EcoMUVE 2011 in Chappaqua: Findings and Insights

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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

Perennial Challenges in Classrooms

- Classrooms are barren places without rich resources or ways to simulate the real world
- Students are bored compared to the many forms of engagement they have in the rest of their lives
- Teachers are the only way increasingly large numbers of students can get help personalized to their needs
- Paper and pencil, item-based assessments cannot measure deep knowledge and sophisticated skills

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"

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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 - June 2012

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.

ies NATIONAL CENTER FOR EDUCATION RESEARCH

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Design-based Research

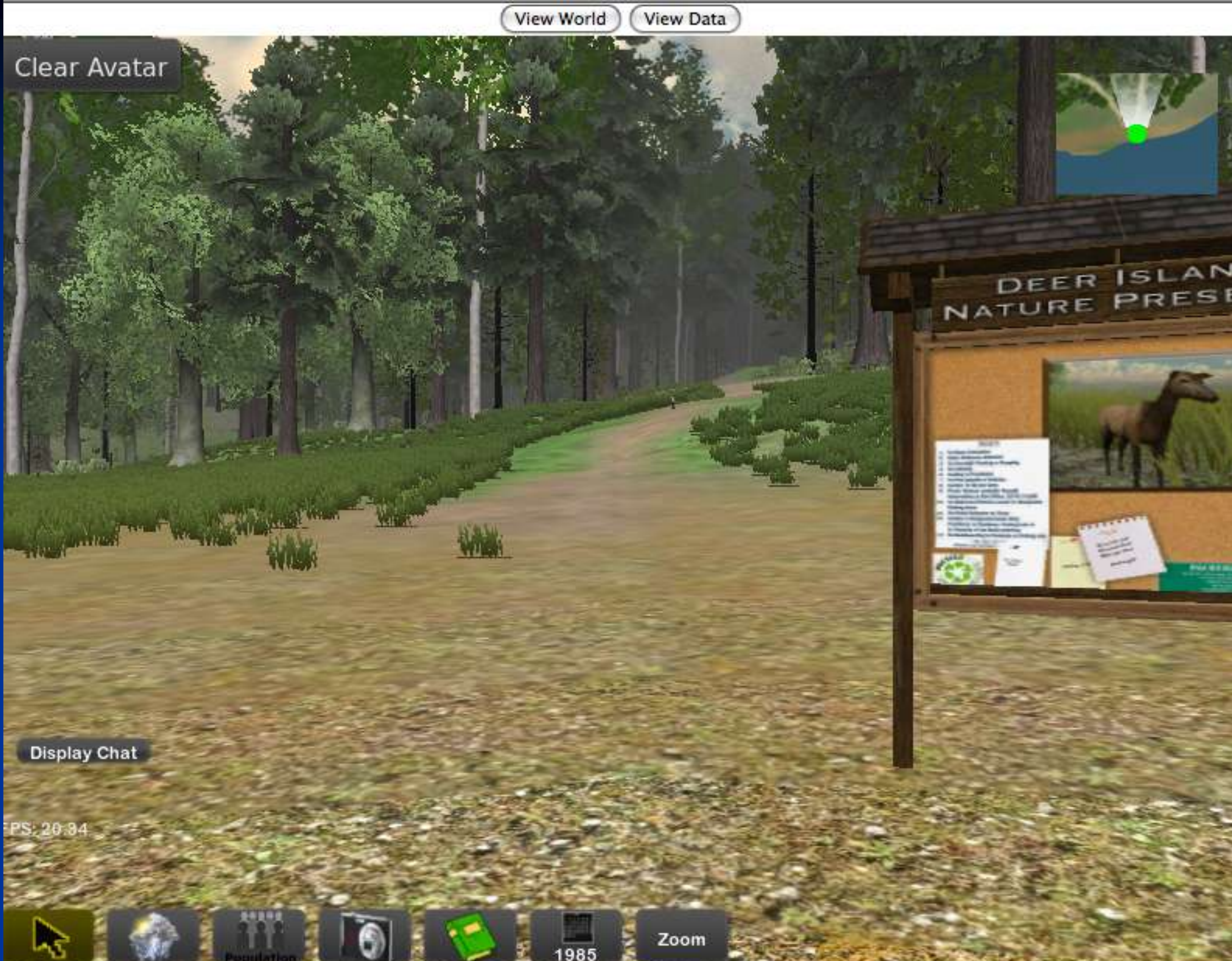
- Ecosystems have complex causal dynamics.
- Even after instruction, students often retain misconceptions.
- In our experience, MUVEs can help students engage in authentic science inquiry and gain deeper understanding.
- Our goal is to develop EcoMUVE as a MUVE that, as part of a larger curriculum, will 