Recent Advances in Science Learning Games

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Overview

• Game Culture and Technology
• Games in Science and Science Learning Games (SLG)
• Early SLGs
• Recent Game-like Environments
• Next-generation SLGs
• Future SLGs and Emerging Opportunities
Game Culture and Technology

• Games as immersive, experiential literary form -- *game play as emergent narrative*
• Gaming as rapidly growing global industry
• “Modding” and making games as practice-based *learning* and *career development*
• Games as *new media* and cultural form
• Game culture as *social movement*
Games as a *new medium*
L.A. Renews Its Libraries as Modern Civic Centers

More than just housing books, the new and refurbished branches bring people together.

By Noam N. Levey, Times Staff Writer

On a dusty, hot summer afternoon in South Los Angeles, 13-year-old Joseph Robinson and 9-year-old Franklin Flores are in a favorite place — huddled in front of a computer terminal playing RuneScape together.

For the boys, one black and one Latino, the new Ascot branch library at Florence Avenue and Main Street is their daily meeting place, a refuge from a gritty neighborhood where interracial tensions recently sparked violence at a local high school.

In the Pico-Union neighborhood, older residents go to their new branch for a library-sponsored Coffee and Conversation, which brings together strangers to talk about Iraq, immigration or whatever topic may be in the news.
Research objective

• Employ networked computer game technology in ways that integrate
  – social learning opportunities
  – scientific visualization methods
  – external scientific datasets
  – science work practices
  – open source software community dynamics
  – playful fun

to develop, deploy, and evolve single/multi-player games for informal science education in different science disciplines.
Early SLGs

• **Computer games for Operations Research**
  – Game theory (1940-1950s)

• **Games for Artificial Intelligence**
  – Samuel’s Chess and Checkers games (1950-1960s)

• **Non-game science learning or scientific reasoning environments**
  – Sophie (1970s)
  – Plato

• **“Science inspired” games**
  – Science as source for fantasy or make-believe (science fiction)
  – May be fun to play, but unclear if any science learning facilitated
    • Best outcome--inspiration to discover scientific knowledge
    • Worst outcome--fantasy treated as factual scientific knowledge
Zoo Tycoon -- Dinosaurs
Nanosaurus
(Dinosaurs with Jetpacks!)
# 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**

- **The Slippery Slope**
  - pass through security exit door
  - Droid Requirements
    - treads and wheels

**Ranking:**
- Apprentice
- Designer
- Master
Game-like educational environments with science/engineering content

- **River City** (Chris Dede et al., Harvard)
  - An interactive 3D computer simulation for middle science students in learning disease transmission and scientific method, while addressing national science education standards.

- **Quest Atlantis** (Sasha Barab, IndianaU)
  - A learning and teaching project that uses a 3D multi-user environment to immerse children, ages 9–12, in socially responsible educational tasks, consistent with local academic standards.

- **Whyville.net**
  - Corporate sponsored Web site with multiple games targeting 8–15 year old girls and boys (more than 2.2M users, more than 50% female)

- **SciCentr.org** at Cornell Theory Center
  - Online science museum that uses online multi-user virtual worlds for informal science and technology outreach.
Introducing River City
Welcome to River City!

Welcome to the River City Project. With funding from the National Science Foundation, we have developed an interactive computer simulation for middle science students in learning disease transmission and scientific method. River City has the look and feel of a videogame but contains content developed from National Science Education Standards, National Educational Technology Standards, and 21st Century Skills.
Quest Atlantis
In Whyville, citizens earn a salary of "clams", our virtual currency, by participating in a wide range of educational games and activities. They include:

- **The Skater** is a simulation-based game on angular momentum. It challenges you to answer the question, "How do skaters get spinning so fast?"

- **The Spin Game** extends the Skater activity by addressing the issue of rotational axes and symmetries.

- **The House of Illusion** is an exhibit on visual illusions.

- **The Sun Spot Puzzle** introduces you to the concept that sun rise and sun set times vary according to your latitude.

