The Role of Computer Games in Informal STEM Education and Learning

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Science Learning Games (SLG) for Informal STEM Education at Regional Science Centers

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

- Web-based SLG: *DinoQuest Online*
  - Addresses CA science education standards for K-6 grades
  - Interoperates with *DinoQuest*
  - Designed for internationalization
  - Developed by UCI GameLab

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
  - open source software community dynamics
  - playful fun

  to develop, deploy, and evolve single/multi-player games for informal K-12 STEM education in different disciplines.

But first, some background on science learning games

Contemporary SLGs

-- *Droidworks* (electro-mechanical system design)

-- *KineticCity* (life science)

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

-- *Industry Player* (commodity trading system)

-- *GTR* (motorsports racing simulation)

-- *NASCAR 2007* (motorsports racing simulation)

LucasArts Droidworks


Reward:
Cybot Galactica AT-9 Tank Locomotion System
#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
Mos Eisley
Jundland Wastes
Tosche Station
1
2
3
4
5
6
7
8


PLAY SCIENCE GAMES NOW!
KINETIC CITY
MISSION TO VEARTH
WHAT IS KINETIC CITY ?
THE MOST AMAZING SCIENCE SITE ON THE INTERNET !
LOGIN OR SIGN UP NOW!
NSF
Kinetic City: Mission To Vearth is produced by the American Association for the Advancement of Science, with major funding from the National Science Foundation. Copyright 2002 AAAS
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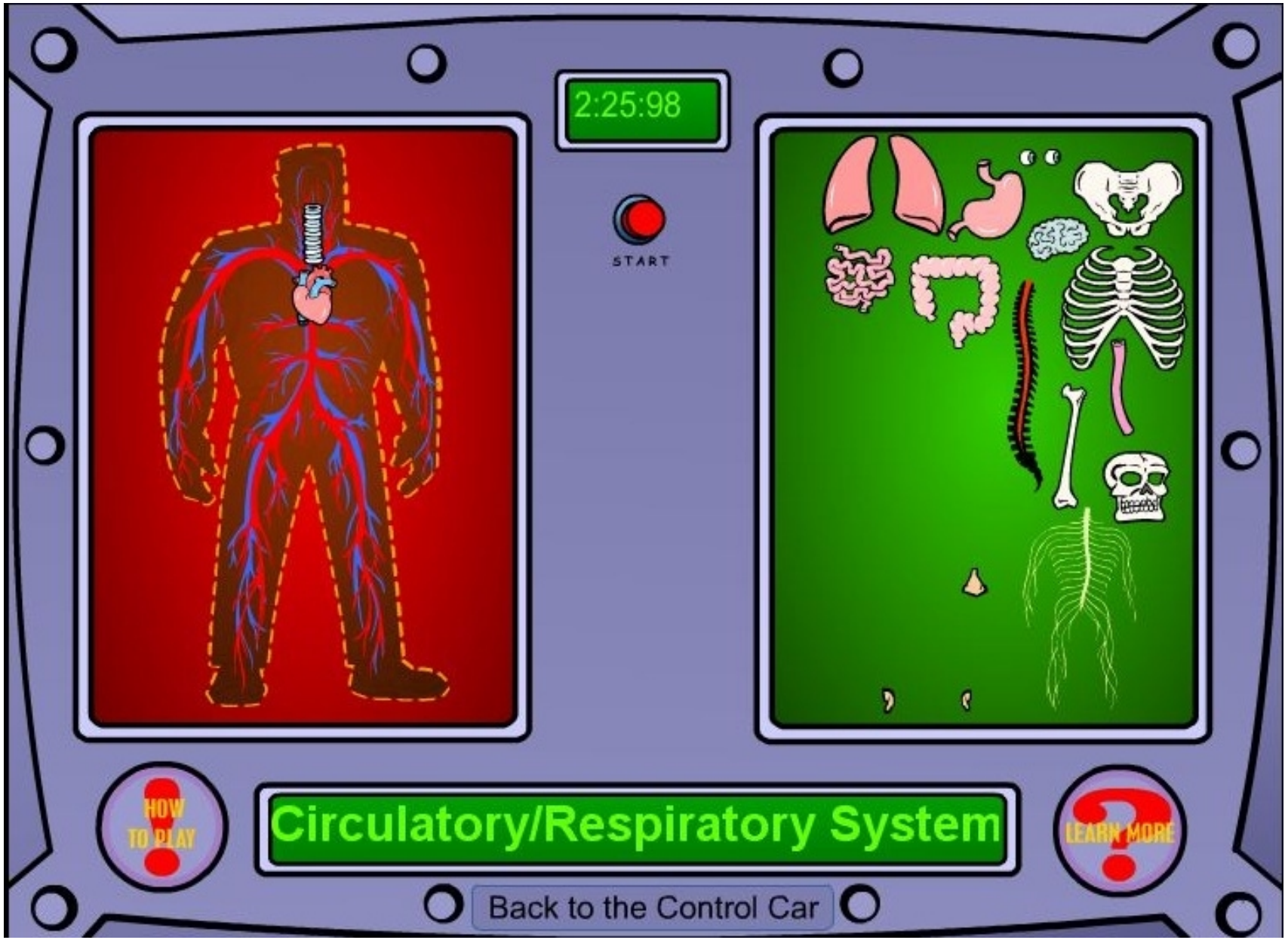
FOR EDUCATORS