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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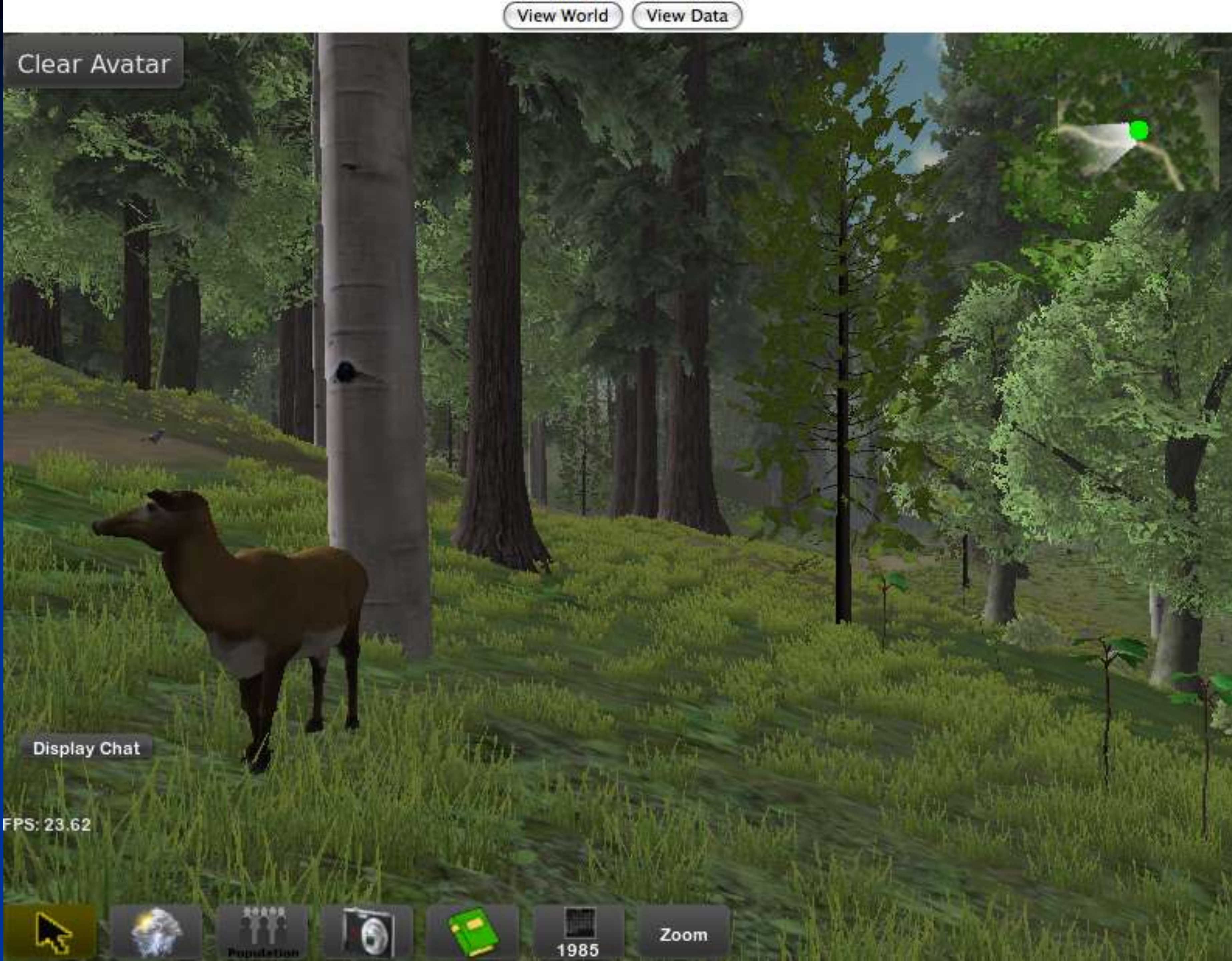
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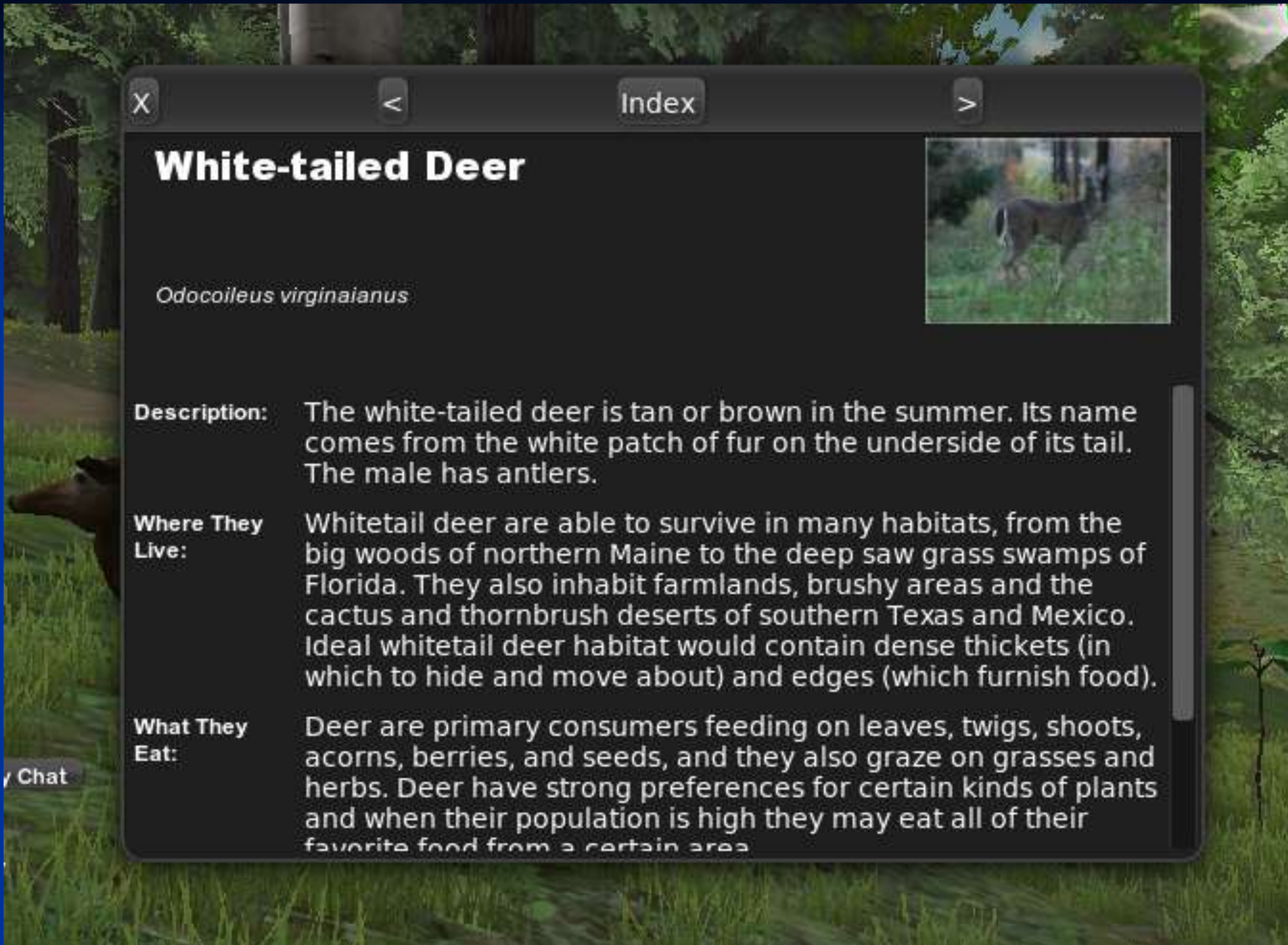
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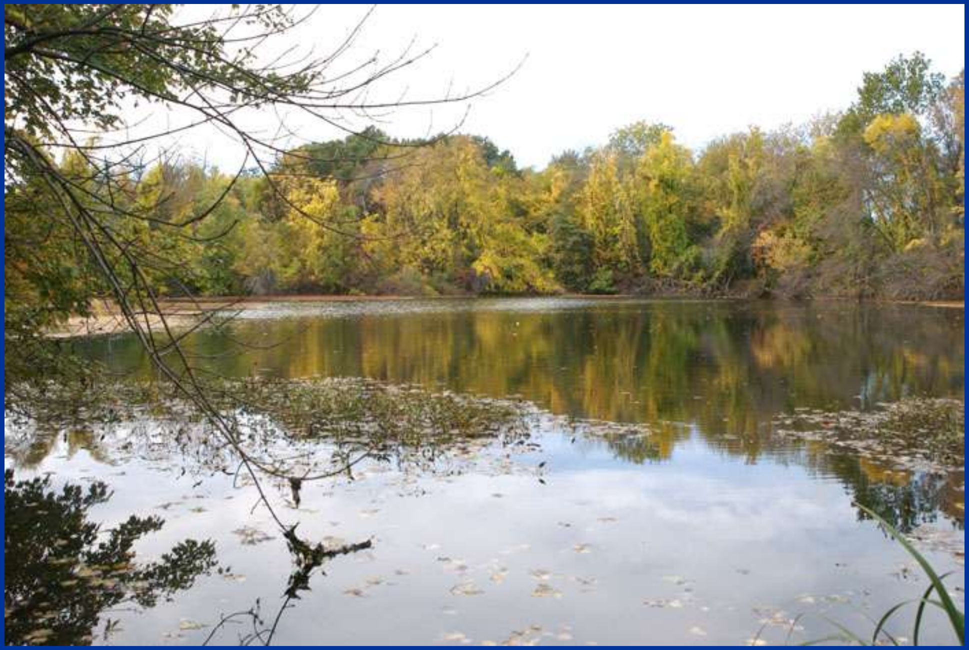
White-tailed Deer
Odocoileus virginaianus
Description:
The white-tailed deer is tan or brown in the summer. Its name comes from the white patch of fur on the underside of its tail. The male has antlers.
Where They Live:
Whitetail deer are able to survive in many habitats, from the big woods of northern 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
Chat

