

Data Visualizations for Immersive, Authentic Simulations

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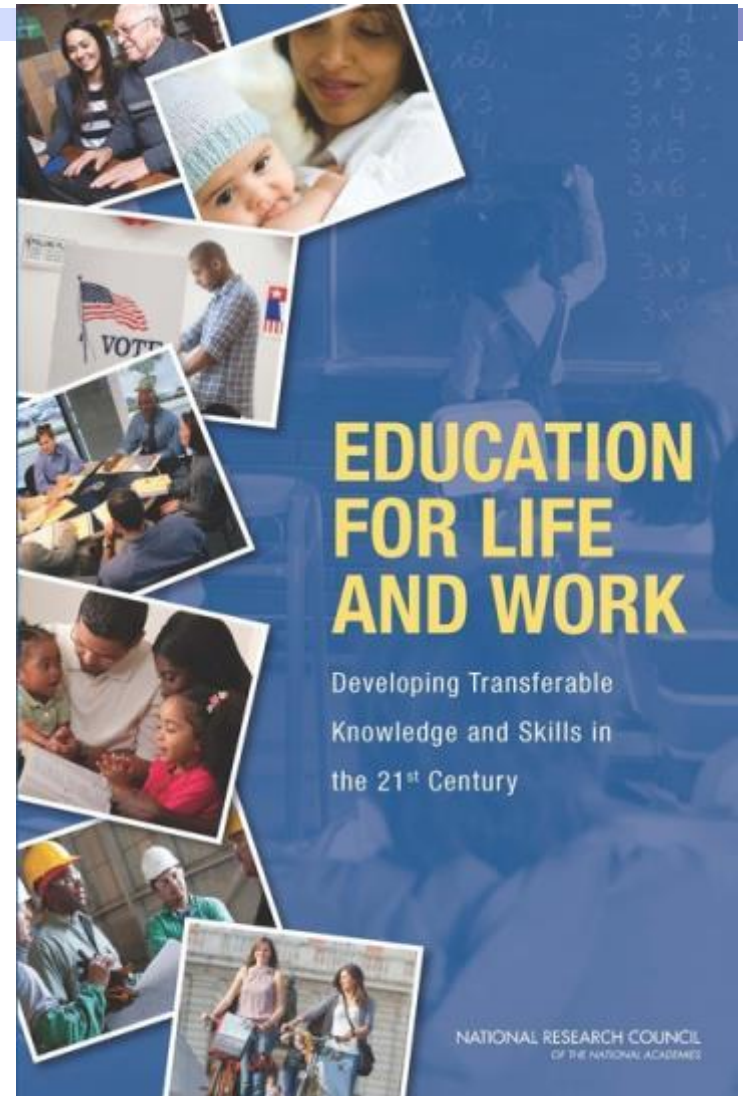
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National Research Council (2012)

Today's children can meet future challenges if their schooling and informal learning activities prepare them for adult roles as citizens, employees, managers, parents, volunteers, and entrepreneurs.





Dimensions of Advanced Knowledge and Skills



| <i>Cognitive Outcomes</i> | <i>Intrapersonal Outcomes</i> | <i>Interpersonal Outcomes</i> |
|---|---|--------------------------------------|
| Cognitive processes and strategies | Intellectual Openness | Teamwork and Collaboration |
| Knowledge | Work Ethic and Conscientiousness | Leadership |
| Creativity | Positive Core Self-Evaluation | Communication |
| Critical Thinking | Metacognition | Responsibility |
| Information Literacy | Flexibility | Conflict Resolution |
| Reasoning | Initiative | |
| Innovation | Appreciation of Diversity | |



Diagnostic Assessment Formative for Learning

- Formative, diagnostic assessment provides *more leverage for improvement* than summative measures
- Formative, diagnostic assessment is *richer and more accurate* than summative measures
- Potentially, formative, diagnostic assessment *could substitute for* summative measures.



Understanding Performances is Vital for Learning/Assessment

- Distributed learning: collaborative, mediated, scaffolded, and data-generating
- Cognition is distributed across human minds, tools/media, groups of people, and space/ time; dispersed physically, socially, and symbolically
- Event-logs of performances and communications provide insights



Interfaces for “Immersive” Learning

- **Multi-User Virtual Environments:**
Immersion in virtual contexts with digital artifacts and avatar-based identities
- **Ubiquitous Computing:**
Mobile wireless devices coupled to smart objects for “augmented reality”
- **Virtual Reality**
Full sensory immersion via head-mounted displays or CAVES

River City—Interface

The screenshot shows a virtual world interface with several key components:

- 1. View and Action Space:** The top navigation bar with menu options (File, Web, Help) and action buttons (TURN_AROUND, WAVE, JUMP, SPIN, YES, KARATE, KICK).
- 2. Virtual Space:** The central 3D environment showing a character in a dark vest and white shirt in a room with other characters and furniture.
- 3. Chat Window:** A text-based communication area at the bottom left showing a conversation between characters like Aaron Nelson, Hospital Cook, and Nurse Patterson.
- 4. Hints Machine:** A panel on the right titled 'Admissions Chart Hints' with tabs for Hint 1, Hint 2, and Hint 3, and instructions to click on message tabs.
- 5. Display Space:** A table on the right showing a list of patients in River City.
- 6. Toolbar:** A set of navigation icons (home, search, etc.) at the bottom right.
- 7. Health Meter:** An 'Environment Health Meter' at the bottom right showing a progress bar and the value 84%.

Teammate chat box. This is where students communicate with their teammates.



| River City # | Name | Age | Tenement | Illness | Date |
|--------------|-------------------|-----|-------------------|--|-----------|
| 1 | Keith Goldman | 51 | Tenement 1 | Fever, violent chills - 2nd admission | 1/2/1879 |
| 2 | Erica Loskill | 8 | Tenement 1 | Intense episode of fever, violent chills | 1/3/1879 |
| 3 | Chris Johnson | 7 | Tenement 1 | Diarrhea, dehydration, stomach pain | 1/4/1879 |
| 4 | Maria Garces | 23 | Tenement 2 | labor | 1/5/1879 |
| 5 | Paula Pounder | 25 | Middle class home | mild diarrhea, stomach cramps | 1/6/1879 |
| 6 | Catherine Poynter | 14 | Middle class home | Fever, chills - 2nd admission | 1/9/1879 |
| 7 | Mary White | 24 | Tenement 1 | labor | 1/10/1879 |
| 8 | Mrs. Pabisky | 49 | Tenement 2 | cough, fever | 1/10/1879 |
| 9 | Arthur Russell | 10 | Tenement 1 | rash | 1/12/1879 |
| 10 | Joshua | 17 | Tenement 1 | Stomach pain, | 1/17/1879 |



Student's Role in River City

- Travel back in time 6 times between 1878-79
- Bring 21st century skills and technology to address 19th century problems
- Help town understand and solve part of the puzzle of why so many residents are becoming ill
 - Work as a research team
 - Keep track of clues that hint at causes of illnesses
 - Form and test hypotheses in a controlled experiment
 - Make recommendations based on experimental data



