MIT STEP/TEA

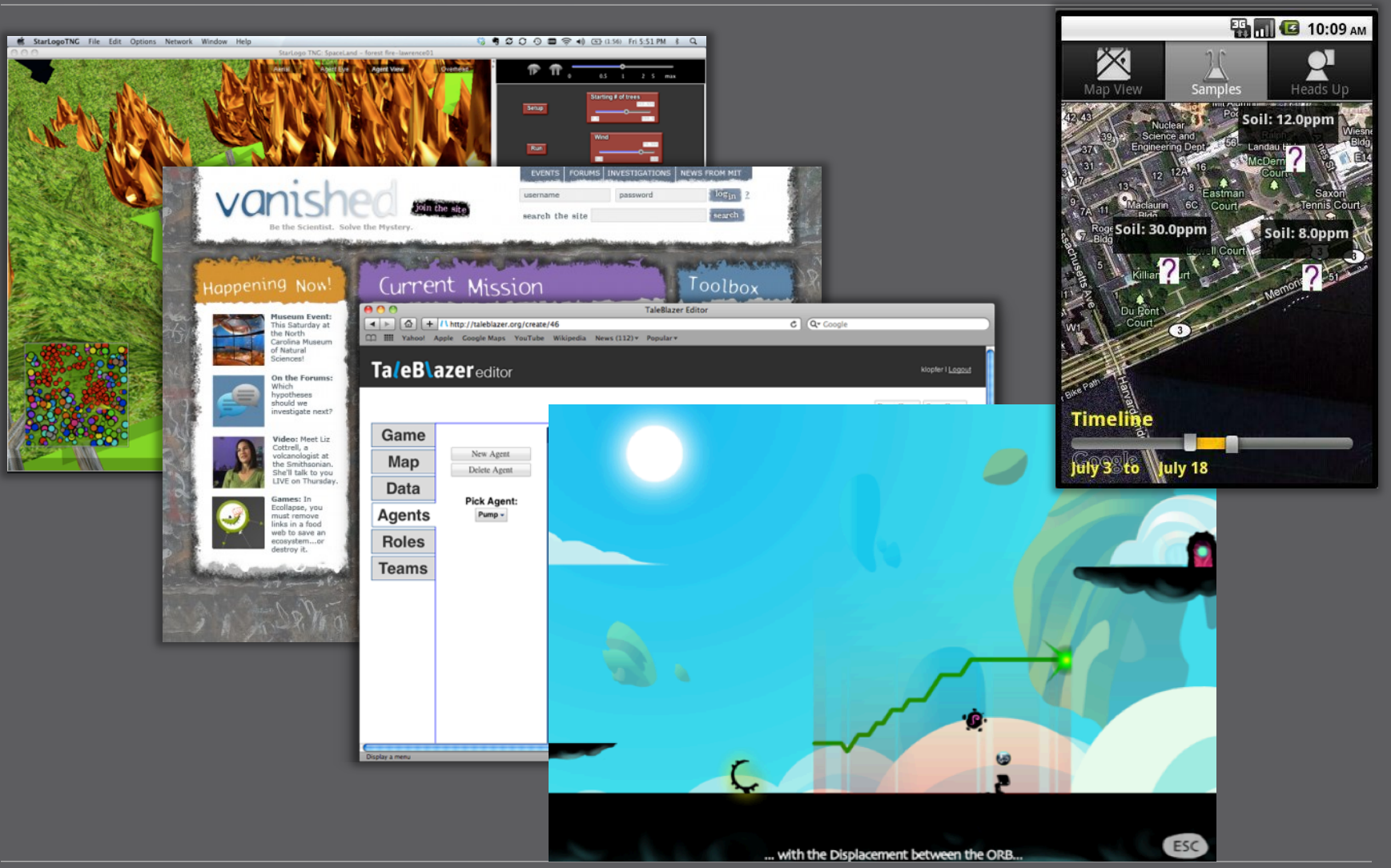
Learning Games Are Hard Fun

ERIC KLOPFER: MIT SCHELLER TEACHER EDUCATION PROGRAM (STEP) | THE EDUCATION ARCADE (TEA) | LEARNING GAMES NETWORK (LGN) | CMS, MEDIA LAB & ESD AFFILITATIONS

STEP/TEA Pedagogical Frameworks

- **What kind of learning environments?**
  - Create highly **engaged**, motivated students
  - Provide **immersive** environments, **relevant** problems
  - Facilitate **collaborative, project-based** learning
  - Game-like, active, "**Hard Fun**"
    - A teacher heard one child using these words to describe the computer work: "It's fun. It's hard…" I have no doubt that this kid called the work fun because it was hard rather than in spite of being hard. [S. Papert, 2002]
  - Applicable to **formal** and **informal** settings, **extending learning** beyond walls of the school, beyond hours of the school-day

Learning Through Game Play and Creation



Games? Learning?

The Legacy of Math Blaster

- Edutainment
  - Where play is the reward for learning

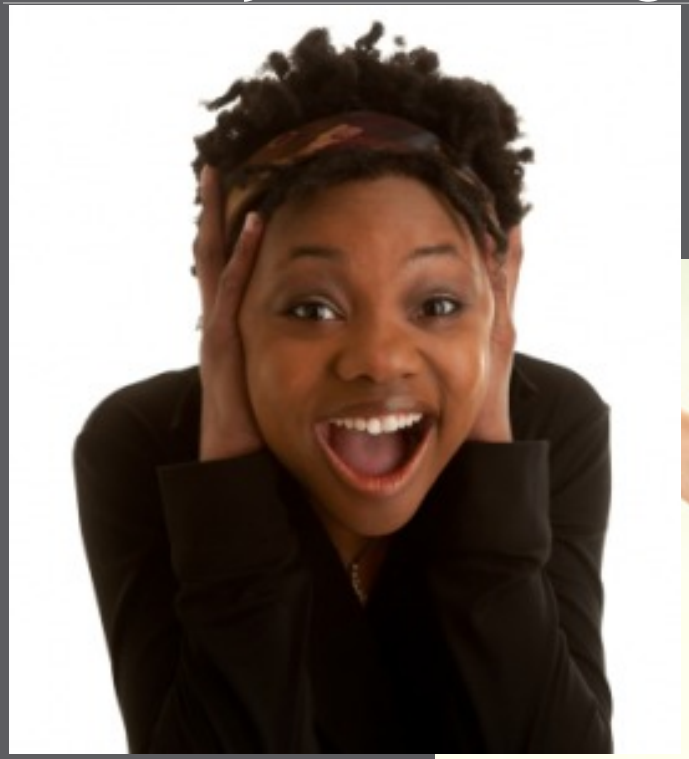
The Legacy of Math Blaster

- Edutainment
  - Gets kids to eat broccoli
  - But doesn't promote healthy eating
  - What happens when the chocolate goes away?

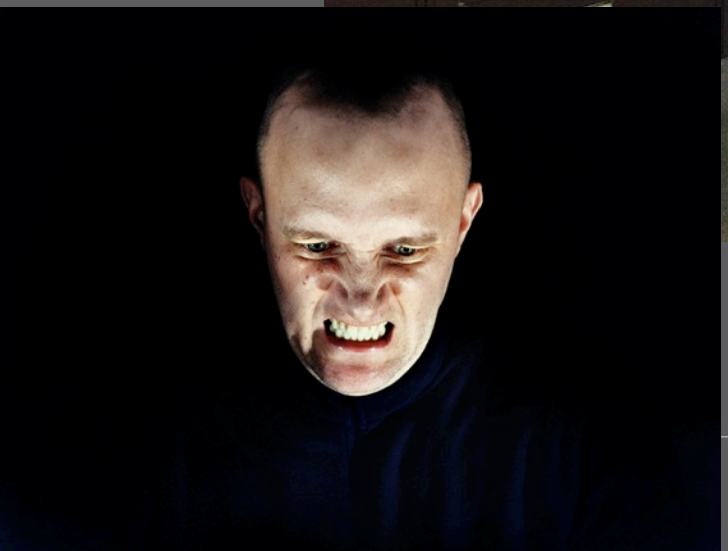
The Legacy of Math Blaster

– Instead learning should be **playful**

The Joy of Gaming?



The Joy of Gaming = Hard Fun



Feedback?

- How can we provide more feedback?

Feedback

- When should we provide feedback?
  - Frequency and response type

Gamification Everywhere

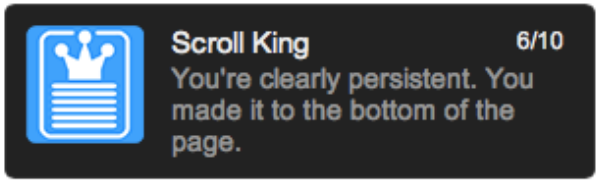
ir. Zichermann said. “We use game concepts to get them to focus on things.”

fits that description. After graduating from high school, Mr. Kroll said, he was overweight, living at home and playing World of Warcraft at least six hours a rned things around after starting to work out at a gym regularly with the help of pp on his iPhone called Fitocracy, in which badges are awarded by a robot ed.

who has lost about 75 pounds, says he plays video games less frequently now, enjoys the gamelike challenges that the app sets for him at the gym. He said the him “the same satisfaction of getting points and leveling up” that he gets from

vder and her 9-year-old daughter, Emma, also know how well embracing games Ms. Snawder signed up for a service called Zamzee to encourage Emma to be ically active.

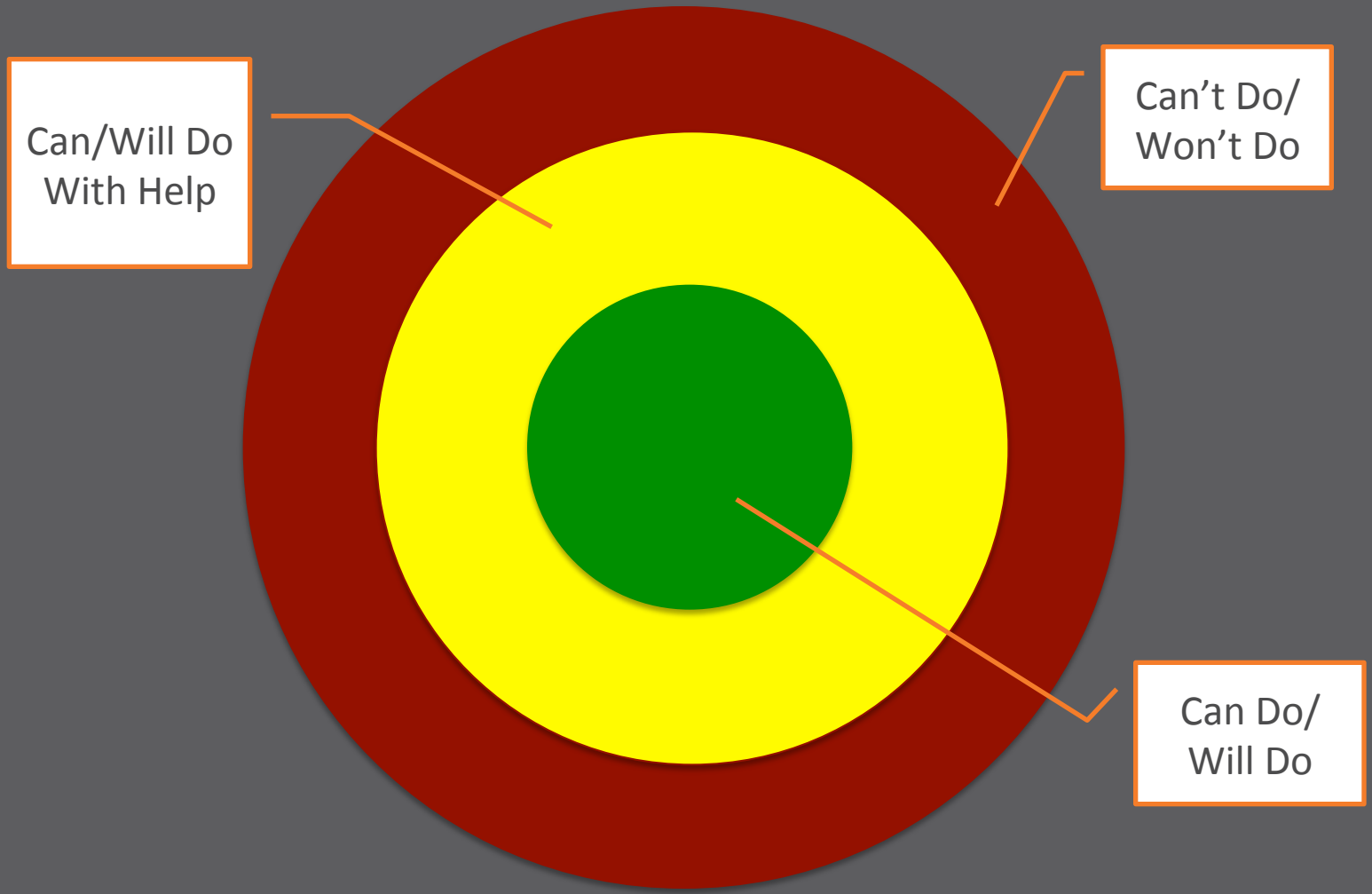
ut the day, Emma wears a small motion sensor that records her activity level and oints for a brisk walk, an impromptu dance party in the living room and any



Learning Goals?

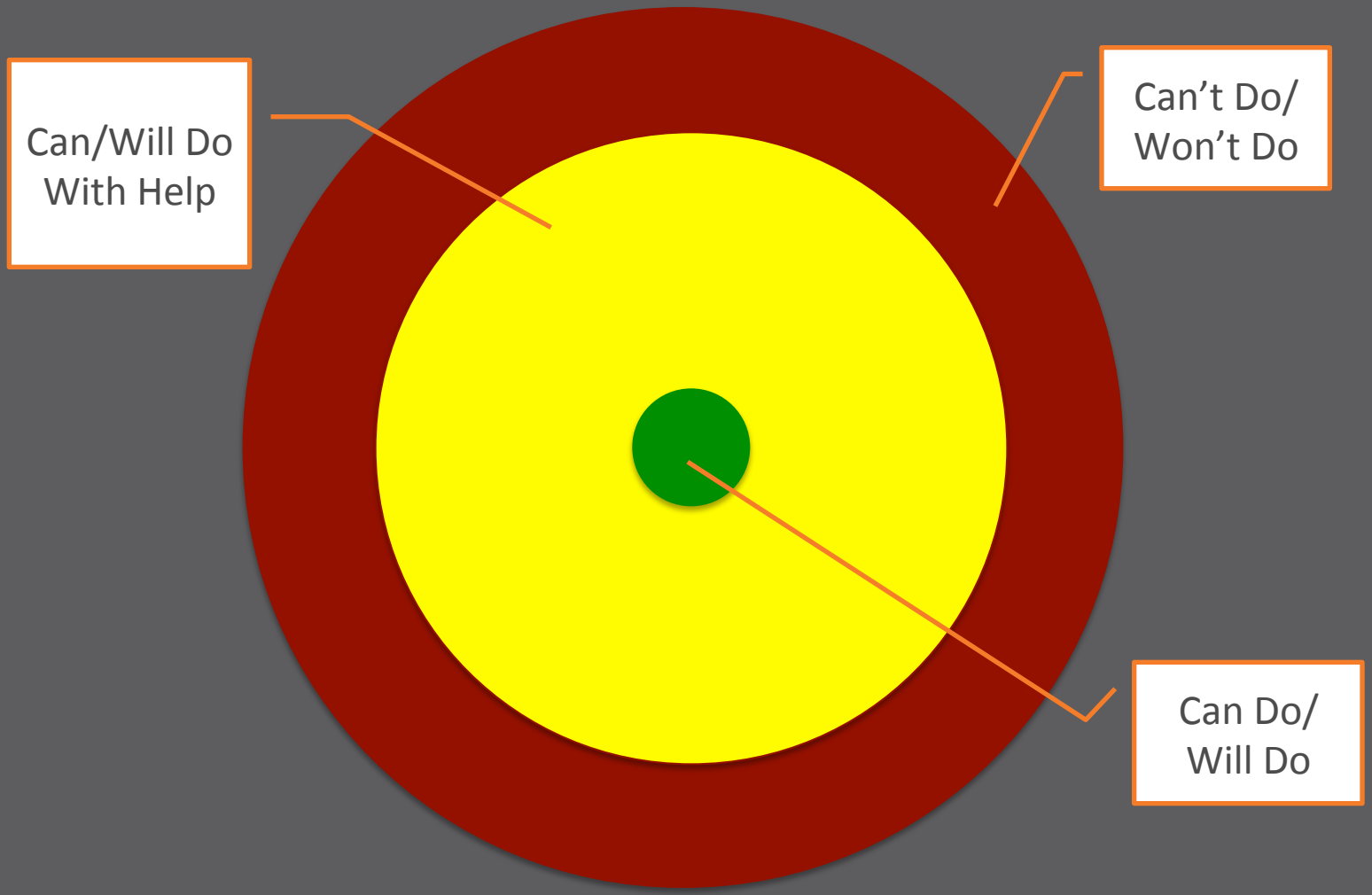
- Cognitive Skills
- Non-cognitive skills
  - Persistence
  - Grit
- Metacognitive skills
  - Reflection
  - Abstraction

Zone of Proximal Development



Vygotsky

Zone of Proximal Development



The Fun of Structure

Structured, goal-oriented, feedback-driven can be fun

In games we willingly submit to arbitrary rules and structures in pursuit of mastery, but only if we can continue to be playful.