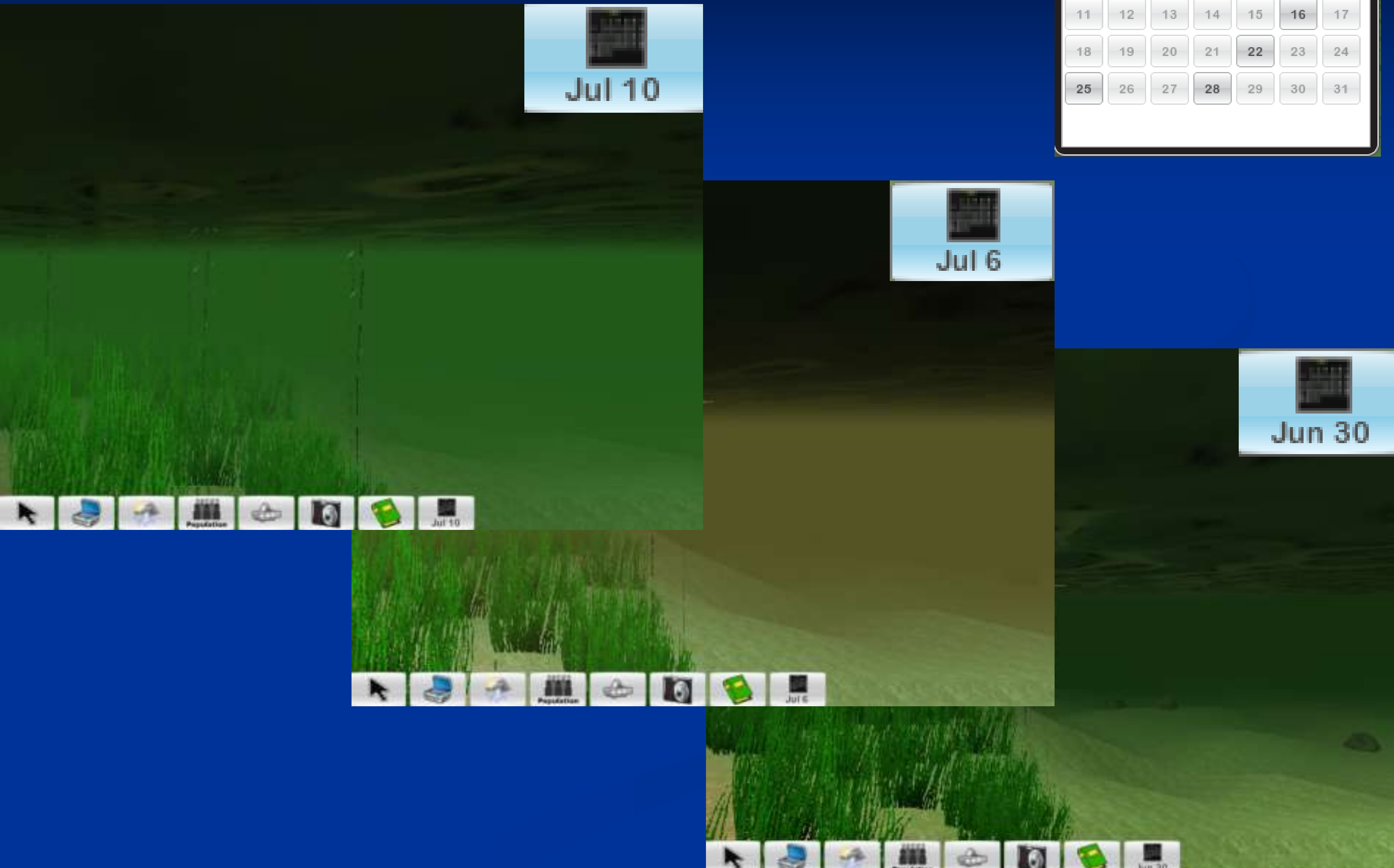

X
Field Guide
Amecian Beech
Cerulean Warbler
Chipping Sparrow
Eastern Chipmunk
Eastern Garter Snake
Eastern Tiger Swallowtail
Fly Honeysuckle
Fox
Hemlock
Indigo Bunting
Meadow Vole
Ovenbird
Pileated Woodpecker
Quaking Aspen