Capturing Data on Change over Time

Visit 1



Fall, 1878

Visit 2



Winter, 1879

Visit 3



Spring, 1879

Visit 4



Summer, 1879

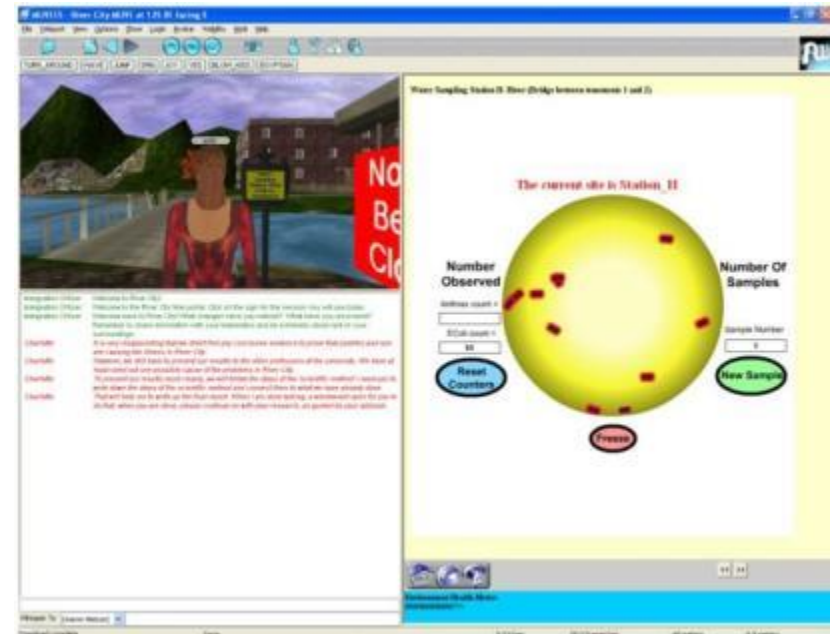
Students visit the same places and see how things change over time. They spend an entire class period in an individual season, gathering data.

River City Activities

Figure 1: Lab Equipment inside the University



Figure 2: River Water Sampling



<http://muve.gse.harvard.edu/rivercityproject>



“Evidence Gathering”

- An important, generic inquiry process
 - **amount** (how much evidence per time spent)
 - **range** (coverage/balance among all the types of evidence)
 - **saliency** (importance of the evidence in understanding causality in the situation)
 - **clustering** (grouping of evidence based on its causal affiliation)



Evidence of Student Work

■ **Assessment data:**

- **Pre-post content**
- **Pre-post affective**
- **Embedded assessments (formative)**
- **Performance assessment (summative)**

■ **Contextual Data:**

- **Attendance records**
- **Demographic data**
- **School data**
- **Observations**
- **Interviews**

■ **Active Data:**

- **Team chat**
- **Notebook entries**
- **Tracking of in-world activities:**
 - **Data gathering strategies**
 - **Pathways**
 - **Inquiry processes**



Types of Rich Datastreams

- **Multi-User Virtual Environments:**
Immersion in virtual contexts with digital artifacts and avatar-based identities
- **Augmented Realities**
- **Wikis and other forms of Social Media**
- **Asynchronous Discussions**
- **Intelligent Tutoring Systems**
- **Games**

Event Logs as Observational Data



Indicates with Timestamps

- Where students went
- With whom they communicated and what they said
- What artifacts they activated
- What databases they viewed
- What data they gathered using virtual scientific instruments
- What screenshots and notations they placed in team-based virtual notebooks

unobtrusive observational data

Logfiles: Events, Chats, Notebooks...



| | A | B | C | D | E | F | G | H | I | J | K | L | M |
|----|------------|--------|---------|-------|------------|-----------|-----------|-----------|------------|---------|--------|-----------|--|
| 1 | administra | testID | eventID | stage | timestamp | locationX | locationY | locationz | locationYa | assetID | detail | studentID | Description |
| 2 | 3141592 | 497 | 0 | 0 | 2009-12-06 | 0 | 0 | 0 | 0 | 1 | 1 | 102282 | assessment started |
| 3 | 3141592 | 497 | 1 | 1 | 2009-12-06 | 364 | 23 | -76 | 0 | 2 | 10 | 102282 | stage started |
| 4 | 3141592 | 497 | 2 | 1 | 2009-12-06 | 263 | 10 | -6 | 270 | 2 | 10 | 102282 | stage started |
| 5 | 3141592 | 497 | 3 | 1 | 2009-12-06 | 263 | 8 | -6 | 270 | 14 | 1 | 102282 | notebook opened |
| 6 | 3141592 | 497 | 4 | 1 | 2009-12-06 | 263 | 7 | -6 | 270 | 14 | 2 | 102282 | nitrate tab clicked in notebook |
| 7 | 3141592 | 497 | 5 | 1 | 2009-12-06 | 257 | 8 | -397 | 0 | 143 | 20 | 102282 | Arrow selection of Surface of the bay in front of the tent |
| 8 | 3141592 | 497 | 6 | 1 | 2009-12-06 | 0 | 0 | 0 | 0 | 2 | 11 | 102282 | stage ended |
| 9 | 3141592 | 497 | 7 | 1 | 2009-12-06 | 0 | 0 | 0 | 0 | 2 | 13 | 102282 | stage ended ungracefully |
| 10 | 3141592 | 497 | 8 | 1 | 2009-12-06 | 0 | 0 | 0 | 0 | 1 | 3 | 102282 | |
| 11 | 3141592 | 498 | 0 | 0 | 2009-12-06 | 0 | 0 | 0 | 0 | 1 | 1 | 102282 | assessment started |
| 12 | 3141592 | 498 | 1 | 1 | 2009-12-06 | 364 | 23 | -76 | 0 | 2 | 10 | 102282 | stage started |
| 13 | 3141592 | 498 | 2 | 1 | 2009-12-06 | 263 | 10 | -6 | 270 | 2 | 10 | 102282 | stage started |
| 14 | 3141592 | 498 | 3 | 1 | 2009-12-06 | 263 | 8 | -6 | 270 | 14 | 1 | 102282 | notebook opened |
| 15 | 3141592 | 498 | 4 | 1 | 2009-12-06 | 263 | 7 | -6 | 270 | 14 | 2 | 102282 | nitrate tab clicked in notebook |
| 16 | 3141592 | 498 | 5 | 1 | 2009-12-06 | 263 | 7 | -6 | 270 | 14 | 3 | 102282 | pop density tab clicked in notebook |
| 17 | 3141592 | 498 | 6 | 1 | 2009-12-06 | 263 | 7 | -6 | 270 | 14 | 4 | 102282 | salinity tab clicked in notebook |
| 18 | 3141592 | 498 | 7 | 1 | 2009-12-06 | 263 | 7 | -6 | 270 | 14 | 2 | 102282 | nitrate tab clicked in notebook |
| 19 | 3141592 | 498 | 8 | 1 | 2009-12-06 | 263 | 7 | -6 | 270 | 14 | 1 | 102282 | notebook opened |
| 20 | 3141592 | 498 | 9 | 1 | 2009-12-06 | 0 | 0 | 0 | 0 | 2 | 11 | 102282 | stage ended |
| 21 | 3141592 | 498 | 10 | 1 | 2009-12-06 | 0 | 0 | 0 | 0 | 2 | 13 | 102282 | stage ended ungracefully |
| 22 | 3141592 | 498 | 11 | 1 | 2009-12-06 | 0 | 0 | 0 | 0 | 1 | 3 | 102282 | |
| 23 | 3141592 | 499 | 0 | 0 | 2009-12-06 | 0 | 0 | 0 | 0 | 1 | 1 | 102282 | assessment started |
| 24 | 3141592 | 499 | 1 | 1 | 2009-12-06 | 364 | 23 | -76 | 0 | 2 | 10 | 102282 | stage started |
| 25 | 3141592 | 499 | 2 | 1 | 2009-12-06 | 263 | 10 | -6 | 270 | 2 | 10 | 102282 | stage started |
| 26 | 3141592 | 499 | 3 | 1 | 2009-12-06 | 263 | 8 | -6 | 270 | 14 | 1 | 102282 | notebook opened |
| 27 | 3141592 | 499 | 4 | 1 | 2009-12-06 | 263 | 7 | -6 | 270 | 14 | 2 | 102282 | nitrate tab clicked in notebook |
| 28 | 3141592 | 499 | 5 | 1 | 2009-12-06 | 233 | 4 | -5 | 291 | 3 | 4 | 102282 | teleport KB kelp |
| 29 | 3141592 | 499 | 6 | 1 | 2009-12-06 | 236 | 6 | -4 | 291 | 2 | 11 | 102282 | stage ended |
| 30 | 3141592 | 499 | 7 | 4 | 2009-12-06 | 129 | 10 | 125 | 0 | 2 | 10 | 102282 | stage started |
| 31 | 3141592 | 499 | 8 | 4 | 2009-12-06 | 124 | 2 | 117 | 108 | 212 | 20 | 102282 | Arrow selection of Striped surfperch |
| 32 | 3141592 | 499 | 9 | 4 | 2009-12-06 | 123 | 0 | 123 | 0 | 107 | 22 | 102282 | Population density reading for Bull kelp |
| 33 | 3141592 | 499 | 10 | 4 | 2009-12-06 | 129 | 10 | 118 | 180 | 209 | 22 | 102282 | Population density reading for Sea otter |
| 34 | 3141592 | 499 | 11 | 4 | 2009-12-06 | 137 | 0 | 121 | 37 | 200 | 22 | 102282 | Population density reading for Cowardin algae |
| 35 | 3141592 | 499 | 12 | 4 | 2009-12-06 | 133 | 0 | 117 | 0 | 111 | 24 | 102282 | Temperature reading for Bay floor |
| 36 | 3141592 | 499 | 13 | 4 | 2009-12-06 | 133 | 0 | 117 | 0 | 111 | 25 | 102282 | Turbidity sample taken of Bay floor |
| 37 | 3141592 | 499 | 14 | 4 | 2009-12-06 | 108 | 0 | 107 | 37 | 200 | 23 | 102282 | Salinity reading for Corraline algae |
| 38 | 3141592 | 499 | 15 | 4 | 2009-12-06 | 122 | 0 | 117 | 0 | 111 | 24 | 102282 | nitrate reading for Bay floor |