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Structure is Fun

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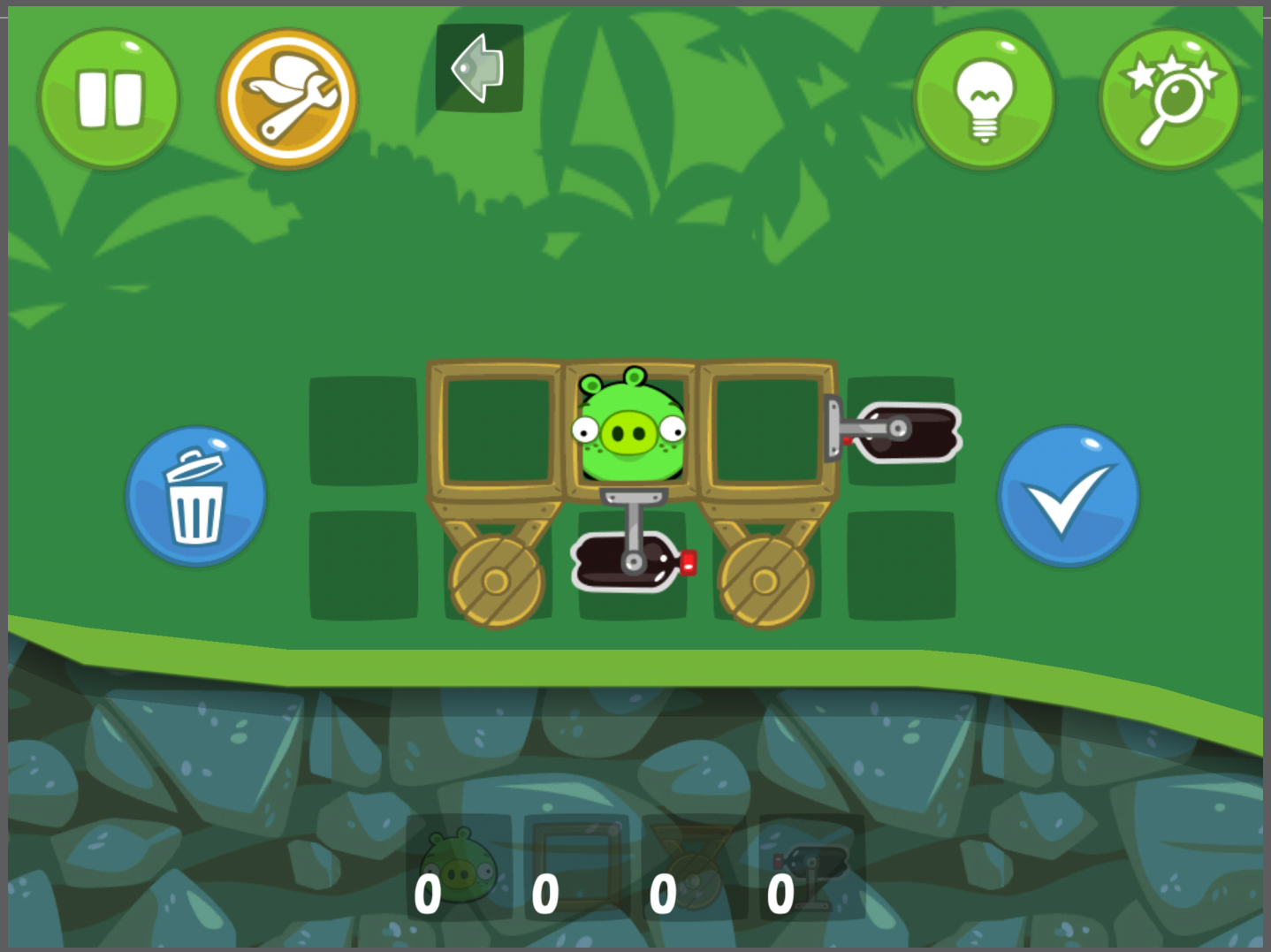
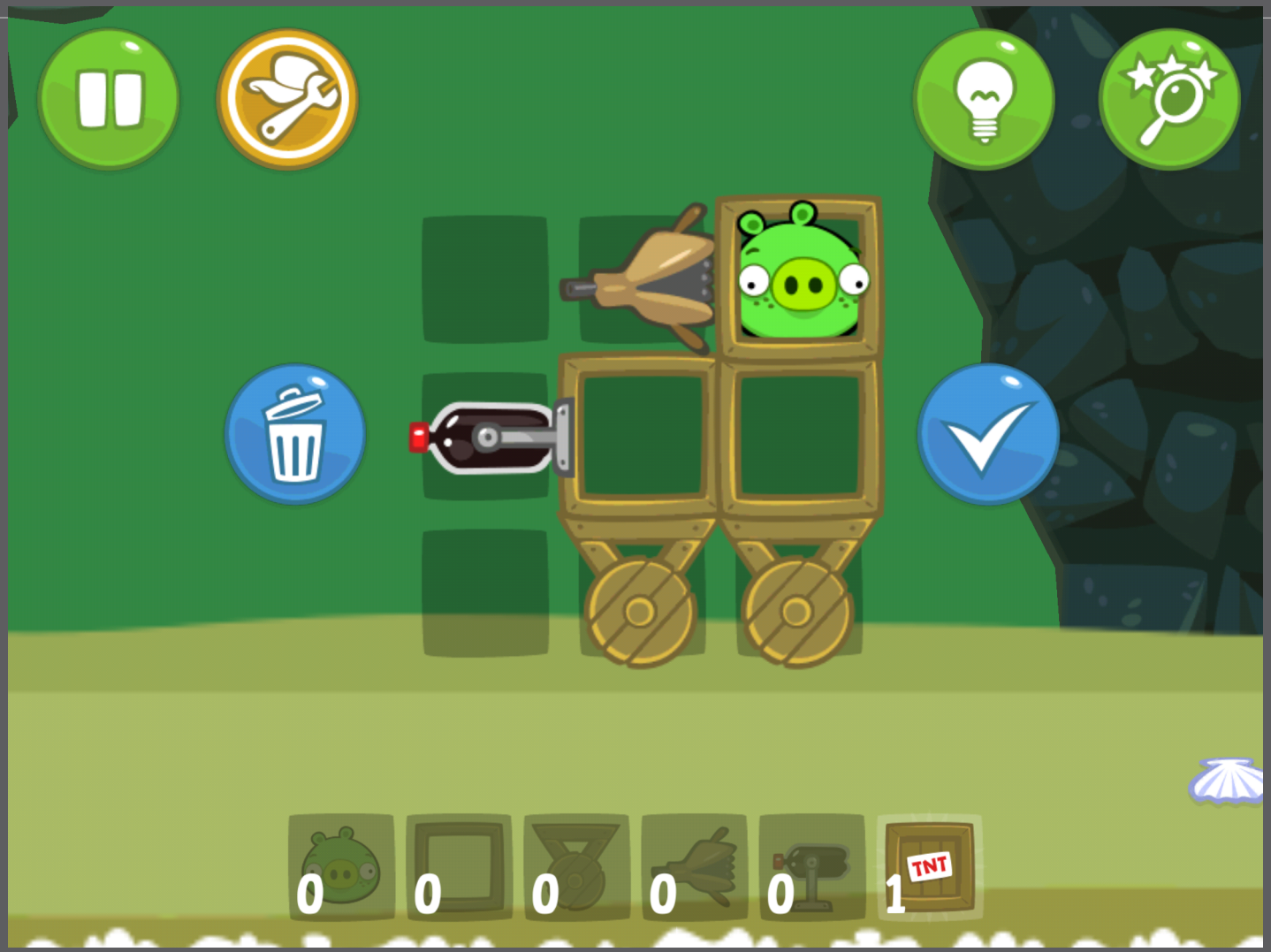


Structure is Fun



Structure is Fun

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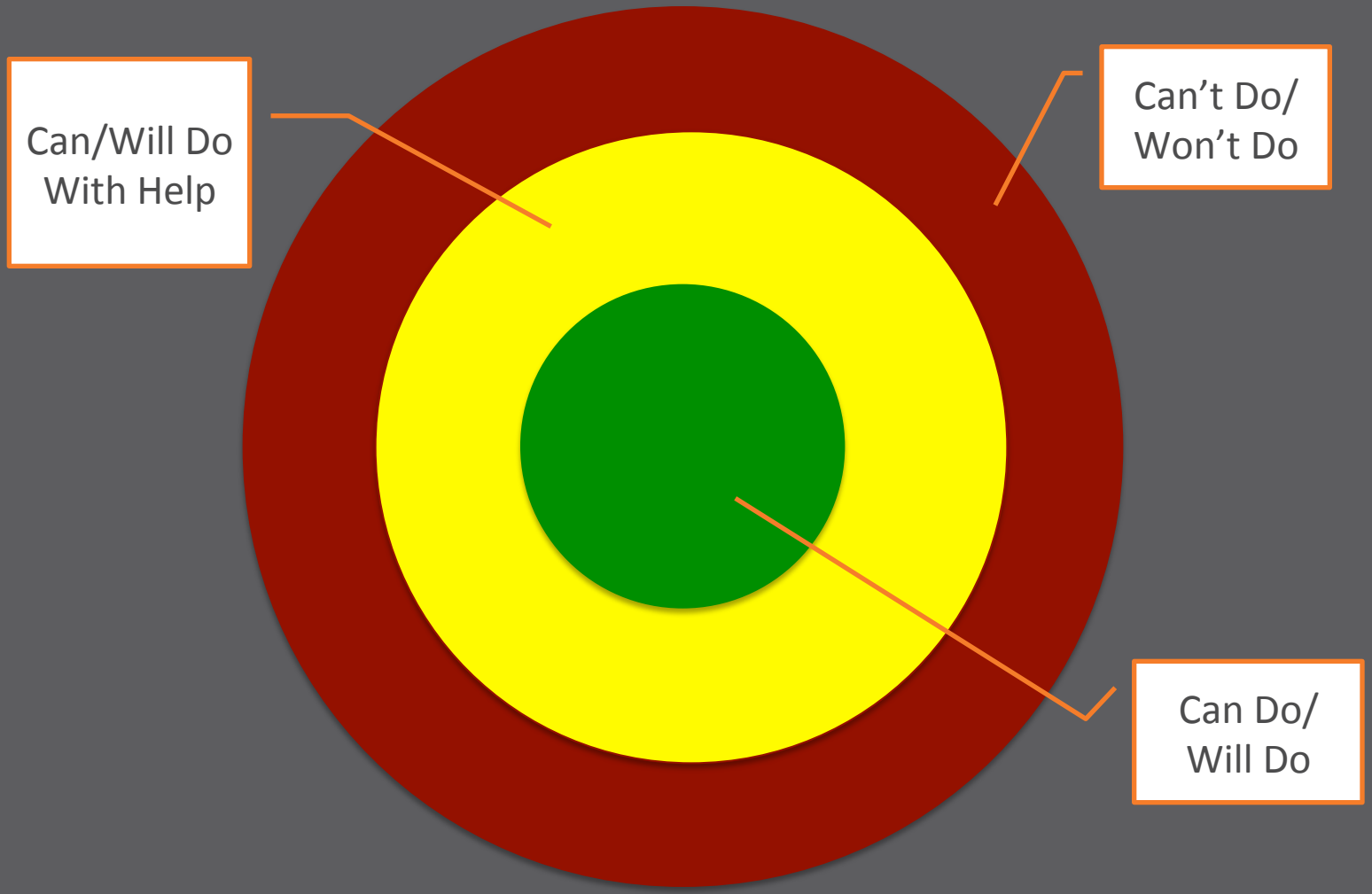
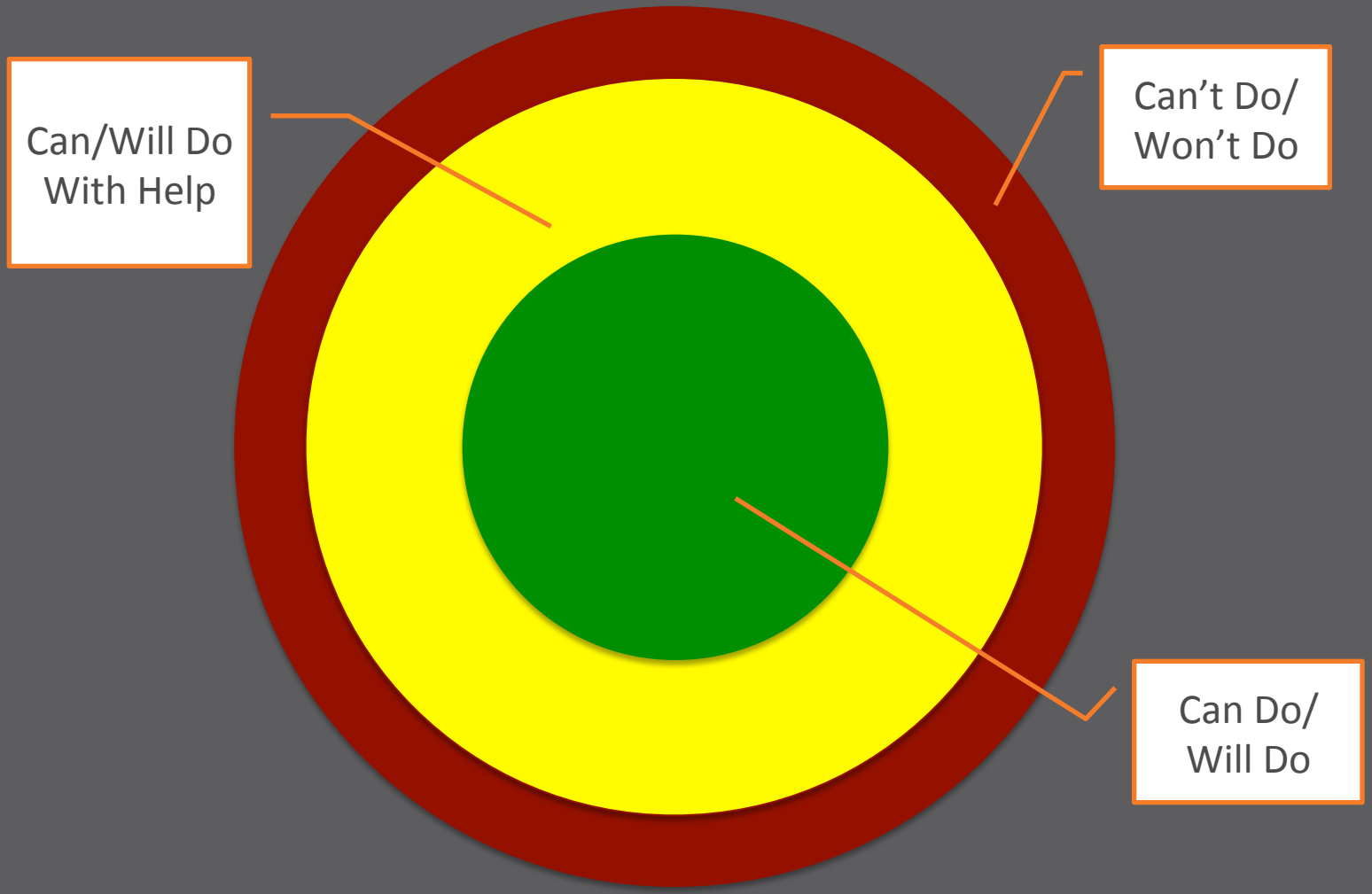
Zone of Proximal Development