KineticCity MiniGame--Body System Identification



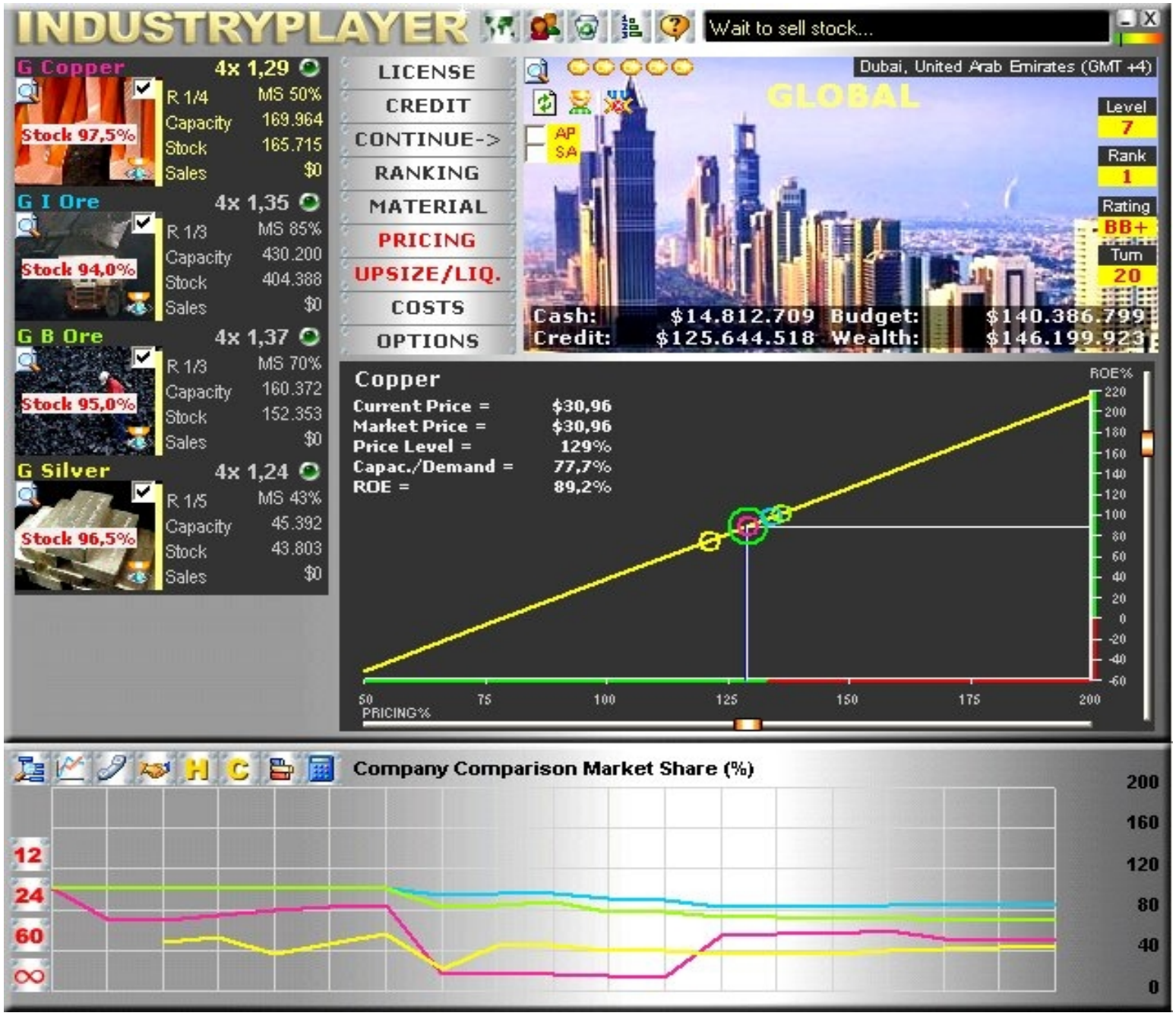
KineticCity Body System *Identification Game* Play-to-Learn techniques

- 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)

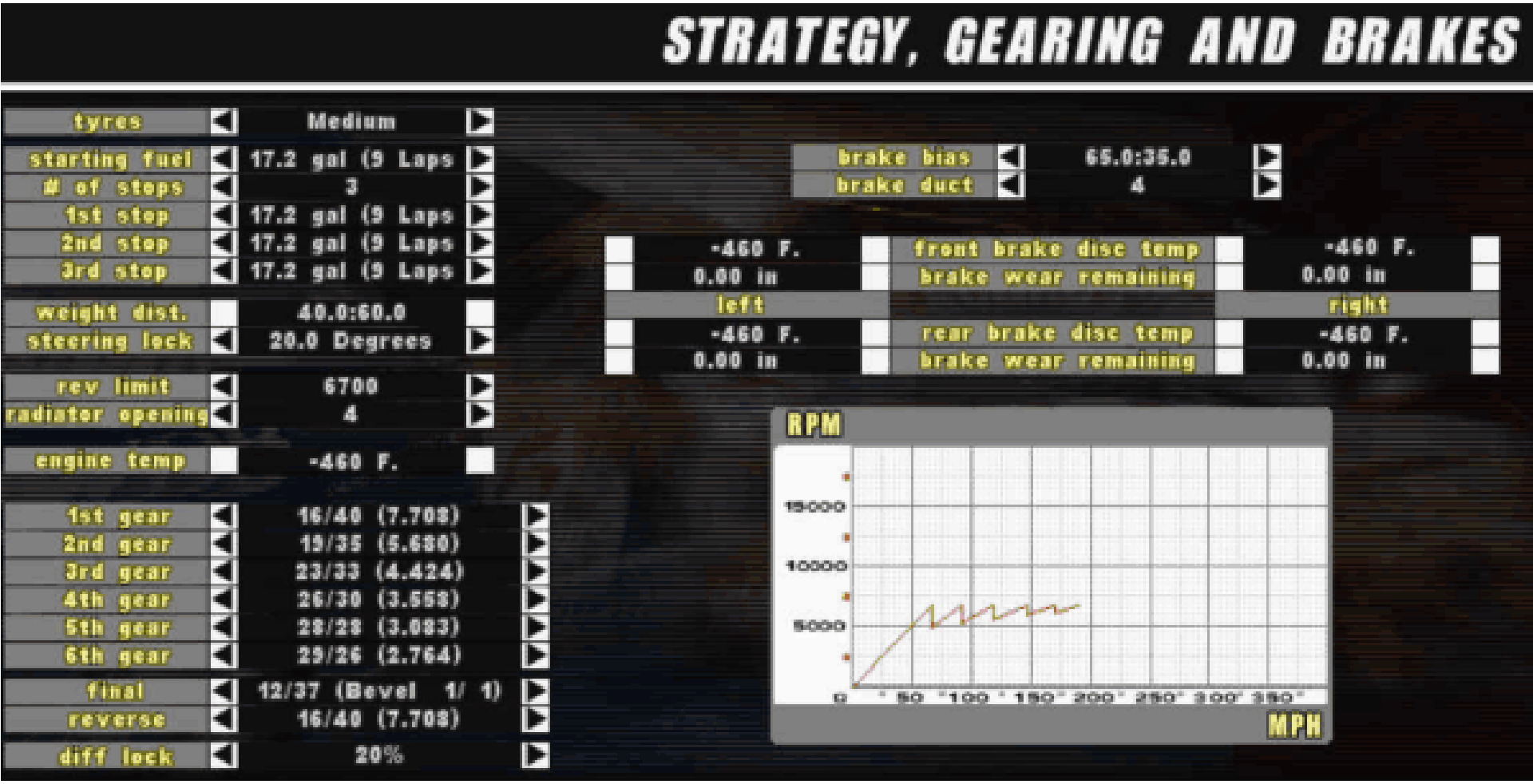
- Placing all correct system components allows advancement to next system; any mistake resets (removes) placed components requiring iterative play.
  - Failure-driven (trial+error iteration) and spatial-shape reasoning
  - Play-learning anomalies
    - Some components resize, others don't
      - Nerve 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?

