



Game-Based Learning Assessments

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Playing with Data: Developing digital supports for middle-school science teachers using game-based formative assessment

Award no. 1503255

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- 3-year design-based research project—we've just completed Year 1
- Using a game called *Mars Generation One: Argubot Academy*
- The game helps build “the mechanics” of argumentation skills, using Steven Toulmin’s basic model of argumentation and Douglas Walton’s argumentation schemes
- Students build robots by matching claims to evidence within the correct argumentation scheme



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Crash Course in Argubot Academy Argot



ARGUBOT:

Special robots used by the kids in Argubot Academy. They're powered by a claim core and represent an argument in argubot duels.



CLAIM CORE: The core powers the argubot. It's made of up of a claim -- a position taken in an argument. And evidence -- the thing that supports a claim. Without a claim core, an argubot won't power up!



CRITICAL QUESTIONS:

An advanced attack used against an argubot that has a related and supporting claim core. When the core is solid, students need to go to critical question attacks!



ARGU-MECH: A super-argubot, this argu-mech doesn't have just one claim core, but many! It's built to make complex arguments with multiple claims and multiple pieces of evidence.



EVO-1: Argubots start out life as Evo-1 bots. They're powered by a claim core but can't carry critical question attacks or shields. Level them up and they might evolve to Evo-2!



EVO-2: Is the next level in an argubot's life. Evo-2 argubots have claim cores that can be protected by critical question shields -- that's a shield made up of backing.

Learning Events & Time Played

In addition to showing total time played, this report reveals critical accomplishments in the game and how these accomplishments align with curriculum standards.

Common Core Standards in this Game

- CCSS.ELA-Literacy.WHST.6-8.1a
- CCSS.ELA-Literacy.WHST.6-8.1b

← Achievement 1-3 / 5 →

Name	Bot Champion	Evidence Cadet	Bot Defender	Time Played
	Student has won three argubot battles in a row!	Great detective work! Student has collected a wide range of evidence.	Student dominated a battle by successfully critiquing an opposing argument while defending his/her own.	
Standards	■	■	■	
Abba A.				8 minutes
Alex K.				4 days
Betty W.	🟢			5 days
Bob S.	🟢		🟢	an hour
Bron T.				an hour

Competency Levels

- Not started
- In progress
- Tracking toward standard completion
- Standard complete
- Needs support

Standards Report

This report shows students' advancement through the standards as they play. The content shown here is based on key in-game learning events that provide strong evidence of standards progression.

Name	Common Core			
	English Language Art			College and Career Readiness
	RI.6.8	RI.7.8	RI.8.8	CCRA.R.1
	Trace and evaluate argument and claims in text; distinguish those supported (and not supported) by reasons and evidence.	Trace and evaluate argument and claims in text; distinguish those supported (and not supported) by reasons and evidence.	Trace and evaluate argument and claims in text; assess sound reasoning and relevant/sufficient evidence; recognize when irrelevant evidence is introduced.	Make logical inferences from close reading of text; support conclusions drawn with specific evidence.
Michelle C	🟢	🟢	🟢	🟢
Bron T	🟢	⚪	⚪	⚪
Cooper W	🟢	🟢	🟢	🟢
Heather K	🔴	⚪	⚪	⚪

Shout Out and Watch Out Report

This report provides a snapshot of how students are doing right now. Celebrate your students' success (Shout Out) and identify students in need of help (Watch Out!).

Shout Out!

Watch Out!

← 1-3 / 3 Watch Out! →

Name	Contradictory Mechanic	Irrelevant Mechanic	Straggler
	In their most recent six attempts to build claim-evidence pairs, the player has created three or more contradictory pairs.	In their most recent six attempts to build claim-evidence pairs, the player has created three or more pairs with irrelevant evidence.	Student is having difficulty distinguishing between evidence that is 'not supporting' and 'not relevant' in opponent arguments.
Alex K.			🔴
Betty W.	🔴		🔴
Cooper W.	🔴		🔴
David E.	🔴		🔴
Jaime G.	🔴		🔴

TEACHER REPORT

Research Questions

1. Is there promising evidence that teachers who have access to the revised dashboard interface and accompanying educative materials are able to improve formative assessment and differentiated instruction practices, as compared to peers who do not have access to the educative materials?
2. How do teachers make sense of and use the data, and what factors enable or limit their use of the data?

