Computer Games for Informal Science Education

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Science Learning Games (SLG) for Informal Science/Technical Education

Physical interaction quest game: *DinoQuest*
- Life-size dinosaurs models (e.g. T-Rex, Argentinosaurus, Velociraptors)
- Family-based problem-solving and collective learning in physical environment
- Game progress tracked via user-controlled IR transmitters activating embedded sensor net

Web-based SLG: *DinoQuest Online*
- Addresses CA science education standards for K-6 grades
- Interoperates with *DinoQuest*
- Designed for internationalization
- Developed at UCI GameLab
Transforming Science and Engineering via computer games and virtual worlds

Game Web environments can become platforms for experimentally interacting with emerging scientific models or processes (simulations)

Science learning games may create new engine for innovation!
- Global earth systems science game engine
- Nanotechnology device design games
- Fusion energy simulation games
- Supply chain/infrastructure transformation quest
Objective

How best to employ networked computer game technology in ways that integrate
– social learning opportunities
– scientific visualization methods
– external scientific datasets
– science work practices
– playful fun

to develop, deploy, and evolve single/multi-player games for informal science/technical education in different disciplines.
But first, some background on science learning games
Contemporary SLGs

-- *Droidworks* (mechanical system design)

-- *KineticCity* (life science)

-- *Genius Task Force Biology* (ecology simulation, in German)

-- *Industry Player* (commodity trading system)

-- *GTR* (motorsports racing simulation)
  – *NASCAR: The Game* (Nov. 2012)
LucasArts Droidworks
#1 The Slippery Slope

**Mission Briefing:**
Get your droid through the security exit door at the top of the cliff. In the area nearby, there are objects that can help your droid reach its goal. The speed and weight of your droid are important factors.

**Droid Info**

**Mission Goals**

- #1 The Slippery Slope
  - pass through security exit door

**Droid Requirements**

- treads and wheels

**Ranking:**

- Apprentice
- Designer
- Master
KineticCity MiniGame--Body System Identification
KineticCity Body System Identification Game Play-to-Learn techniques

– Given prompt (e.g., Circulatory/Respiratory system) select, drag, and place system components into correct locations

– System component identification (e.g., heart, arteriole-venal network, esophagus, lungs) and location
  * By iconic form/shape (no names)

– Placing all correct system components allows advancement to next system; any mistake resets (removes) placed components requiring iterative play.

– Failure-driven (trial+error iteration) and spatial-shape reasoning
  * Play-learning anomalies
    - Some components resize, others don’t
      * Nerve and arteriole-venal networks resize on placement (automatically), but bones don’t
    - Systems are partial--why some components, but not others?
    - Which system -- cardio-pulmonary system vs. “circulatory/respiratory” system?
GTR racing simulation

### Strategy, Gearing, and Brakes

<table>
<thead>
<tr>
<th>Tyres</th>
<th>Medium</th>
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<tbody>
<tr>
<td>Starting Fuel</td>
<td>17.2 gal (9 Laps)</td>
</tr>
<tr>
<td># of Stops</td>
<td>3</td>
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<tr>
<td>1st Stop</td>
<td>17.2 gal (9 Laps)</td>
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<tr>
<td>2nd Stop</td>
<td>17.2 gal (9 Laps)</td>
</tr>
<tr>
<td>3rd Stop</td>
<td>17.2 gal (9 Laps)</td>
</tr>
<tr>
<td>Weight Dist.</td>
<td>40.0:60.0</td>
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<tr>
<td>Steering Lock</td>
<td>20.0 Degrees</td>
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<tr>
<td>Rev Limit</td>
<td>6700</td>
</tr>
<tr>
<td>Engine Temp</td>
<td>-460 F.</td>
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</table>

### Gearing

<table>
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<tr>
<th>Gear Type</th>
<th>Ratio</th>
<th>(MPH)</th>
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<tbody>
<tr>
<td>1st Gear</td>
<td>16/40</td>
<td>(7.703)</td>
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<tr>
<td>2nd Gear</td>
<td>19/35</td>
<td>(5.680)</td>
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<tr>
<td>3rd Gear</td>
<td>23/33</td>
<td>(4.424)</td>
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<tr>
<td>4th Gear</td>
<td>26/30</td>
<td>(3.553)</td>
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<tr>
<td>5th Gear</td>
<td>28/28</td>
<td>(3.083)</td>
</tr>
<tr>
<td>6th Gear</td>
<td>29/26</td>
<td>(2.764)</td>
</tr>
<tr>
<td>Final (Bevel 1/1)</td>
<td>12/37</td>
<td></td>
</tr>
<tr>
<td>Reverse</td>
<td>16/40</td>
<td>(7.703)</td>
</tr>
</tbody>
</table>

### RPM

- Front Brake Disc Temp: -460 F.
- Rear Brake Disc Temp: -460 F.
- Engine Temp: -460 F.
DinoQuest at DSC
Fast Facts about *Discovery Science Center*
Located in Santa Ana, California

At the Center:
- 500,000+ annual visitors (2011)
- 100,000 annual field trip visitors from schools
- Provides in-service science teaching training to 1000+ K-12 teachers/yr.