Data Analytics

- How to make sense of all this active data (too much rather than too little)?
- How to use active data to improve instructional design and formative evaluation?
- How to cross-reference and synthesize these various types of data to improve student learning?

Visualization of Student Activities



Citizen Number:

World:

| Hum | Citizen | Avatar |
|-----|---------|--------|
| 0 | 1459 | Bender |

World:

Instance:

Date/Time:

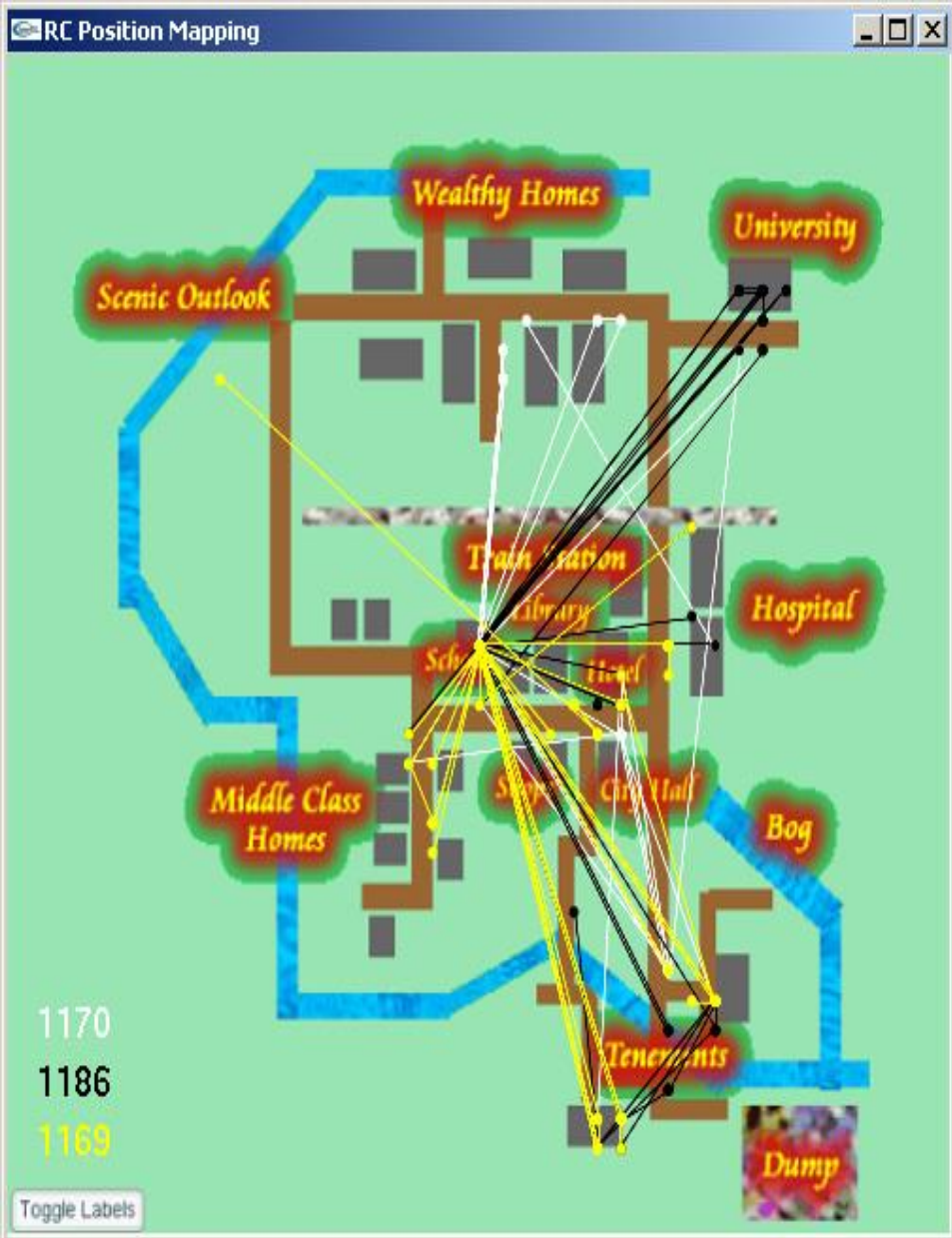
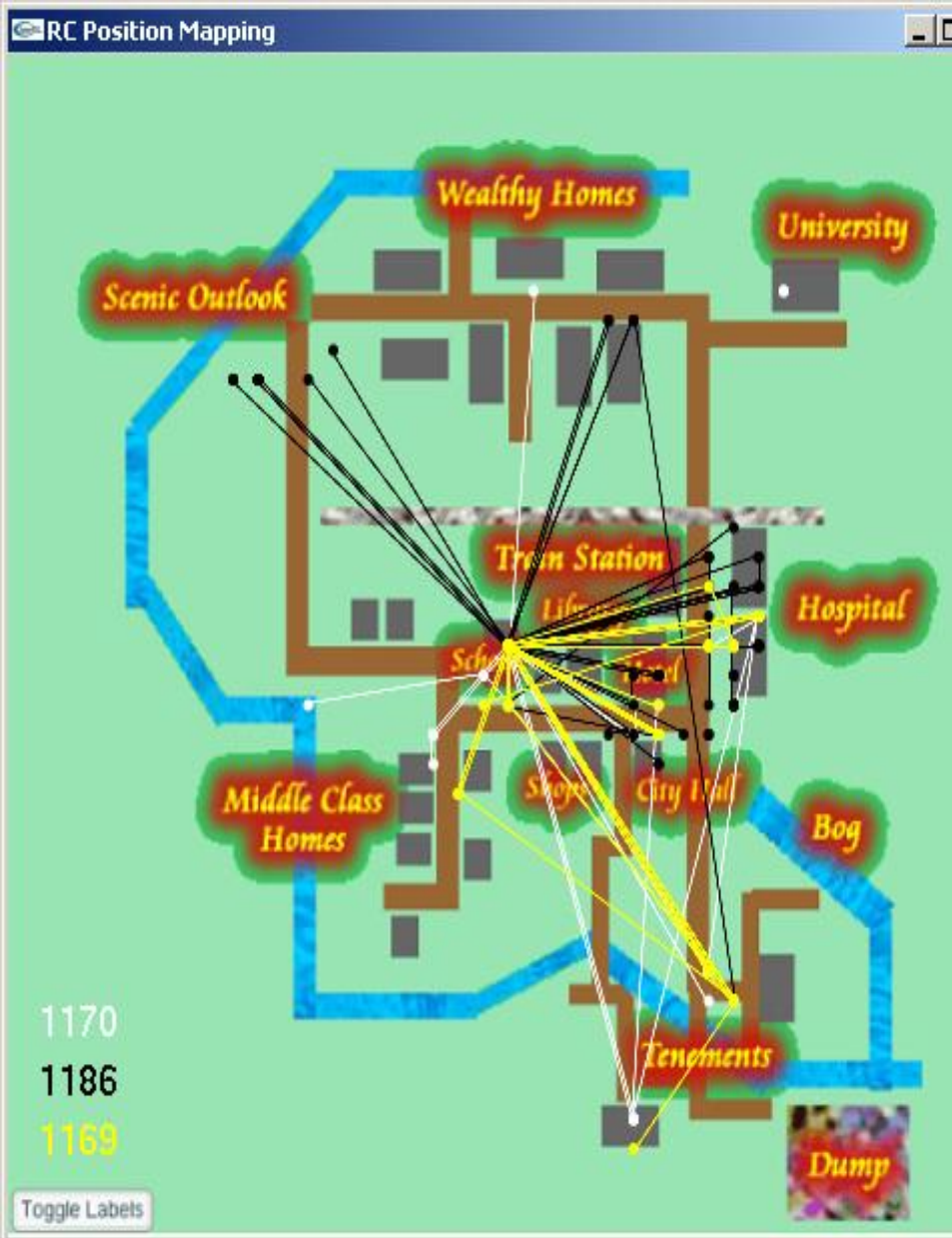
Event Type:

Action:

What's New?

Text:

| Index | Type | Date |
|-------|------|-------------------|
| 74 | 8 | 10/18/04 09:47:44 |
| 75 | 8 | 10/18/04 09:47:52 |
| 76 | 8 | 10/18/04 09:48:01 |
| 77 | 13 | 10/18/04 09:48:01 |



Shorty's (1169) Team, Session 2

Shorty's Team, Session 3

Attaining "Powers": Sessions 2 and 4



Usage of Individualized Guidance



Bug Catcher: Bog Hints

Hint 1 Hint 2 Hint 3

Click on one of the message tabs above to view hints about this area, object, or River City citizen.

River City

Mosquito Catcher- Next to the Bog:

The current site is Bog

Number Observed
Mosquito count =

Reset Counter

Number Of Samples
Sample Number:

New Sample

Freeze

A screenshot of the "Mosquito Catcher" interface. It features a central yellow oval grid containing several black mosquito icons. Above the grid, the text "The current site is Bog" is displayed. To the left of the grid, there is a "Number Observed" section with a "Mosquito count" input field and a "Reset Counter" button. To the right, there is a "Number Of Samples" section with a "Sample Number" input field and a "New Sample" button. Below the grid, there is a "Freeze" button.



Moby (Dan Schwartz – Stanford)



Hypothetico-deductive reasoning.

- Students try to induce the rule that regulates the appearance of flowers.
 - Fire is necessary and sufficient.
 - Fire or Rain are necessary.
 - Fire and not Rain are sufficient.
 -
- They then teach the rule to Moby.
- Moby plays a guessing game against an evil agent using the deductive rule.



Interacting with Animated Pedagogical Agents

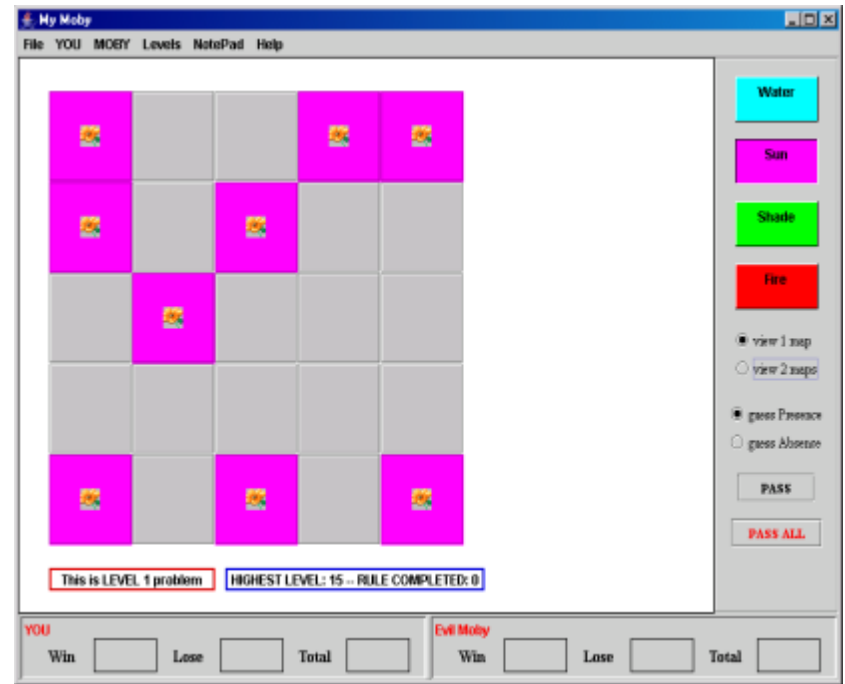
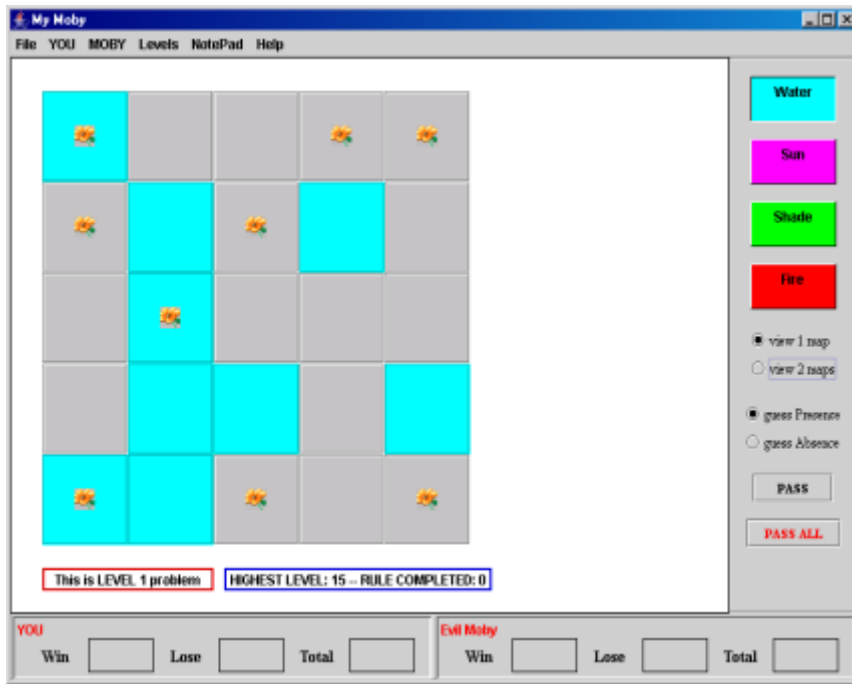


| Ask Dr. C. Your Personal Mars Expert | Ask Dr. C. Your Personal Mars Expert |
|--|---|
|  |  |
| Brian N Diane K Jody C | Brian N Diane K Jody C |
| Why is Mars called the Red Planet? <input type="text"/> <input type="button" value="CLEAR"/> <input type="button" value="SEND"/> | <input type="text"/> <input type="button" value="CLEAR"/> <input type="button" value="SEND"/> |
| <p>Dr C: Busy day today! But I still have time to answer any of your questions about Mars, space, or science.</p> <p>Diane K: Why is Mars called the Red Planet?</p> | <p>Diane K: Why is Mars called the Red Planet?</p> <p>Dr C: Mars probably got the nickname, The Red Planet, due to the rusty color of its soil, which is comprised of iron-rich minerals. The Egyptians called it 'the red one' because it appears more reddish in the night sky. What makes it appear reddish is a combination of the fact that its surface is comprised of iron-rich minerals that essentially rust (or oxidize) and that the dust made of these minerals is kicked up into the atmosphere, giving the atmosphere a reddish hue from far away. The Martian surface is not all</p> |

Inducing a rule

(Dan Schwartz – Stanford)

- Click on factors and they overlay on flowers.





