How Immersion in Virtual Worlds Helps Learners in the Real World

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The Core Challenge We Face

- Shifts in the knowledge and skills society values
- Development of new methods of teaching and learning
- Changes in the characteristics of learners

Emerging information technologies are reshaping each of these—and changing how we learn and know.

Focus on A Particular Suite of Understandings and Performances

Collaborative Problem Resolution via Mediated Interaction:

- **Problem Finding Before Problem Solving**
- **Comprehension by a Team, Not an Individual**
- **Making Meaning Out of Complexity:**
  - Utilizing sophisticated tools and representations
  - Recognizing and matching patterns
  - Judging the value of alternative formations
  - Communicating to others with differing perspectives

Situated Learning and Transfer

- constellations of architectural, social, organizational, and material vectors that aid in learning culturally based practices
  - apprenticeship (the process of moving from novice to expert within a given set of practices)
  - legitimate peripheral participation (tacit learning similar to that involved in internships)
  - high fidelity is not important unless essential for task (e.g., interpreting photographic images)

Next Generation Interfaces for "Immersive Learning"

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

January 2009 issue of *Science*

EcoMUVE

- Funded by the Institute of Education Sciences of the U.S. Department of Education.
- Middle school science
  - Ecosystems, Causal complexity.
- Two MUVE-based modules implemented over two weeks within a four week ecosystems curriculum.
- Timeline: July, 2008 - July 2011

Project Overview

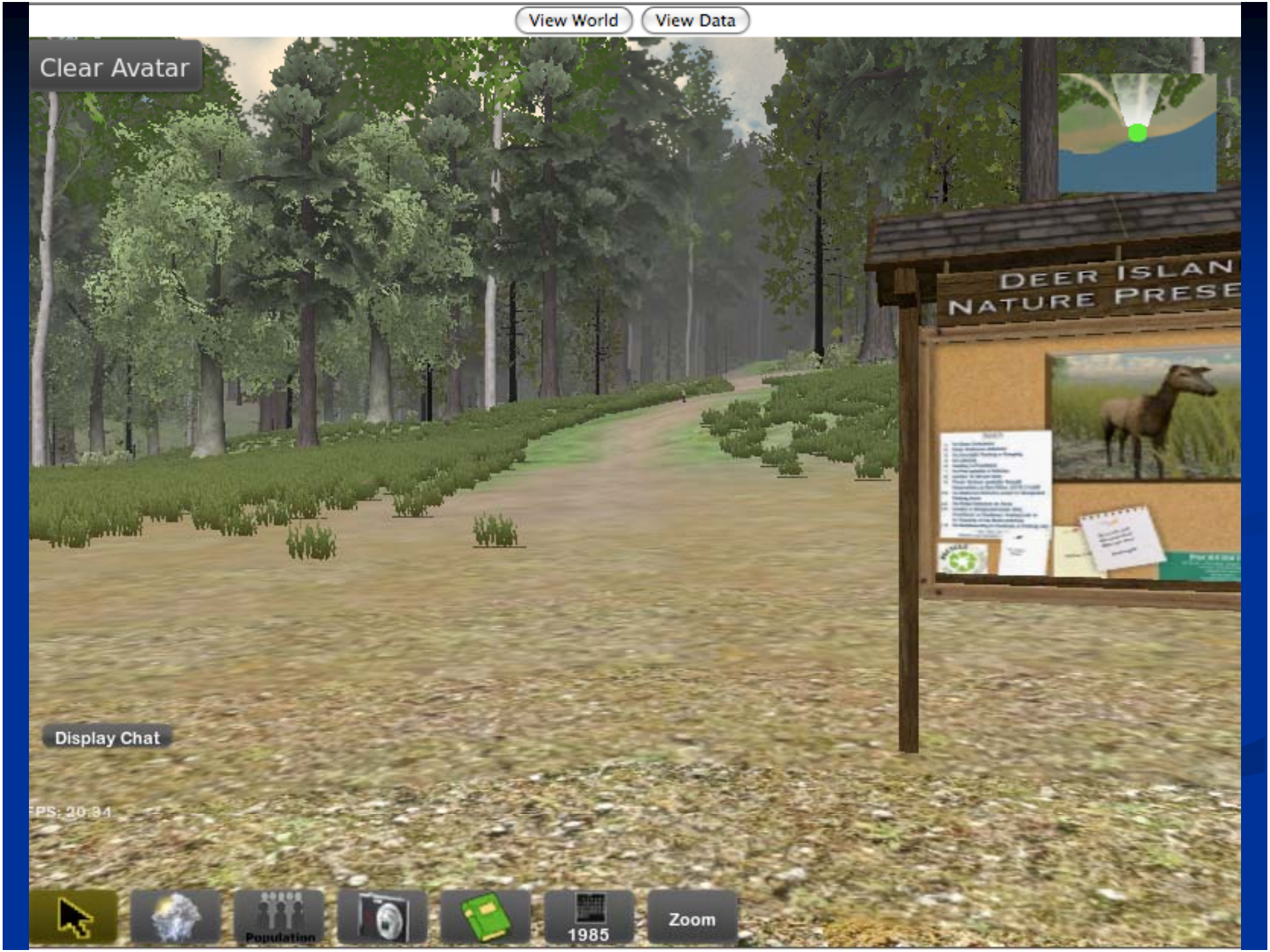
- Ecosystems have complex causal dynamics.
- Even after instruction, students often retain misconceptions.
- In our experience, MUVEs can help students engage in authentic science inquiry and gain deeper understanding.
- Our goal is to develop EcoMUVE as a MUVE that, as part of a larger curriculum, will enable a richer understanding of ecosystems and complex causality.

Expert Reasoning About Ecosystems Involves Reasoning About:

- spatial scales involving action at a distance, where impacts are felt far from their causes.
- time delays between causes and their effects.
- causes that can be non-obvious or act in concert with obvious causes.
- processes and steady states in contrast to event-based reasoning.

Why are MUVEs Promising for Teaching Certain Ecosystems Concepts?

- Zoom-in to the microbial world or out to macroviews (such as a population view).
- Ability to speed up time, slow down time, advance to different points in the past or future, illustrate scenarios.
- Ability to show parallel interacting objects/beings and their emergent effects (distributed causality).
- Ability to monitor the on-going state of systems.
- Ways to graph patterns, showing the relationship between individual behaviors and population level outcomes.
- Ways to illustrate different causal patterns in play.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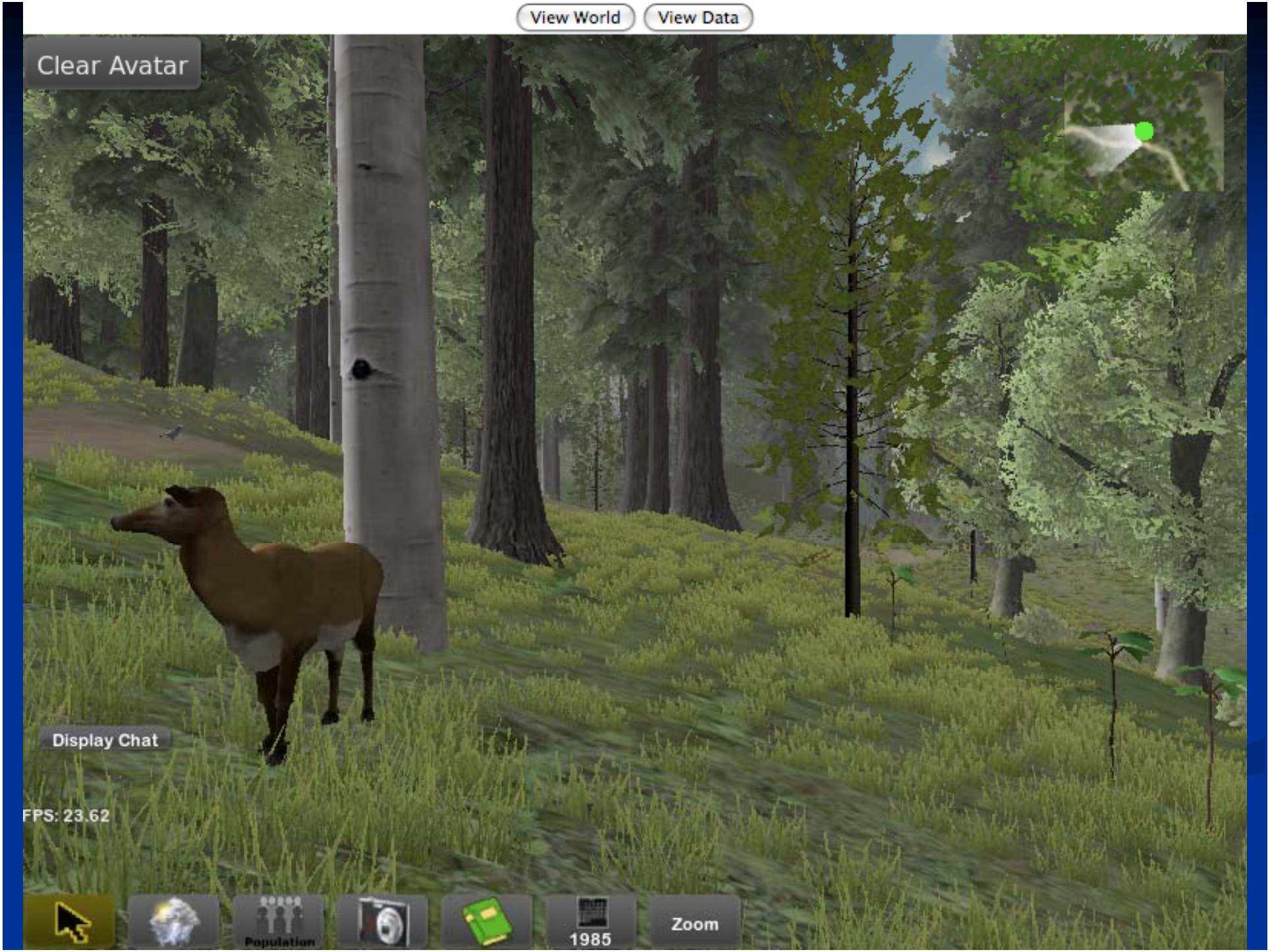
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White-tailed Deer

