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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- Glasslabgames.org
• 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
**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 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 align with curriculum standards.

**Common Core Standards in this Game**

- CCSS ELA: Literary WHST.8.1a
- CCSS ELA: Literary WHST.8.1b

**Achievement 1-3-1**

<table>
<thead>
<tr>
<th>Name</th>
<th>Bot Champion</th>
<th>Evidence Collector</th>
<th>Bet Defender</th>
<th>Time Played</th>
</tr>
</thead>
<tbody>
<tr>
<td>Abba A</td>
<td>Student has won three argument battles in a row</td>
<td></td>
<td></td>
<td>8 minutes</td>
</tr>
<tr>
<td>Alex K</td>
<td>Student dominated a battle by successfully criticizing an opposing argument while defending his/her own</td>
<td></td>
<td></td>
<td>4 days</td>
</tr>
<tr>
<td>Betty W</td>
<td></td>
<td>Student has created a wide range of evidence.</td>
<td></td>
<td>5 days</td>
</tr>
<tr>
<td>Bob S</td>
<td></td>
<td></td>
<td></td>
<td>1 hour</td>
</tr>
<tr>
<td>Bron T</td>
<td></td>
<td></td>
<td></td>
<td>1 hour</td>
</tr>
</tbody>
</table>

**Standards Report**

The 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.

<table>
<thead>
<tr>
<th>Name</th>
<th>RI 6.8</th>
<th>RI 7.8</th>
<th>RI 8.6</th>
<th>CCRA.R.1</th>
</tr>
</thead>
<tbody>
<tr>
<td>Michele</td>
<td>green</td>
<td>green</td>
<td>green</td>
<td>green</td>
</tr>
<tr>
<td>Bron T</td>
<td>green</td>
<td>green</td>
<td>green</td>
<td>green</td>
</tr>
<tr>
<td>Cooper W</td>
<td>red</td>
<td>green</td>
<td>green</td>
<td>green</td>
</tr>
<tr>
<td>Heather K</td>
<td>red</td>
<td>green</td>
<td>green</td>
<td>green</td>
</tr>
</tbody>
</table>

**Shout Out and Watch Out Report**

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

**Shout Out**

- Alex K
- Betty W
- Cooper W
- David E
- Jaime O

**Watch Out**

- Alex K
- Betty W
- Cooper W
- David E
- Jaime O

**Contradictory Mechanic**

- In their most recent six attempts to build claim-evidence pairs, the player has created three or more contradictory pairs.

**Irrelevant Mechanic**

- In their most recent six attempts to build claim-evidence pairs, the player has created three or more pairs with irrelevant evidence.

**Straggler**

- Student is having difficulty distinguishing between evidence that is 'not supporting' and 'not relevant' in opponent arguments.
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

This material is based upon work supported by a grant awarded to WestEd from the National Science Foundation (DRL-1503481). Any opinions, findings, conclusions or recommendations expressed in this material are those of the authors and do not necessarily reflect the views of the National Science Foundation.
SimScientists Games

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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

<table>
<thead>
<tr>
<th>Model Level</th>
<th>Ecosystems Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Component</td>
<td>Organisms &amp; their roles</td>
</tr>
<tr>
<td></td>
<td><img src="image1.png" alt="Image of organisms" /></td>
</tr>
<tr>
<td>Interaction</td>
<td>Flow of matter &amp; energy</td>
</tr>
<tr>
<td>Emergent</td>
<td>Populations &amp; changes</td>
</tr>
<tr>
<td></td>
<td><img src="image2.png" alt="Image of interactions" /></td>
</tr>
</tbody>
</table>
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

Regular Instruction → Embedded Assessment + Reflection Activity

Regular Instruction → Embedded Assessment + Reflection Activity

Regular Instruction → Benchmark Assessment
Ecosystem Roles
Organisms, and populations of organisms, are dependent on their environmental interactions both with living things and with nonliving factors.

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.

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.
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.
Pictures as Evidence
Build Food Web Model of Flow of Energy and Matter (Tier 1)
Tier 3 Food Web
Collaboration in Game

Dr. Jonas (Field Scientist) and Georgia (Peer)

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.

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


Contact Information

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What Lies Below...Implicit STEM Learning in Games
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.
<table>
<thead>
<tr>
<th>Leveling Up</th>
<th>Imp Studies</th>
<th>EDM Studies</th>
<th>HLM Studies</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Bridge classes show sig gains in pre/post tests</td>
<td>EDM detectors reveal behaviors consistent with implicit understanding</td>
<td>&quot;It's how they play the game&quot;</td>
</tr>
<tr>
<td>Impulse</td>
<td>Same gains for Bridge, Games, and Control groups</td>
<td>Data mining models distinguish STEM errors (e.g. law of reflection and slope) from puzzle errors</td>
<td>We can see when they are struggling</td>
</tr>
<tr>
<td>Ravenous</td>
<td>In progress</td>
<td>n/a</td>
<td>Do kids go outside?</td>
</tr>
</tbody>
</table>
Computational Thinking Learning Progression

- Trial and Error
- Testing a Solution
- Implementing a Solution
- Identifying a Strategy
- Generalizing a Solution

- Problem Decomposition
- Abstraction
- Generalization
Alert

Sofia created a group of Zoombinis where all have the same trait for at least one attribute.

Close  Show Me
It Takes a Team

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

newknowledge.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?