SimScientists Games

- *DRK12 PI Meeting*
- *June 2, 2016*

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SimScientists Games

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Andrew Grillo-Hill

Kim Luttgen

- Kevin Huang

- IAI
- Jody Underwood
- Lisa Holt






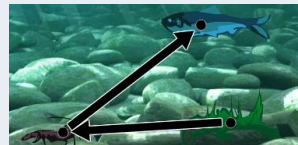

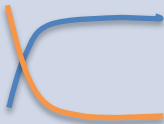
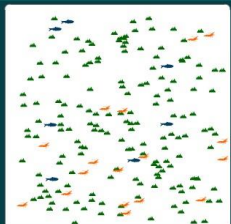
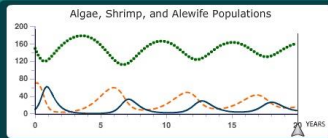
Advisors

- Rodger Bybee
- Douglas Clark
- Kenji Hakata
- Eric Klopfler
- Anna Rafferty
- Valerie Shute

Research Questions

- Utility of games as formative assessment resources
- Quality and coherence of the game activities
- Feasibility of classroom use of SimScientists games
- Effect of game use on student outcomes
-

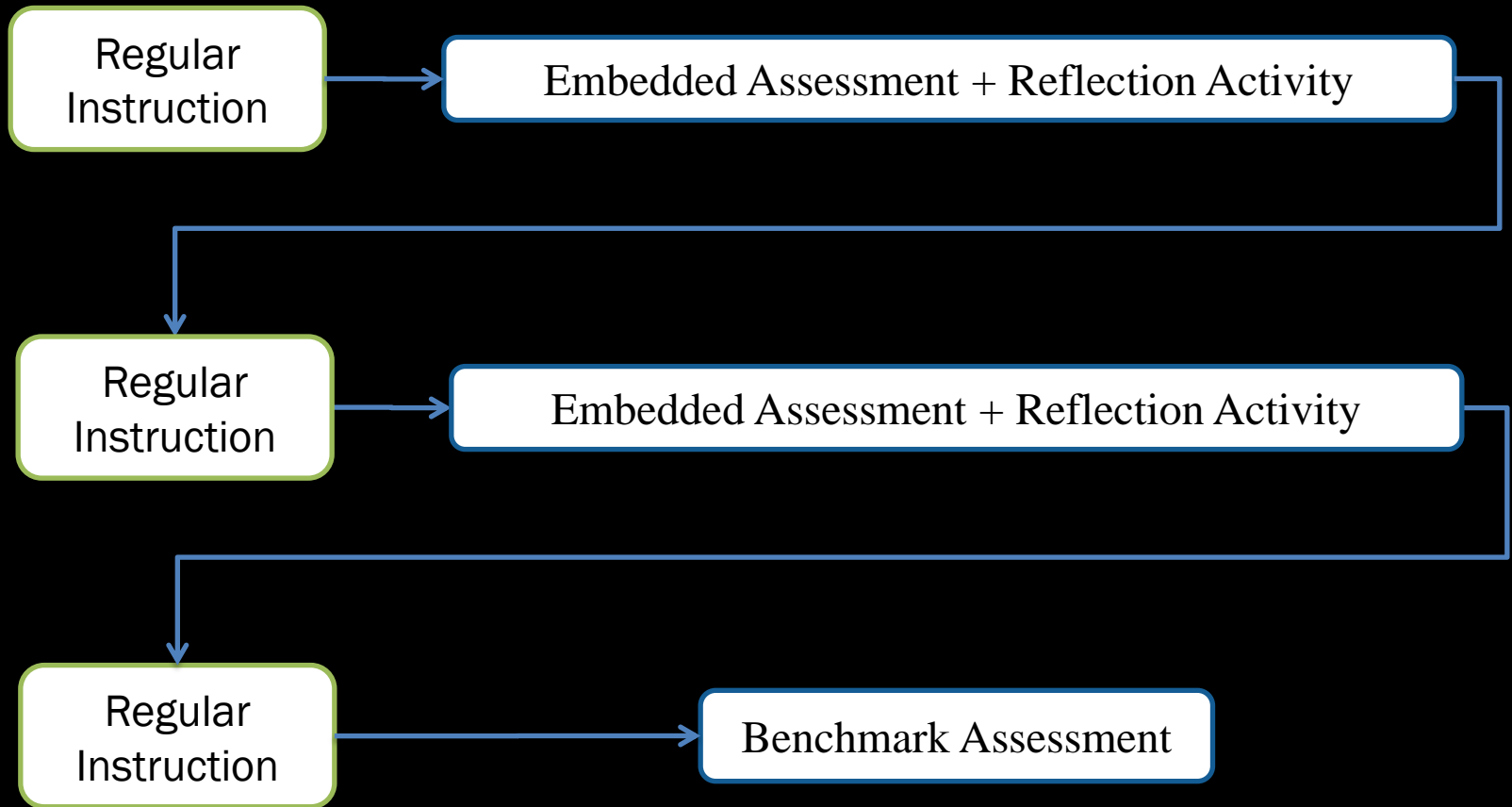
Target Models of Complex Systems

Model Level	Ecosystems Unit																				
<p>Component</p> 	<p>Organisms & their roles</p> <div data-bbox="772 492 1767 564" style="border: 1px solid black; padding: 5px; display: flex; justify-content: space-around; align-items: center;"> Algae  Shrimp  Alewife  </div>																				
<p>Interaction</p> 	<p>Flow of matter & energy</p> <div style="display: flex; justify-content: space-around;">   </div>																				
<p>Emergent</p> 	<p>Populations & changes</p> <div style="border: 1px solid black; padding: 5px;"> <table style="width: 100%; border-collapse: collapse;"> <thead> <tr> <th colspan="2">Starting Values</th> </tr> </thead> <tbody> <tr> <td>Algae</td> <td>150</td> </tr> <tr> <td>Shrimp</td> <td>70</td> </tr> <tr> <td>Alewife</td> <td>10</td> </tr> </tbody> </table> <div style="display: flex; justify-content: space-around; margin-top: 10px;">   </div> <table style="width: 100%; border-collapse: collapse; margin-top: 10px;"> <thead> <tr> <th>Years</th> <th>Start</th> <th>End</th> </tr> </thead> <tbody> <tr> <td>Algae</td> <td>150</td> <td>161</td> </tr> <tr> <td>Shrimp</td> <td>70</td> <td>17</td> </tr> <tr> <td>Alewife</td> <td>10</td> <td>7</td> </tr> </tbody> </table> </div>	Starting Values		Algae	150	Shrimp	70	Alewife	10	Years	Start	End	Algae	150	161	Shrimp	70	17	Alewife	10	7
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SimScientists Assessment Task Design Principles

- Simulations model complex science systems
- Authentic, problem-based inquiry
- Feedback and scaffolding in embedded assessments
- Formative use of Progress Reports
- Follow up Reflection Activities that foster
 - Collaborative science practices
 - Discourse for sense-making and scientific argument

SimScientists Assessments Embedded & Benchmark