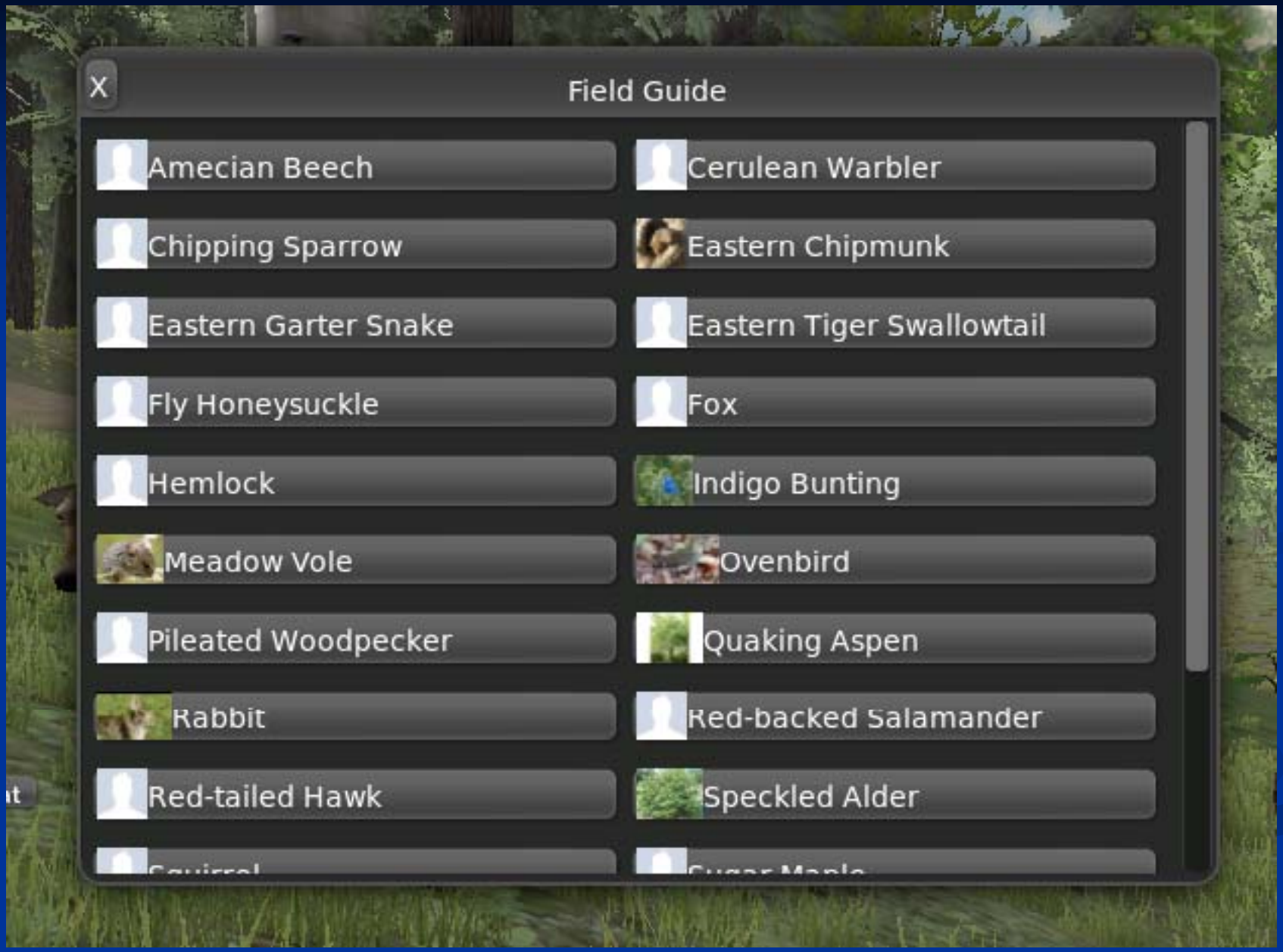
Odocoileus virginaianus

Description: The white-tailed deer is tan or brown in the summer. Its name comes from the white patch of fur on the underside of its tail. The male has antlers.

Where They Live: Whitetail deer are able to survive in many habitats, from the big woods of northern Maine to the deep saw grass swamps of Florida. They also inhabit farmlands, brushy areas and the cactus and thornbrush deserts of southern Texas and Mexico. Ideal whitetail deer habitat would contain dense thickets (in which to hide and move about) and edges (which furnish food).

What They Eat: Deer are primary consumers feeding on leaves, twigs, shoots, acorns, berries, and seeds, and they also graze on grasses and herbs. Deer have strong preferences for certain kinds of plants and when their population is high they may eat all of their favorite food from a certain area

Chat


X
Field Guide
Amecian Beech
Cerulean Warbler
Chipping Sparrow
Eastern Chipmunk
Eastern Garter Snake
Eastern Tiger Swallowtail
Fly Honeysuckle
Fox
Hemlock
Indigo Bunting
Meadow Vole
Ovenbird
Pileated Woodpecker
Quaking Aspen
Rabbit
Red-backed Salamander
Red-tailed Hawk
Speckled Alder

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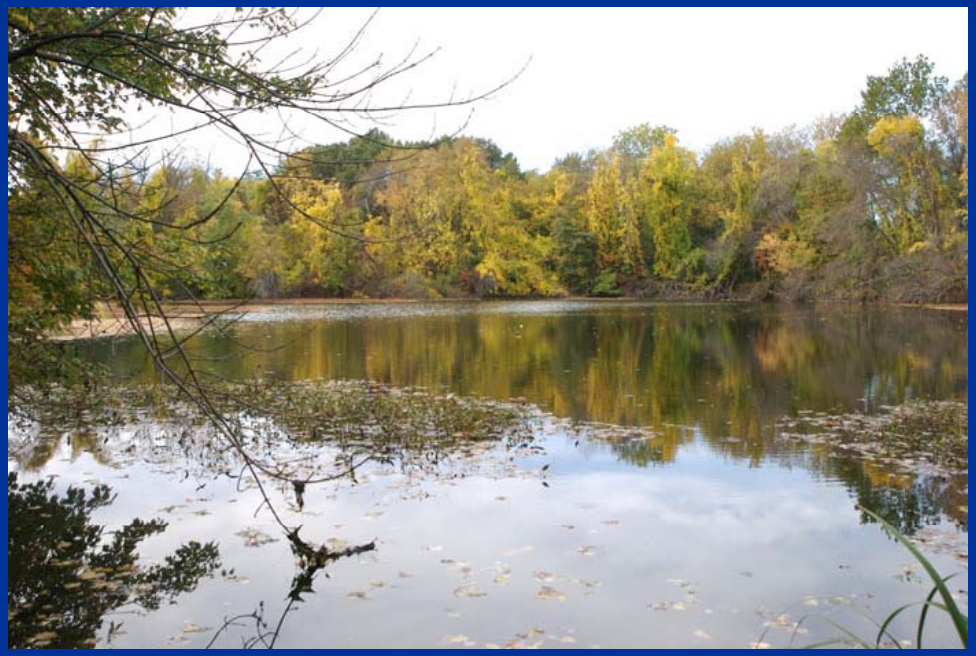
Module 1: Pond Ecosystem