Potential Insights for Students

Evolution over time of:

- Engagement
- Information-Seeking
 - Sources: context, agents, artifacts, databases, virtual scientific instruments, hints...
- Collaboration, including use of virtual notebook
- Content Mastery
- Inquiry strategies



Potential Insights for Teachers

- Diagnostic, formative information about individual students
 - Engagement
 - Level and types of hints accessed
 - Skewed information-gathering patterns
- Diagnostic, formative information about students collectively
 - Level of collaboration
 - Degree to which types of hints are needed
 - Degree to which some kinds of information resources are underutilized
 - Patterns of scores on embedded content assessments



(by_luddebenke)



representation



Module 1: Pond Ecosystem

Modeled after Black's Nook Pond in Cambridge, MA

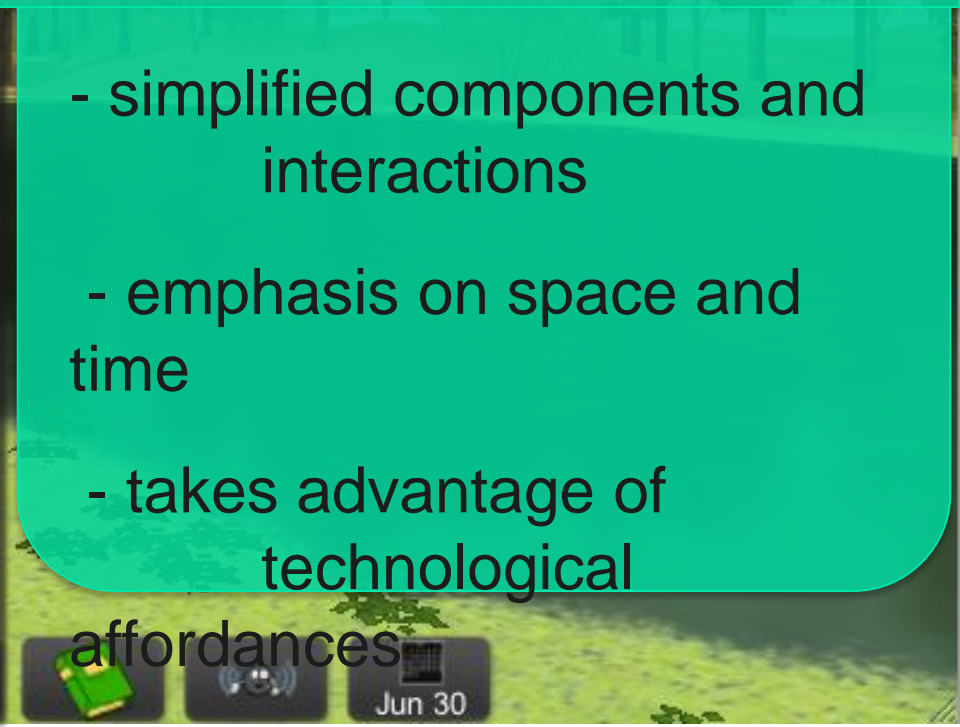


<http://ecomuve.gse.harvard.edu>



EcoMUVE is a **MODEL** of a natural environment

- simplified components and interactions
- emphasis on space and time
- takes advantage of technological affordances





Non-obvious causes

A submarine tool explores the microscopic organisms in the pond, helping students understand that organisms that they cannot see play a critical role in the pond ecosystem.



Carbon Atom

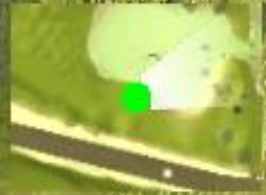
Hi, I'm a CARBON atom! I'm a part of a starch molecule in this duckweed plant. Whoa! My duckweed plant just got eaten by a duck! Now I'm in the duck's stomach.

OK

Atom Tracker

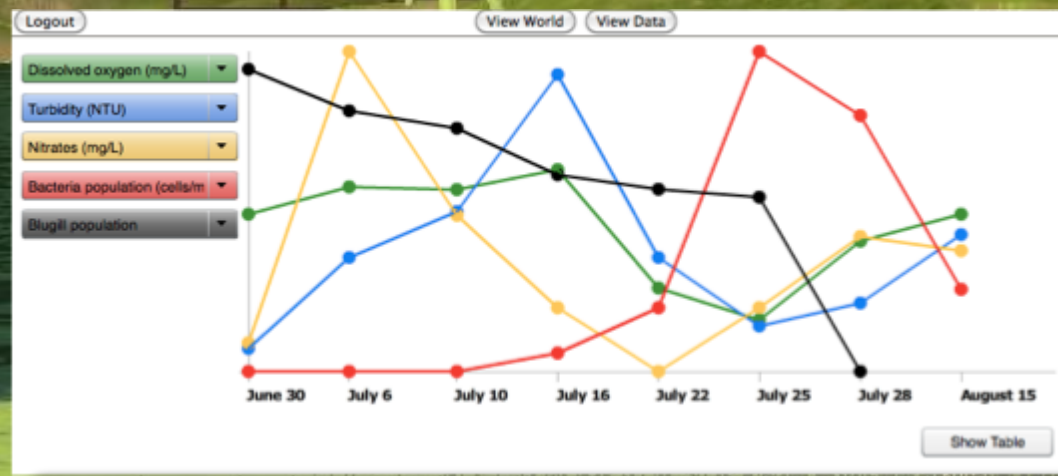
Atom tracker allows students to track three specific simulated atoms over time – oxygen, carbon, and phosphorus – these anthropomorphized atoms give students an “atom’s-eye-view” of conservation of matter.