In the Schools (via Outreach programs):
- 150,000 annual students in science outreach programs
Inspire Youth of Today in Science via science adventure quests

- Blending video game culture and physical exhibits
- Puts visitors into a science adventure video game
- $7Million expansion at DSC
- Dinosaur themed, but focused on (K-6) Life Science
Discovery Science Center Goals

Create a physical exhibit that blends:
- Natural history museum collection,
- Interactive, hands-on science exhibits,
- Video game culture,
- Science research practices via “collaboratories”

Create a Cyberinfrastructure for distance learning over the Internet.

Engage and explain CA/National Science Education Standards.

Create electronic performance tracking ability for better evaluation capabilities.

Workforce development

Create a mechanism that continues to drive visitors between a brick & mortar science center and the Internet/Web site multiple times.

Increase repeat usage of science center exhibits and increase visitation.

Create a replicatable and sustainable model.
Technology:
Embedded sensors and wireless (IR) transmitter Activation
Go to *Field Station* and *Select a Mission* by site or lab

8 Educational Missions:
- Aimed at California Science Education Standards for grades K-6
- Mission topics: Predator / Prey, Trace Fossils, Anatomy, Habitats, Identification
- Missions selected, tracked, and completed at networked multi-media kiosks
- Provides family-friendly science learning experiences
DinoQuest in-game research team and collaboratories: diverse science *role models* (ethnicity, age, gender)
Role play (see oneself as a scientist)

After selecting a mission, head out to the dig site!
Situated role play

Search dig site and identify objects in the mission.

Computer and sensor network automatically tracks your progress and success.
Video game play mechanics

“Upload” data collected to collaboratories via on-site networked kiosks

Earn Research Points for each item found.

Obtain fossils with encoded DNA as reward for completing each mission.

Ability to save data and come back another day.
DinoQuest Online

Online Science Learning Games

– Distance learning,
– Expands on science topics,
– Additional, in-depth science missions,
– Earn points and Dino DNA by completing missions.
– Level-up into multi-player dinosaur ecology simulation (Dinosphere)
DinoQuest Online (released in Summer 2007)

- Log in with password online or from DSC
- Go to each collaboratory
- http://www.dqonline.org
  register OR enter “demo” “demo”

- Same scientists as DinoQuest at DSC
- Expand upon science education standards in each lab
Multiple science learning games:

*Dinosaur Dig Pit* field site collab game

Different objectives for each game.
Multiple science learning games: Narrative content

Backbones and Ribs

Vertebrae provide structure for the animal and are divided into sections depending on where they are located along the back. Thoracic vertebrae are in the chest area and provide attachment points for the ribs. Ribs make up a bony case that protects many important internal organs, such as the heart and lungs. Bony projections on the vertebrae are attachment points for muscles. The Apatosaurus, being more massive, had larger processes on its vertebrae than the Allosaurus. Many of the larger dinosaurs, such as Apatosaurus and Allosaurus also had “belly ribs,” called gastralia, that were not attached to the backbone or the other ribs. The purpose of the “belly ribs” are not specifically known.

In 1987, amateur paleontologist Stan Sacrison discovered “Stan,” a T-rex embedded in the Hell Creek Formation in South Dakota. 199 fossilized bones were recovered, including the best preserved and most complete T-rex skull ever found. Stan’s bones showed evidence of healed injuries: broken ribs and vertebrae, damaged facial bones, and a large hole in the back of its skull.
DinoQuest Online Reconstruction Lab
DinoQuest Reconstruction Laboratory (in-game tutorial/help view)

1. Your goal is to rebuild this.

2. Move the fossils out to the anchors.

3. Rotate objects with this tool.

4. Keep track of your progress here.
Multiple science learning games:
*Zoology and Systems* collab games

- Build a working digestive system out of available organs and “connectors”
- Move Oxygen and CO2 through a cardio-pulmonary system
Gain points by matching prey/predator and food chain relations via *Tetris*-like game play.

Multiple science learning games: *Ecology/Habitat* collab game.
Multiple science learning games:

*Biomechanical* collab mini games

- Mass and balance
- Proportion and speed
- Matching anatomical structures to diet
Multiple science learning games:
Resource interaction collab game spaces

*MyLab* - shows missions completed both online and at the DSC

*DinoSphere* – allows building of your own Dinosaur with DNA collected from missions.

Go back online or go to DSC to obtain different DNA by completing more missions!
Evaluation Potential

– DinoQuest and DinoQuest Online allow for the following evaluations:

– **Player Centered**: scores and missions completed identify progress and feedback in context.
– **Exhibit Centered**: ability to test content comprehension by player quiz upon completing mission.

– **Independent Evaluation**: to ask which method is best and why: physical exhibit, online learning games, or both?
Games can employ advanced scientific models, simulations, visualizations

– Global climate change game
– Nanotechnology-based “incredible machines” design game
– Plasma fusion energy game
  – (what about “cold fusion” or low-energy nuclear reaction games?)
BBC Climate Challenge game
Incredible (nanotech) machines
CERN Quantum Game

TOOLS

Accelerate the Particle

![Accelerate the Particle Diagram]

PLAY GAME

(may take a few moments to load)

game created by CERN

THE HEART OF THE MATTER

Research at CERN that garnered a Nobel Prize in 1984: Carlo Rubbia and Simon Van der Meer for the discovery of the "W and Z particles, communicators of the weak interaction."
Thank You!

This presentation can be found on the Web at the following location:

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- EON Reality
- Naval Postgraduate School, and others

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