Modeled after Black's Nook Pond in Cambridge, MA



Change over Time

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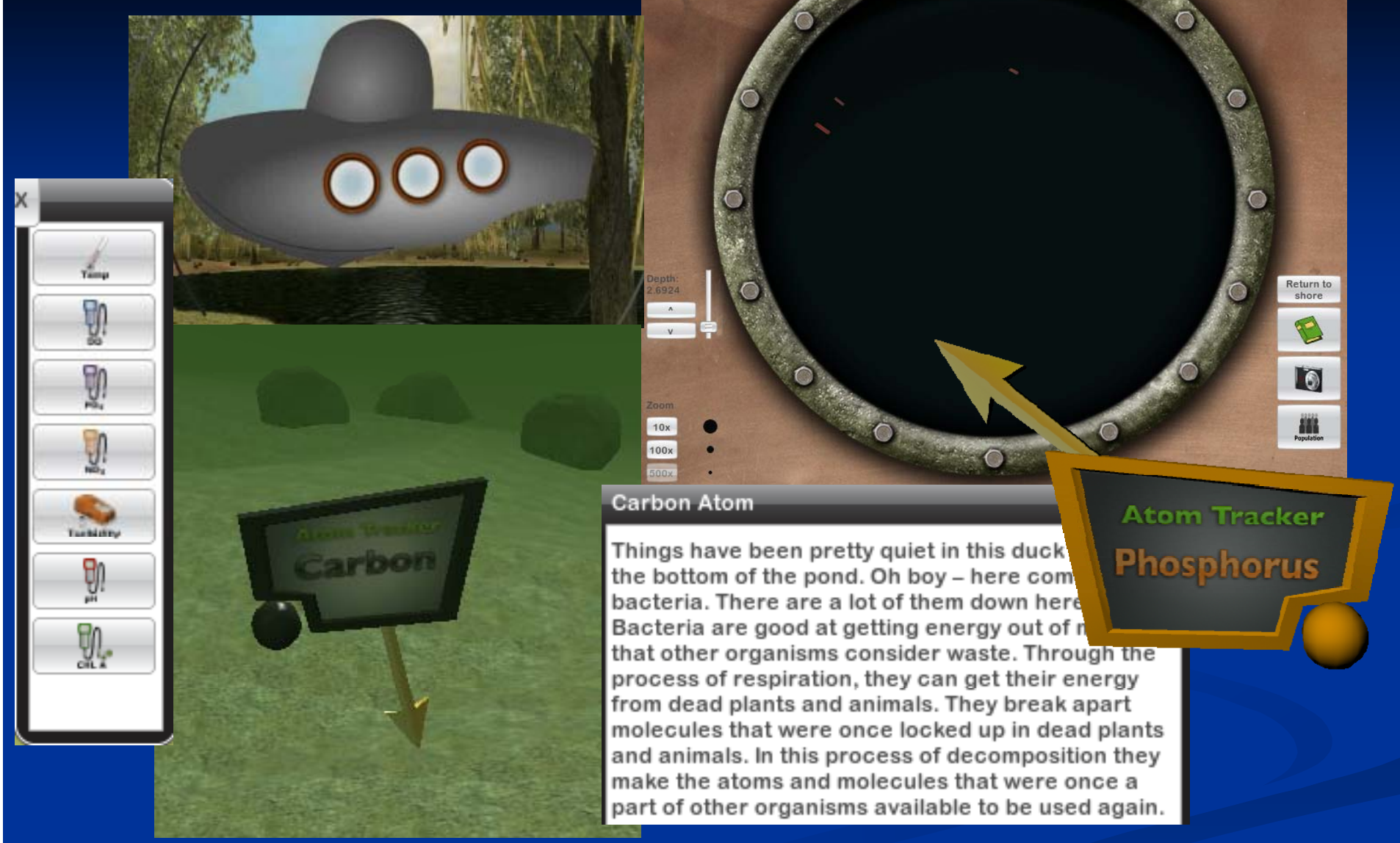
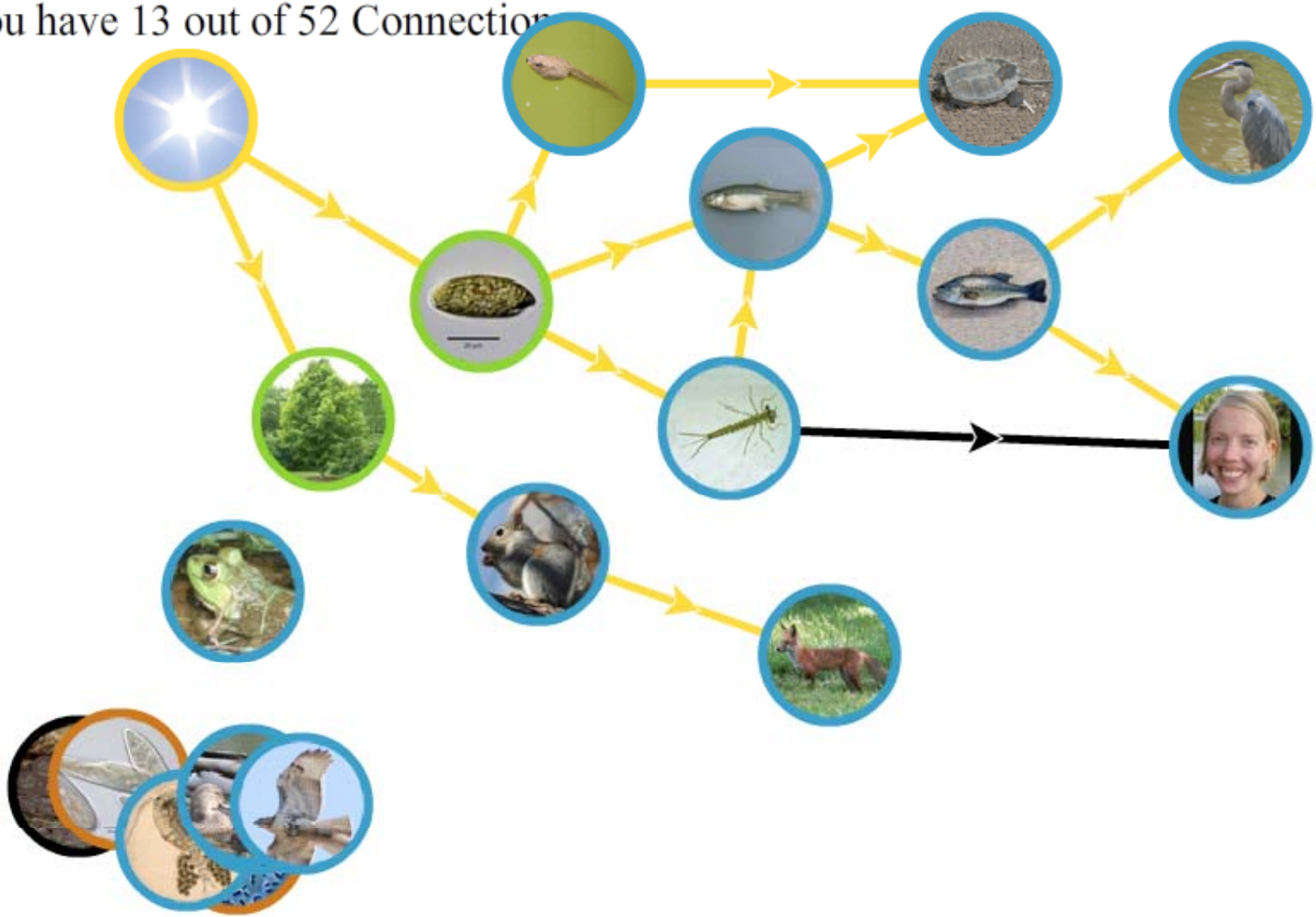