Sample Progress Reports to Students

Ecosystems

Report for Grasslands - Food Web life science

Completed on 12/11/2014/Desi Arnez

Ecosystem Roles

Organisms, and populations of organisms, are dependent on their environmental interactions both with living things and with nonliving factors.

ON TRACK

Interactions

Predatory interactions may reduce the number of organisms or eliminate whole populations of organisms. Mutually beneficial interactions, in contrast, may become so interdependent that each organism requires the other for survival. Although the species involved in these competitive, predatory, and mutually beneficial interactions vary across ecosystems, the patterns of interactions of organisms with their environments, both living and nonliving, are shared. Food webs are models that demonstrate how matter and energy is transferred between producers, consumers, and decomposers as the three groups interact within an ecosystem. Transfers of matter into and out of the physical environment occur at every level. Decomposers recycle nutrients from dead plant or animal matter back to the soil in terrestrial environments or to the water in aquatic environments.

ON TRACK

Developing and Using Models

Science often involves the construction and use of a wide variety of models and simulations to help develop explanations about natural phenomena. Models make it possible to go beyond observables and imagine a world not yet seen. Models enable predictions of the form "if...then...therefore" to be made in order to test hypothetical explanations.

ON TRACK

SimScientists Embedded Assessments

Formative Assessment Features

- Graduated coaching within embedded assessments
 - On core ideas/misconceptions
 - On practices applying core ideas and cross-cutting concepts
- Progress Report by concepts within system model levels and practices targets
 - *On Track, Progressing, Needs Help*
 - For individual student
 - For teacher
 - Class summary with drill-down into student detail
 - Used to suggest teams and groups for jig-saw structured reflection activities that adjust instruction and support collaboration and discourse

SimScientists Games

Design Principles

- Evidence centered design
- Model based learning
- Cognitive learning research
 - Meaningful, real world problem
 - Active problem solving/investigation
 - Formative assessment with feedback, scaffolding
 - Scientific discourse
- Motivation and engagement research
 - Challenge
 - Achievement
 - Rewards

SimScientists Games

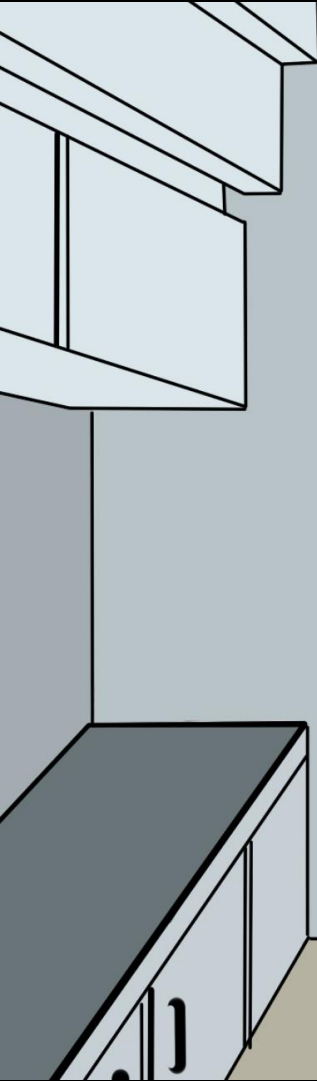
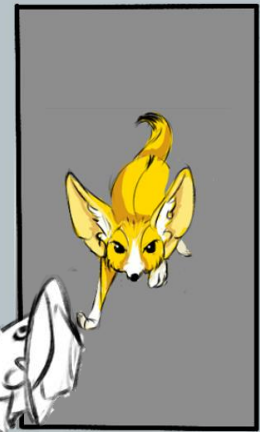
Design Constraints