Rabbit
Red-backed Salamander
Red-tailed Hawk
Speckled Alder

Module 1: Pond Ecosystem

Modeled after Black's Nook Pond in Cambridge, MA



Change over Time



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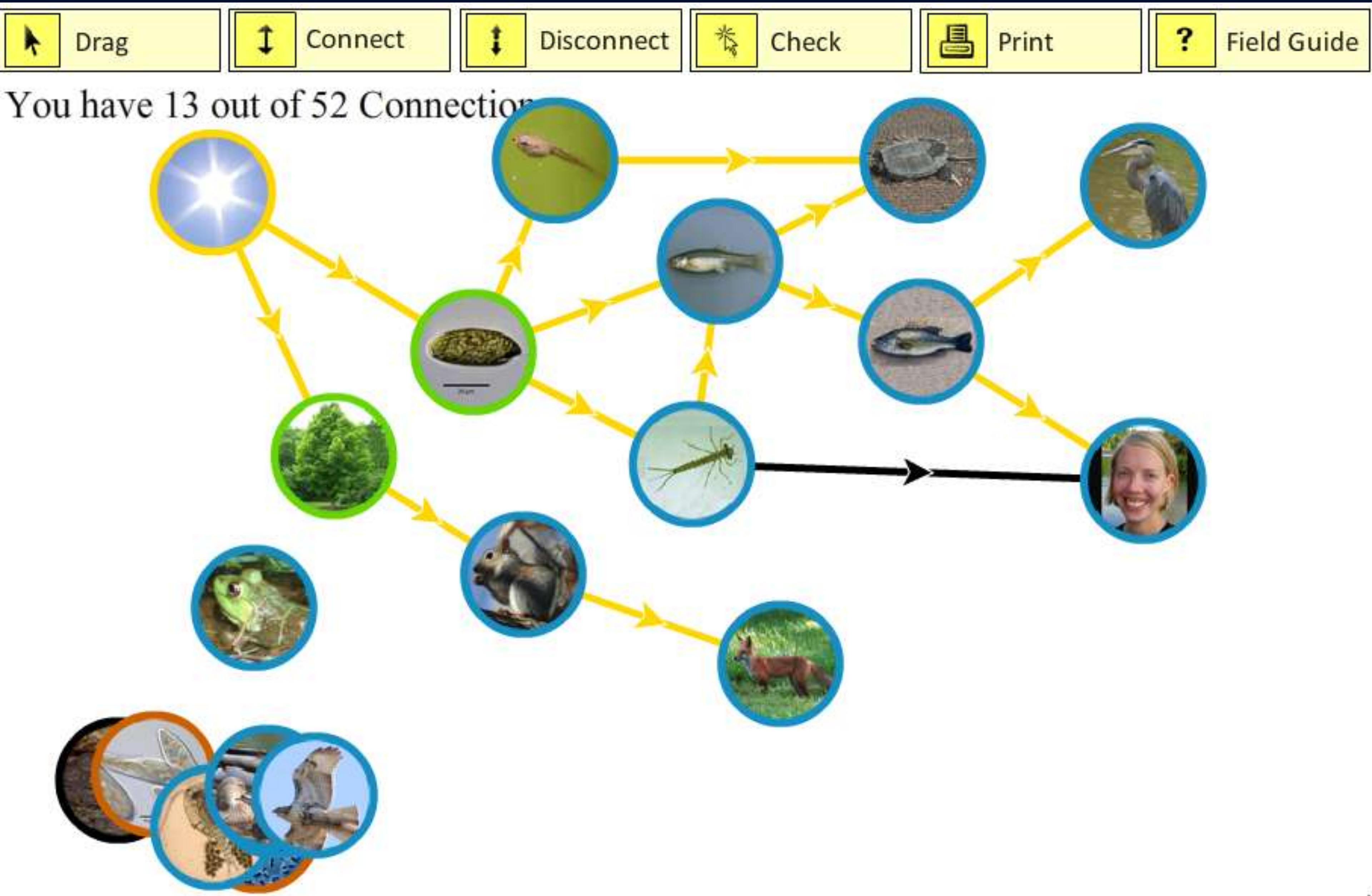
Non-Obvious Causes