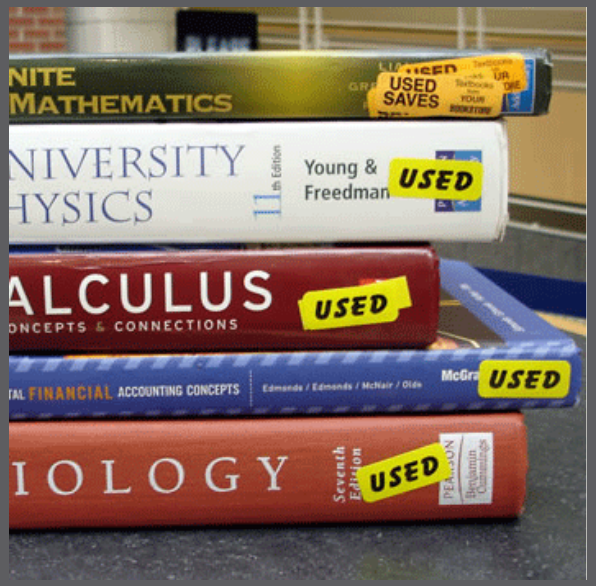
Zone of Proximal Development

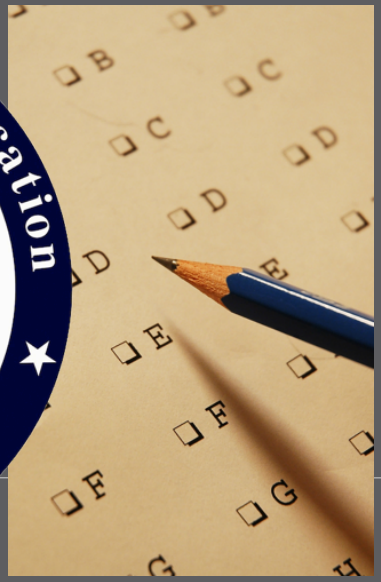


Making Real Learning Games

- New technologies and pedagogies can create learning opportunities that are simultaneously **fun** and **playful**
- Not just a superficial candy coating, they are linked at the deepest levels
- Games can engage players in learning that is specifically applicable to "**schooling**"

Ecology of School

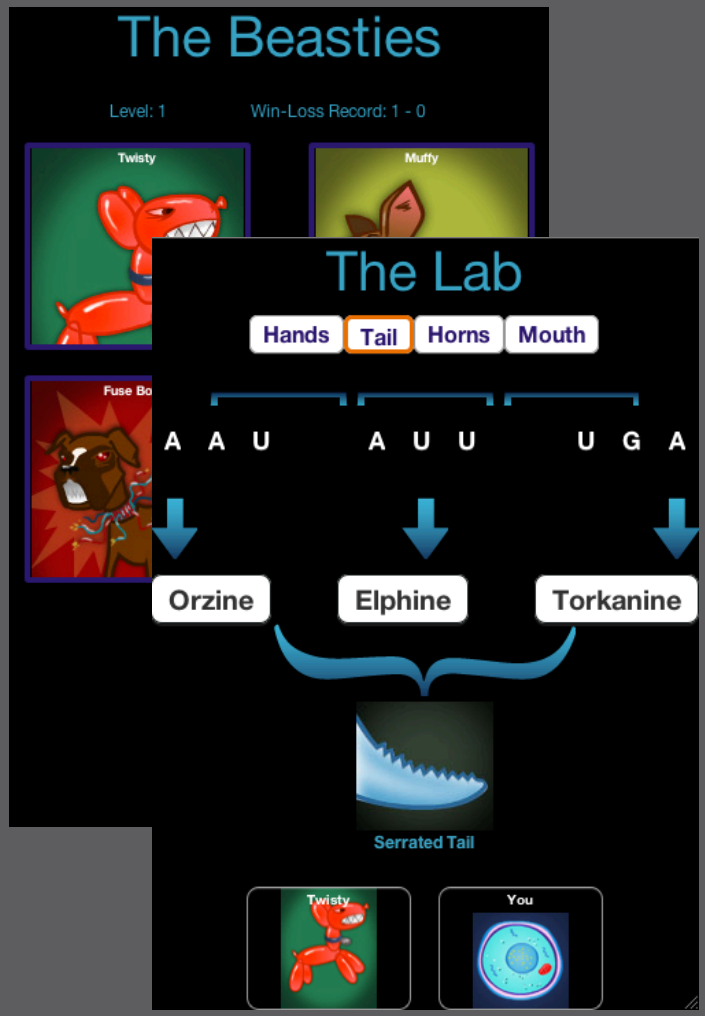




Mobile Social Games

UbiqGames

- Designed for the Mobile Web
- Paced to encourage short and frequent game play
- Played in the “interstitial” spaces in school
- Connected to specific class learning goals through curriculum

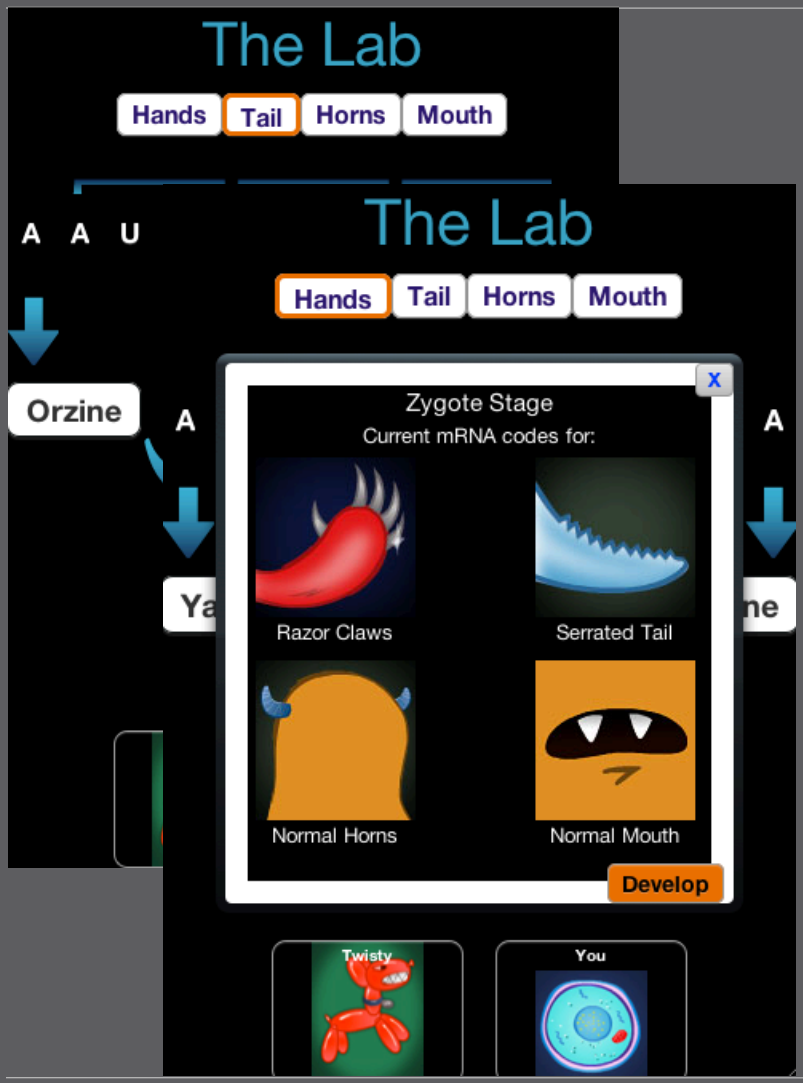


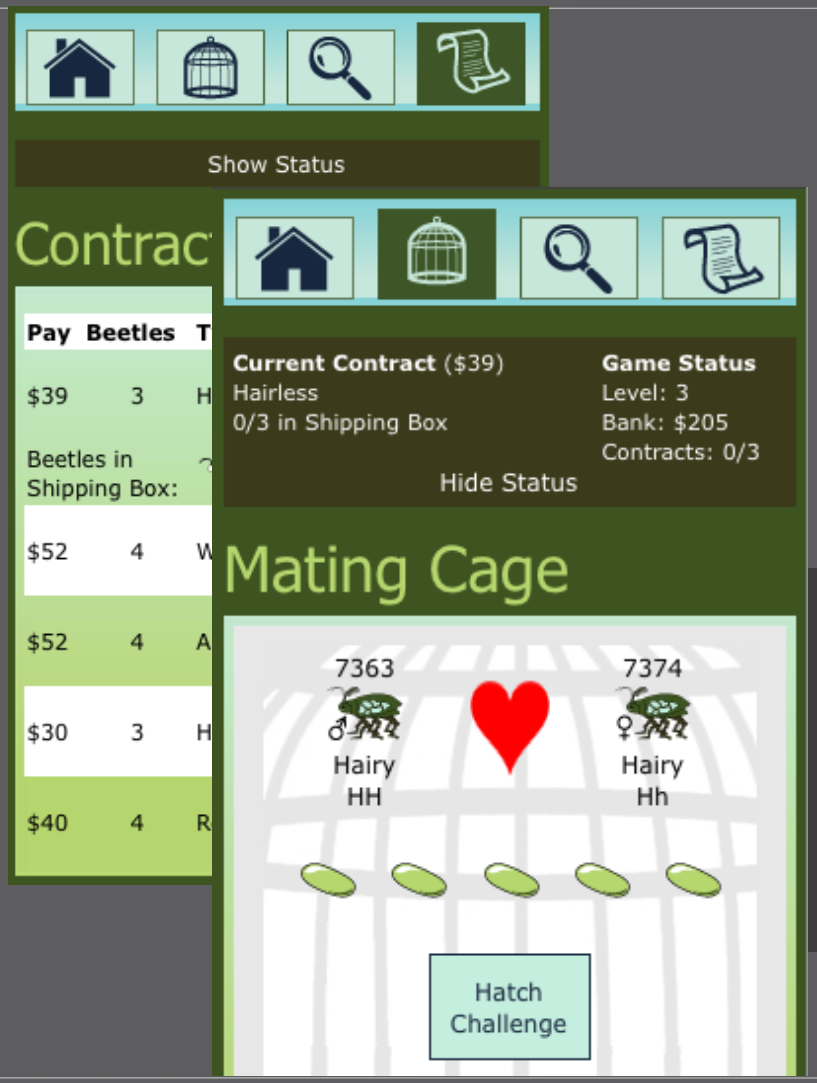
The UbiqBio Project

UbiqBio
mobile games for biology learning

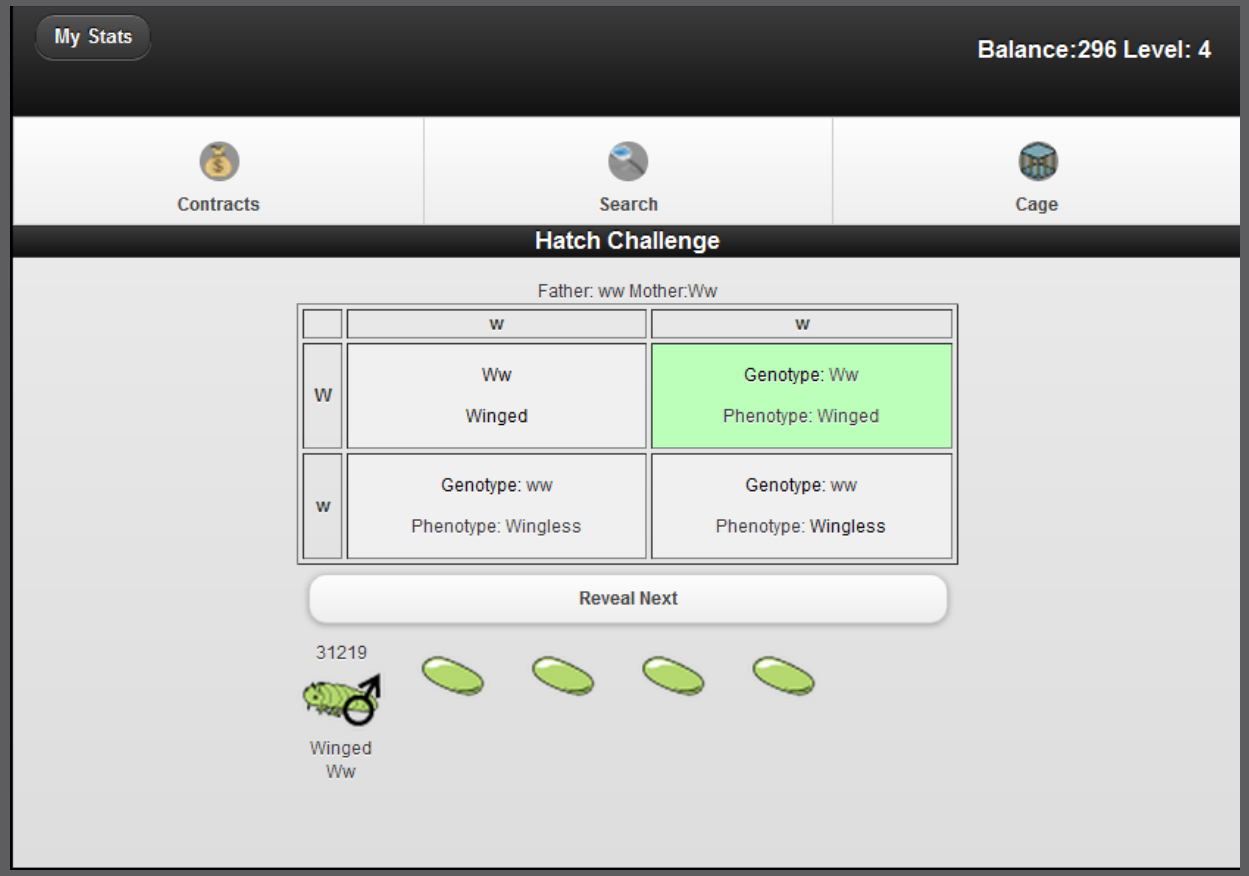
- A two-year NIH-funded research study
- Four standards-based UbiqGames
- Designed to promote deep learning and strong engagement for intro biology students
- Played primarily during outside-of-class time
- Used in-class time to synthesize and discuss concepts
- Includes Teacher Portal to track student/class progress