GENIUS

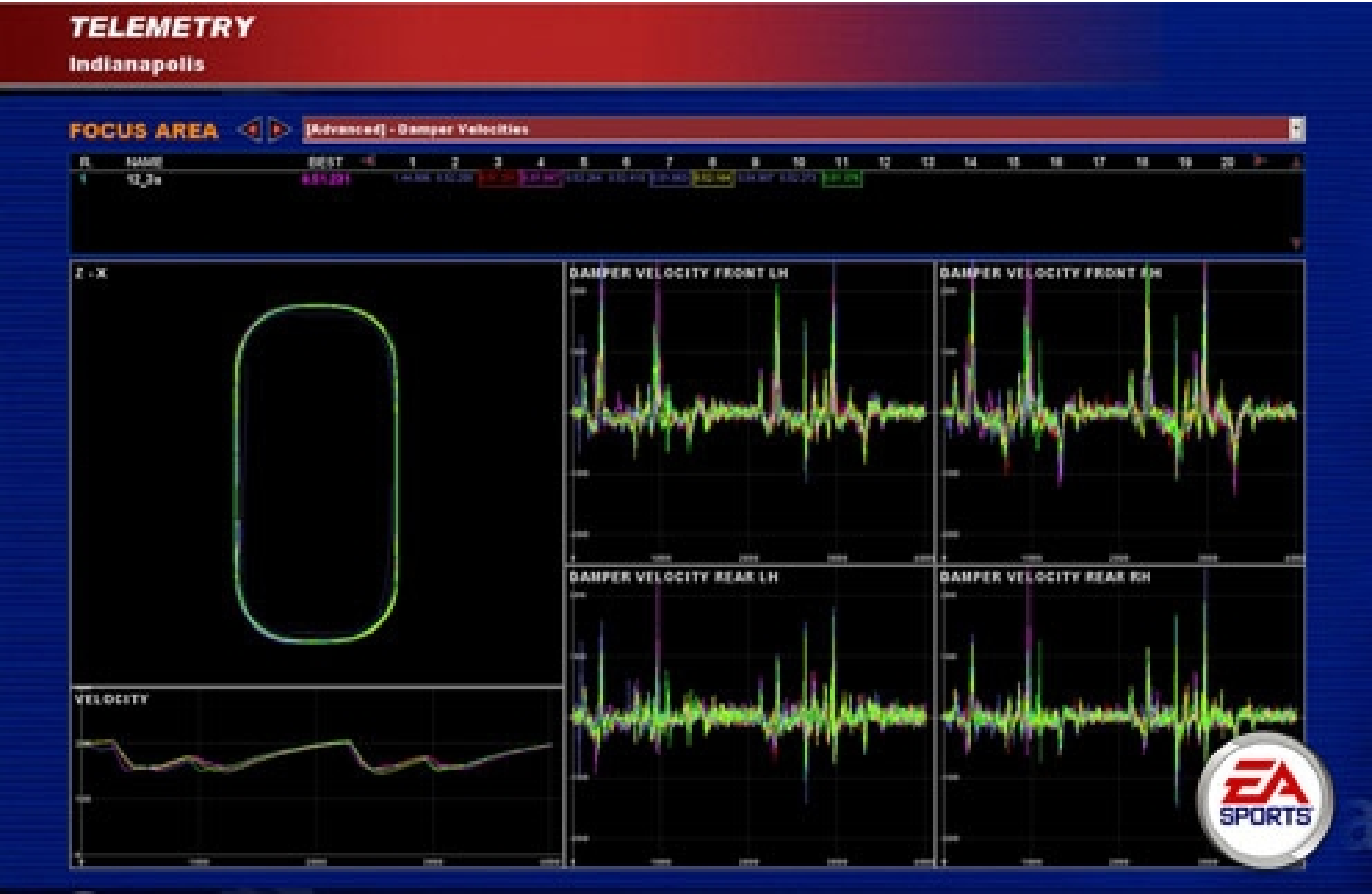
TASK FORCE BIOLOGIE


INDUSTRYPLAYER
Wait to sell stock...
G Copper
4x 1,29
Stock 97,5%
R 1/4
MS 50%
Capacity 169.964
Stock 165.715
Sales $0
G I Ore
4x 1,35
Stock 94,0%
R 1/3
MS 85%
Capacity 430.200
Stock 404.388
Sales $0
G B Ore
4x 1,37
Stock 95,0%
R 1/3
MS 70%
Capacity 160.372
Stock 152.353
Sales $0
G Silver
4x 1,24
Stock 96,5%
R 1/5
MS 43%
Capacity 45.392
Stock 43.803
Sales $0
LICENSE
CREDIT
CONTINUE->
RANKING
MATERIAL
PRICING
UPSIZE/LIQ.
COSTS
OPTIONS
Dubai, United Arab Emirates (GMT +4)
GLOBAL
AP
SA
Level 7
Rank 1
Rating BB+
Turn 20
Cash: $14.812.709 Budget: $140.386.799
Credit: $125.644.518 Wealth: $146.199.923
Copper
Current Price = $30,96
Market Price = $30,96
Price Level = 129%
Capac./Demand = 77,7%
ROE = 89,2%
ROE%
220
200
180
160
140
120
100
80
60
40
20
0
-20
-40
-60
50
75
100
125
150
175
200
PRICING%
Company Comparison Market Share (%)
12
24
60
∞
200
160
120
80
40
0