Unintentional Agency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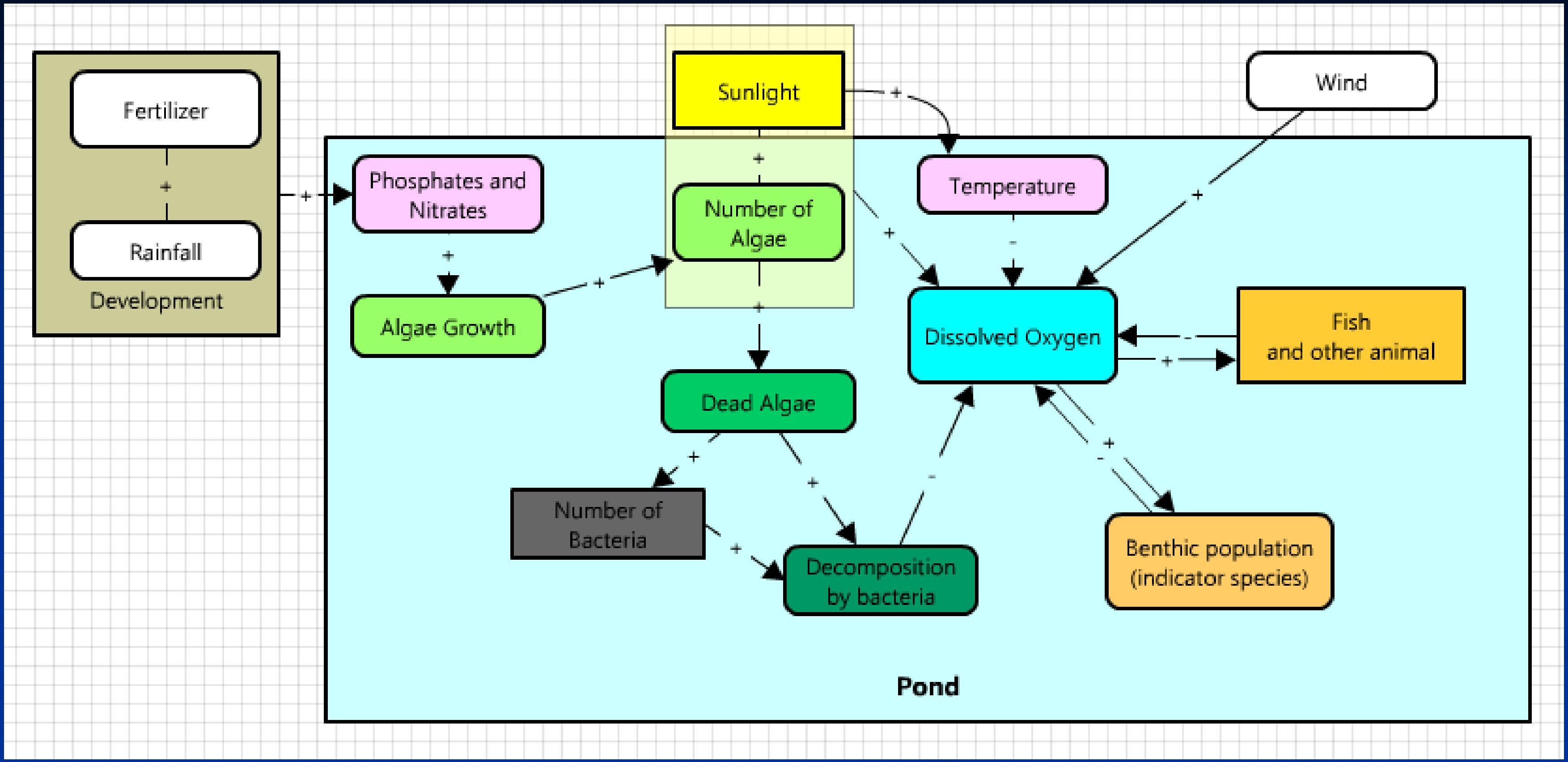