- 2 games, each addressing assessment targets in Progress Reports following Ecosystem embedded assessments
- Also addressing collaboration skills
- Assessment targets for a limited number of core ideas and practices
- 45 minute period to play each game in school



Here are all the organisms we know about in the fox's ecosystem. You can enter each organism's habitat to gather clues by taking pictures of what it eats and what eats it.

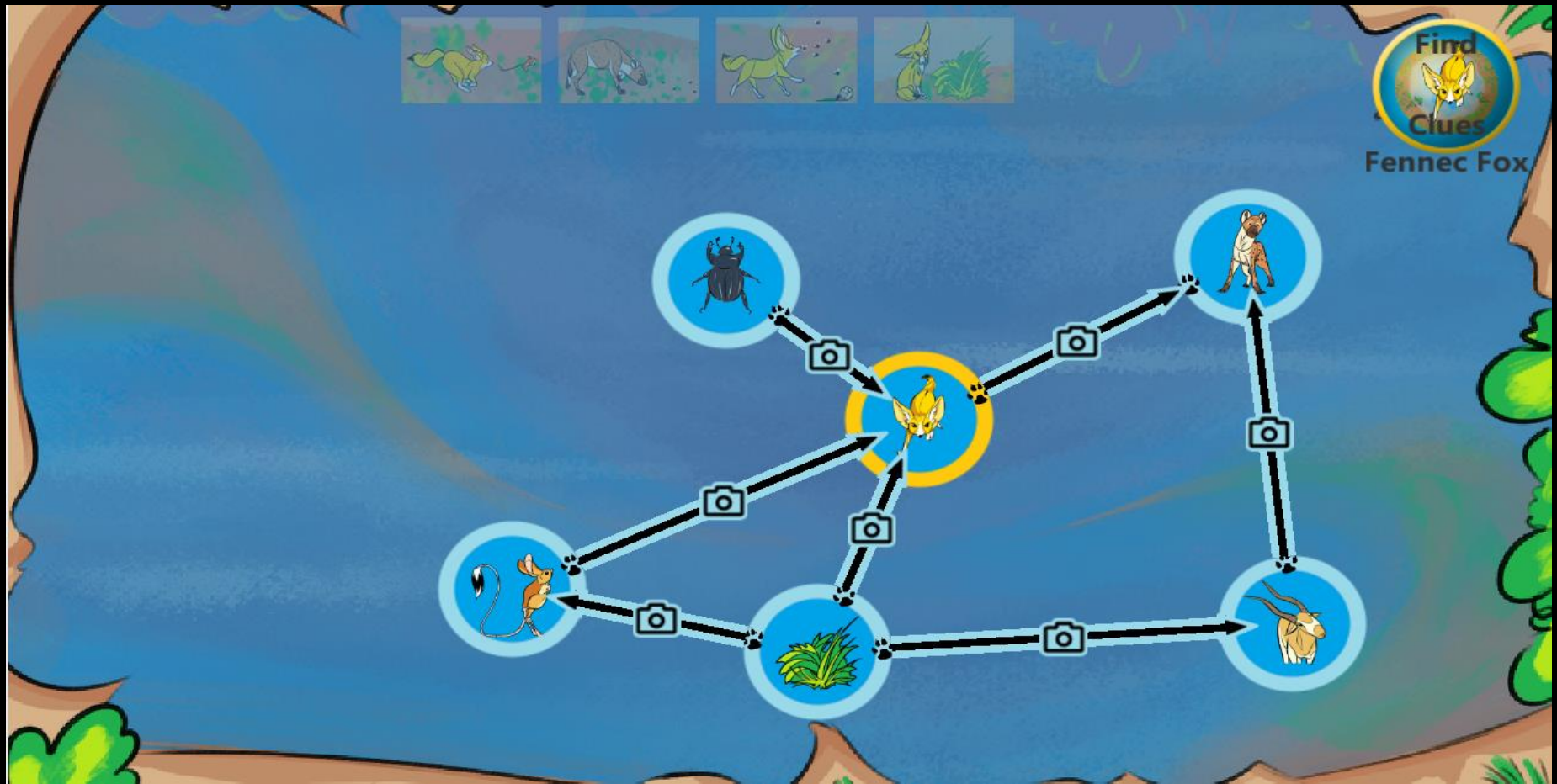
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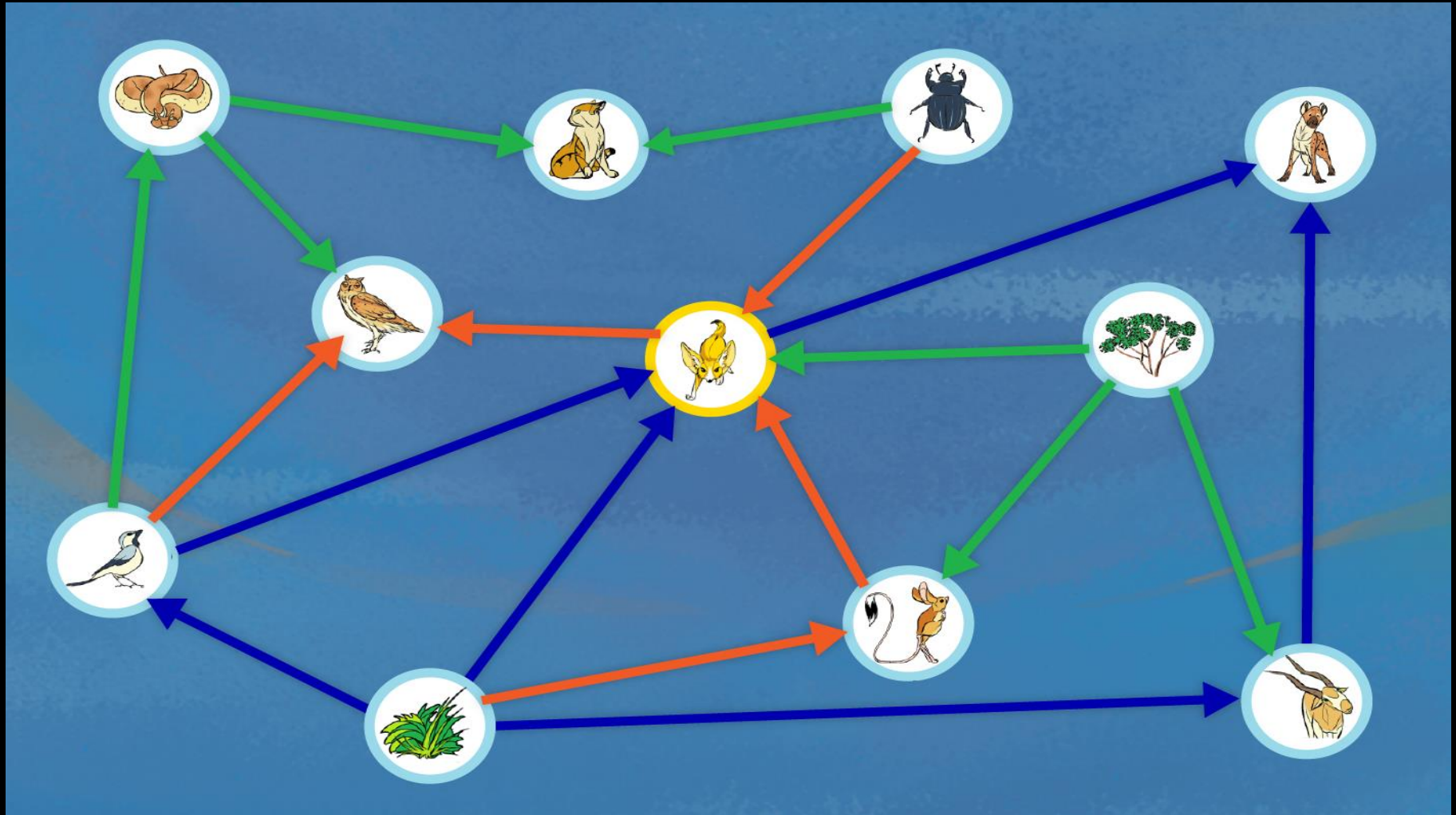
Pictures as Evidence



Build Food Web Model of Flow of Energy and Matter (Tier 1)



Tier 3 Food Web



Collaboration in Game

The image displays a game interface with a chat window on the left and a game map on the right. The chat window shows a conversation between Dr. Jonas (Field Scientist) and Georgia (Peer). The messages are:

- Dr. Jonas: Collect more clues for the fennec fox.
- Georgia: Okay. Now, why didn't my clue stick?
- Dr. Jonas: The arrow and the clue don't match.