GTR racing simulation



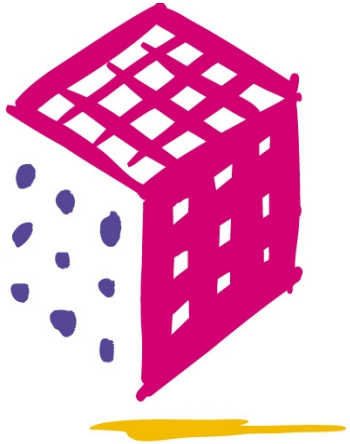
NASCAR Racing 2007



Typical SLG development costs – 1995-2005

- $500K--$5M
- 1-2+ year development schedule
- No major differences in time or cost to develop whether done by commercial game studio or non-commercial (academic) R&D team

DinoQuest at DSC



DISCOVERY
SCIENCE CENTER

Fast Facts about Discovery Science Center

- Located in Santa Ana, California
- 80,000 Sq. Ft.
- Budget: $6,000,000 Earned Income: 82% Contributed Income: 18%

<u>At the Center:</u>

- 425,000 annual visitors (2007)
- 88,000 annual field trip visitors from schools
- Provide in-service science teaching training to 1,100 K-12 teachers/yr.

<u>In the Schools:</u>

- 150,000 annual students in science outreach programs

Inspire Youth of Today in Fields of Science

Science Adventure Quests

- Blending Video Game Culture and Physical Exhibits
- Putting Visitors into a Science Adventure Video Game
- $7 Million Expansion at DSC
- Dinosaur Themed, but focused on Life Science

Discovery Science Center Goals

Create a physical exhibit that blends:

- Natural History Museum Collection,
- Science Center Hands-on Exhibits,
- Video Game Culture,
- Science research practices via “collaboratories”

Create a Cyberinfrastructure for distance learning over the Internet.

Engage and explain CA Science Education Standards.

Create electronic performance tracking ability for better evaluation capabilities.

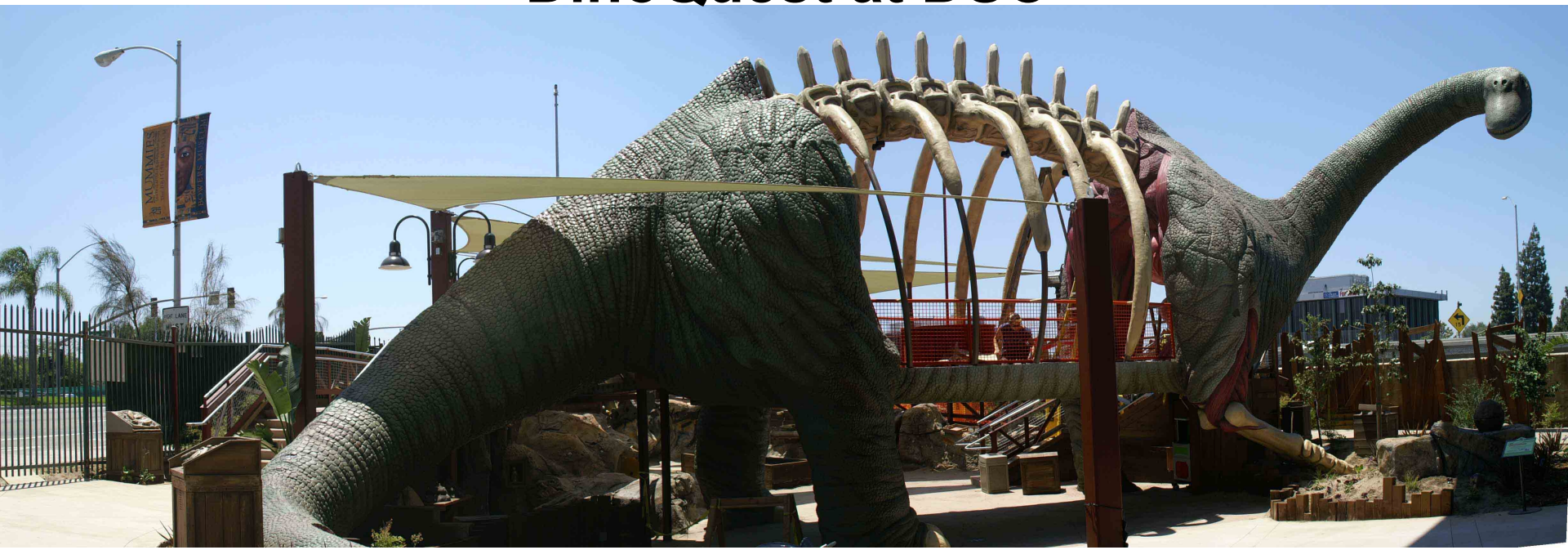
Workforce Development

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.

DinoQuest at DSC



DINO QUEST
DISCOVERY SCIENCE CENTER

DINO QUEST
DISCOVERY SCIENCE CENTER
ONLINE

The IR Transmitter!

- **Picking up information throughout the DQ site.**
- **Tracking visitor's success on missions.**

IR transmitter, sensor network technology, and interactive media from Creative Kingdoms, Inc.