UbiqBio Games



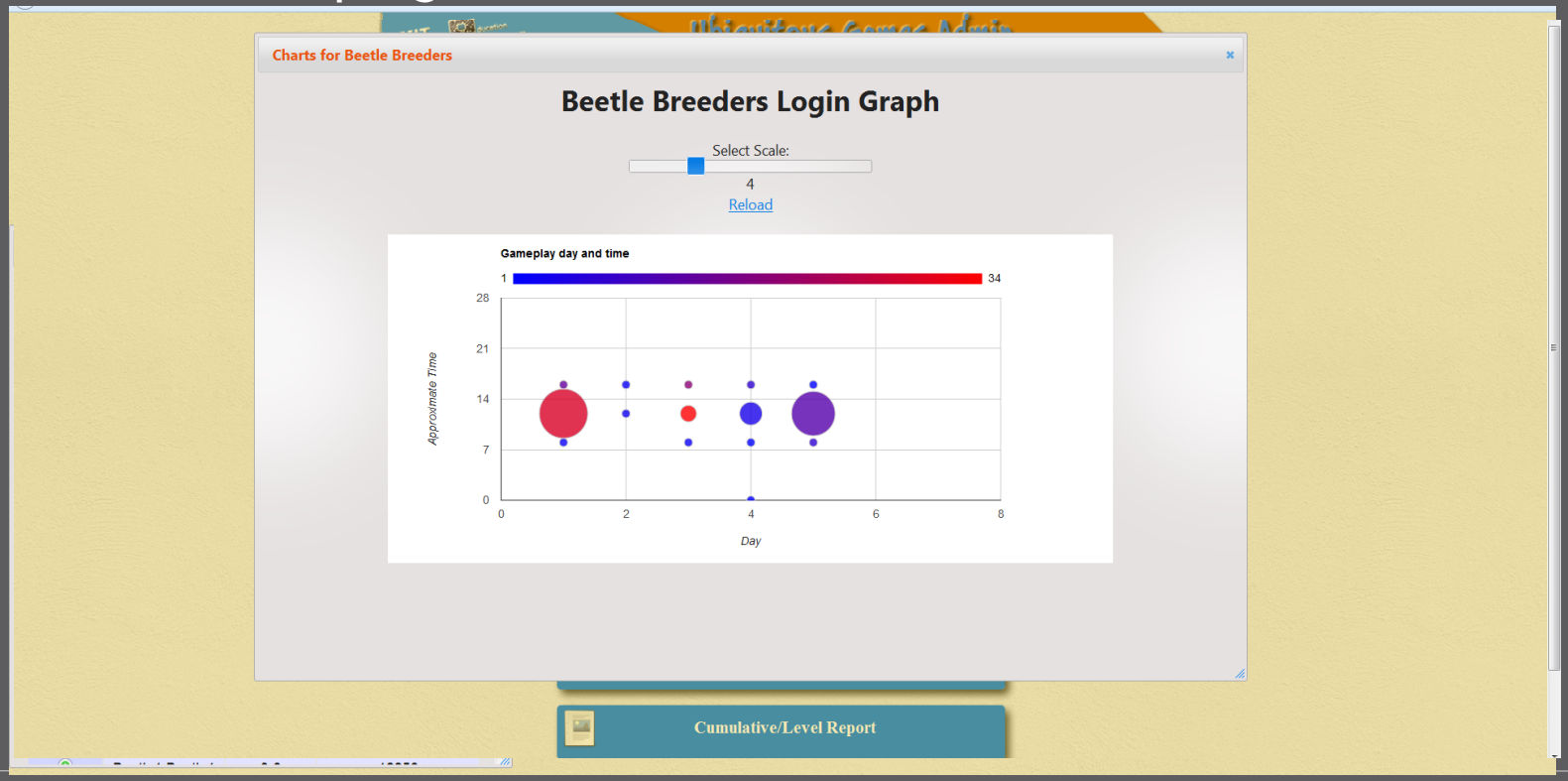


Responsive Design

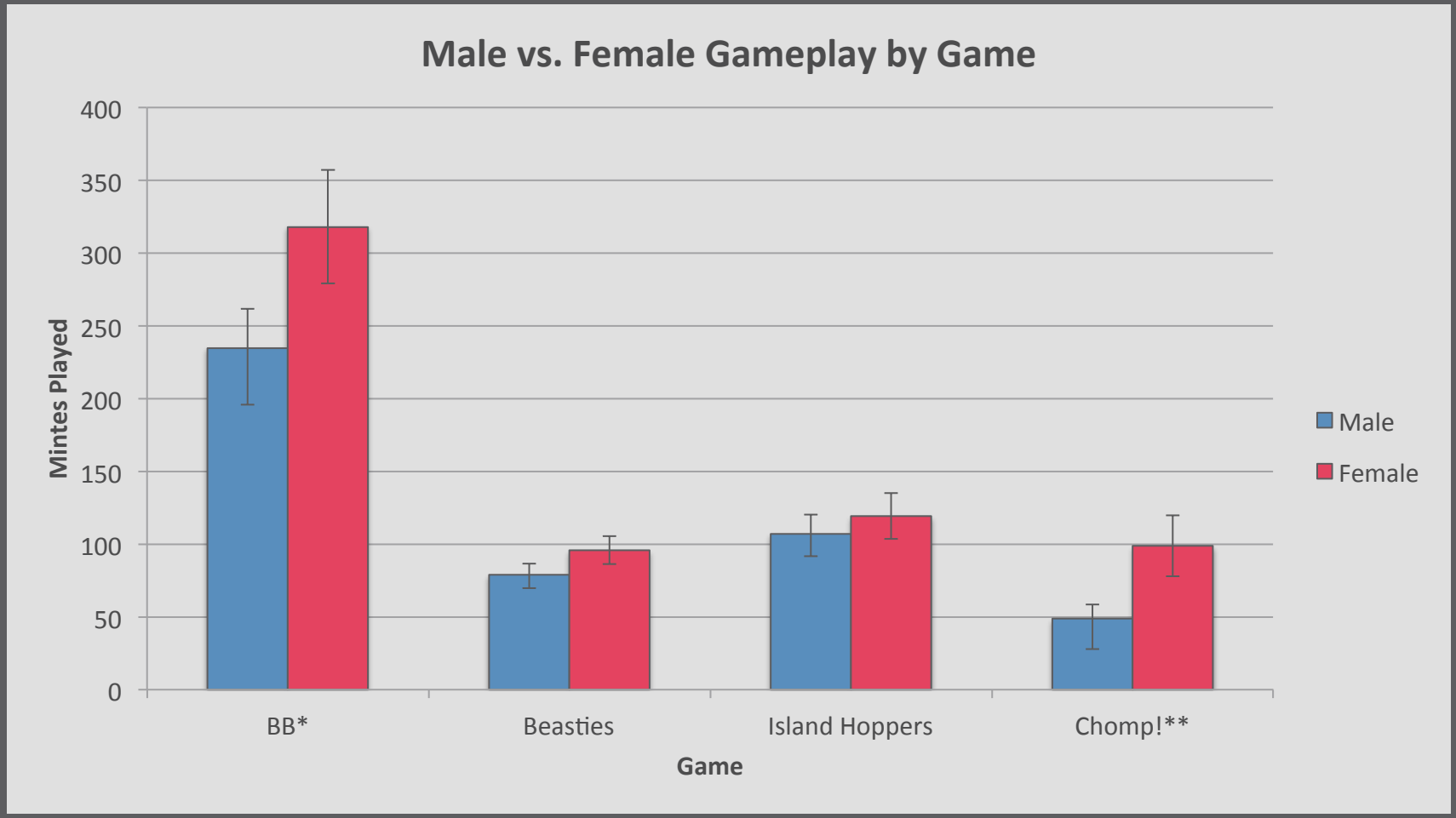


Teacher/Researcher Portal

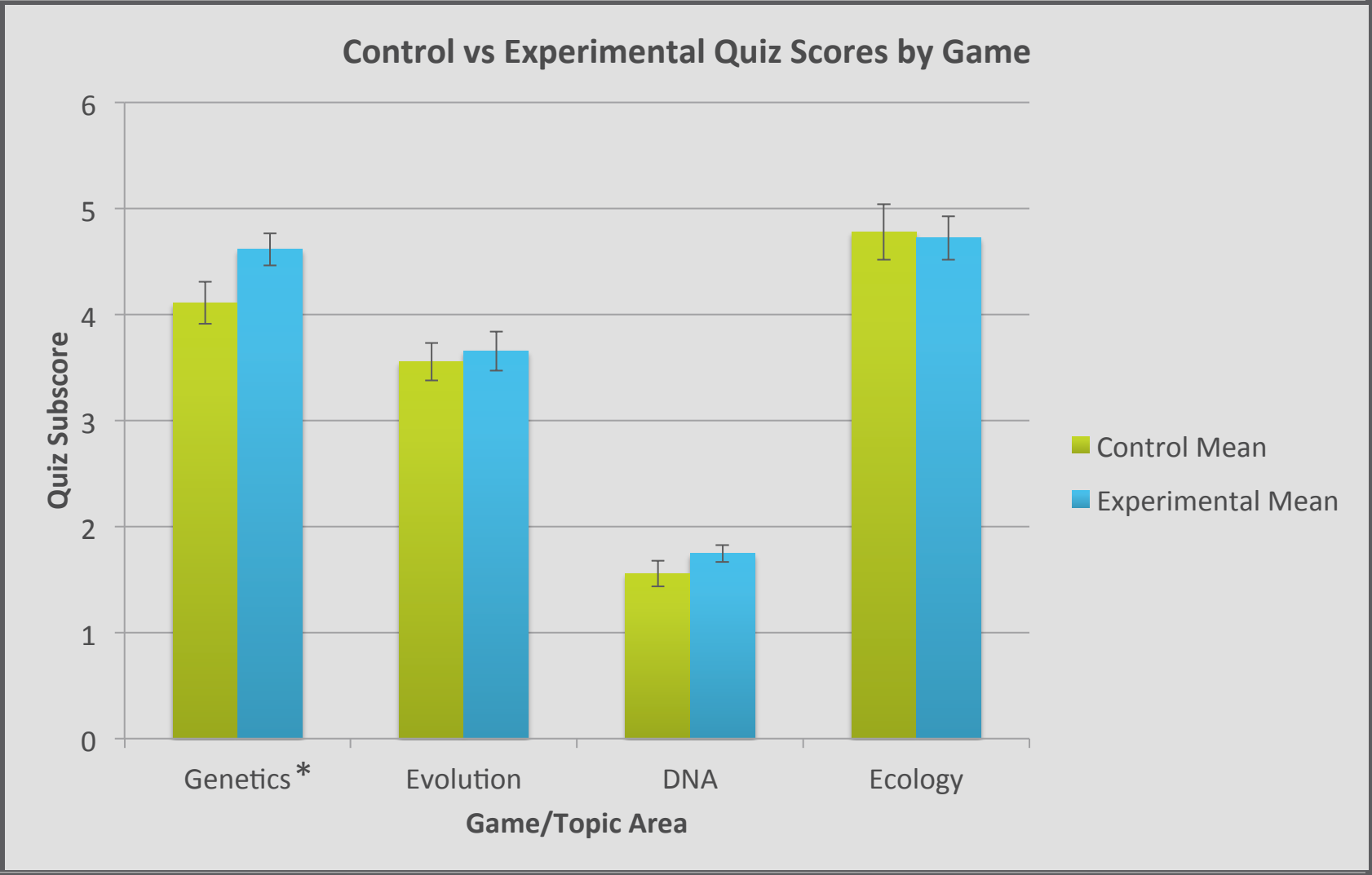
- Teachers
  - create class rosters
  - observe game play
  - track student progress
- Researchers
  - log game play patterns
  - collect student data



Game Play by Gender



Game Impact on Test Scores



Leveling Up?

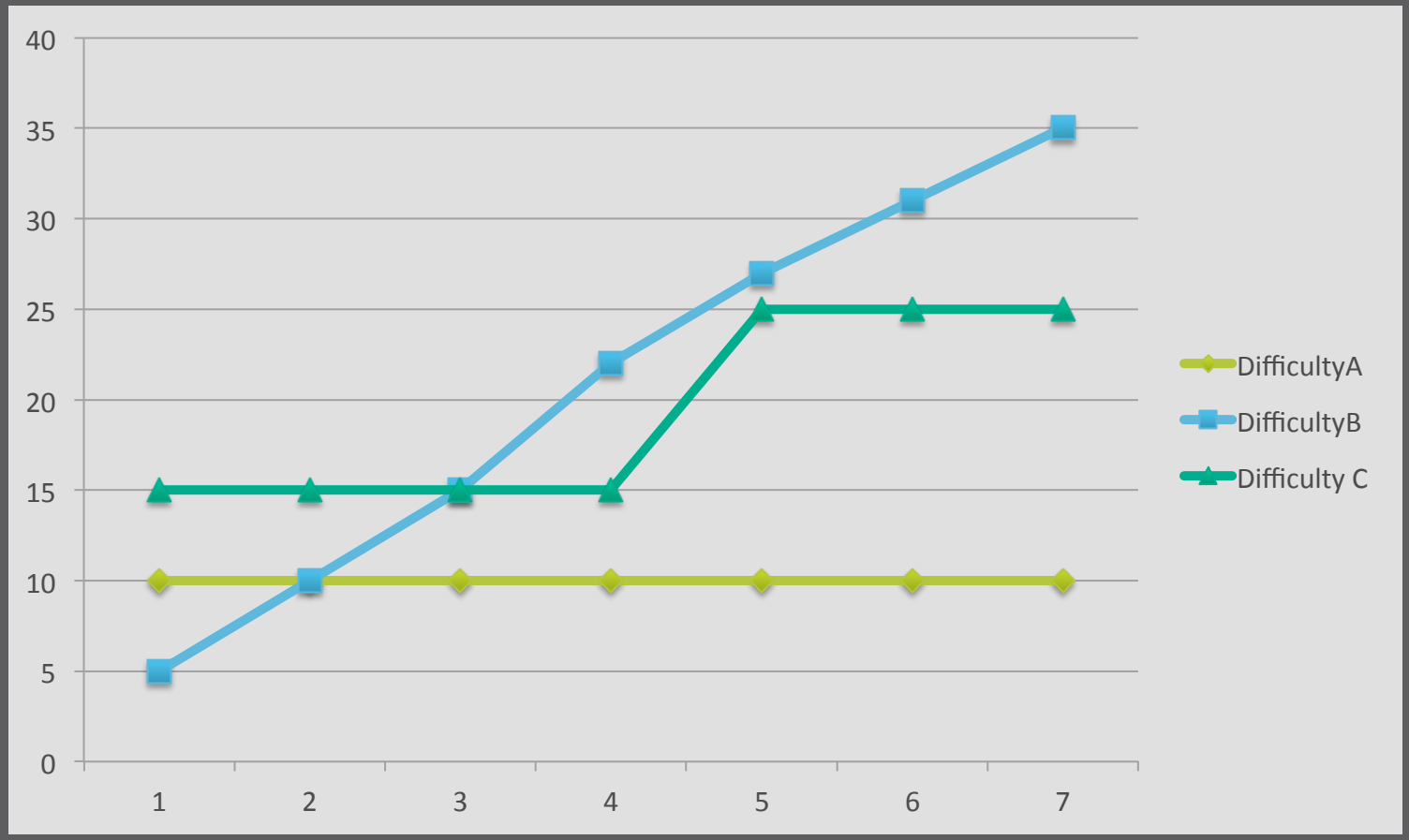
- How is score on each section impacted by…
  - Time spent playing
  - Levels completed

	Genetics	DNA	Evolution	Ecology
Time (10K)	-.039	.0647	-.223	x
Level	.245	x	.0138	x

???

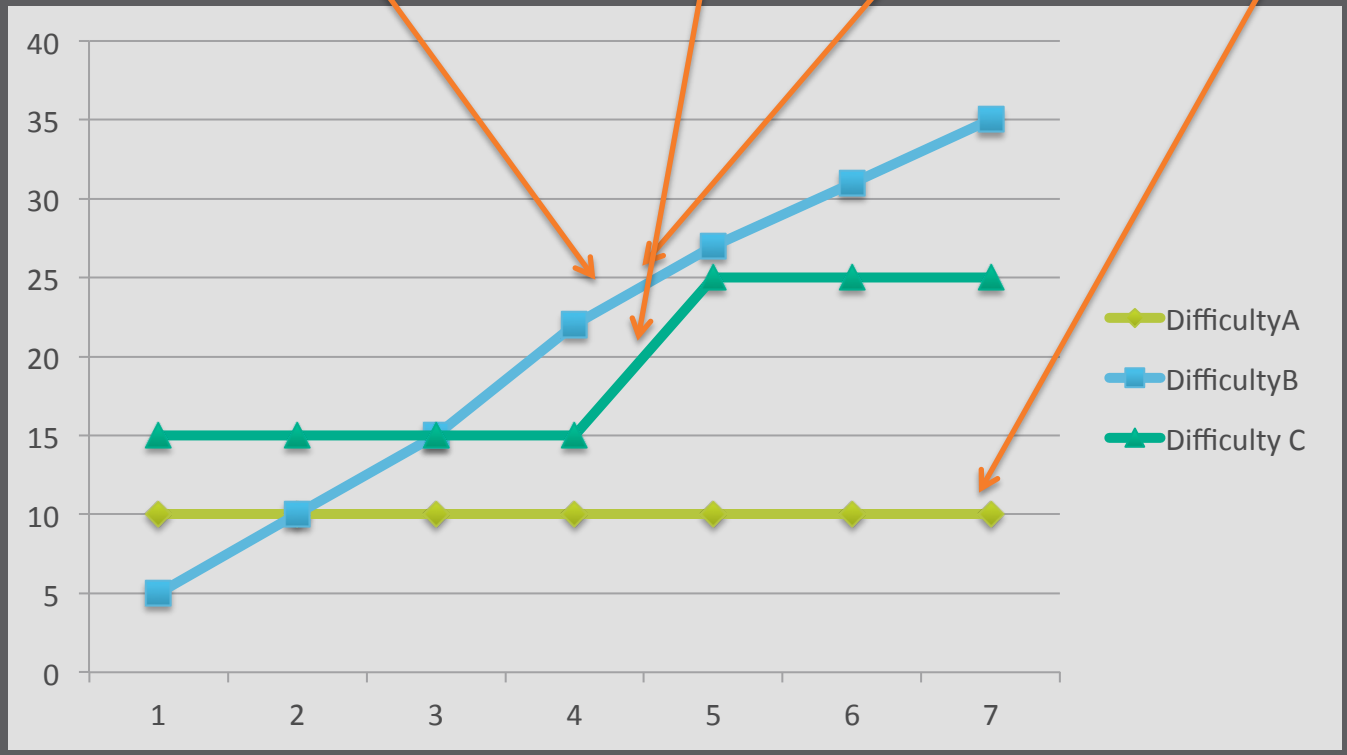
Do Games Work?