The response options for Georgia are:

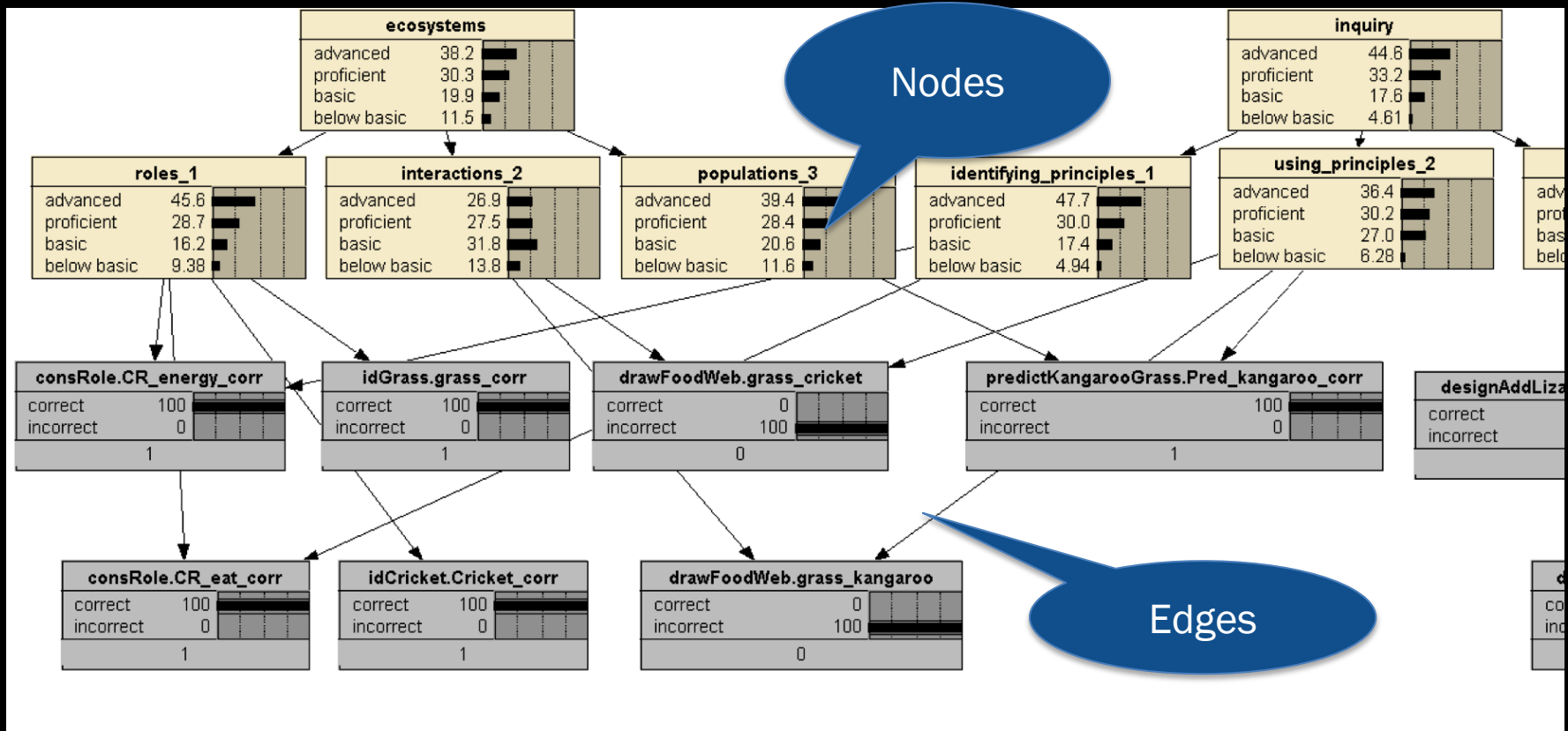
- Yes they do.
- What's different?
- You're right, I'll fix it.
- What should I do to fix it?

The game map on the right shows a network of nodes connected by arrows. The nodes include a yellow fennec fox icon (highlighted), a brown fennec fox icon, a white fennec fox icon, a green fennec fox icon, and a brown fennec fox icon. A 'Find Clues' button is visible in the top right corner. The map is titled 'Fennec Fox Clues'.

SimScientists Games

- Evidence Model
 - Student responses to explicit questions/activities in the game
 - Observable variables in BN
 - Scoring aggregated to rewards, badges

Fragment of a Bayes Net From the Calipers II Ecosystems Benchmark Assessment



Note: the conditional probabilities associated with the edges are not visible in this view

SimScientists Game Architecture

- Game Activities Producing Evidence about Progress on Assessment Targets
 - Responding to activity tasks and questions
 - In Game 1, by
 - collecting pictures, videos of organisms and their roles (eating/being eaten by other organisms), entering images in notebook, classifying the roles,
 - placing into the energy flow model, aka foodweb
 - In Game 2, by
 - Designing, running, interpreting graphs of simulations of population dynamics by changing numbers of organisms in the population
 - Making predictions, explaining population changes, critiquing, developing arguments of others' designs, explanations, recommendations
 -