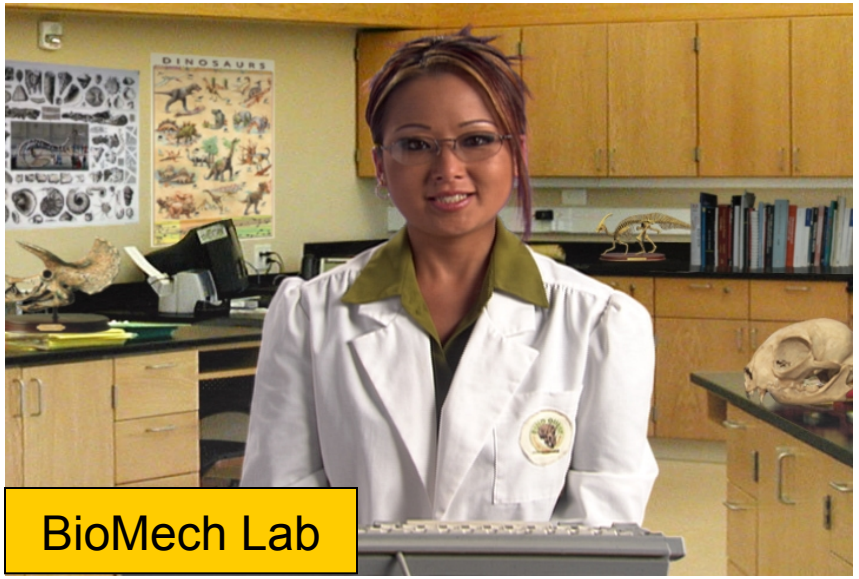
Technology:
Embedded Sensors and Transmitter Activation

Go to Field Station and Select a Mission

8 Educational Missions:

- Aimed at California Science Education Standards for grades K-6
- Mission topics: Predator / Prey, Trace Fossils, Anatomy, Habitats, Identification
- Each mission focuses on a different collaboratory and field of science
- Missions selected, tracked, and completed at networked multi-media kiosks

Field Site



BioMech Lab

Zoology Lab

Habitat Lab

DinoQuest 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!

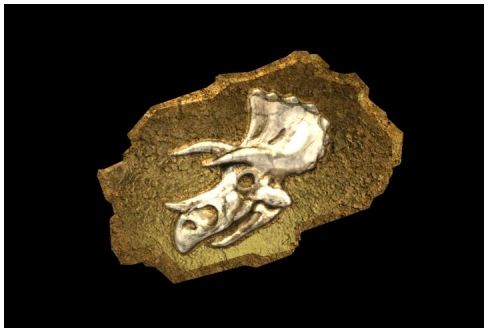
Situated role play

Search dig site and identify objects in the mission.

Computer and sensor network automatically tracks your success.

Video Game 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

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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)

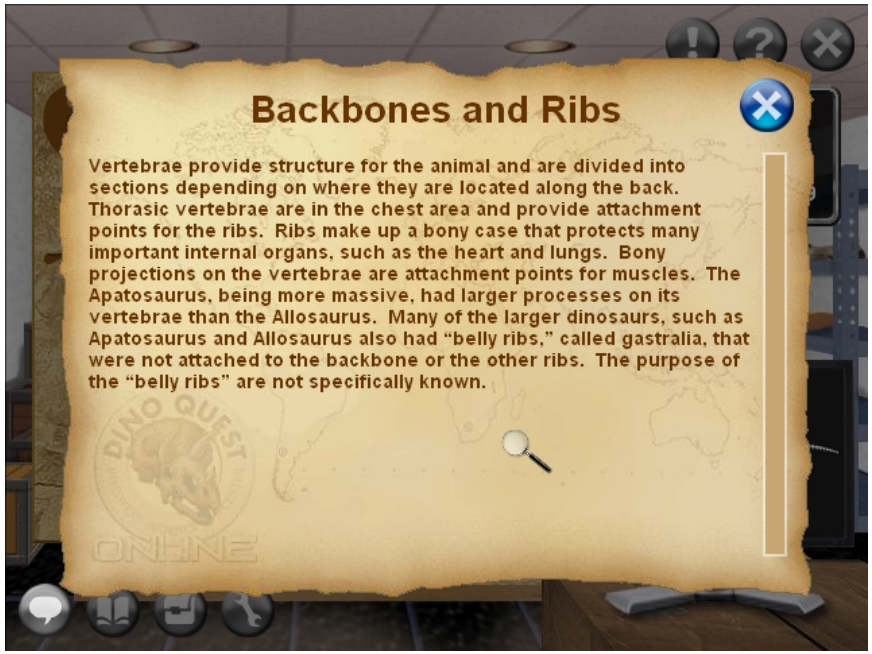
- Log in with password online or from DSC
- Go to each collaboratory
- http://www.dqonline.org
  - register OR enter “demo” “demo”

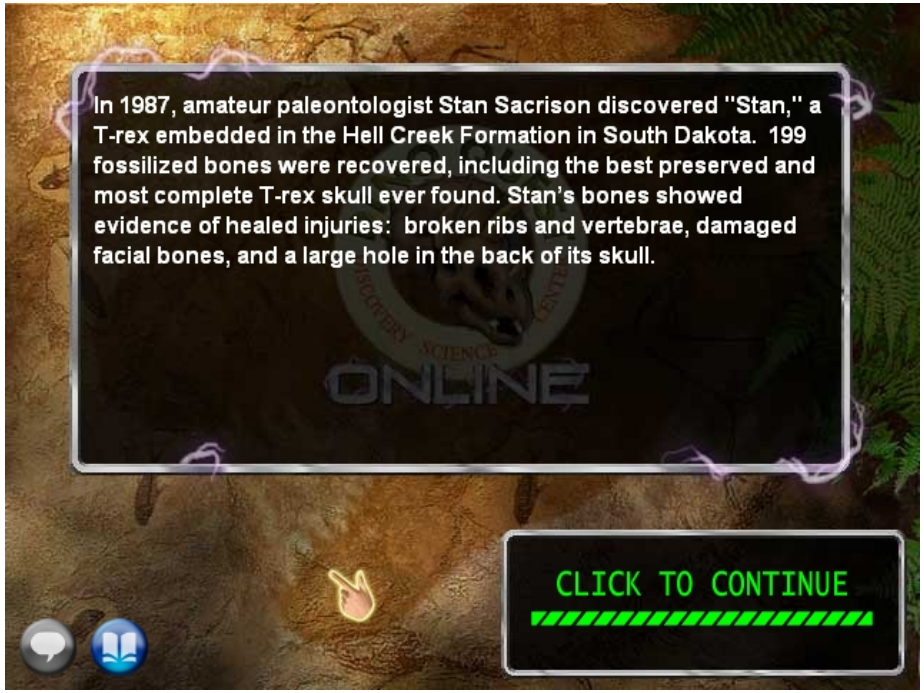
- Same scientists as **DinoQuest** at DSC
- Expand upon science education standards in each lab