- Not all games are the same

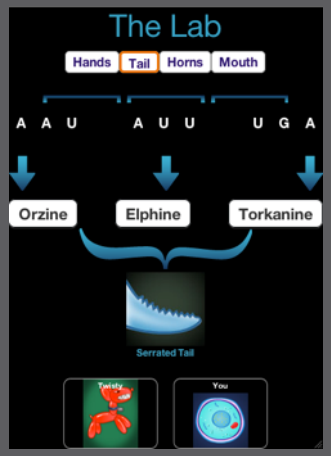


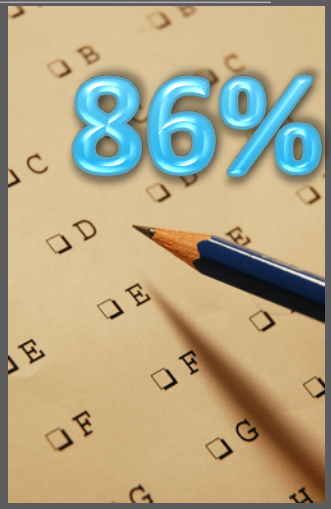
What Makes Games Work?

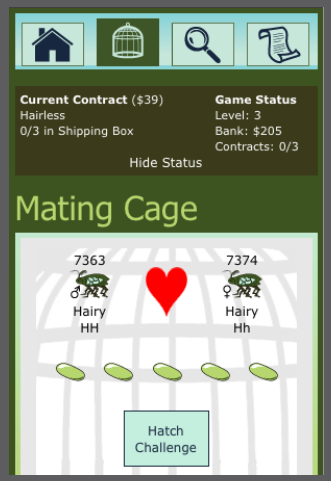
	Genetics	DNA	Evolution	Ecology
Time (10K)	-.039	.0647	-.223	x
Level	.245	x	.0138	x

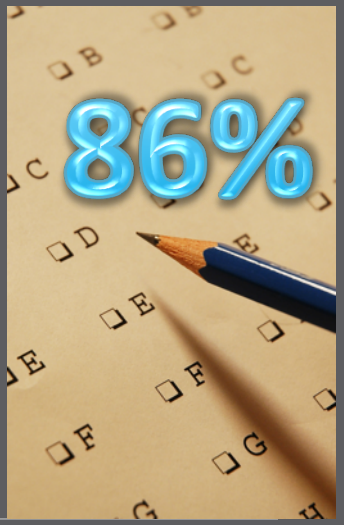


Games as Treatments?









The Medical Model

Radix - An MMO for STEM Learning

FILAMENTGAMES

BILL & MELINDA GATES foundation


Pinetreek
The Radix Endeavor

Why an MMOG

(Massively Multiplayer Online Game)

- Self-directed
- Collaborative
- Role-playing
- Inquiry-based
- Contextual

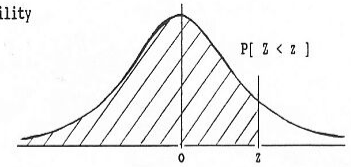
Biology & Math

STANDARD STATISTICAL TABLES

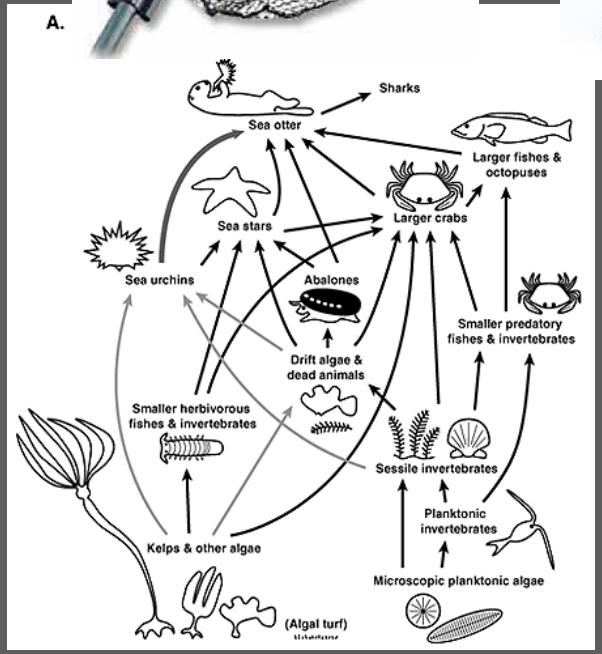
1. Areas under the Normal Distribution

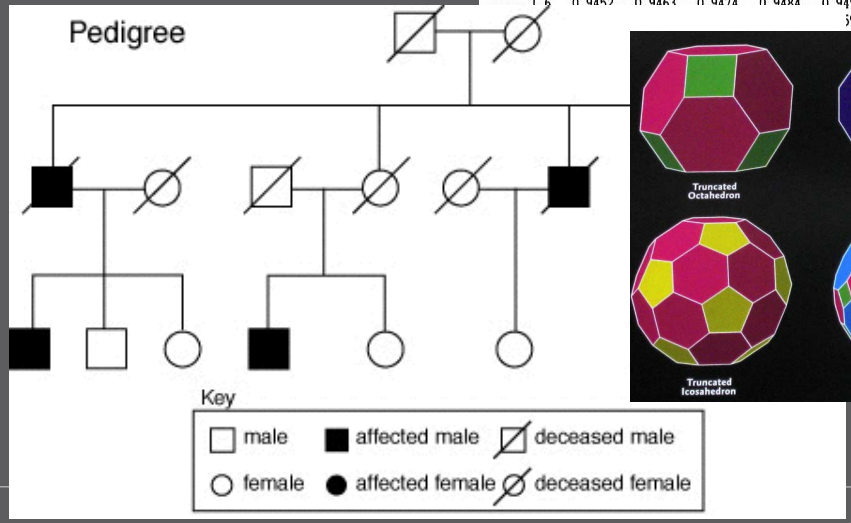
The table gives the cumulative probability up to the standardised normal value z

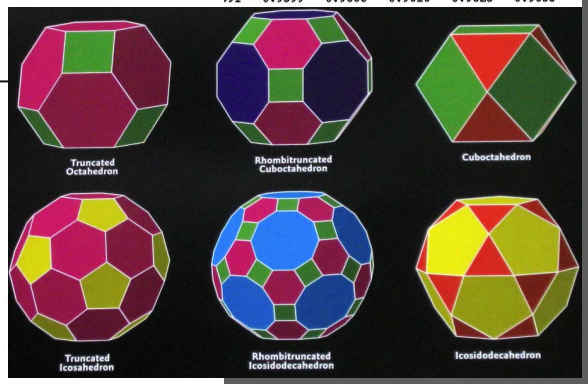
i.e. $P[\,Z < z\,] = \int_{-\infty}^{z} \frac{1}{\sqrt{2\pi}} \exp(-\tfrac{1}{2}Z^2)\, dZ$



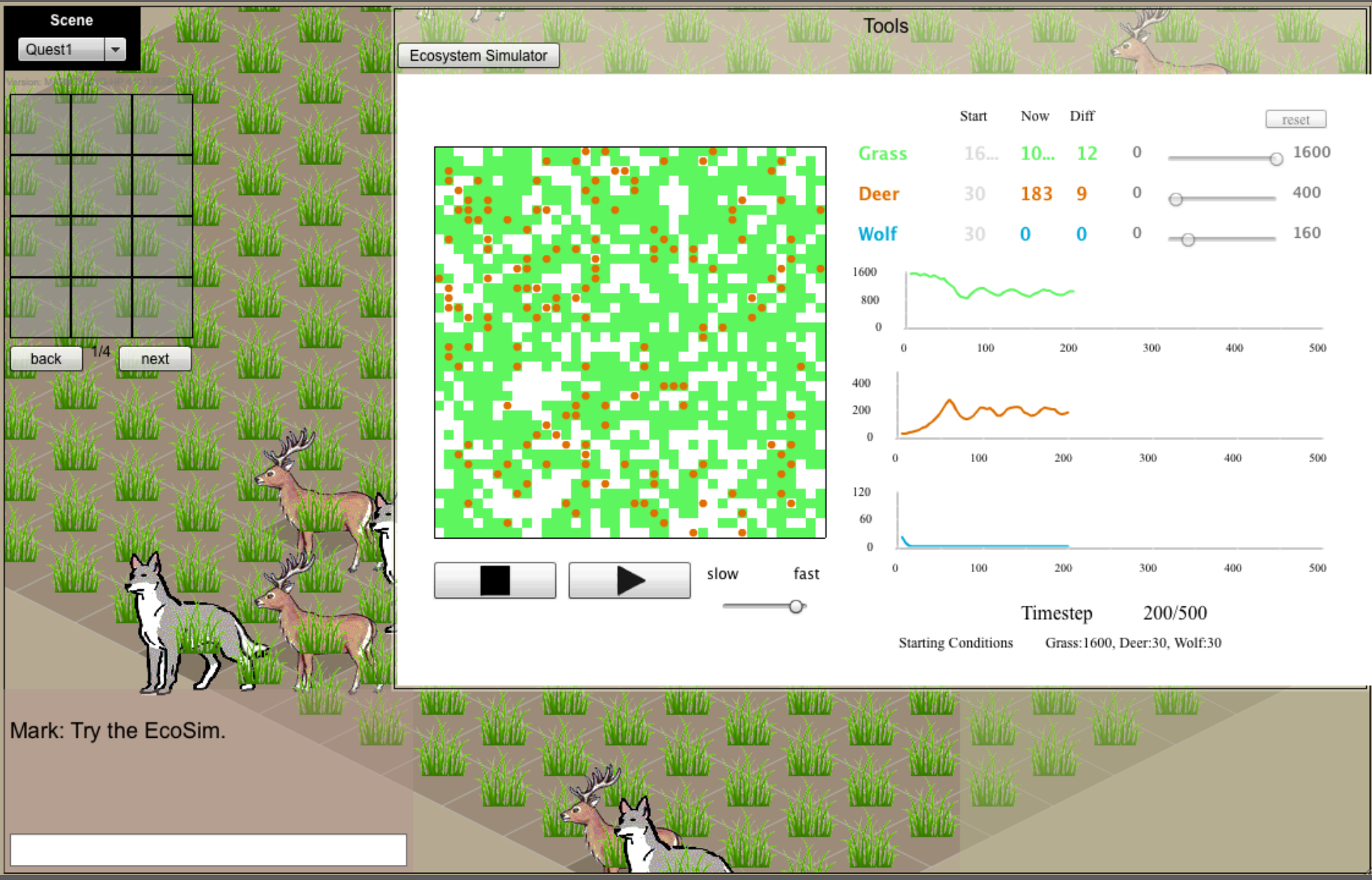
z	0.00	0.01	0.02	0.03	0.04	0.05	0.06	0.07	0.08	0.09
0.0	0.5000	0.5040	0.5080	0.5120	0.5159	0.5199	0.5239	0.5279	0.5319	0.5359
0.1	0.5398	0.5438	0.5478	0.5517	0.5557	0.5596	0.5636	0.5675	0.5714	0.5753
0.2	0.5793	0.5832	0.5871	0.5910	0.5948	0.5987	0.6026	0.6064	0.6103	0.6141
0.3	0.6179	0.6217	0.6255	0.6293	0.6331	0.6368	0.6406	0.6443	0.6480	0.6517
0.4	0.6554	0.6591	0.6628	0.6664	0.6700	0.6736	0.6772	0.6808	0.6844	0.6879
0.5	0.6915	0.6950	0.6985	0.7019	0.7054	0.7088	0.7123	0.7157	0.7190	0.7224
0.6	0.7257	0.7291	0.7324	0.7357	0.7389	0.7422	0.7454	0.7486	0.7517	0.7549
0.7	0.7580	0.7611	0.7642	0.7673	0.7704	0.7734	0.7764	0.7794	0.7823	0.7854
0.8	0.7881	0.7910	0.7939	0.7967	0.7995	0.8023	0.8051	0.8078	0.8106	0.8133
0.9	0.8159	0.8186	0.8212	0.8238	0.8264	0.8289	0.8315	0.8340	0.8365	0.8389
1.0	0.8413	0.8438	0.8461	0.8485	0.8508	0.8531	0.8554	0.8577	0.8599	0.8621
1.1	0.8643	0.8665	0.8686	0.8708	0.8729	0.8749	0.8770	0.8790	0.8804	0.8830
1.2	0.8849	0.8869	0.8888	0.8907	0.8925	0.8944	0.8962	0.8980	0.8997	0.9015
1.3	0.9032	0.9049	0.9066	0.9082	0.9099	0.9115	0.9131	0.9147	0.9162	0.9177
1.4	0.9192	0.9207	0.9222	0.9236	0.9251	0.9265	0.9279	0.9292	0.9306	0.9319
1.5	0.9332	0.9345	0.9357	0.9370	0.9382	0.9394	0.9406	0.9418	0.9429	0.9441
1.6	0.9452	0.9463	0.9474	0.9484	0.9495	0.9505	0.9515	0.9525	0.9535	0.9545
					91	0.9599	0.9608	0.9616	0.9625	0.9633








Scene
Genetic...
Tools
Punnett Square
back
1/4
next
Deion: I have a quest for you.
You collected: Purple flower
You collected: Purple flower
You collected: Seeds
You collected:
You collected: Purple flower
You collected: Purple flower
You collected: Seeds


Scene
Quest1
back
1/4
next
Tools
Ecosystem Simulator
Start
Now
Diff
reset
Grass
16...
10...
12
0
1600
Deer
30
183
9
0
400
Wolf
30
0
0
0
160
1600
800
0
0
100
200
300
400
500
400
200
0
120
60
slow
fast
Timestep
200/500
Starting Conditions
Grass:1600, Deer:30, Wolf:30
Mark: Try the EcoSim.

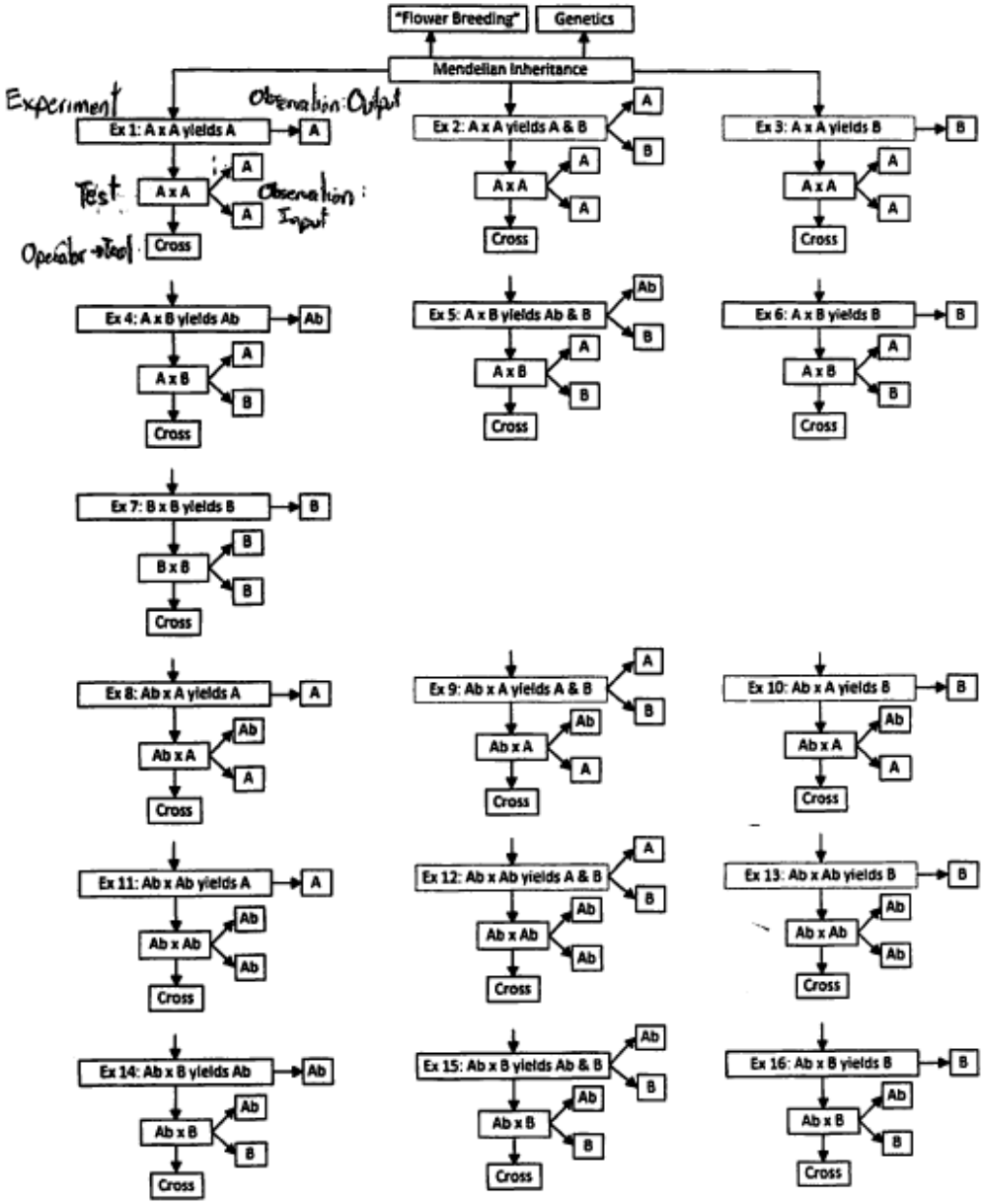


Figure 16: 16 Experiments of type A, Ab, and B flower breeding.