SimScientists Selected Publications

- Davenport, J. L., & Quellmalz, E. S. (2014). Assessing science inquiry and reasoning using dynamic visualizations and interactive simulations. Forthcoming chapter in *Learning from Dynamic Visualizations: Innovations in Research and Practice*.
 - Quellmalz, E. S., Davenport, J. L., Timms, M.J., DeBoer, G.E., Jordan, K.A., Haung, C., & Buckley, B.C. (2013). Next-generation environments for assessing and promoting complex science learning. *J Ed Psych*, 51, 523-554.
- Buckley, B. C., & Quellmalz, E. S. (2013). Supporting and assessing complex biology learning with computer-based simulations and representations. In D. Treagust & C.-Y. Tsui (Eds.), *Multiple Representations in Biological Education* (pp. 247-267). Dordrecht: Springer.
- Quellmalz, E. S., Timms, M. J., Silberglitt, M. D. & Buckley, B. C. (2012). Science assessments for all: Integrating science simulations into balanced state science assessment systems. Invited article, *Journal of Research in Science Teaching (JRST)*, 49, 363–393.
- Quellmalz, E. S., Timms, M. J., Buckley, B. C., Davenport J., Loveland, M., & Silberglitt, M. D. (2012). 21st century dynamic assessment. In M. Mayrath, J. Clarke-Midura, & D. H. Robinson (Eds.), *Technology-based assessments for 21st century skills: Theoretical and practical implications from modern research* (pp. 55–90). Charlotte, NC: Information Age.
- Quellmalz, E. S., Silberglitt, M. D., & Timms, M. J. (2011). How can simulations be components of balanced state science assessment systems? *Policy brief*. San Francisco: WestEd.
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- Quellmalz, E. S. & Pellegrino, J. W. (2009). Technology and testing. *Science*, 323, 75–79.
- Quellmalz, E. S., DeBarger, A. H., Haertel, G., Schank, P., Buckley, B., Gobert, J., Horwitz, P., & Ayala, C. (2008). Exploring the role of technology-based simulations in science assessment: The Calipers Project. In J. Coffey, R. Douglas, & C. Stearns (Eds.), *Science assessment: Research and practical approaches* (pp. 191–202). WDC: National Science Teachers Association.

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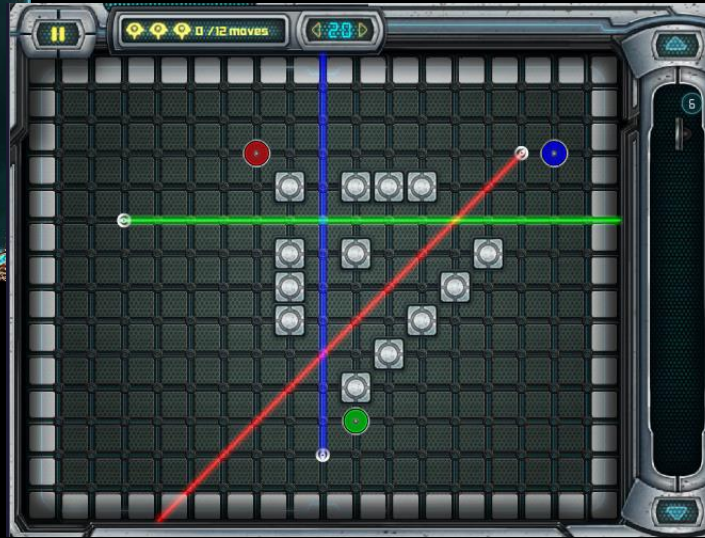
Zoombinis



What Lies Below...Implicit STEM Learning in Games



Leveling Up



1. Pre/post Assessments with Control/Games/Bridge classes.
2. EDM studies to measure how learners play the games.
3. HLM studies to see if how they play makes a difference in STEM learning.

Leveling Up

Imp Studies



Bridge classes show sig gains in pre/post tests

EDM Studies

EDM detectors reveal behaviors consistent with implicit understanding

HLM Studies

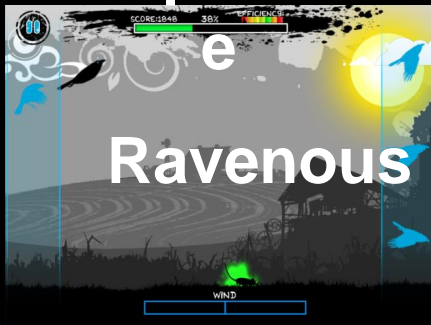
"It's how they play the game"



Same gains for Bridge, Games, and Control groups

Data mining models distinguish STEM errors (e.g. law of reflection and slope) from puzzle errors

We can see when they are struggling



In progress

n/a

Do kids go outside?