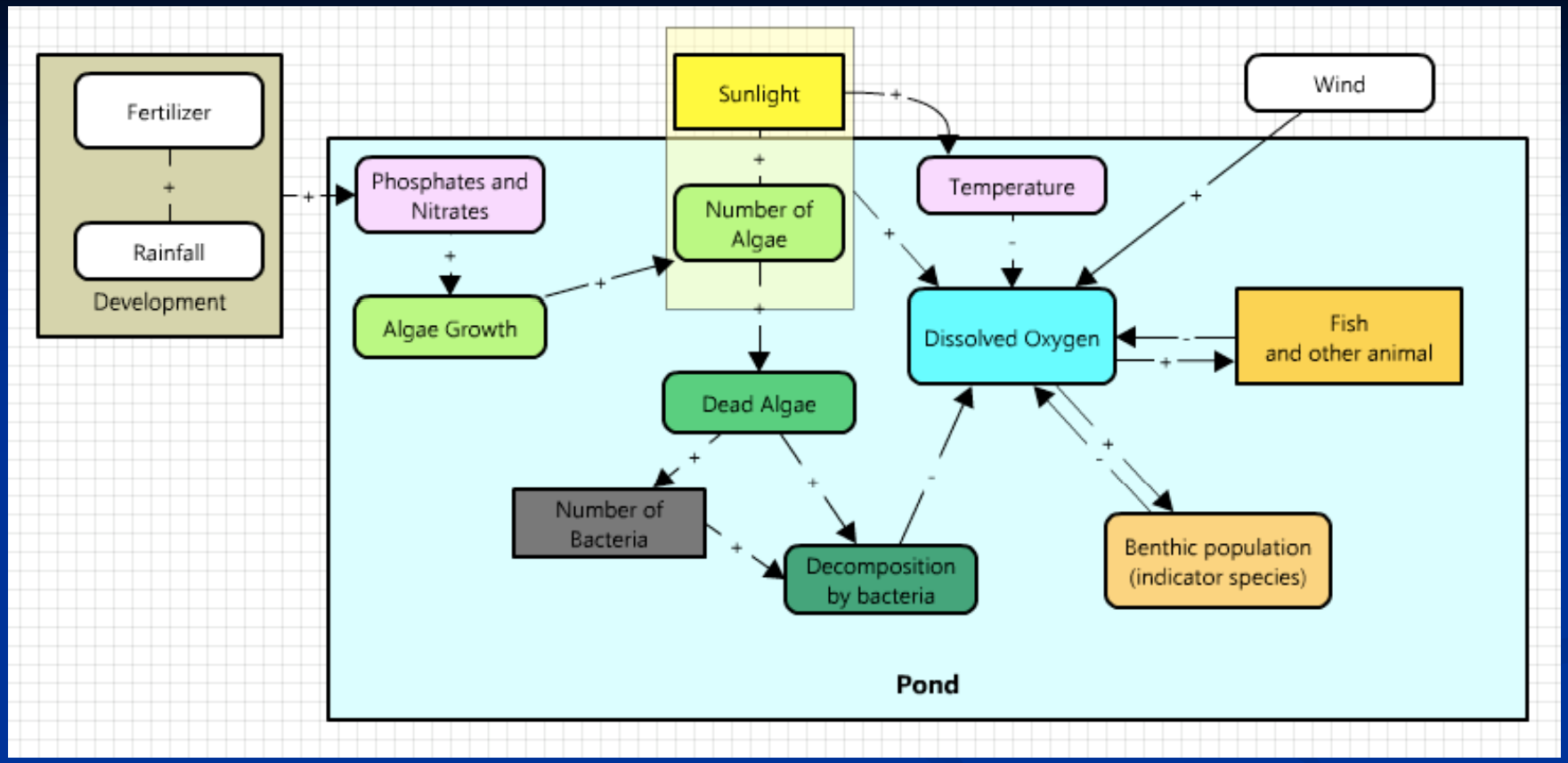
Non-Obvious Causes

Unintentional Agency

Drag | Connect | Disconnect | Check | Print | ? Field Guide

You have 13 out of 52 Connection





Interaction between Biotic and Abiotic Factors

Runoff causes increased phosphate levels, leading to increased plant growth. Plant decomposition by bacteria consumes oxygen, causing the eventual fish kill.

www.ecomuve.org

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Design-Based Research

Early pilot tests conducted in the spring of 2010 with students in 7th and 8th grade

Focus on Complex Causal Factors

- Spatially Local versus Action at a Distance
- Obvious vs. Non-Obvious Causes
- Immediate vs. Time Delayed Effects
- Event-Based versus Process-Oriented Causality

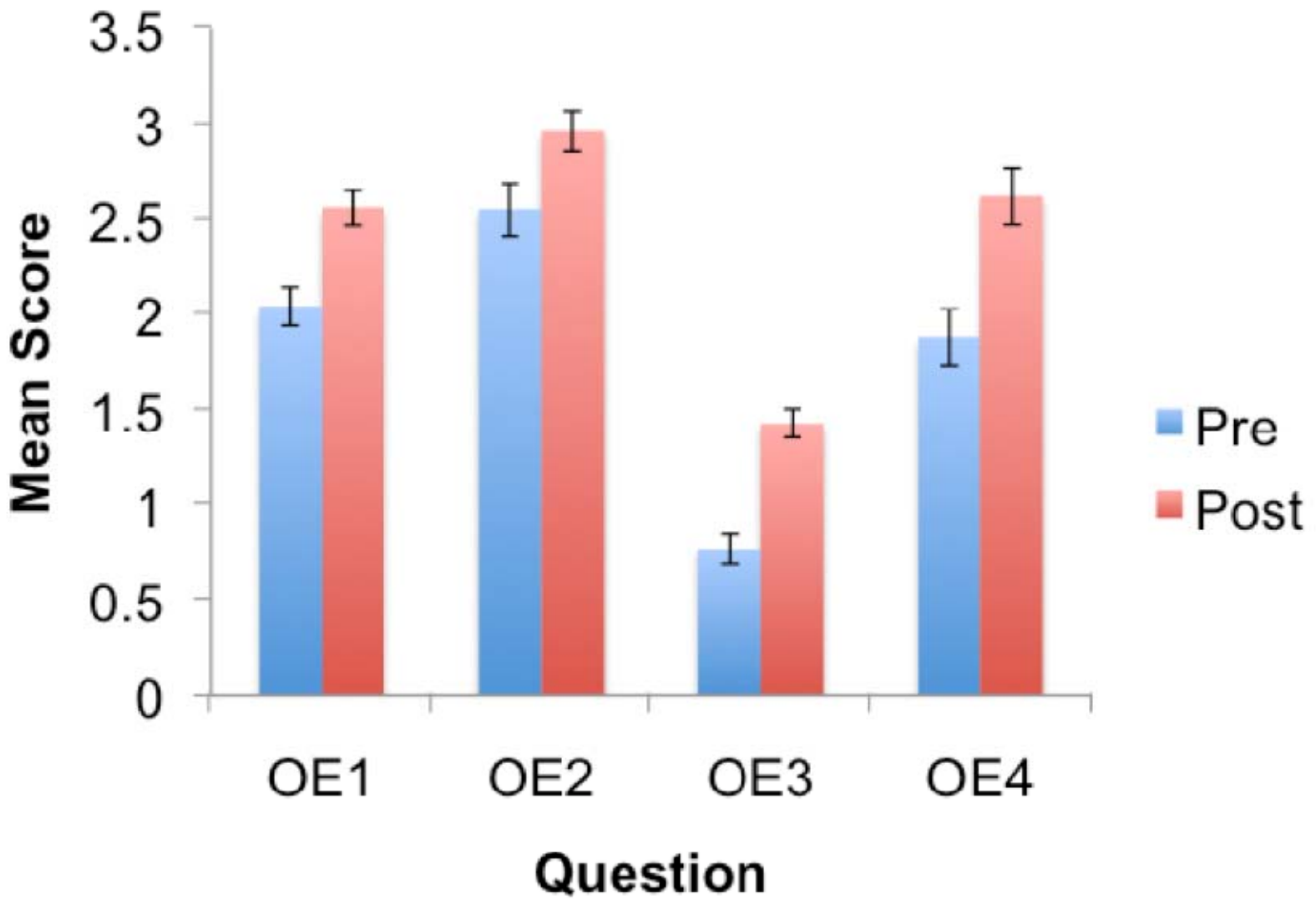
Open-ended Content Questions

OE 1.) Resources are living and non-living things that organisms use from the environment. List the resources that are used by minnows (a small fish).

OE 2.) List the resources that are used by willow trees.

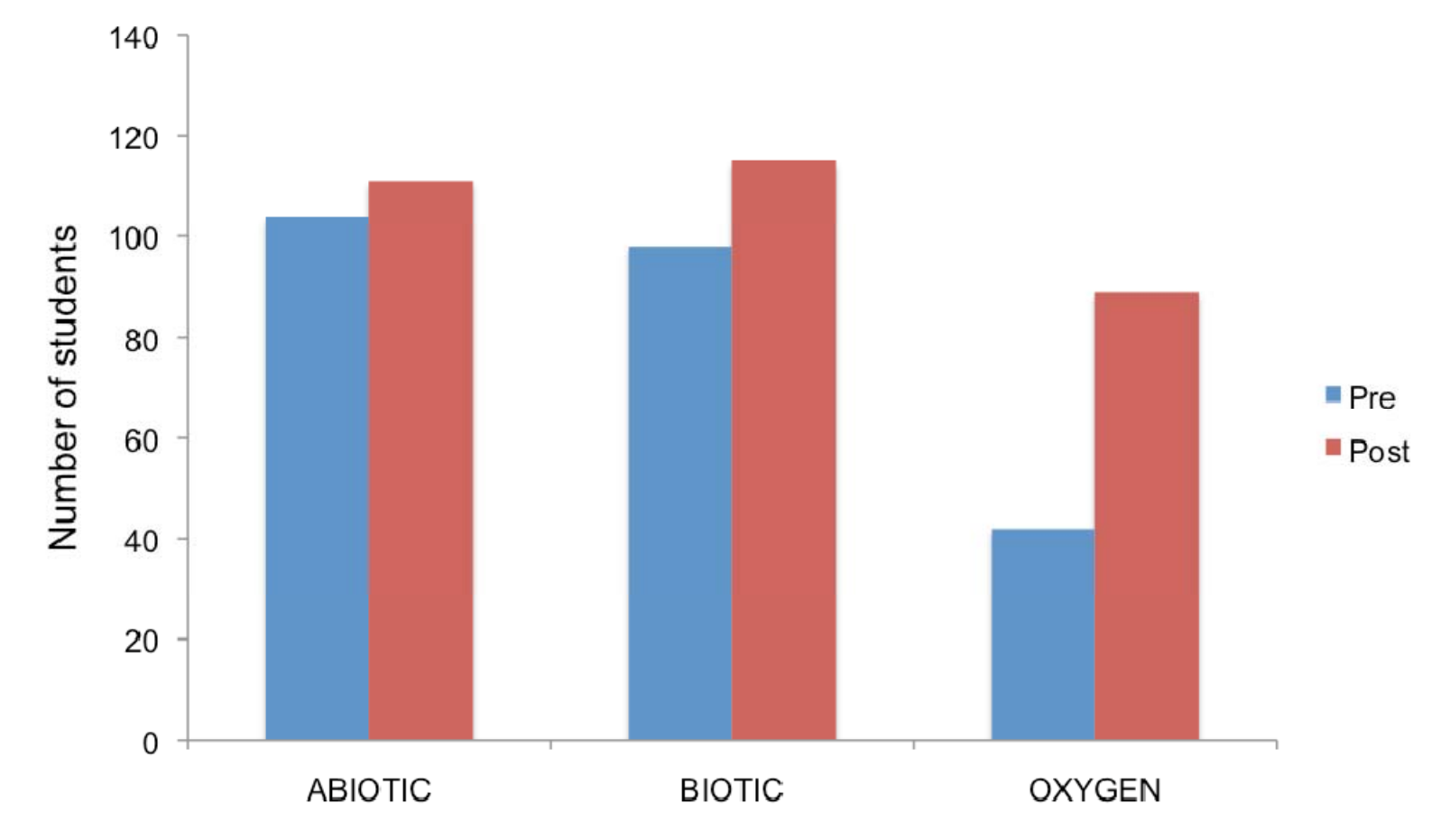
OE 3.) There are gases (like oxygen and carbon dioxide) dissolved in the water of lakes, streams and ponds. Describe at least three ways that these gases get into the water.