red red white

A B


Welcome, Susan.
Students
Unit Planning
Guide
Account Settings
Logout
Select All
Skip Ahead
Remove
New Student
Recent Activity
01:23 - playerJudy picked a Pink Flower
01:20 - Shasta bred a Yellow Flower
01:14 - i_<3_wigs completed Smell the Roses
01:14 - Applesauce bred an Orange Flower
01:01 - Dio_Man bought a Cowboy Hat
12:58 - BulldogHux signed in
12:57 - BulldogHux signed out
12:50 - SurferDude99 completed Petal to the...
Student Name
Username
Progress
Current Quest
Appleseed, John
Applesauce
Plague Hunter
Burbank, Luther
Shasta
Petal to the Metal
Burnham, Leo
leoPlayer
Smell the Roses
Douglas, David
SurferDude99
Smell the Roses
Dioscorides, Pedanius
Dio_Man
Learning the Ropes
Huxley, Thomas
BulldogHux
Plague Hunter
Linnaeus, Carl
i_<3_wigs
Plague Hunter
Status
Stuck on Plague Hunter for 12 minutes.
- Needs to breed Yellow Flower
- Needs to reach the North Gate.
Chat Log
[01:23] judyPlayer: Hey, another pink flower!
[01:21] i_<3_wigs: How do you get to the north gate?
[01:18] Applesauce: Whoa... you guys need to see this.
[01:18] Applesauce: North gate, here I come.
Detailed Progress
Learning the Ropes
Petal to the Metal
Smell the Roses
Plague Hunter
TIME
Smith, Judy
judyPlayer
Plague Hunter
Thomas, Jack
jackPlayer
Petal to the Metal
Wilson, Lara
laraPlayer
Plague Hunter

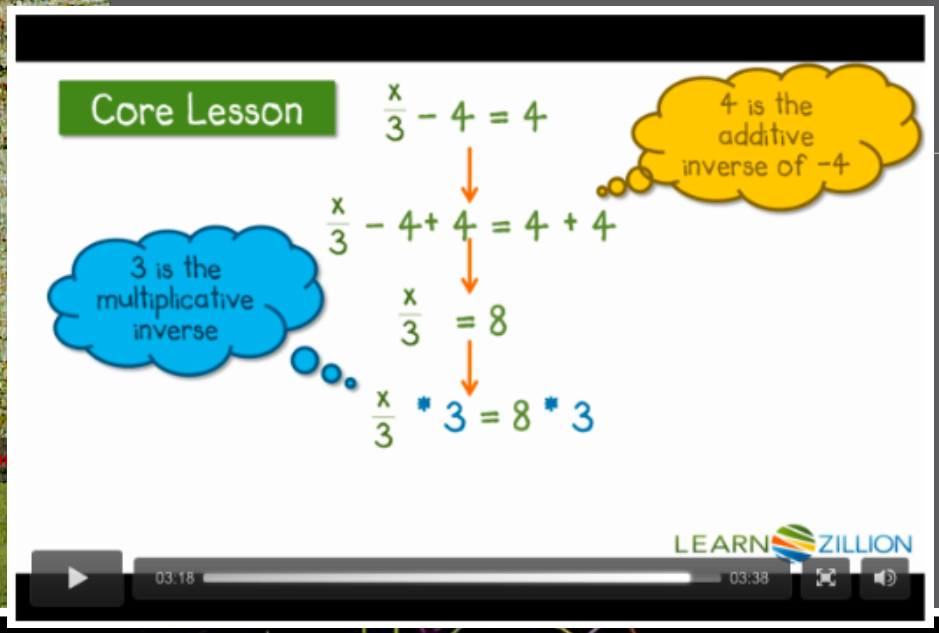
Home Screen

- Shows the progress of students on a quest.
  - Number of successes / Number of attempts
  - Color coded where red means no success and green means always successful
  - Blue indicates a student has started a quest
  - Grey indicates a student has never started the quest.
- Class average computed at top.

MATH PERIOD 1 ▾ **Hello Mr. Smith | Logout**

SUCCESS RATES

Students	Surface Area & Volume				Ratios	
	Box Builder Part 1	Box Builder Part 2	Box Builder Part 3	Box Builder Part 4	Scale Figure Drawing	Correct Map Part 1
Class	63%	46%	58%	48%	61%	57%
Alpha	2/2	3/4	5/5	1/2	1/1	1/2
Bravo	0/4				1/5	2/4
Charlie	2/4	0/5			2/2	1/3
Delta	4/4	3/3	1/1	1/4	0/4	
Echo					1/1	1/3
Foxtrot	1/1	1/1	2/5	2/4	1/4	1/5
Golf	2/3	0/4			3/5	3/4
Hotel	1/5	0/3			1/4	2/2
India	3/4	1/3	2/5	1/2	4/5	0/5
Juliet	1/5	2/5	1/2	2/4	1/1	1/2
Kilo	4/4	2/3	1/3	4/4	3/4	1/1
Lima	3/4	2/5			3/3	
Mike	1/5	3/4	4/4	4/5	1/3	4/5
November	4/4	1/5	1/1	0/3	1/1	1/1
Oscar	3/4	0/4				
Papa	3/3	2/2	1/1	0/2	1/1	1/4
Rome					1/3	2/4
Sierra	0/4				4/4	1/2
Tango	3/3	1/3	2/2	3/3	3/4	4/4
Uniform	4/5	1/3	1/3	0/1	1/1	4/5
Victor	3/3	4/4	2/5	1/5	4/4	2/4
Whiskey	2/2	2/4	0/3		0/3	
Yankee	2/4	3/4	2/3		5/5	5/5
Zulu	1/1	2/3	1/2	1/3	1/2	2/3

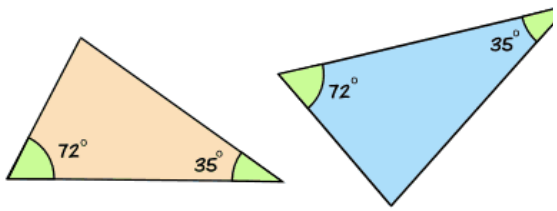


AA

AA stands for "angle, angle" and means that the triangles have two of their

> If two triangles have two of their angles equal, the triangles are sir

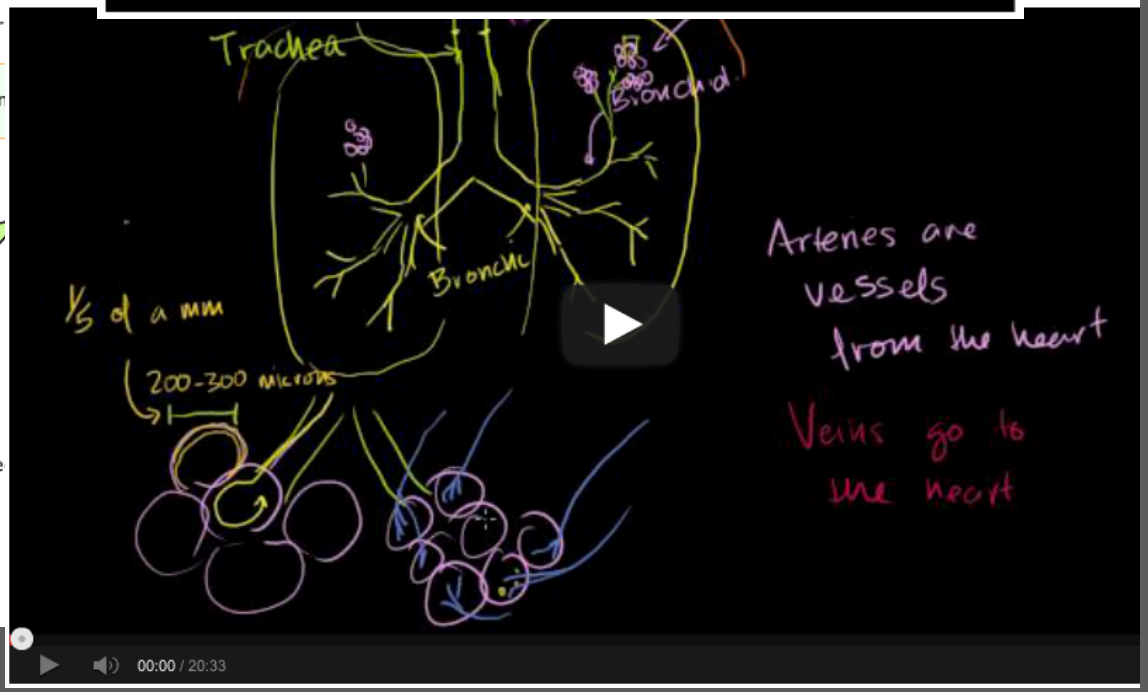
For example, these two triangles are similar:



If two of their angles are equal, then the third angle must also be equal, be
triangle always add to make 180°.

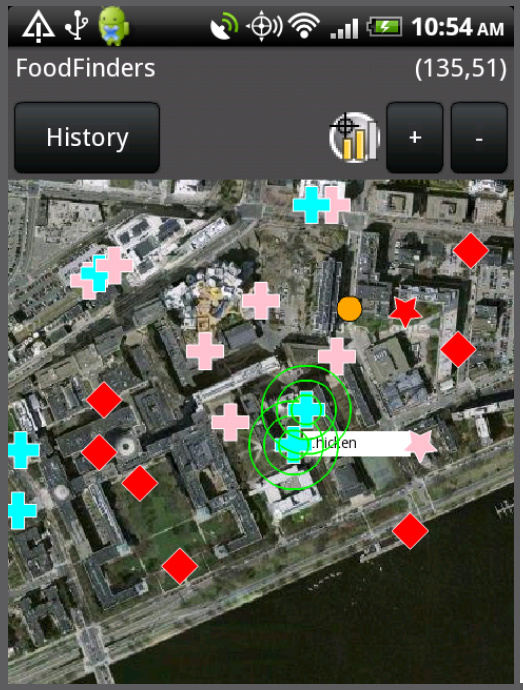
In this case the missing angle is 180° - (72° + 35°) = 83°.

So AA could also be called AAA.

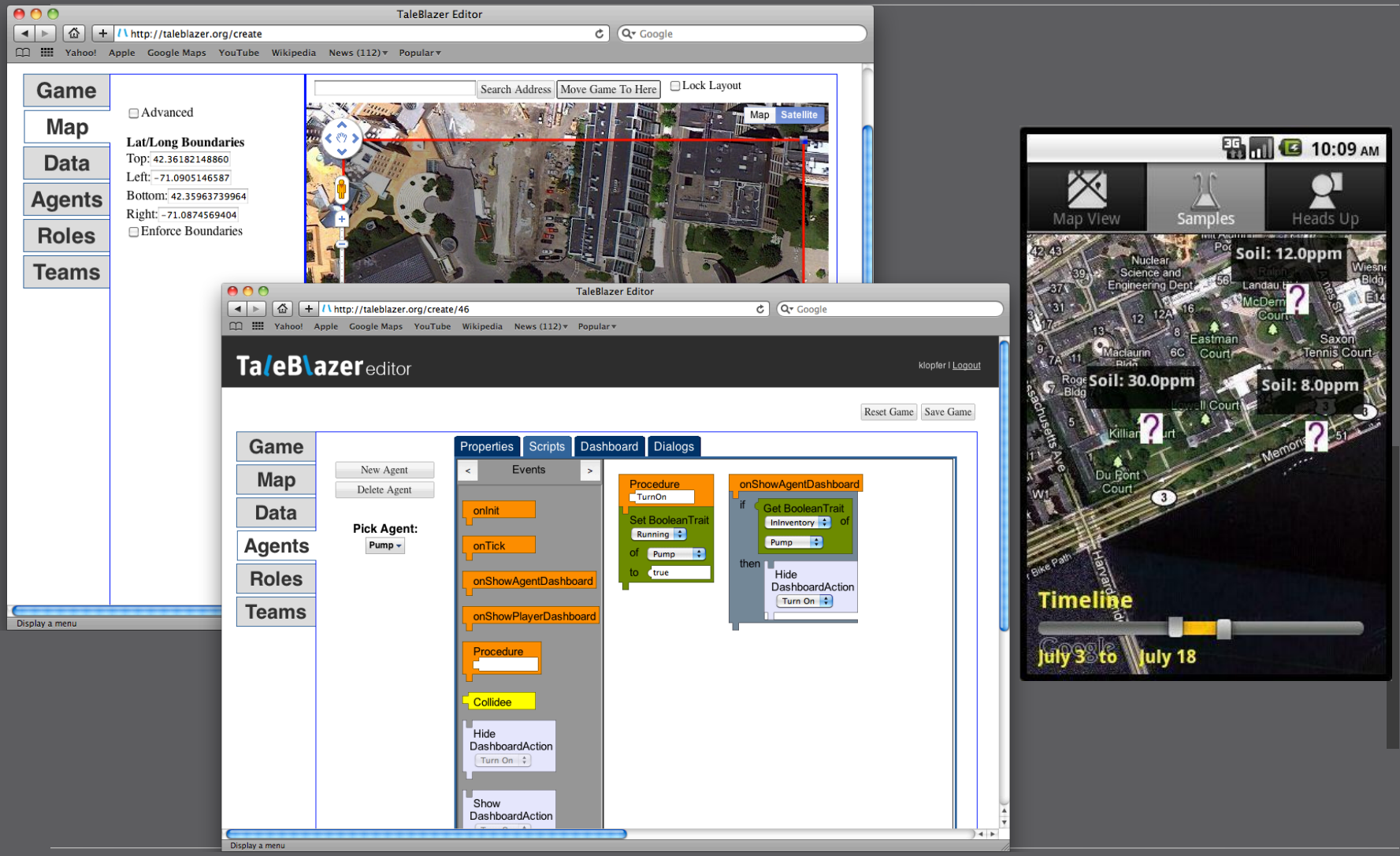


Augmented Reality Games

- Computer simulation on mobile device triggered by real world context

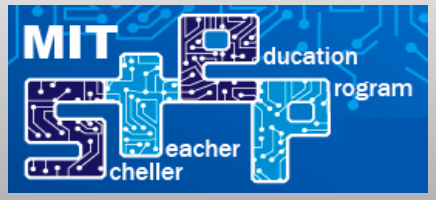


Kids Making Games



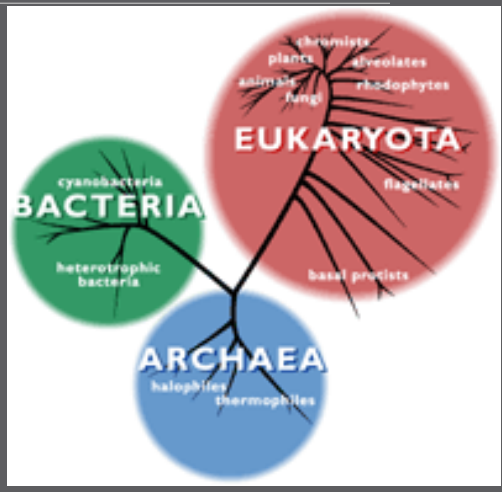
BioGraph

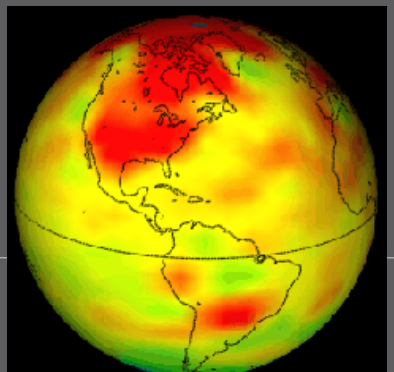
Graphical programming for constructing complex systems understanding in biology

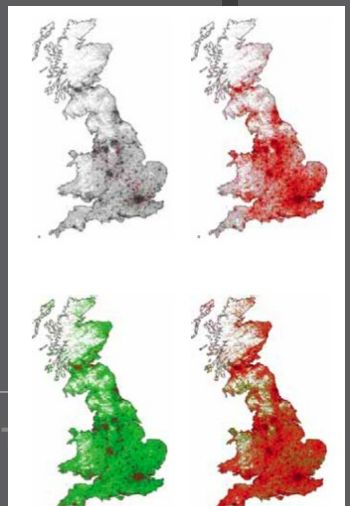


Science is Not Just for Scientists Anymore...