TI Nspire



X

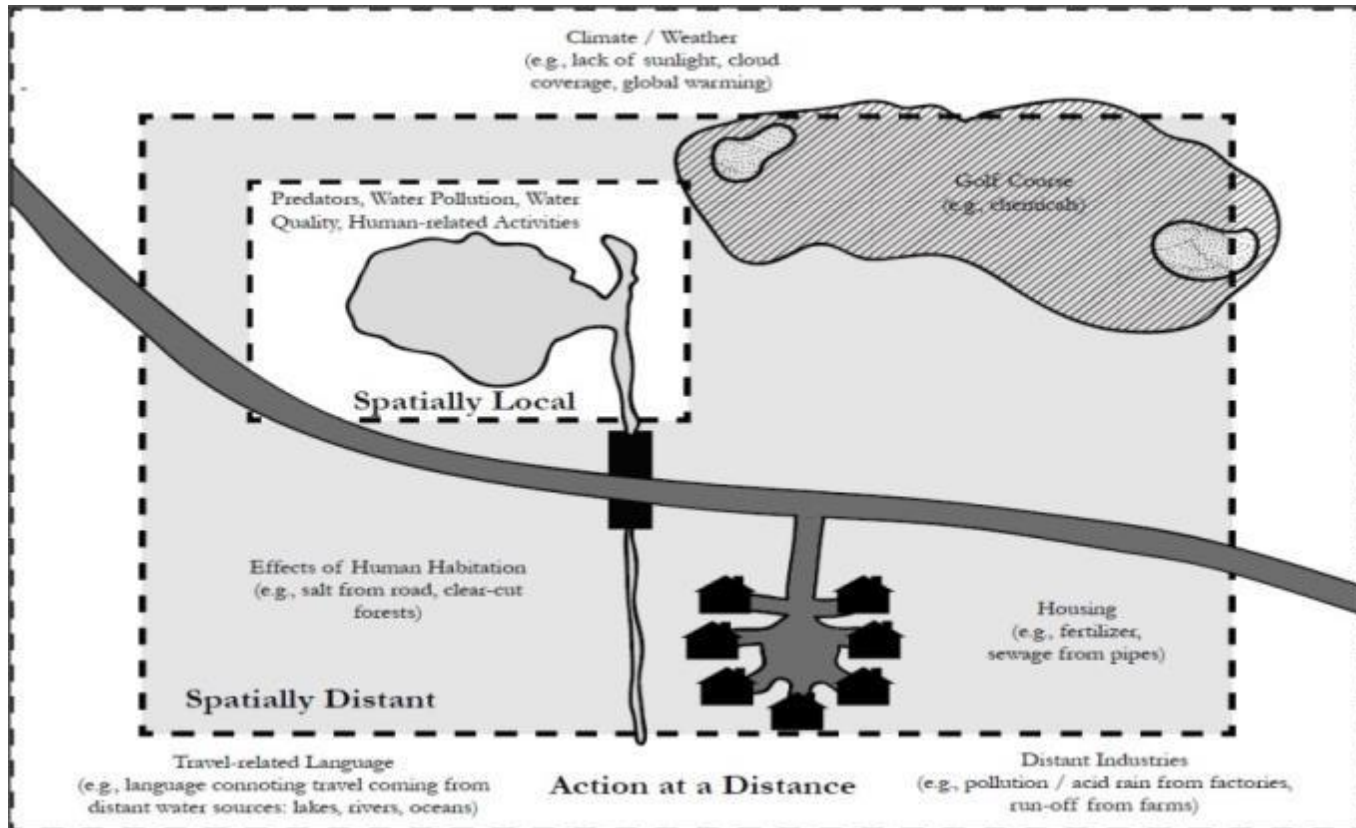
- Temp
- DO
- pH
- NO₂
- Turbidity
- pH
- CHL a



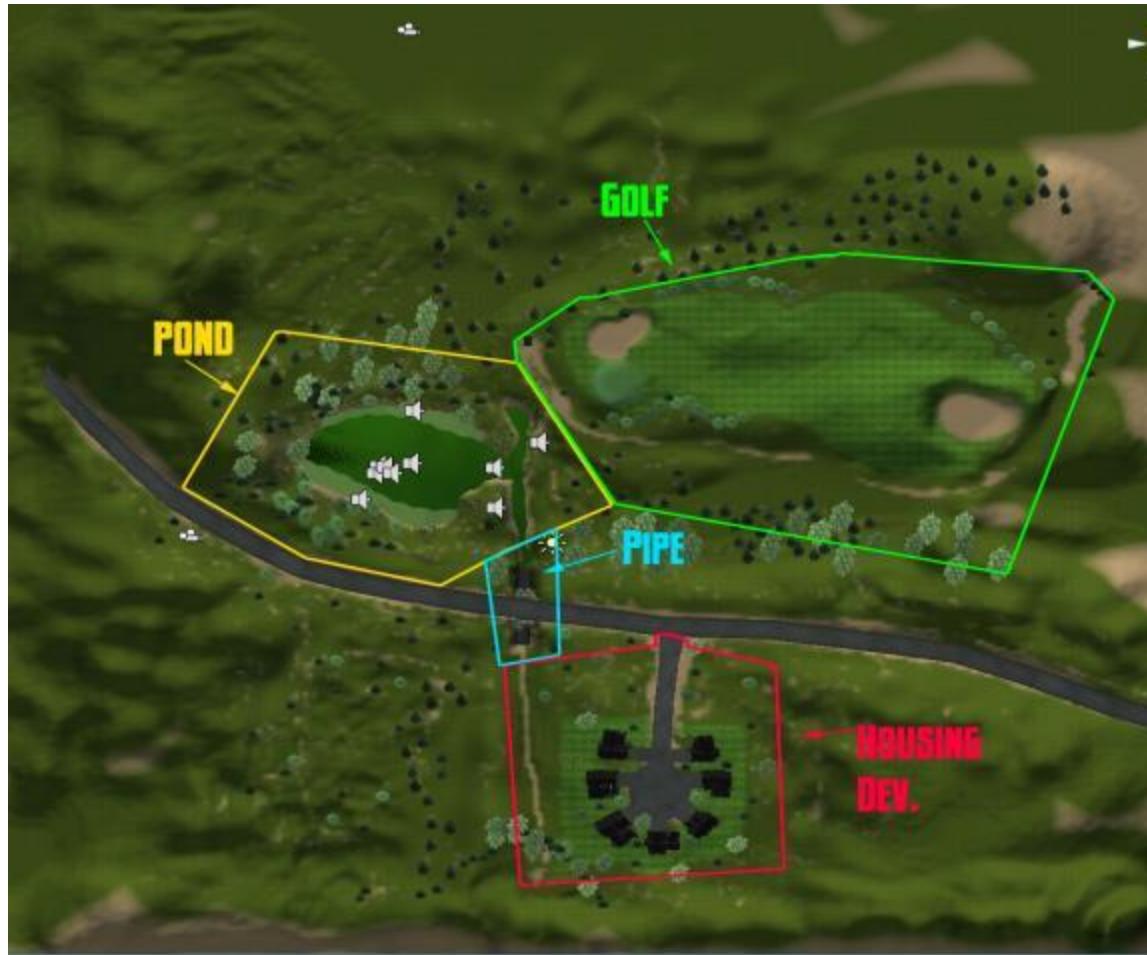
Texas Instruments NSpires with Vernier Environmental Probes

Population Jun 30

Coding Schema for Fish Die-Off

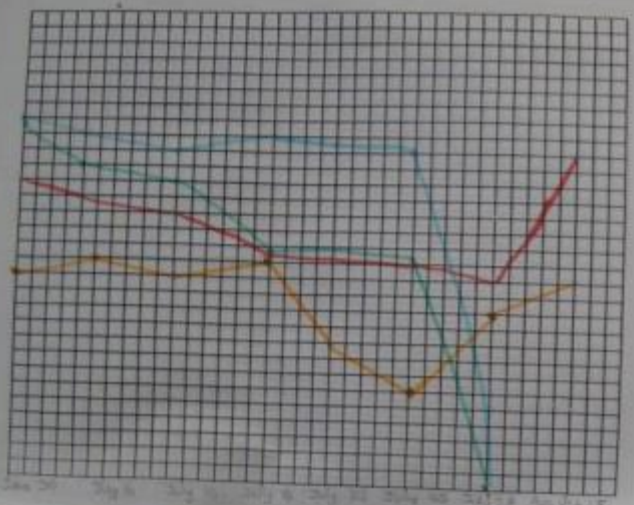


Studying Student Movement Within EcoMUVE





Fish Killed Concept Map



- largemouth bass population
- bluegill population
- minnow population
- heron population

The fish really started dying when the oxygen started decreasing. The heron could have ate the fish that why the minnow population increased and the heron population decreased.

Pungent Susan was planting fertilizer, but the next day it rained and the fertilizer got into the pond and killed some fish.

Sewage from contaminated water, killing the fish.

Humans caused sewage and fertilizer accidents.