Interaction between Biotic and Abiotic Factors

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

www.ecomuve.org


Settings
DELL
OPTIPLEX 780

	EcoMUVE	Comparison Curriculum (modified version of Environmental Detectives by Lawrence Hall of Science)
Problem-based	why did the fish die	why did the fish die
Understanding changes over time	Time travel to different virtual dates	Timeline activity
Understanding action at a distance	Explore virtual landscape with avatar	Observe landscape features on a 2-D map
Incorporation of non-MUVE tech	Food web tool, Learning Quests	Food web tool, Learning Quests
Team work	Jigsaw pedagogy – each student has a role	Student work in teams and split tasks during the laboratory activities
Multiple forms of evidence	Tacit experiences in virtual world allow observation of the pond; data collection and graphing; talking to characters	Hands-on laboratory activities, data collection and graphing; clues from "suspects"
Representations of learning	Concept maps, graphs, oral presentation	Concept maps, graphs, oral presentation

Results from Chappaqua: Gains in Content Understanding

- Gains in overall content understanding were significant for both EcoMUVE (pre_mean = 20.1, post_mean = 22.4, p-value < 0.001,) and the comparison curriculum (pre_mean = 19.5, post_mean = 20.4, p-value = 0.03)
- Effect size was greater in EcoMUVE (0.65 compared to 0.23)
- Gains were specifically seen in:
  - Understanding of ecosystems processes like respiration
  - Understanding of water quality variables like chlorophyll, turbidity, phosphates, and nitrates

Results from Chappaqua: Positive gains in Affective Measures

Gains in affective measures were observed in both the EcoMUVE (3.5 -> 3.7, p-value < 0.001) and comparison curriculum (3.6 -> 3.8, p-value = 0.002).

- EcoMUVE: “I am interested in learning about plants and animals.”
- EcoMUVE: “I think that it is important for me to learn about ecosystems.”
- EcoMUVE & CC: “I am able to figure out the reasons why things happen in nature.”
- EcoMUVE & CC: “I understand what scientists do to study ecosystems.”
- CC - “I think that it is important for *everyone* to learn about ecosystems.”
- CC - “It is important to take measurements of ecosystems all the time.”

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

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 they took 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
15	3141592	498	4	1	2009-12-08	263	7	-6	270	14	2	102282	nitrate tab clicked in notebook
16	3141592	498	5	1	2009-12-08	263	7	-6	270	14	3	102282	pop density tab clicked in notebook
17	3141592	498	6	1	2009-12-08	263	7	-6	270	14	4	102282	salinity tab clicked in notebook
18	3141592	498	7	1	2009-12-08	263	7	-6	270	14	2	102282	nitrate tab clicked in notebook
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
38	3141592	499	15	4	2009-12-08	133	0	117	0	111	21	102282	nitrate reading for Bay floor