- Current **public controversies**
  - Global climate change
  - Evolution and origins of life
  - Spread of emerging diseases
- Are these simulations to be believed?
- Understanding these and future issues in science and society require understanding systems and simulations





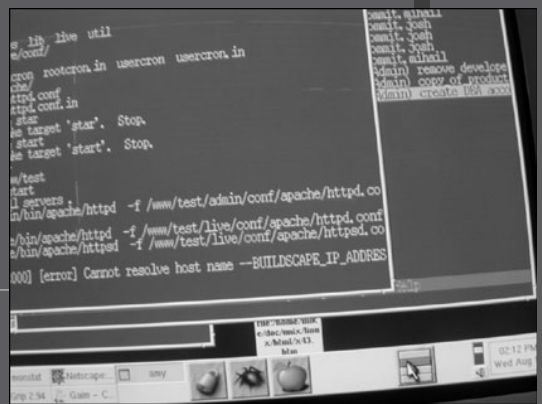


Our Primary Goal

- Enable/empower students to “think scientifically”
  - Use the **tools of scientists**
  - Develop the **habits of mind of scientists**
- Science is driven by **modeling** and **simulation**
- How do we make this accessible **conceptually** & **technically** to students?

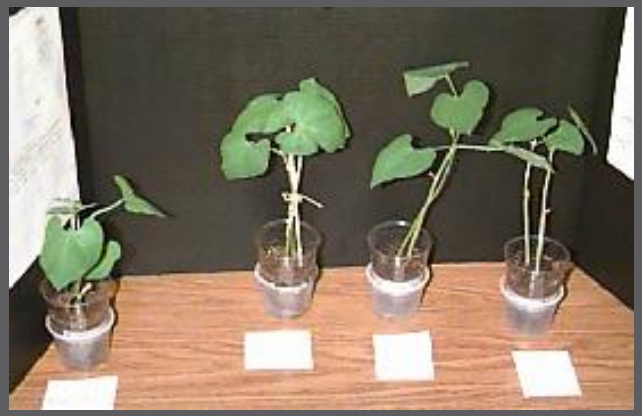
Our Secondary Goal

- Increase interest/understanding of programming
  - Interest in **building careers** in much needed area
  - Understanding for **all users** of computers from macros to troubleshooting
- Yet, programming is on the decline
  - Programming **classes are disappearing** and relegated to those who are already interested
  - Outside of school opportunities are also scarce due to missing expertise and perceived interest



New Paradigms for New Ideas

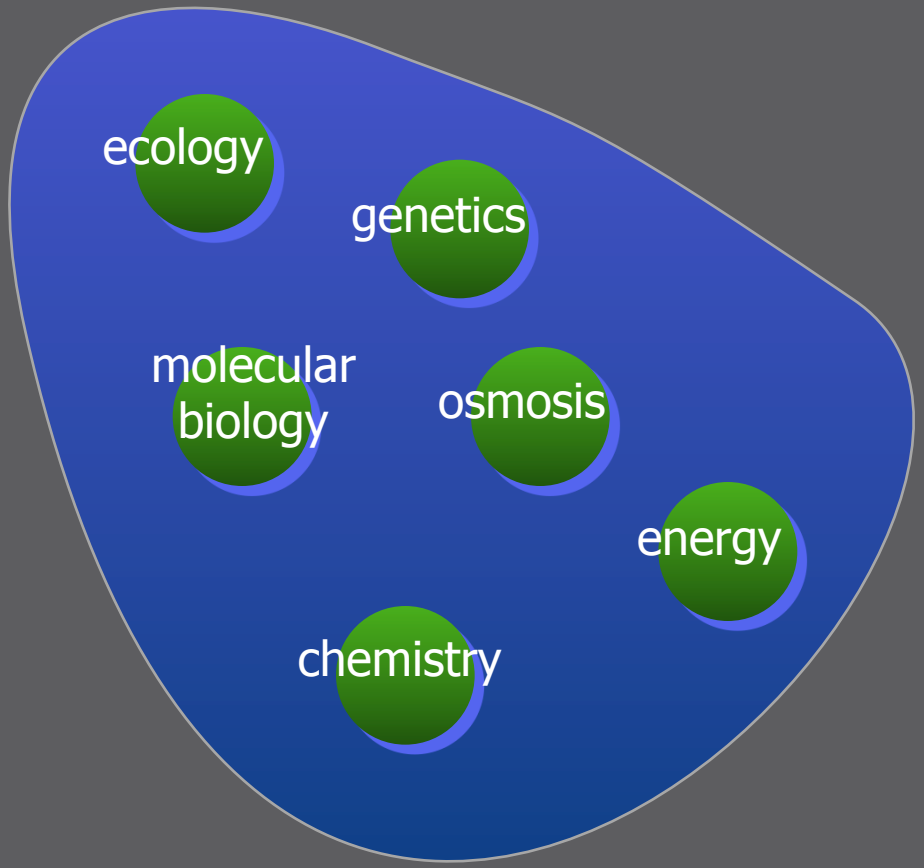
- Traditional pedagogies and technologies make some ideas accessible
- But leave others unapproachable



"In this demonstration, the students have isolated the effect of single variables on the growth of a bean plant"

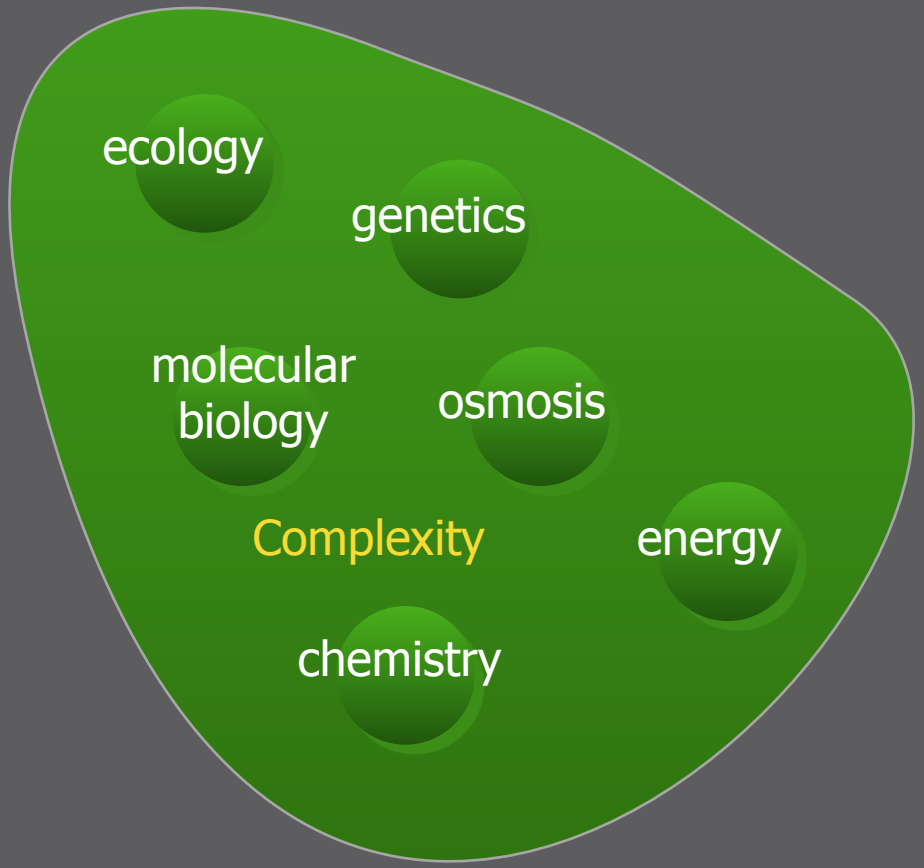
"In this experiment, the students have ignited a forest fire to study the effects of tree density on the spread of fires."

Islands of Science



- Science is traditionally thought of as islands of topics
- We learn bits of facts within subjects, and few connections between subjects

Complex Systems Connections



- Complex systems is a way of learning that transcends particular concepts and classes
- Understanding the common themes that arise in natural, artificial, and social systems
- Improve science understanding through CS

What Color is Your Box?

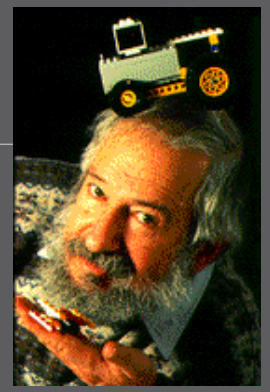
Black Box

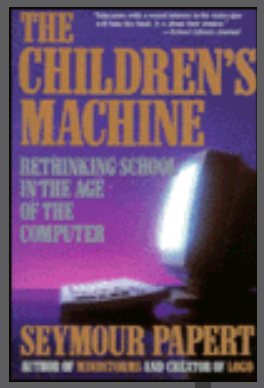
Glass Box

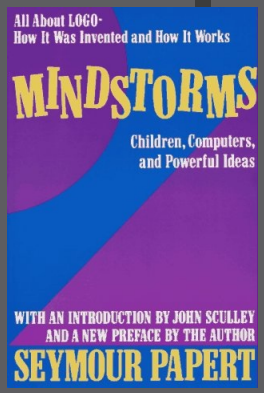
- Using simulations in the classroom has a lot of benefits (e.g. Phet, Pedagogica, Gizmos)
- Getting inside of them can change classroom practice and perspective and depth of student learning

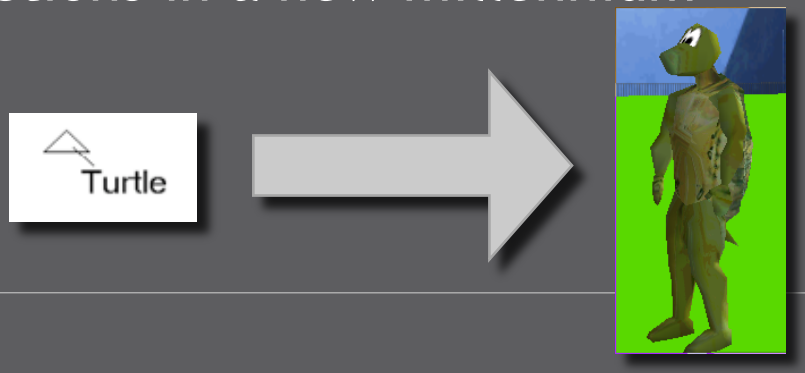
Constructivist Computational Heritage

- Seymour Papert
  - Programming/Logo
  - Learning to **think through programming**
- **Hard fun**
  - It is fun because it is hard
- Constructionism
  - Learning by creating
- New directions in a new millennium



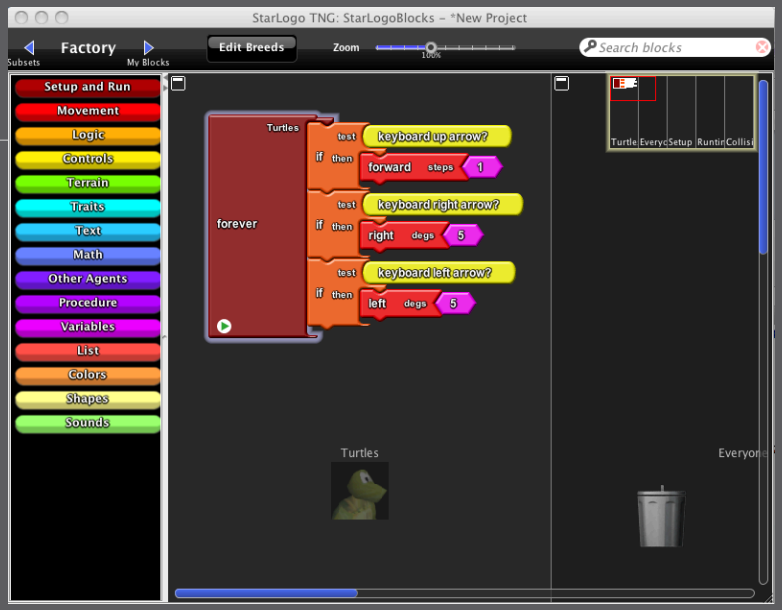


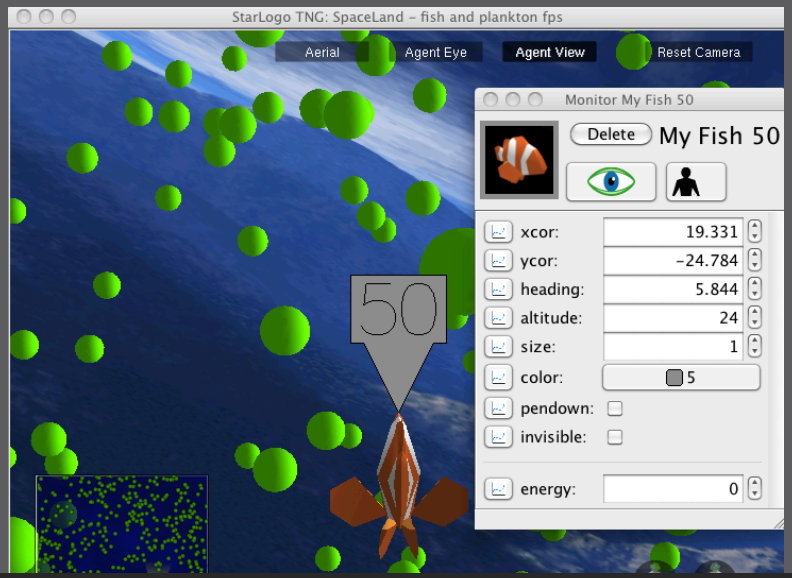


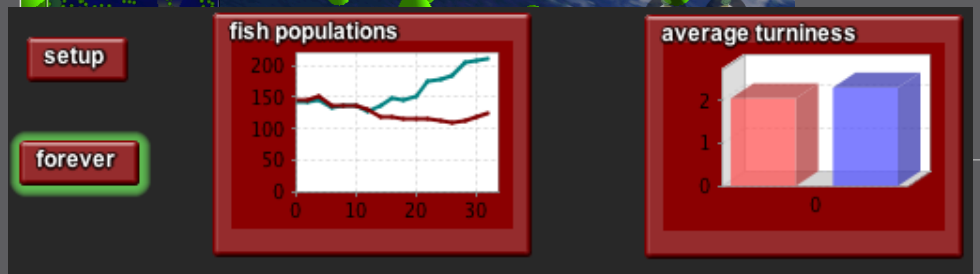


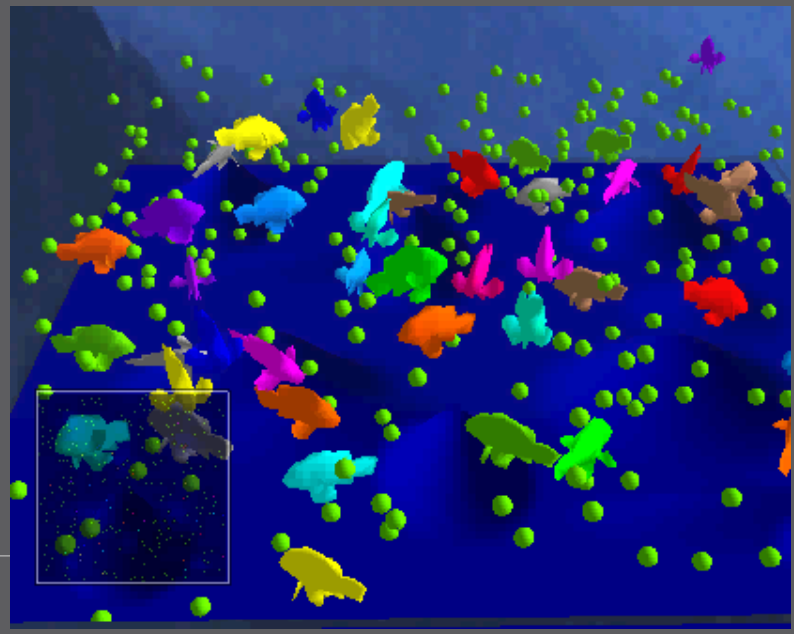
StarLogo TNG

- Easy and Playful
- 1st and 3rd person perspectives
- Blurring games and simulations