Multiple Science Learning Games:
Dinosaur Dig Pit Field Site Collab Game

- Different objectives for each game.

Multiple Science Learning Games: Narrative Content

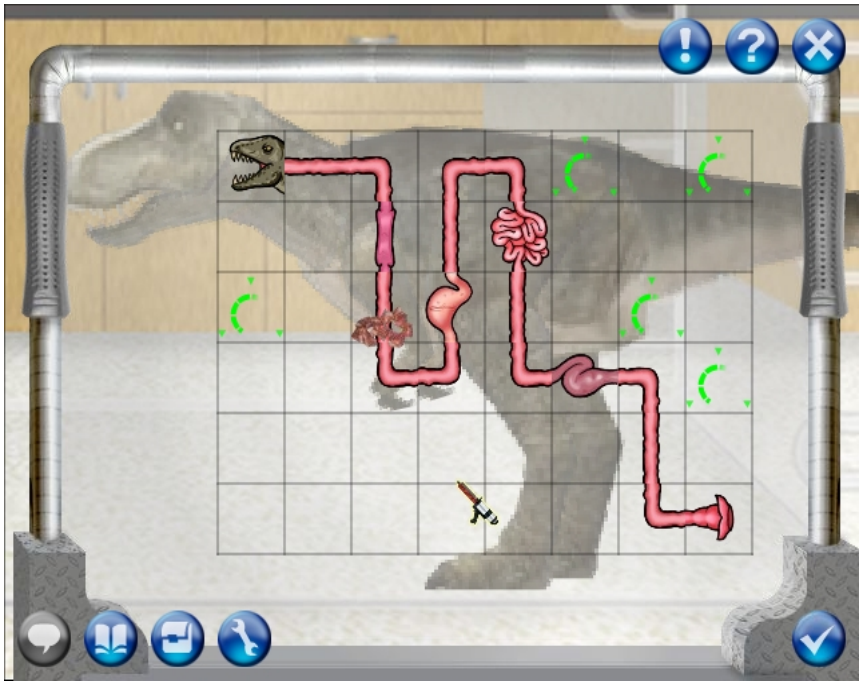




DinoQuest Online *Reconstruction* Lab

DinoQuest Reconstruction Laboratory (embedded tutorial view)

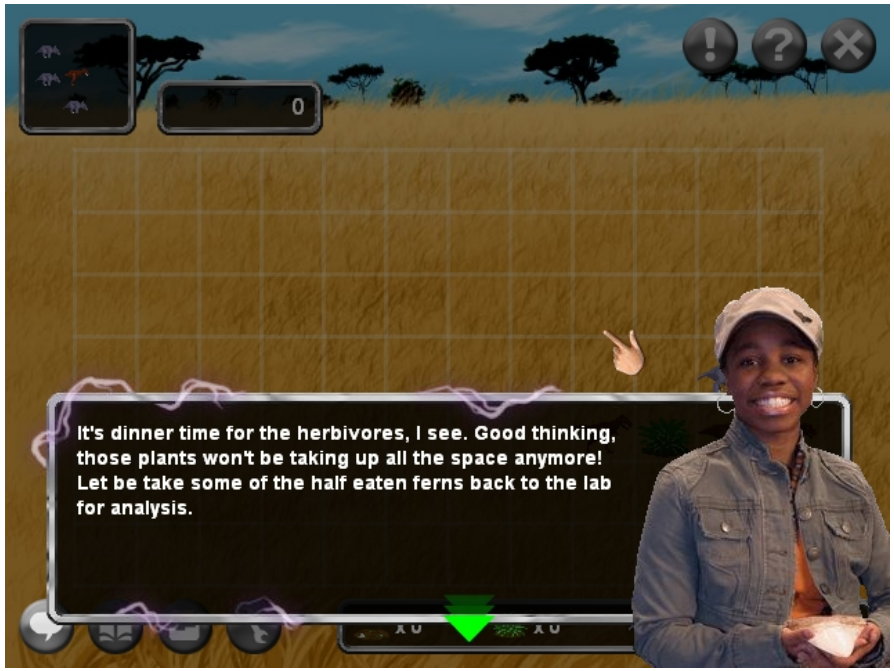
Multiple Science Learning Games: *Zoology and Systems* Collab Games



- Build a working digestive system out of available organs and “connnectors”

- Move Oxygen and CO2 through a cardio-pulmonary system

Multiple Science Learning Games: *Ecology/Habitat* Collab Game



- Gain points by matching prey/predator and food chain relations via *Tretis*-like game play

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:

