create several hundred blue turtles and a few red turtles [hint: Setup]
- ❑ Make them wiggle! [hint: Forever]
- ❑ Create a collision block in which blue turtles turn red when they encounter red turtles [hint: Lesson 4 Student Activity #2 Guide]
- ❑ Create a slider and an if-then for the probability of transmission rate [hint: Lesson 4 Student Activity #2 Guide]

Bonus!

- ❑ Add a line graph with a line for infected turtles and one for healthy turtles [hint: Lesson 6 Student Activity #1]
- ❑ Add a slider (or more) for one (or more) of the following:
  - ✧ Number of original healthy population
  - ✧ Number of original sick population

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Let's take it further! We're gonna add a Doctor!

- Open up the epidemic model again
  - www.slnova.org/Mhagaman/projects/78895/
- Remix it and give it a new exciting title
- Follow the directions from the video here:

https://youtu.be/fHOCZqyPcZ4

-Add to public gallery and share on Doc!

Reinforce Concepts

Definitions:

- Qualitative means relating to, measuring, or measured by the *quality* of something (its size, appearance, value, etc.) rather than its quantity.

- Quantitative means relating to, measuring, or measured by the *quantity* of something rather than its quality.

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Designing and Running Experiments

- Use the Experimental Design form to describe your experiment.
- Plan and run an experiment.
- Describe and share their findings.
  - Think-pair-share
  - Round-robin
  - Group discussion

Use!

Modify!

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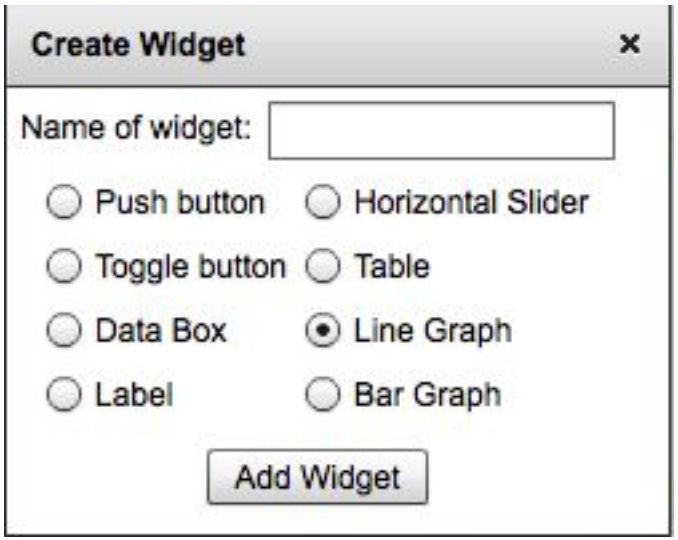
Instrumenting your Model

- Let's create a new "line graph" widget called "Population Healthy and Sick."
- We'll use it to track #red (sick) and #blue (healthy) over time.



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Instrumenting your Model

- Drag the line graph off to the side of Spaceland.
- Double click on New Series and change its name to "CountHealthy" then select blue as its line color.
- Add another Series and change its name to "CountSick" then select red as its line color.
- Finally, click "Edit Widgets" to leave editing mode and returning to play mode.

Use! Modify!

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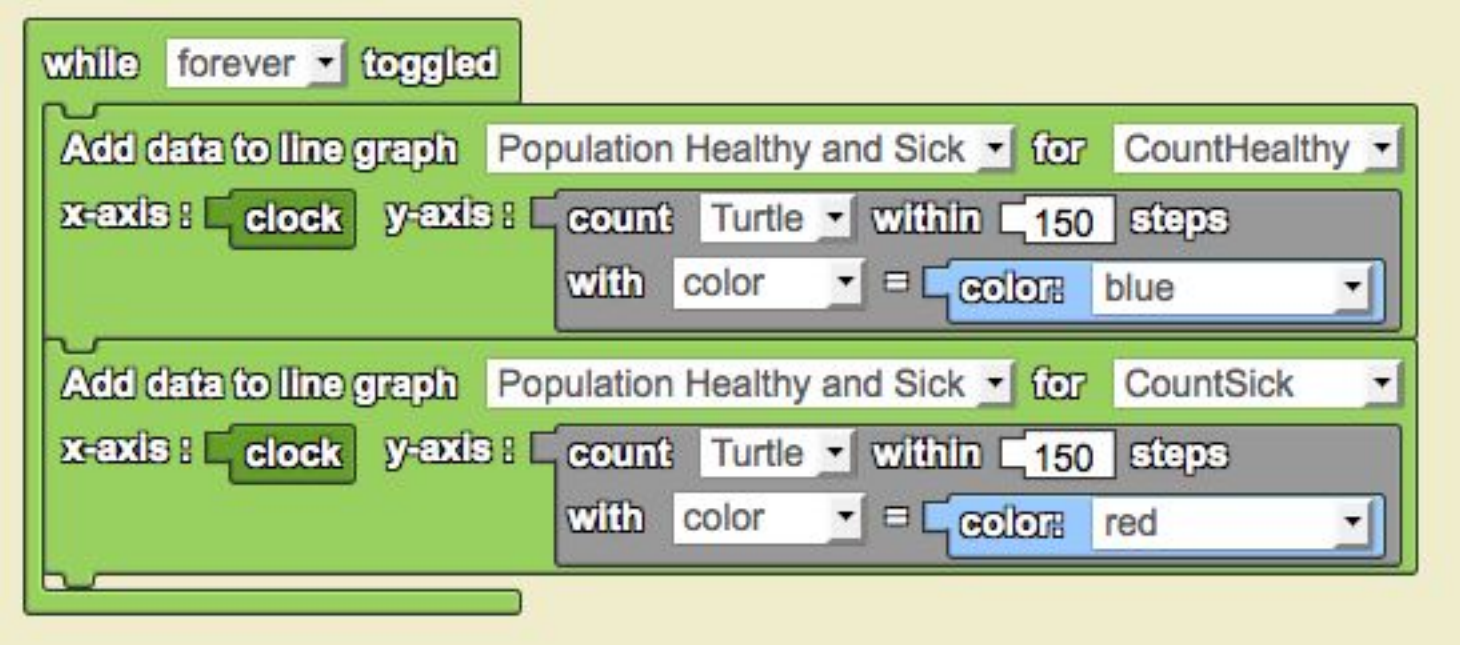
Instrumenting your Model

- We want The World to update the line graph each time through the forever loop.



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Use! Modify!

Test your Model

- Does the line graph work?
- What patterns can you see that were difficult to see without the line graph?

Use!

Modify!

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Review

- Where was the CT in modeling epidemics?
- How can computer models of epidemics be used to better understand the spread of disease?
- Why is it important to instrument models?

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Discussion

- Think about possible ways students could extend this model.
- Final Assignment:
  - How could you use Web 2.0 resources to deepen the learning for your students during the epidemic model?

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In closing:

-Reflect!

-In small groups (2 pairs) discuss:

-What was the best part of the day?

-What was the most exciting thing you learned?

Be ready to share!

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Did we meet the Goals for the Day?

- Gain understanding of using models to run experiments
- Gain understanding of how CS relates to modern scientific practice
- Learn how to create a simple Agent-based Model
- Use and identify Web 2.0 resources for use within classroom and with CT and CS

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THANK YOU!

Websites:

projectguts.org (curriculum & resources tabs)

teacherswithguts.org (JOIN!)

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Teachers with GUTS

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