RAIN

Algal blooms
Algal blooms are a natural phenomenon that occurs in many bodies of water. They are caused by a rapid increase in the number of algae in the water. Algal blooms can be harmful to humans and animals if they ingest the algae. Some algal blooms can also cause skin irritation and respiratory problems.

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FERTILIZER

PEOPLE

CHLOROPHYLL

SUNLIGHT

BLUE GREEN ALGAE

GREEN ALGAE

BLUE GILL

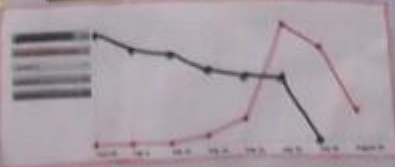
OXYGEN

BACTERIA

LARGE MOUTH BASS

FATHEAD MINNOWS

TURBIDITY



largemouth bass

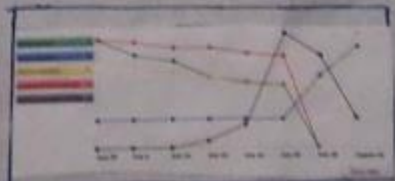
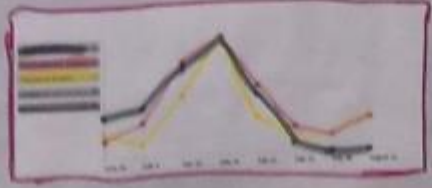
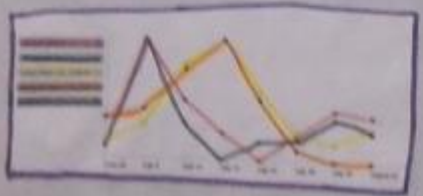
Characteristics

- Largemouth bass are large fish with a dark stripe along the length of their body.
- They can find largemouth bass in the water near the edge of a pond. Largemouth bass are more than 10 inches and usually have a lot of orange patches around the eyes. They often can be found in heavily wooded areas, grassy fields, ponds or ditches.
- Largemouth bass are omnivorous. Largemouth bass eat bluegills, worms, fish, tadpoles, snails, or aquatic insects like the chironomids. Sometimes largemouth bass may grab the small insects or organisms living near to the water.
- Largemouth bass are usually eaten by humans or other fish and birds. They are also eaten by baldpate.

sunlight

Characteristics

- Sunlight is the light that comes from the sun and other stars.
- It is the energy that keeps the earth warm and makes it possible for life to exist.
- Sunlight is made up of different colors of light. These colors are called the visible spectrum.
- Sunlight is also made up of different types of energy. These types of energy are called electromagnetic waves.





1976



2014





(Conner Flynn)

Augmenting Real World Ecosystems

<http://ecomobile.gse.harvard.edu>

EcoMOBILE



Minuteman Commuter Bikeway

Minuteman Commuter Bikeway

An aerial map of a pond area with various activity labels and location pins. The labels include: 'Marla', 'Calculate the Turbidity Index', 'Meet Up', 'Measure the pH here', 'Observe the Pond', 'Private Investigator', 'Mac Invertebrates', 'Waterway Two', 'Measure the Phosphates', 'Microscopic Specialist', 'Observe the pond', 'Where does the water come from?', 'Respiration Animation', 'Measure the Dissolved Oxygen', 'Location Point Two', 'Measure the Water Temperature', 'Footprint', and 'Waterway One'. A green tree icon labeled 'Parker Meadow' is also visible.

Marla

Calculate the Turbidity Index

Meet Up

Measure the pH here

Observe the Pond

Private Investigator

Mac Invertebrates

Waterway Two

Measure the Phosphates

Microscopic Specialist

Observe the pond

Where does the water come from?