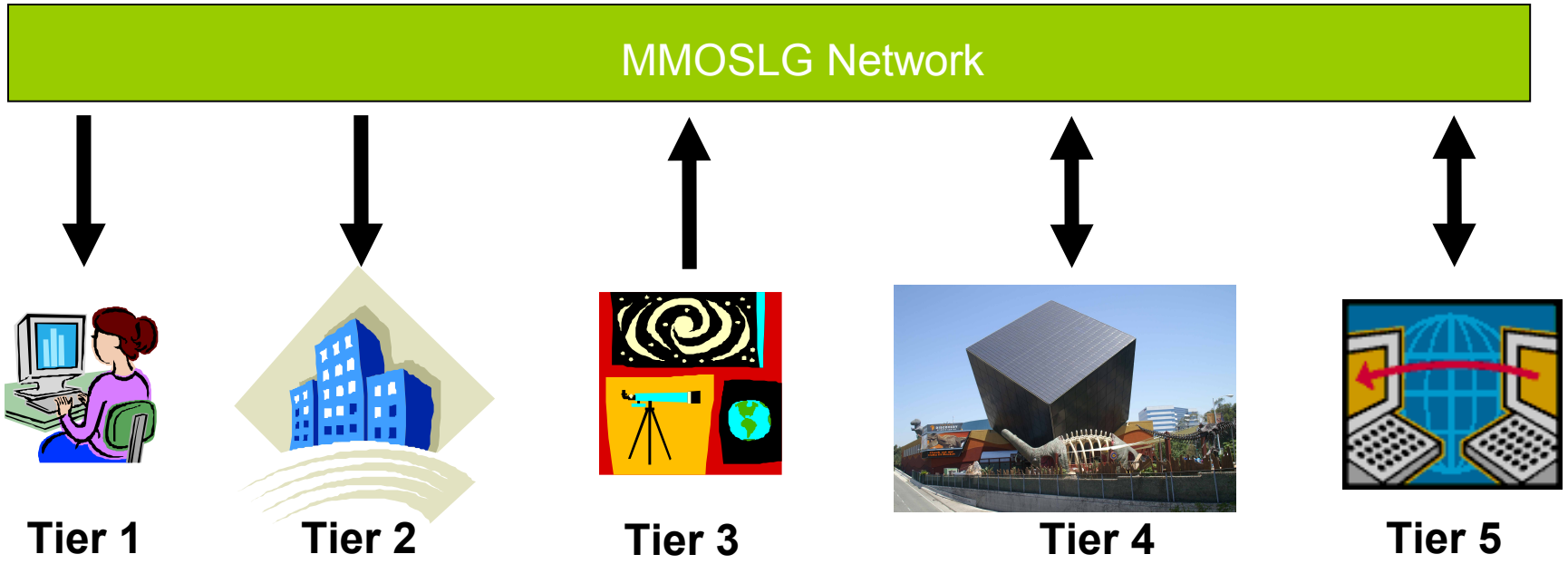
Player Centered: scores and missions completed identify progress and provide feedback in context.

Exhibit Centered: ability to test content comprehension by player quiz upon completing mission.

Challenge the Professor

Independent Evaluation: to ask which method is best and why: physical exhibit, online learning games, or both?

DSC+UCI working to develop network of SLG-based science centers



Tier 1: Individual player connection: your Internet connection at home.

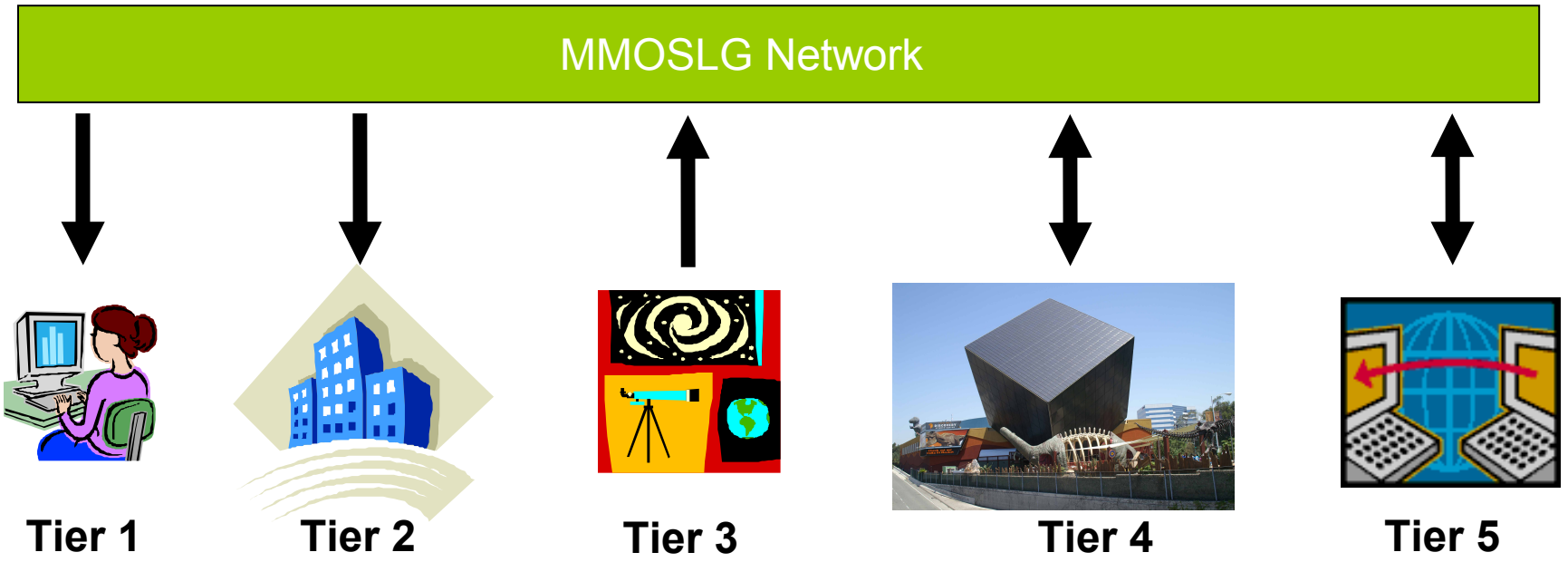
Tier 2: Local institutional connection: library, science center, school.

Tier 3: Regional science center provides local exhibit content connected online.

Tier 4: “Gateway” science centers provide open interfaces and content.