OE 4.) What factors in the environment might cause the number of individuals in a population to change over time? List as many as you can think of.



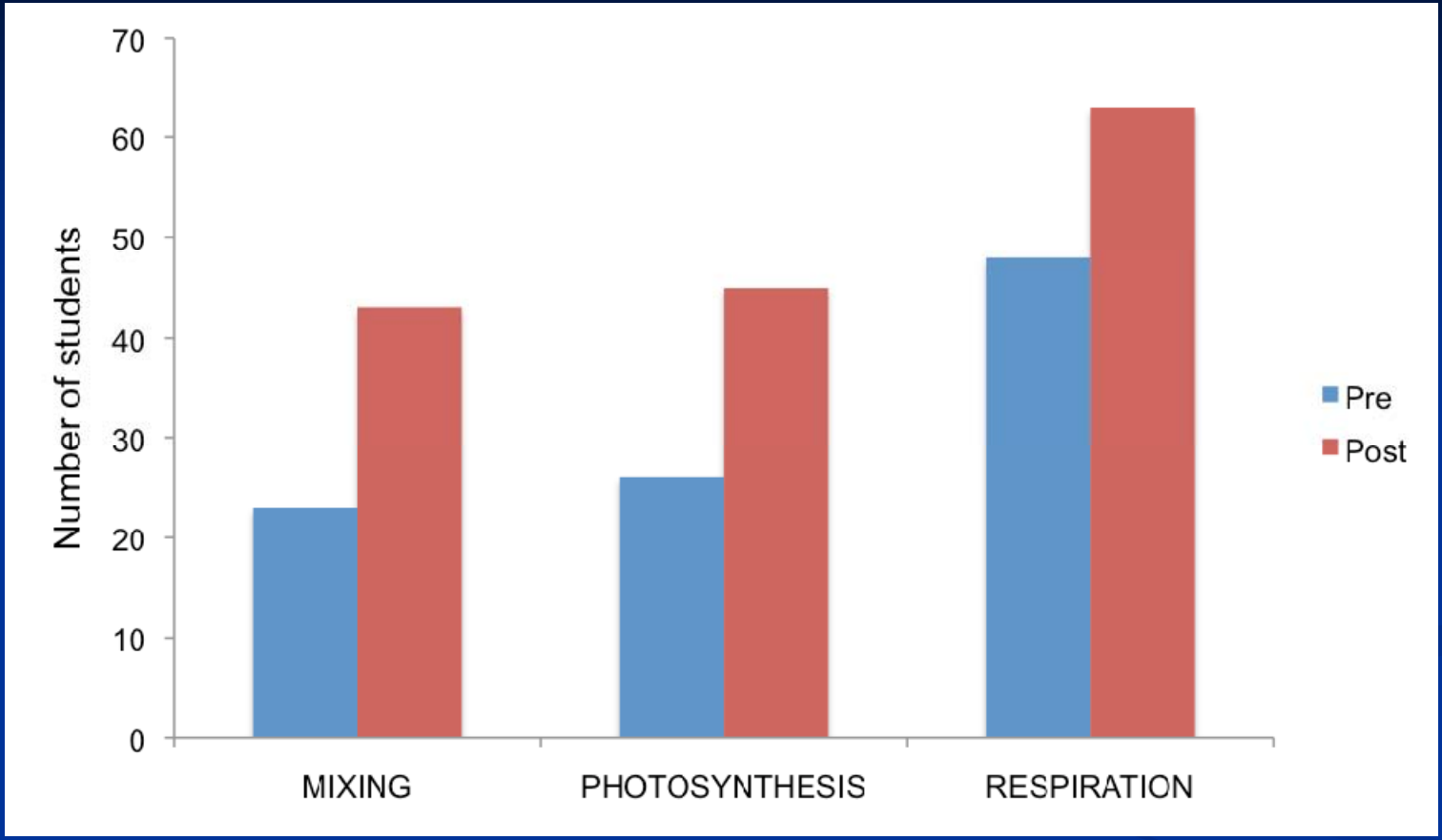
There were significant gains on open-ended questions about biotic and abiotic factors, photosynthesis, and respiration.

Specific Content Analysis



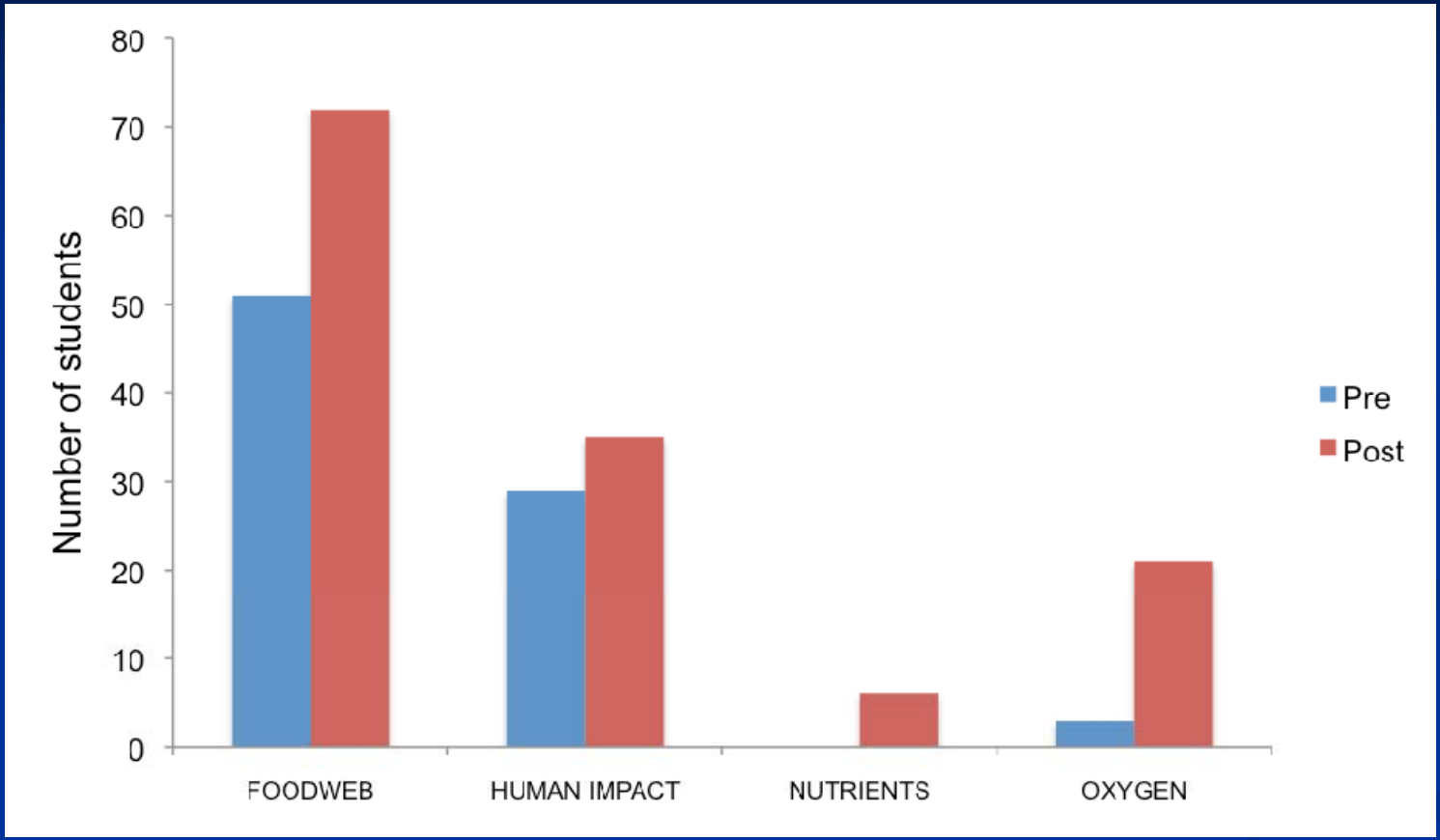
For Q1, resources used by minnows, we coded for "abiotic", "biotic", and for identifying "oxygen" by name. Responses that were coded as "biotic" or "oxygen" both significantly increased.