Respiration Animation

Measure the Dissolved Oxygen

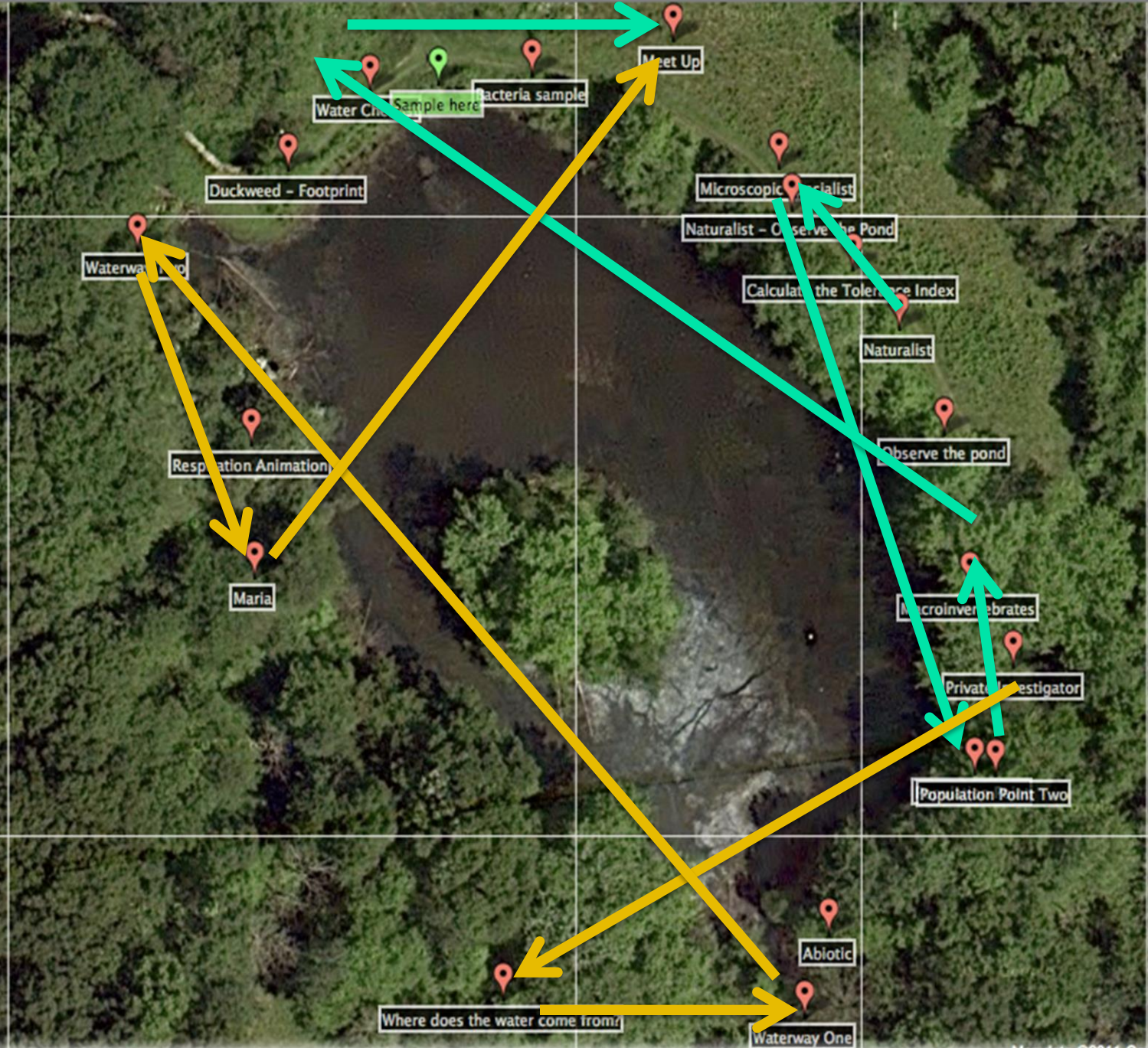
Location Point Two

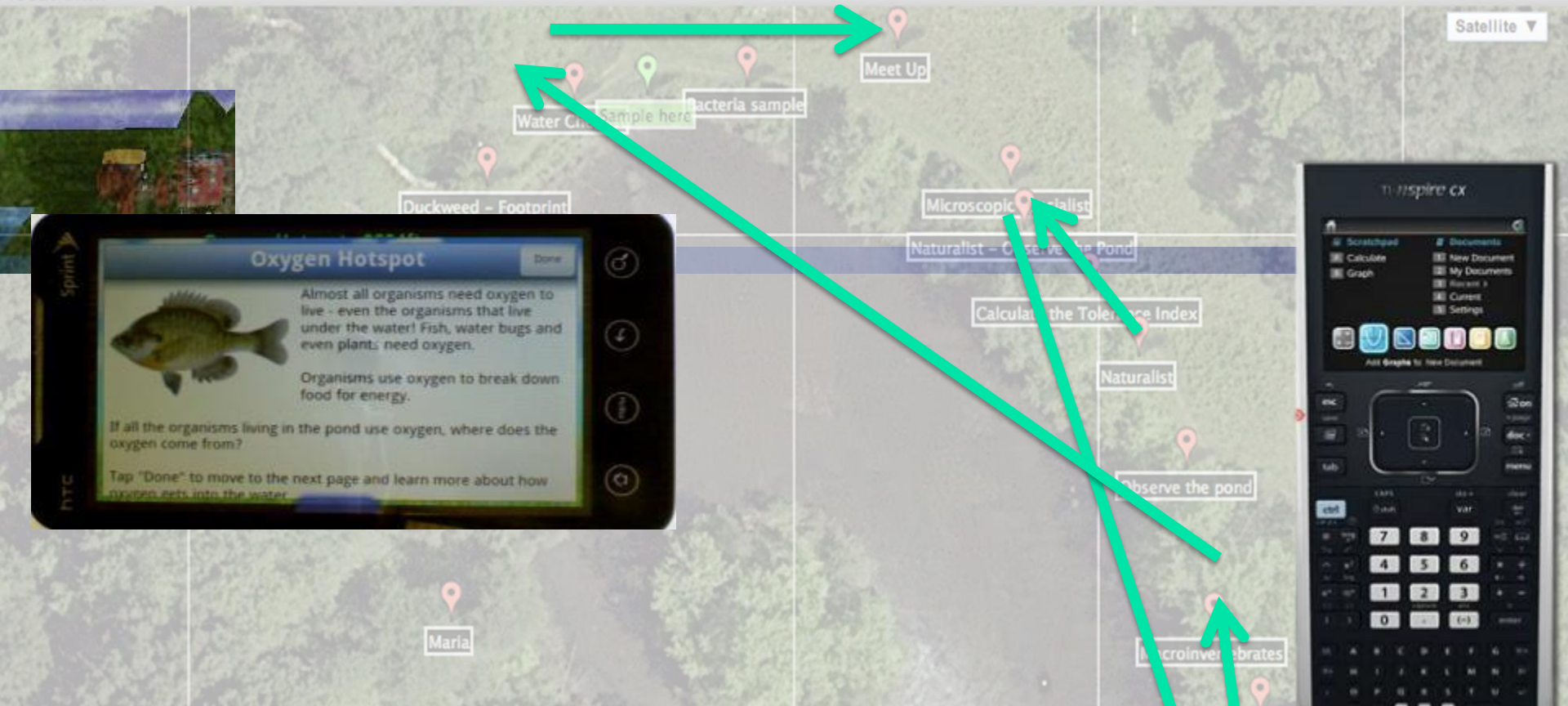
Measure the Water Temperature

Footprint

Waterway One

Parker Meadow





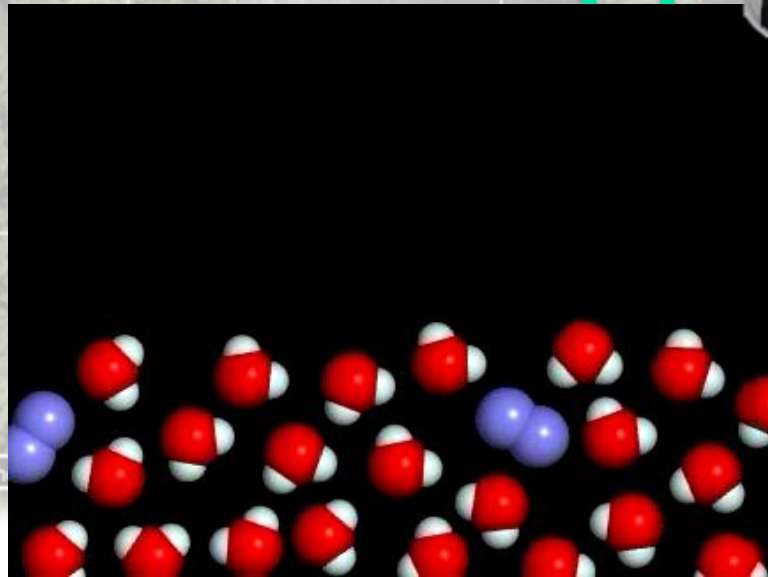
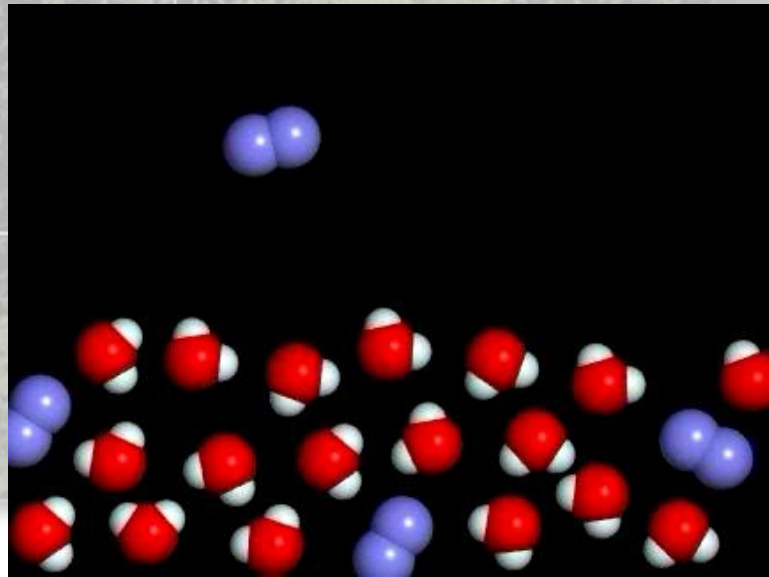

Oxygen Hotspot

Almost all organisms need oxygen to live - even the organisms that live under the water! Fish, water bugs and even plants need oxygen.

Organisms use oxygen to break down food for energy.

If all the organisms living in the pond use oxygen, where does the oxygen come from?

Tap "Done" to move to the next page and learn more about how oxygen gets into the water.



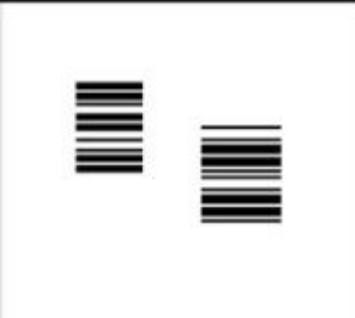
Data

Information

Knowledge

Understanding

Wisdom



(Nick Webb)





Community: Social Media

■ Sharing

- Social Bookmarking
- Photo/Video Sharing
- Social Networking
- Writers' Workshops and Fanfiction

■ Thinking

- Blogs
- Podcasts
- Online Discussion Forums
- Twitter

■ Co-Creating

- Wikis/Collaborative File Creation
- Mashups/Collective Media Creation
- Collaborative Social Change Communities



Multi-dimensional Learning

- Classrooms
- Richly Contextualized Real World Learning
 - Internships, apprenticeships
- Community
 - Face-to-face and virtual