Tier 5: Science Center Network for **Massively Multiplayer Online Science Learning Games (MMOSLGs).**

Cyberinfrastructure for Science Centers



Cyberinfrastructure allows for:

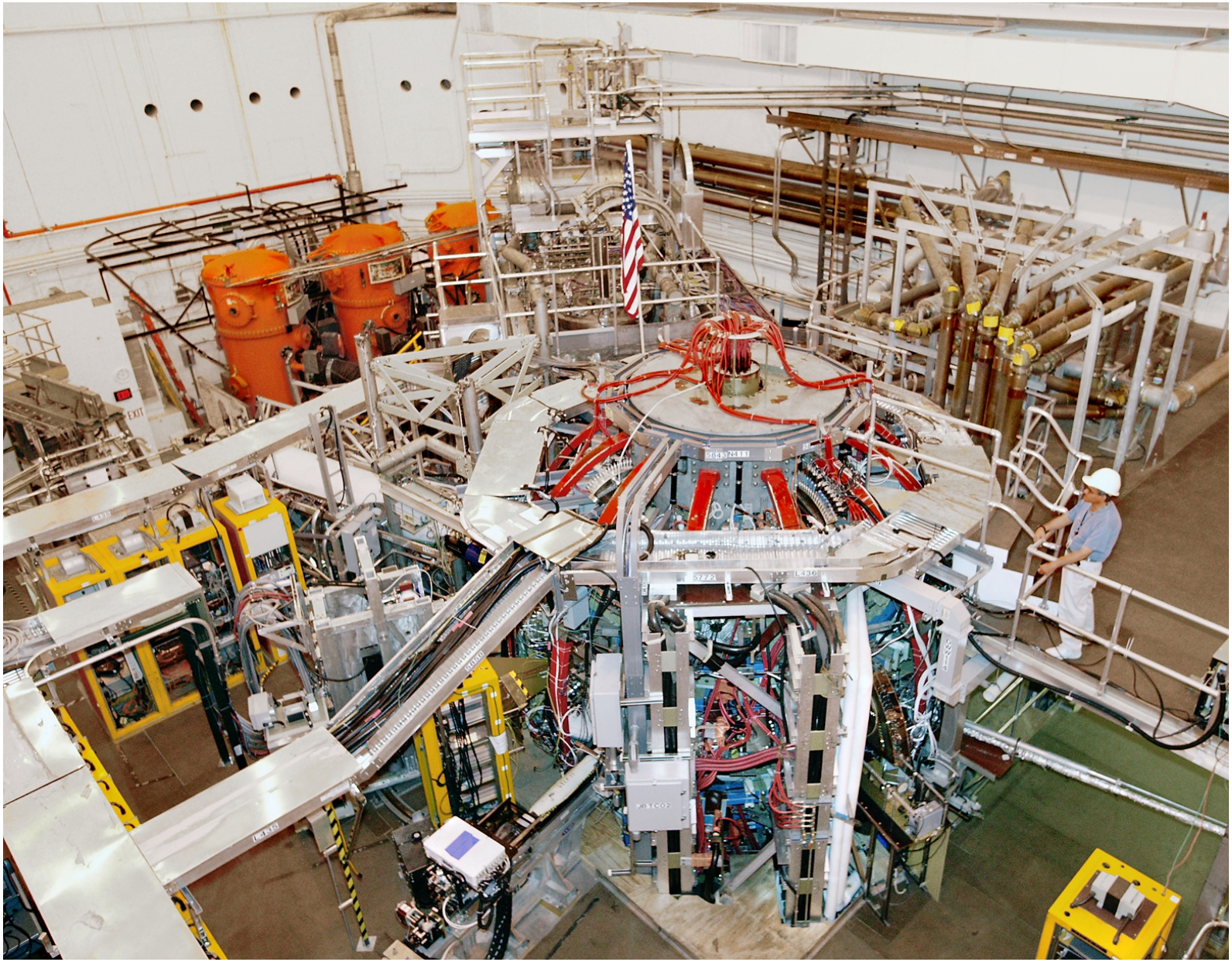
- *Networked Science/Technical Education Centers* across the U.S. (and beyond).
- Can be applied in multiple scientific, technological, or engineering domains
- Can be further developed and expanded w/open source software components, infrastructure, and open content.
- Ties into existing networks of STEM online learning materials.

Transforming STEM Learning via *The Game/Virtual Worlds Web*

- Future STEM games can employ advanced scientific models, simulations, visualizations
  - Global Climate Systems Science game engine
  - Nanotechnology-based “incredible machines”
  - Environmental ecology preservation/restoration
  - Supply chain/infrastructure transformation quest
- Game Web environments can become platforms for experimentally interacting with emerging scientific models, business processes, and domains of expertise
- STEM Learning Games represent a new engine for innovation!

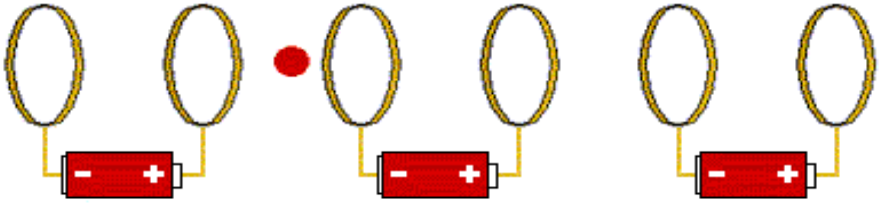
Incredible (nanotech) machines

Plasma fusion simulation exploration game



TOOLS

Accelerate the Particle



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."

UCI Game Lab Partners and Sponsors

- California Institute for Telecommunications and Information Technology: *Calit2 at* UCI-UCSD
- UCI Institute for Software Research
- UCI Arts, Computation, and Engineering (ACE) Program
- UC Humanities Research Institute
- Discovery Science Center, Santa Ana, CA
- Daegu Global R&D Collaboration Center, Daegu, South Korea
- National Science Foundation
- Intel
- Sun Microsystems
- EON Reality
- and others

For further information, see http://cgvw.ics.uci.edu