Specific Content Analysis



Q3 asked students to list ways that gases like oxygen and carbon dioxide get into ponds. We looked for specific responses which were covered in the curriculum: mixing from the air, photosynthesis, and respiration of aquatic organisms. All three responses increased significantly on the post-survey.

Specific Content Analysis



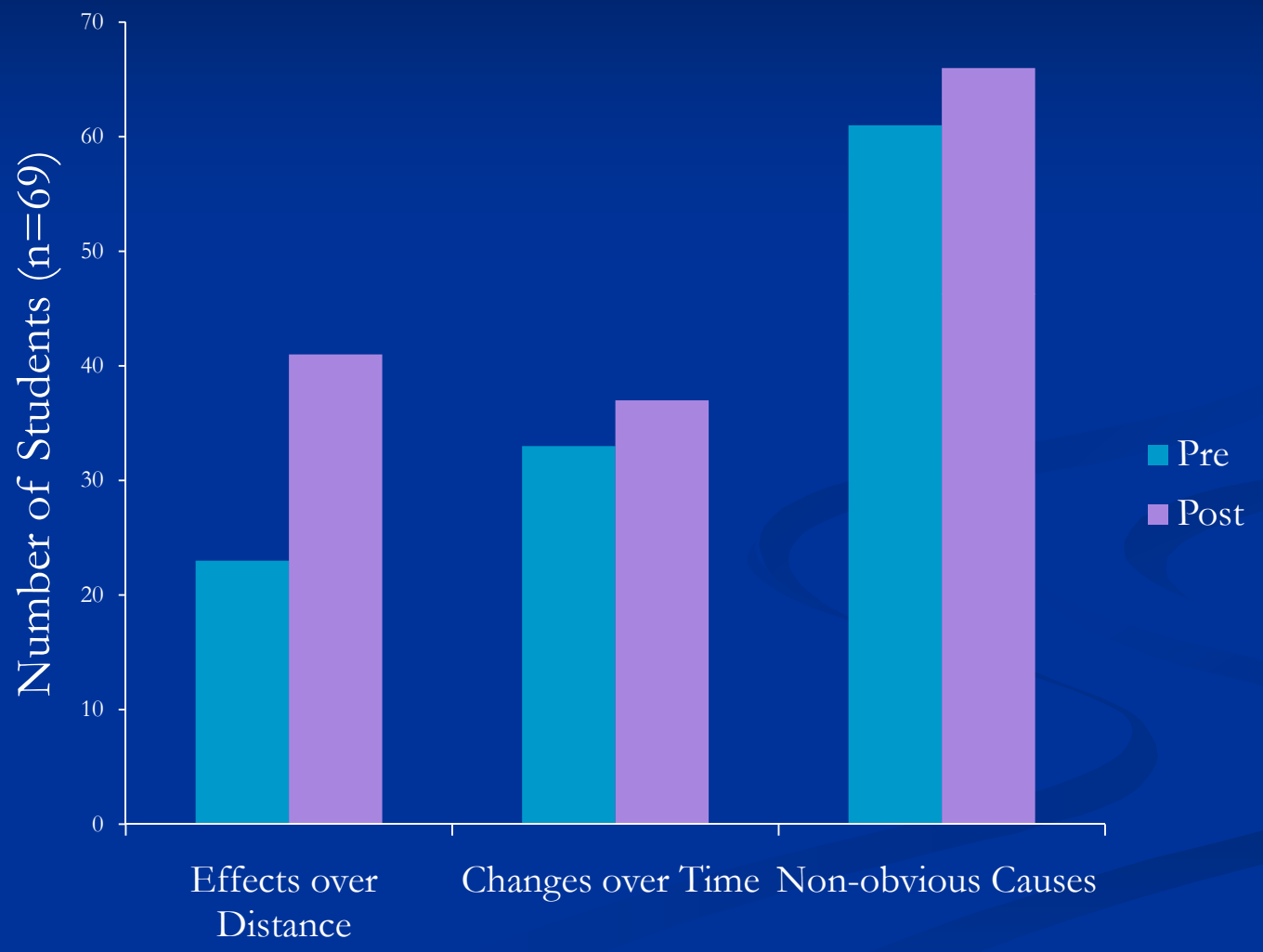
Q4 asked student to list factors in the environment that might cause a population to change over time. We looked for concepts included in the EcoMUVE curriculum: "foodweb," "human impact," "nutrients," and "oxygen". Student responses coded as "foodweb", "nutrients" and "oxygen" all increased significantly, while responses related to human impacts did not increase significantly.

Survey to Assess Changes in Causal Understanding

Each statement indicates the mayor's tendency to believe that causal agents must be 1) in close proximity to the effects, 2) temporally immediate, and 3) clearly visible. The three statements are:

- "We need to focus on the area right around the pond. The fish probably died because of something that's in the pond or right next to it."
- "We need to focus on the last couple of days. The fish probably died because of something that just happened in the last day or two."
- "We need to focus on the things that we can see. The fish probably died because of something that's obvious if we just look for it."

Changes in Causal Understanding



Design

- Seventh and eighth graders (n = 81) in three middle school classes participated in the study
- Introduced to the EcoMUVE at the beginning of the week and given an opportunity to explore it
- After an ecological problem was discovered, students took a written assessment (their initial insights into what might have happened; what patterns of inquiry they might undertake; and whether they agreed with a series of statements)
- Students continued working with EcoMUVE and at the end of the week were given a parallel written assessment.

Scoring

- The data was scored blind as to whether it was a pre- or post-assessment by removing identifying information.
- Two independent coders scored the data until they reached between 80% and 95% agreement with one coder coding 100% of the data and the other coding 25%. Remaining cases were discussed until agreement was reached.
- Part 1 answers were coded for whether they reflected causes that were/had: a) obvious versus non-obvious causes; b) local versus non-local causes; and c) event-based versus process–oriented as follows.
- Part 2 dichotomous answers were checked against written explanations and those that agreed (n = 69) were scored as agree or disagree.

Part 1 Results

The pre to post-test analysis showed significant shifts in the following categories:

- fewer spatially local explanations (mean difference = .69 ($t(77) = 3.22$, $p < .0018$);
- fewer obvious causes (mean difference = .91 ($t(77) = 7.50$, $p < .0001$);
- fewer event-based causal explanations (mean difference = .83 ($t(75) = 3.75$, $p < .0003$).

No other significant differences were found.

Sample Pretest Responses

Students talked about the importance of:

- "looking at the water" (s118);
- "finding out what was happening on the days before" (s164);
- "what happened in the last few days?" (s117).

Sample Post-test Responses

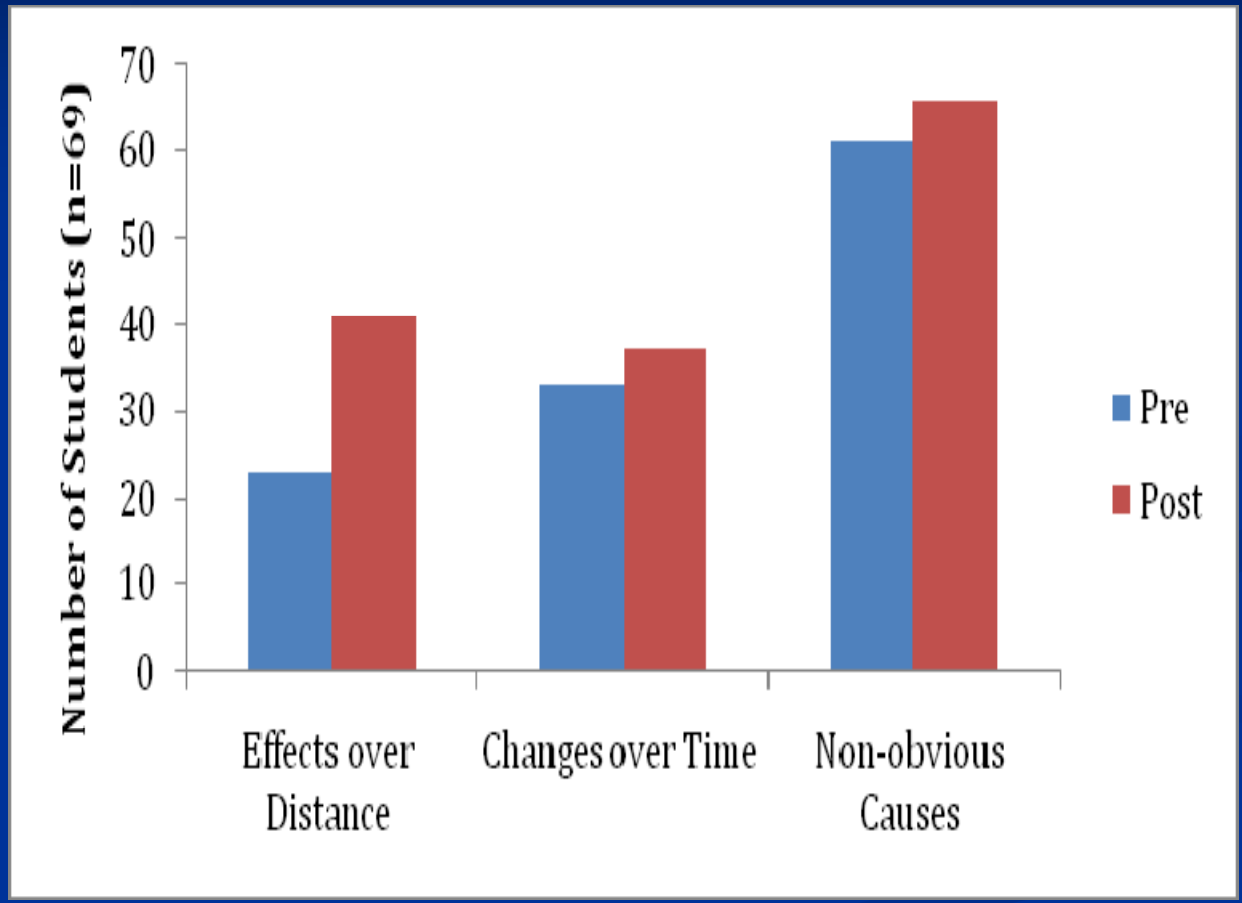
Students mentioned wanting to find out:

- Population levels: "the fish population; algae population; bacteria population; dissolved oxygen; phosphates" (s153).
- There were also answers framed more in terms of action at a distance ("acid rain; chemical gets in pond from factory; chemicals from cars in water" (s 124).

Results: Part 2 Scores

Students demonstrated significant increases in understanding the importance of effects over distance in analyzing ecosystem problems (McNemar test, $\chi2(1,69) = 14.73$, $p < .0001$). Scores on changes over time (McNemar test, $\chi2(1,69) = 1.14$, $p > 0.05$); and non-obvious causes (McNemar test, $\chi2(1,69) = 2.77$, $p > 0.05$) were not significant. (For non-obvious causes this is likely due to students' high pre-survey scores.)

Part 2 Scores: Dichotomous Data



In Summary

- The initial expected reasoning patterns were revealed for "action at a distance" and "event-based causal reasoning." Students were adept at identifying non-obvious causes (signaled by an effect.)
- The domino, narrative patterns in students' post-test explanations suggest directions for possible modifications and for how we design the teacher guide and discussion of EcoMUVE.

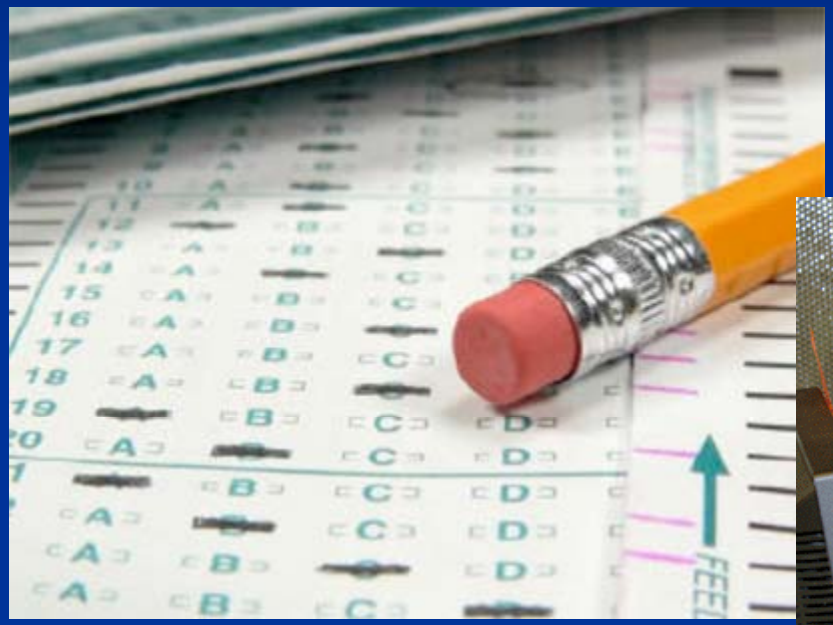
Jenkins' Framework for New Literacies

- ***Play*** — Experimenting with one's surroundings in problem solving
- ***Performance*** — Adopting alternative identities for improvisation and discovery
- ***Simulation*** — Interpreting and constructing dynamic models of real-world processes
- ***Appropriation*** — The ability to meaningfully sample and remix media content
- ***Multitasking*** — Scanning one's environment and shifting focus to salient details
- ***Distributed cognition*** — Fluently using tools that expand mental capacities
- ***Collective intelligence*** — Pooling knowledge with others toward a common goal
- ***Judgment*** — Evaluating the reliability and credibility of different information sources
- ***Transmedia navigation*** — The ability to follow the flow of stories and information across multiple modalities
- ***Networking*** — The ability to search for, synthesize, and disseminate information
- ***Negotiation*** — The ability to travel across diverse communities, discerning and respecting multiple perspectives, and grasping and following alternative norms

Leu's Characteristics of New Literacies

1. Emerging ICT tools, applications, media, and environments require novel skills, strategies, and dispositions for their effective use.
2. New literacies are central to full economic, civic, and personal participation in a globalized society.
3. New literacies constantly evolve as their defining ICT continuously are renewed through innovation.
4. New literacies are multiple, multimodel, and multifaceted.

Assessing Sophisticated Performances Based on Rich Observations



NSES Model of Inquiry

- Identify questions that can be answered through scientific investigation (not independent of knowledge)
- Design and conduct a scientific investigation
- Use appropriate tools and techniques to gather, analyze, and interpret data
- Develop prescriptions, explanations, predictions, and models using evidence
- Think critically and logically to make the relationships between evidence and explanations
- Recognize and analyze alternative explanations and predictions
- Communicate scientific procedures and explanations
- Use mathematics in all aspects of scientific inquiry

An Immersive Model

- Student takes on identity of a scientist
- Students complete quests
- 90 Minutes
- Four Phases:
  1. Orientation
  2. Problem Identification
  3. Experimentation
  4. Competing Explanations