- **The Alien Rescue Game** takes you around the world in search of lost aliens while honing your understanding of how the perceived path of the sun changes throughout the year.

- **The Solstice Safari** is an extended collaborative activity where citizens team up to collect data, plot graphs, and predict the solstices.
Recent SLGs and Science-based Games

- *KineticCity.com* - NSF-AAAS game for learning life science in line with National Science Education standards
- *Task Force Biology* (ecological restoration and economic development via role-playing game)
- *Industry Player* - Commodity-based, multi-industry market simulator
- *GTR* (car racing simulation) - Vehicle dynamics engineering (race car tuning)
- *NASCAR 2007* (racing simulation) - Systems engineering (performance-based system design via telemetry capture and analysis)
KineticCity MiniGame--Body System Identification

Circulatory/Respiratory System
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>
</tr>
<tr>
<td>1st stop</td>
<td>17.2 gal (9 Laps)</td>
</tr>
<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>
</tr>
<tr>
<td>Steering lock</td>
<td>20.0 Degrees</td>
</tr>
<tr>
<td>Rev limit</td>
<td>6700</td>
</tr>
<tr>
<td>Radiator opening</td>
<td>-460 F.</td>
</tr>
<tr>
<td>Engine temp</td>
<td>-460 F.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Gear</th>
<th>Ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>1st gear</td>
<td>16/40 (7.703)</td>
</tr>
<tr>
<td>2nd gear</td>
<td>19/35 (5.680)</td>
</tr>
<tr>
<td>3rd gear</td>
<td>23/33 (4.424)</td>
</tr>
<tr>
<td>4th gear</td>
<td>26/30 (3.553)</td>
</tr>
<tr>
<td>5th gear</td>
<td>28/23 (3.083)</td>
</tr>
<tr>
<td>6th gear</td>
<td>29/26 (2.764)</td>
</tr>
<tr>
<td>Final</td>
<td>12/37 (Bevel 1/1)</td>
</tr>
<tr>
<td>Reverse</td>
<td>16/40 (7.703)</td>
</tr>
<tr>
<td>Diff lock</td>
<td>20%</td>
</tr>
</tbody>
</table>

- Brake bias: 65.0:35.0
- Brake duct: 4

- Front brake disc temp: -460 F.
- Rear brake disc temp: -460 F.
- Brake wear remaining: 0.00 in
- Brake wear remaining: 0.00 in

**RPM Chart**

**MPH Chart**
NASCAR Racing 2007

TELEMETRY
Indianapolis

FOCUS AREA

[Advanced] - Damper Velocities

DAMPER VELOCITY FRONT LH
DAMPER VELOCITY FRONT RH
DAMPER VELOCITY REAR LH
DAMPER VELOCITY REAR RH

VELOCITY
Next-Generation SLG Environments

• *Eco-Raft* -- embodied ecological restoration game (Bill Tomlinson, UCI)

• *Fantastic Voyage through a Pig’s Heart* -- Internal organ fly-through navigation quest, based on volumetric (CAT-scanned) data (Joerg Meyer, UCI)

• *DinoQuest* -- physical multi-mission game environment with embedded multi-media activated via sensor network (Discovery Science Center, Santa Ana, CA)

• *DinoQuest Online* -- Web-based multi-mission, multi-level, multi-genre games integrated with DinoQuest. (Robert Nideffer and Walt Scacchi, UCI, for DSC).
Merging Ecology. . .

Eco-Raft -- ecological restoration via physically embodied, interactive experience

. . .with Technology
DinoQuest

• Physically embodied interactive museum installation

• Gesture-based, interactive exploration using keyed transmitters to designate objects with embedded sensors

• Narrative-based multiple scientific quest environment
  – Life sciences via paleontology
  – Addresses CA science education K-6 standards and beyond
1. Students enter into an area where they will select their Infrared Research Transmitter for the Dino Quest.

2. In the registration and training area they will login to the Quest computer system to create a unique, grade specific ID for themselves and learn more about the exhibit and how to use their research transmitter.

3. Students will then enter the Co-Laboratory where they will select one of six Research Missions and continue their transmitter training.