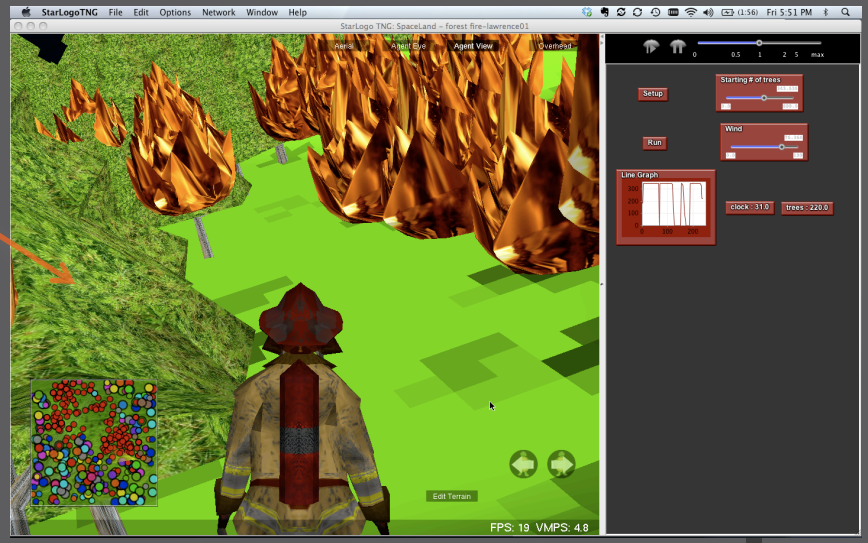


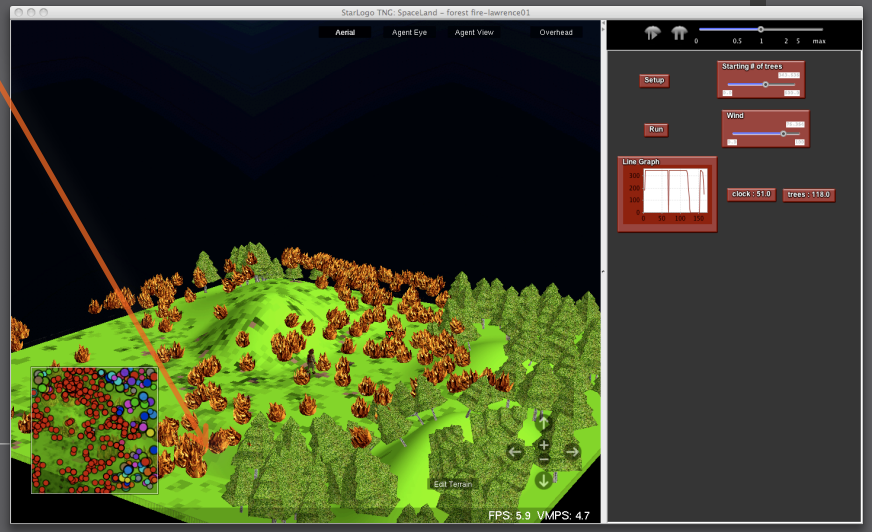




Understanding Complex Systems

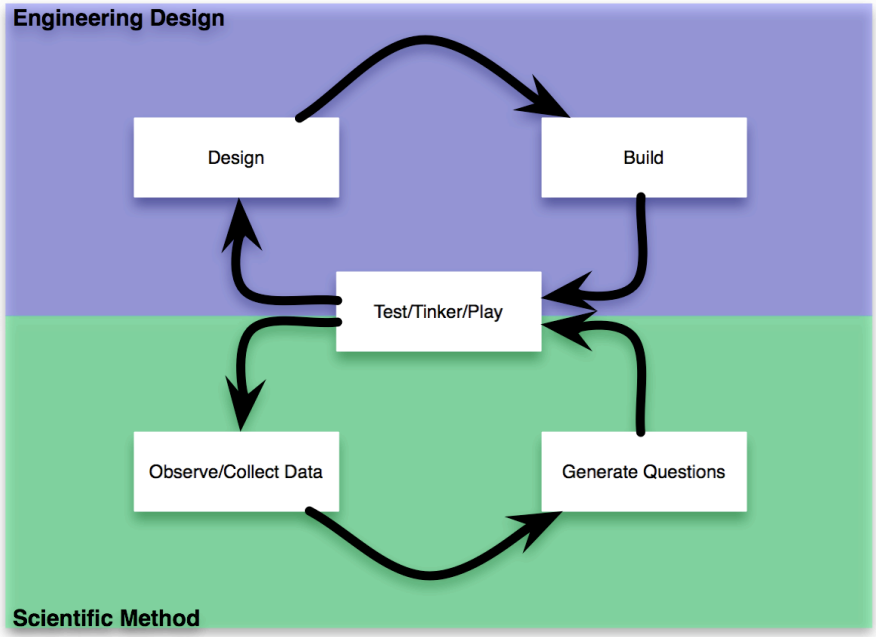
- Connecting **individual actions** to **system-level** behaviors
- Exploring many **complex systems**
  - Biological Systems
  - Social Systems
  - Etc.
- **Analyzing** data, **assessing** risk, **designing** and **testing** solutions





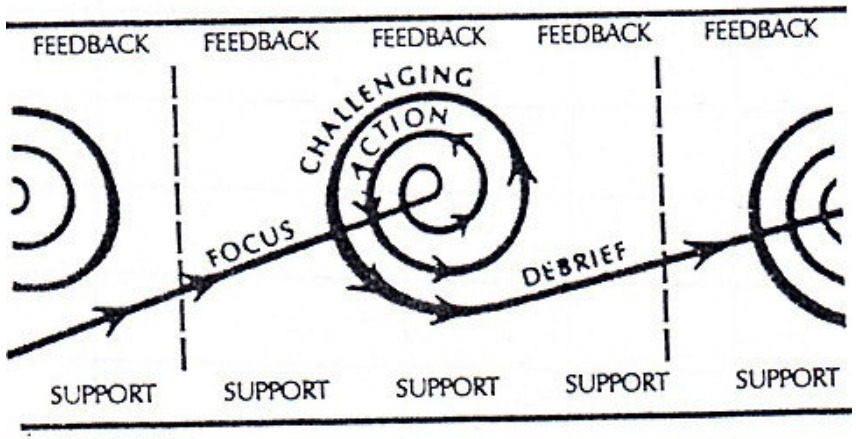
Cycles of Doing & Learning

Games & Simulation Cycle



No single investigation needs to span the whole spectrum from design to building to data collection, but multiple experiences with different parts of this process contribute to an understanding of the role of simulations broadly.

Action Reflection Cycle



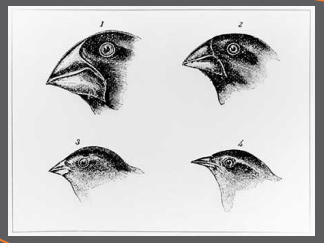
The Action-Reflection Cycle of Experiential Learning is a philosophical framework that closely matches much of the contemporary theory around using games in a classroom.

BioGraph Learning Model

Computational Thinking

Biograph

Complex Systems



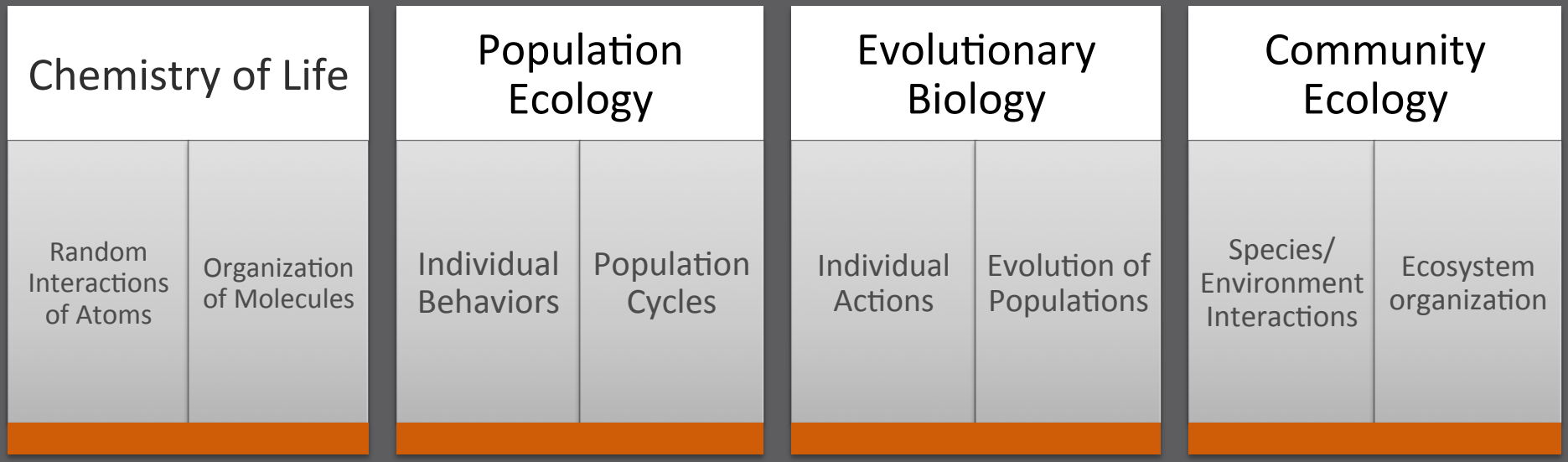
Biology

Predictability, *Processes*, *Order*, and *Emergence and Scale*

- Develop 21st Century skills
- Learn biology concepts better
- Develop complex system and computational thinking

BioGraph Sequence

Integrating biology and complex systems learning in a defined sequence (with constraints)



Scale and Emergence

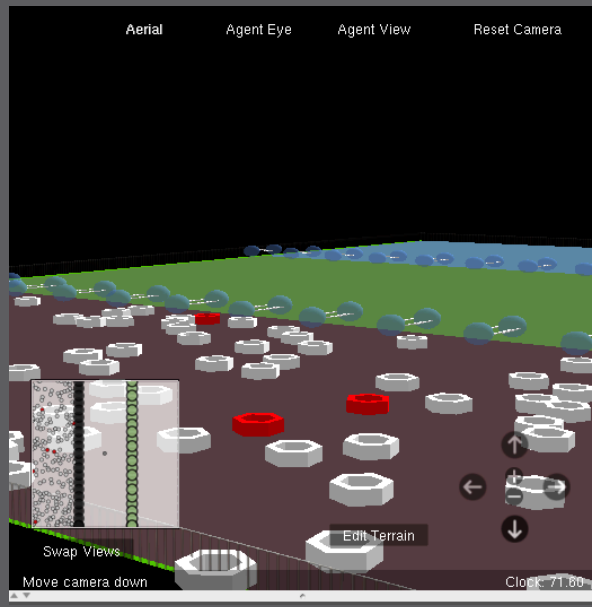
Ex: Sugar Transport (chemistry of life)

Biology Learning Objectives:

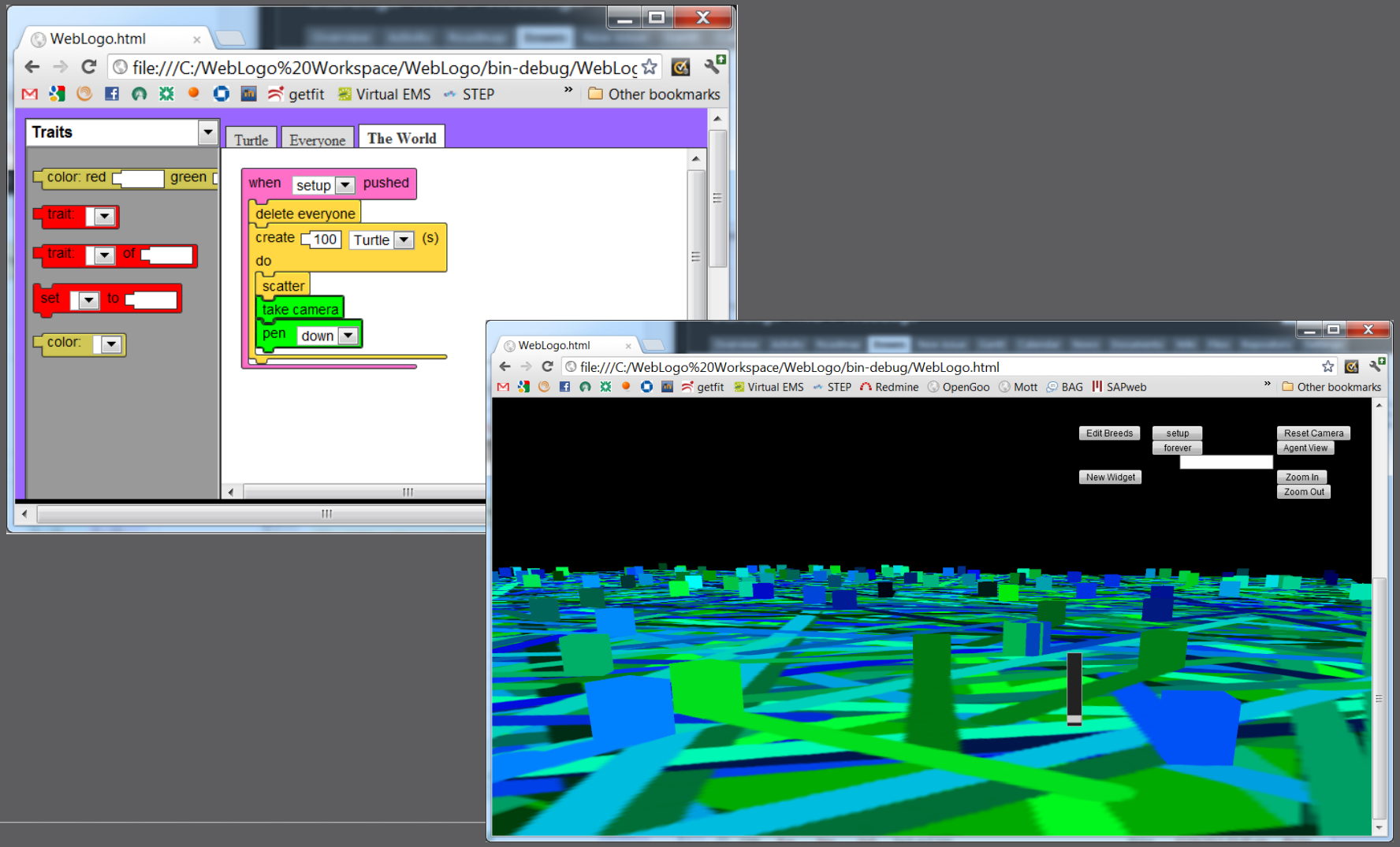
- Understand that nutrients move from the intestine through the epithelial cells into the blood stream.
- Understand that there are different types of transport proteins. Some allow nutrients to flow (facilitated transport/ facilitated diffusion). Others use energy to force nutrients to flow (active and co-transport).

Complex Systems Learning Objectives:

- Understand that random processes can lead to predictable results.



“WebLogo”


WebLogo.html
file:///C:/WebLogo%20Workspace/WebLogo/bin-debug/WebLoc
getfit
Virtual EMS
STEP
Other bookmarks
Traits
Turtle
Everyone
The World
color: red
green
trait:
trait:
of
set
to
color:
when
setup
pushed
delete everyone
create
100
Turtle
(s)
do
scatter
take camera
pen
down
WebLogo.html
file:///C:/WebLogo%20Workspace/WebLogo/bin-debug/WebLogo.html
getfit
Virtual EMS
STEP
Redmine
OpenGoo
Mott
BAG
SAPweb
Other bookmarks
Edit Breeds
setup
forever
Reset Camera
Agent View
New Widget
Zoom In
Zoom Out

- **Thanks to:**

  –US Dept of Education, NSF, NIH, Google, Singapore MDA

  –Judy Perry, Josh Sheldon, Jason Haas, Lisa Stump, Daniel Wendel, Wendy Huang, Scot Osterweil, Caitlin Feeley, Dana Tenneson, Louisa Rosenheck

  –STEP/TEA MEng and UROPs

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