Setting Modifiable for Experimentation

XML file for setting data values and turning on/off objects

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</asset>
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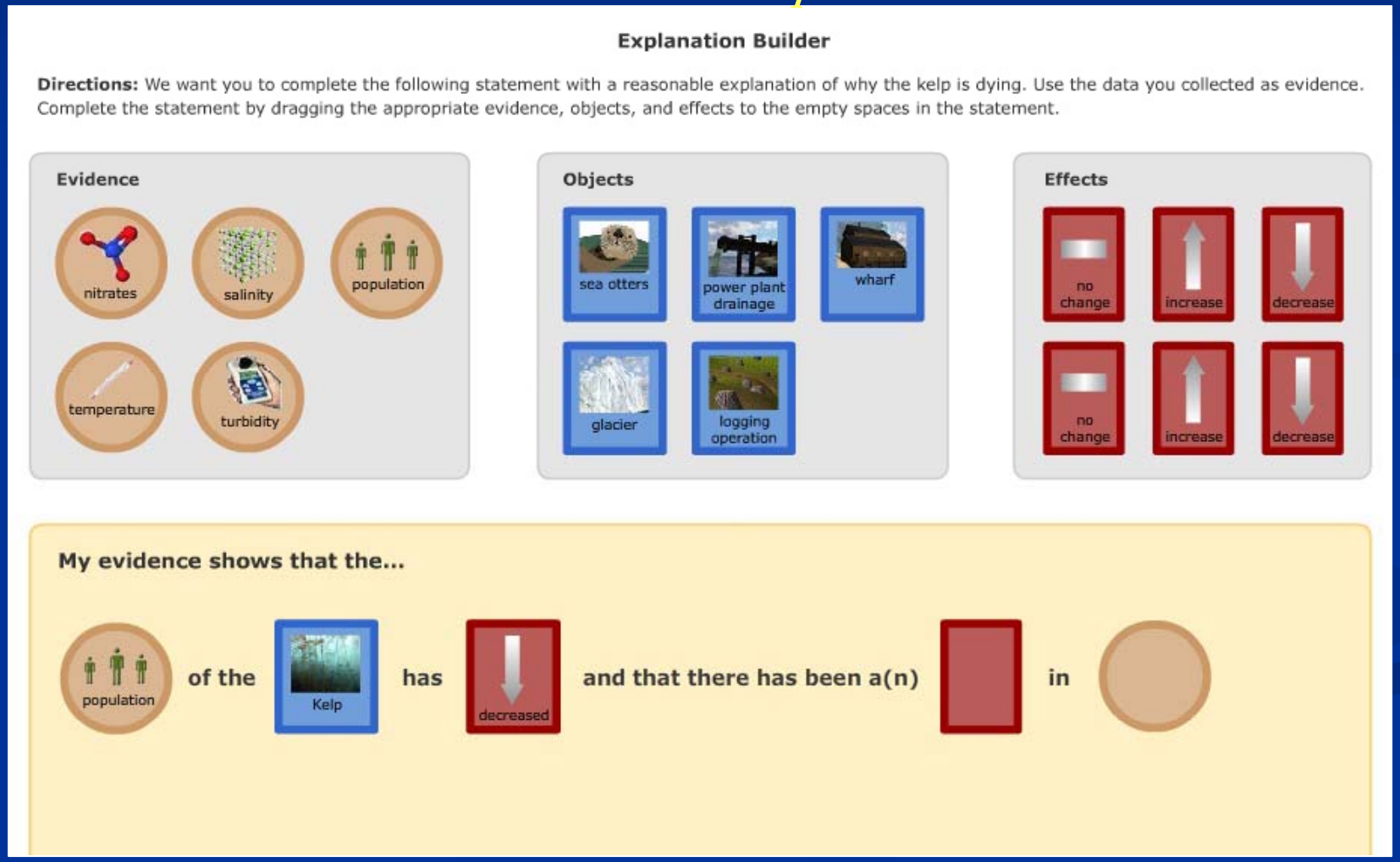
    </properties>
```

Performance Palettes for Explanation

Flash–based Performance Palettes: ***Explanation Builder***



Actions as Basis for Assessments

Logfiles Indicate 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
- What hints they accessed

http://virtualassessment.org/

Logfiles: Events, Chats, Notebooks…

Database of Logdata - Track students' behaviors: where they went, what data they collected, path to solve problem

	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	2009-12-08	0	0	0	0	1	1	102282	assessment started
3	3141592	497	1	1	2009-12-08	364	23	-76	0	2	10	102282	stage started
4	3141592	497	2	1	2009-12-08	263	10	-6	270	2	10	102282	stage started
5	3141592	497	3	1	2009-12-08	263	8	-6	270	14	1	102282	notebook opened
6	3141592	497	4	1	2009-12-08	263	7	-6	270	14	2	102282	nitrate tab clicked in notebook
7	3141592	497	5	1	2009-12-08	257	8	-397	0	143	20	102282	Arrow selection of Surface of the bay in front of the tent
8	3141592	497	6	1	2009-12-08	0	0	0	0	2	11	102282	stage ended
9	3141592	497	7	1	2009-12-08	0	0	0	0	2	13	102282	stage ended ungracefuly
10	3141592	497	8	1	2009-12-08	0	0	0	0	1	3	102282	
11	3141592	498	0	0	2009-12-08	0	0	0	0	1	1	102282	assessment started
12	3141592	498	1	1	2009-12-08	364	23	-76	0	2	10	102282	stage started
13	3141592	498	2	1	2009-12-08	263	10	-6	270	2	10	102282	stage started
14	3141592	498	3	1	2009-12-08	263	8	-6	270	14	1	102282	notebook opened
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17	3141592	498	6	1	2009-12-08	263	7	-6	270	14	4	102282	salinity tab clicked in notebook
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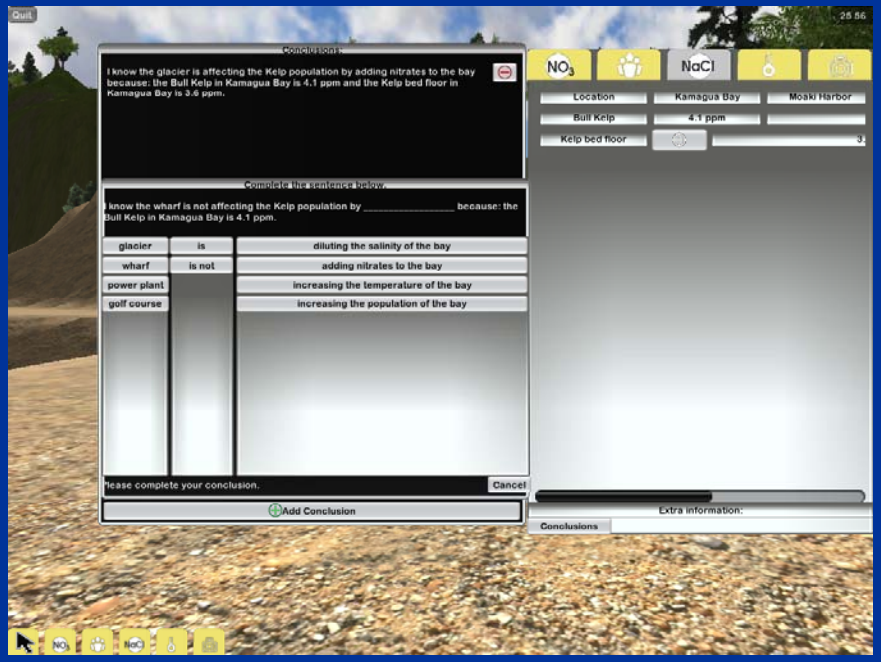
19	3141592	498	8	1	2009-12-08	263	7	-6	270	14	1	102282	notebook opened
20	3141592	498	9	1	2009-12-08	0	0	0	0	2	11	102282	stage ended
21	3141592	498	10	1	2009-12-08	0	0	0	0	2	13	102282	stage ended ungracefuly
22	3141592	498	11	1	2009-12-08	0	0	0	0	1	3	102282	
23	3141592	499	0	0	2009-12-08	0	0	0	0	1	1	102282	assessment started
24	3141592	499	1	1	2009-12-08	364	23	-76	0	2	10	102282	stage started
25	3141592	499	2	1	2009-12-08	263	10	-6	270	2	10	102282	stage started
26	3141592	499	3	1	2009-12-08	263	8	-6	270	14	1	102282	notebook opened
27	3141592	499	4	1	2009-12-08	263	7	-6	270	14	2	102282	nitrate tab clicked in notebook
28	3141592	499	5	1	2009-12-08	233	4	-5	291	3	4	102282	teleport KB kelp
29	3141592	499	6	1	2009-12-08	236	6	-4	291	2	11	102282	stage ended
30	3141592	499	7	4	2009-12-08	129	10	125	0	2	10	102282	stage started
31	3141592	499	8	4	2009-12-08	124	2	117	108	212	20	102282	Arrow selection of Striped surfperch
32	3141592	499	9	4	2009-12-08	123	0	123	0	107	22	102282	Population density reading for Bull kelp
33	3141592	499	10	4	2009-12-08	129	10	118	180	209	22	102282	Population density reading for Sea otter
34	3141592	499	11	4	2009-12-08	137	0	121	37	200	22	102282	Population density reading for Corraline algae
35	3141592	499	12	4	2009-12-08	133	0	117	0	111	24	102282	Temperature reading for Bay floor
36	3141592	499	13	4	2009-12-08	133	0	117	0	111	25	102282	Turbidity sample taken of Bay floor
37	3141592	499	14	4	2009-12-08	108	0	107	37	200	23	102282	Salinity reading for Corraline algae

Differences from Item-based Tests

Multiple Forms of Complex Measures

Products of Inquiry-
Create conclusions and select evidence

Processes of Inquiry-
Gather data and interview people



Formative/Diagnostic

- 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.

Next Generation Interfaces for "Immersive Learning"

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

January 2009 issue of *Science*

"Overlay Devices"

- Wireless mobile devices offer substantial power, at a fraction of the cost for laptops and with greater mobility
- Entertainment and learning are infused anywhere
- One-to-one person-to-device ratio becomes affordable in education

"Augmented Reality"
for entertainment and learning

1976

OFF
SET LEVEL
7 8 9 ÷
4 5 6 ×
1 2 3 −
ON 0 GO +
"LITTLE PROFESSOR"™

2011

Sony Ericsson
-03:36
Orange Girl
Aiphos

Many Mobile Devices

…and More to Come

More Mobile Devices

snapdragon™ by Qualcomm

Always-On Connectivity

All-Day Battery Life

Instant On
(NO standby/sleepstates)

Location Aware

Migration to Cloud Computing

Device Centric

Interaction with the Cloud

Resources on the Cloud

Ubiquitous Access to Personalized & Intelligent Services

Migration of Data, Apps & Services to the Cloud as Wireless Technologies Evolve

U.S. 2010 Educational Tech Plan

1. Learning
2. Assessment
3. Teaching
4. Infrastructure
5. Productivity

http://www.ed.gov/technology/netp-2010

Acknowledgements

We express our appreciation to the teachers and students who allowed us to collect data on their reasoning patterns.

Thank you to Saida Lynneth Solis and David Jeong for blind coding the data and assessing reliability between the two coders.

Our deep appreciation goes to Dr. Kathleen Weathers at the Cary Institute for Ecosystems Studies for her many contributions to the thinking behind this work.

This work is supported by the Institute of Education Sciences, U.S. Department of Education, Grant No. R305A080514 to Chris Dede and Tina Grotzer. All opinions, findings, conclusions or recommendations expressed here are those of the authors and do not necessarily reflect the views of the Institute for Education Sciences.