4. Quest Stations are located throughout the exhibit and assist students in learning and successfully navigating through their research mission.

5. Research Missions: These are educational challenges that align with the Life Sciences curriculum within the California Science Content Standards at a grade specific level. An example would be a 1st grade student learning about comparative anatomy.

6. Adventures: Are student rewards after three successful research missions have been completed. They are a more complex challenge that requires the student to apply the science knowledge learned and engage them in thinking and problem solving—science literacy.
DinoQuest -- live action video (actors) with synthetic laboratory background
DinoQuest Research Team and Collaboratories
Diverse Scientific Role Models (ethnicity, age, gender)
Go to Field Station and Select a Mission

8 Educational Missions:
• Each aimed at California Science Standards
• Mission topics: Predator / Prey, Trace Fossils, Anatomy, Habitats, Identification
• Each mission focuses on a different collaboratory and field of science
• Research Scientists request dig site to be searched & items electronically tagged
Video Game Mechanics

Uplink data collected to *collaboratories*.

- 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.
• Picking up information throughout the physical site.
• Infra-red emitter and embedded sensor network for tracking visitor’s progress on missions.
Technology:
Embedded Sensors and Transmitter Activation
Role play (see oneself as a scientist)

After selecting a mission, head out to the dig site!
Role play (see oneself as a scientist)

Search dig site and identify objects in the mission.

Computer and sensor network automatically tracks your success.
DinoQuest Online

• Web browser-based set of casual games that extend and deepen the DinoQuest experience base through game-based scientific workflows
  – Observational and collection building methods
  – Association development
  – Relationship articulations
    • *Example*: prey-predator or food-consumer with temporal decay functions
DSC DinoQuest Online
DinoQuest Online (released in late March)

- Four SLG collaboratories
- MyLab personal DQO-based collection site (associates FQ and DQO results like “Dino DNA" samples)
- Dinosphere -- Assemble virtual dinosaur via DNA-based body system components

- Same scientists as DinoQuest at DSC
- Each collab game tied to CA science education standards, but experienced via discovery/exploration-oriented game genres
Welcome to Argentina, mi amigo! I am Professor Sanchez and you are just in time to join me on a fossil dig. Don’t worry, I have an extra set of the excavation tools you will need.
Uncovering Tailbones fossil at DigPit
DinoQuest Online Reconstruction Co-Lab
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.
Addressing CA science education standards

- Communicates about investigations
- Understands that learning can come from careful observations and simple experiments
- Recognizes how factors such as gravity can affect common objects
- Describes an observed change in terms of starting conditions, ending conditions, using words, simple diagrams, or graphs
- Identifies what does and does not change when matter experiences an external influence such as push, pull, tip.
Future SLGs

• Games employing advanced scientific models, simulations, and visualizations
  – Global Climate Systems Science Game Engine
    • *SimEarth*-like game with centuries of global weather data sets for scenario design, enactment, and evolution
  – Nanotechnology-based “incredible machines”
  – Plasma fusion exploratory simulation quest
Incredible (nanotech) machines
Plasma fusion simulation exploration game
Accelerate the Particle

Play Game

(may take a few moments to load)

game created by CERN
Learning Scientific Domains through Game Development

• Focused on the development and articulation of concepts, techniques, and mechanisms from a scientific domain using game-play mechanisms
  – Interaction of the W and Z particles by C. Rubbia and S. van der Meer at the Exploratorium.org
Summary results

• Juxtapose physically embodied and online (symbolic reasoning) game-based learning environments

• Enables multi-mode learning situations

• Participation in scientific work roles, work practices, and (suggestive) work settings

• Extensible game content and meta-game environment (e.g., Dino science wiki, integrated information feeds (Web-based science mash-ups)).
Emerging opportunities

• Regional science centers as legitimate, family-friendly venue for informal science education
  – Learning and evaluation challenges when engaging >100K students/year on site, and potentially >1M students/year over the Web

• Enabling cross-cultural language learning via extensible online game environment
Further information

• UCI GameLab: www.ucgamelab.net
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