Zoombinis



Computational Thinking Learning Progression

Trial and Error

Testing a Solution

Implementing a Solution

Identifying a Strategy

Generalizing a Solution

Problem Decomposition

Abstraction

Generalization

Zoombin's Dashboard

Where in the game are my students now?



Zoombin's Dashboard

Where in the game are my students now?



Zoombin's Dashboard

Allergic Cliffs



Highest Level Reached



Students Have Done Well



Students May Be Struggling

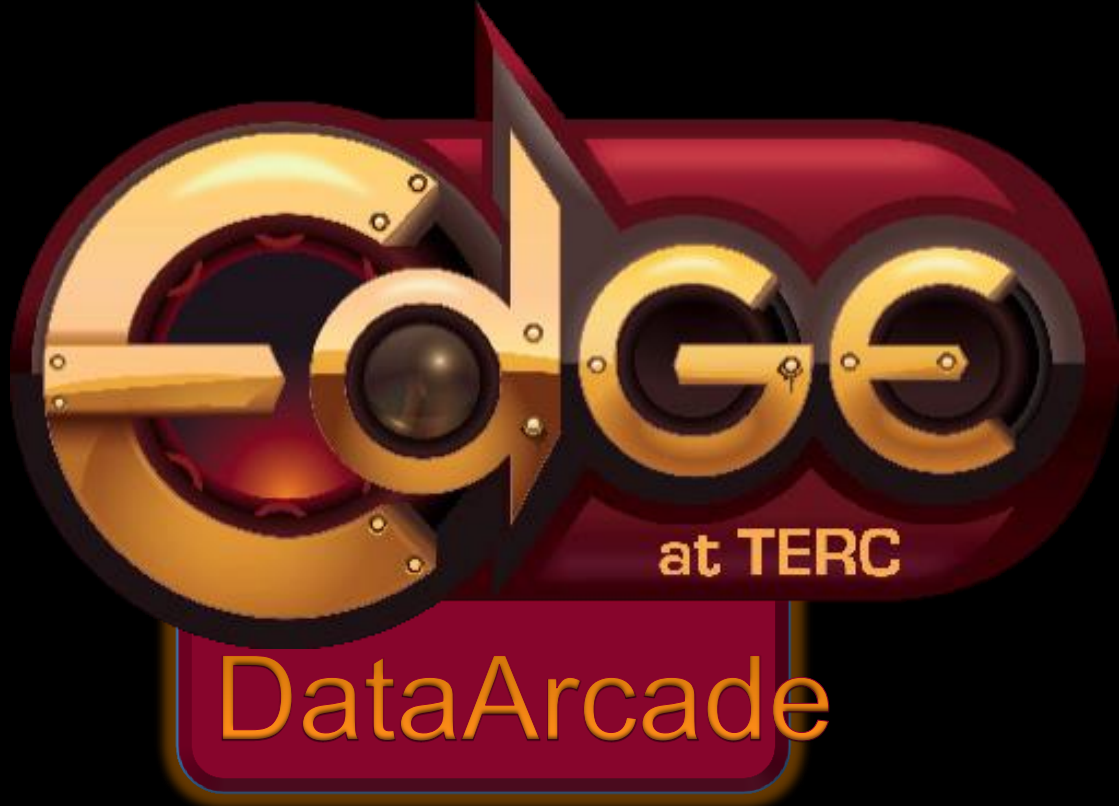


During the Last Students Played this Puzzle



to Completion

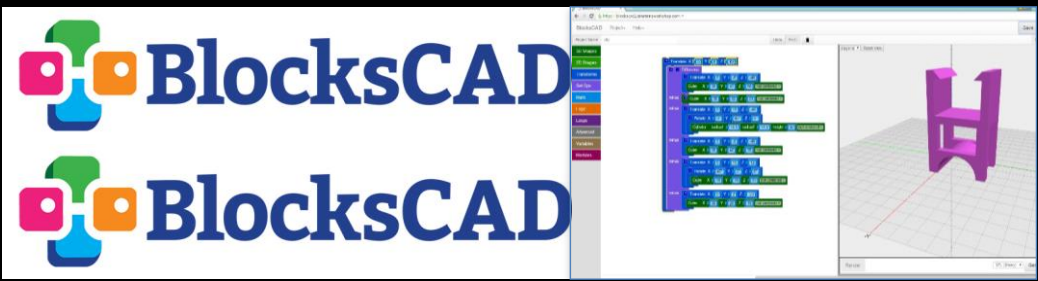




EdGE at Terc
in partnership with
Landmark College & MIT



rti.



It Takes a Team



Erin Bardar; Teon Edwards; Jamie Larsen;
Barbara MacEachern; Katie Stokinger;
Elizabeth Rowe

new
knowledge.org



Questions

What types of topics/skills are ripe for GBLA?

When is GBLA NOT a good idea?

What types of information are most useful for teachers?

What does GBLA offer that is unique?