Differences From Item-based Tests

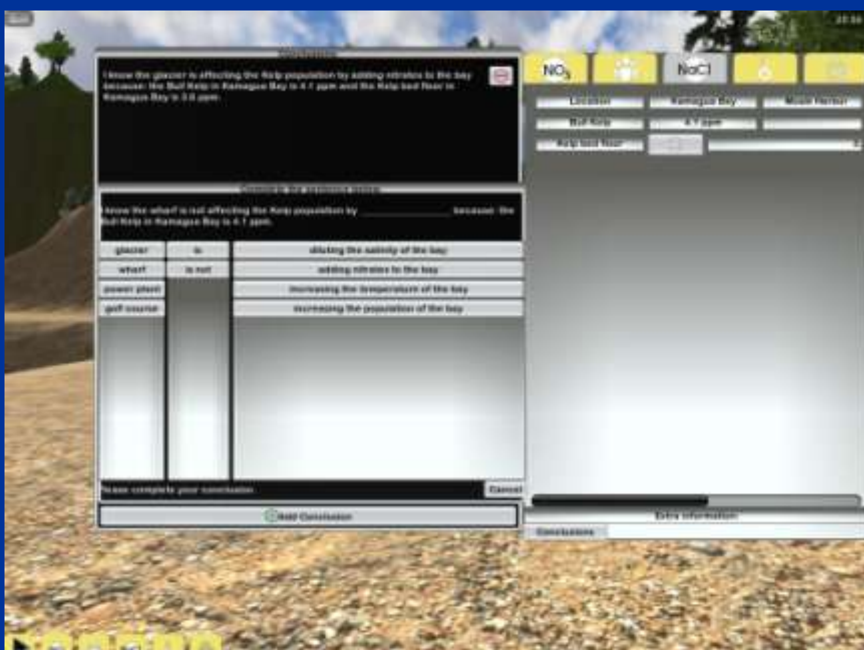
Multiple Forms of Complex Measures

Products of Inquiry

Create conclusions and select evidence.

Processes of Inquiry

Gather data and interview people.



Formative and 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.

Teacher Perceptions - Overview

After using EcoMUVE, teachers felt that the curriculum was feasible, well-aligned with standards, and supported student engagement and learning of science content, complex causality, and inquiry.

Survey of teachers participating during Spring 2011 (n=16).

	Average Rating
Engagement	4.3
Science content learning	4
Complex causality learning	4.1
Inquiry learning	4.3

Average rating of EcoMUVE curriculum on four criteria on a scale of 1-5 (5=excellent, 4=good, 3=medium, 2=fair, 1=poor).

Teacher Perceptions - Chappaqua

- I see EcoMUVE as an excellent short curriculum and as I have mentioned previously, I think it could be an incredible project-based assessment opportunity for students. – Teacher A

- The EcoMUVE curriculum fits perfectly with our 8^{th} grade curriculum on the local level, the objectives were appropriately accessible to most students and it meets the curricular standards of critical thinking, ecosystem dynamics and relationships, and interpreting graphic trends. – Teacher B

- I think it went very well. I think it was well-received by the students. I think that very valid and good learning took place. – Teacher C

Teacher Feedback

Chappaqua teachers were very helpful in suggesting changes to the software and the curriculum. For example:

- Reinforcing connections in the graph view of abiotic vs. biotic factors.
- Posting teams' concept maps around the room and using a "gallery walk" for students to see and critique each other's hypotheses.
- Revising the atom tracker activity.
- Avoiding too much repetitive data collection, especially in the forest module.

Participation in Future Years

All of the Chappaqua teachers expressed interest in using EcoMUVE again, if they continue to teach science.

Teacher C in particular expressed interest in extending the curriculum:

"If I had this whole program to do again, but wasn't doing it with a comparison curriculum so I needed to keep a time frame, I could easily see adding a couple of weeks to it, and putting in enough of my own embellishment, that would make it an excellent vehicle for teaching what I've normally taught. ."

(Conner Flynn)

EcoMUVE is going Mobile

http://ecomobile.gse.harvard.edu

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2011

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"

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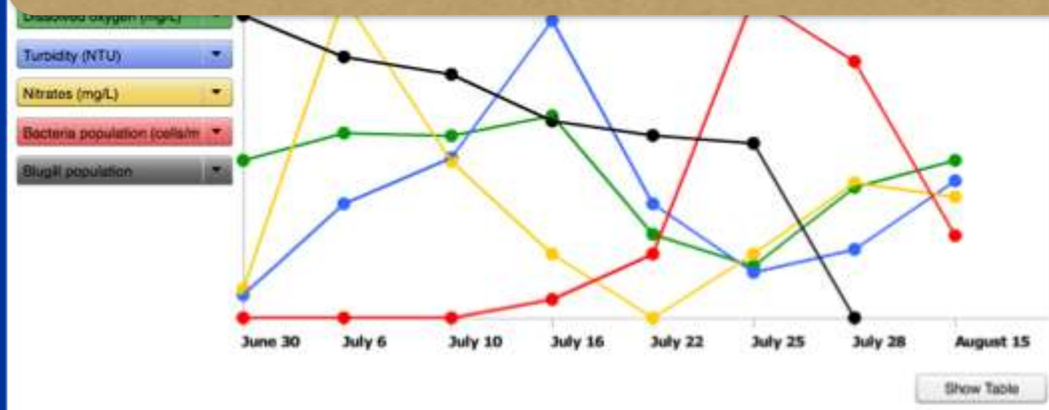
上環
九龍(西)
西
W
康樂廣場
機場快綫站
愛丁堡廣場
九龍


Sheung Wan
Kowloon (W)
Connaught Place
Airport Express Station
Edinburgh Place
Kowloon

Texas Instruments NSpires with Vernier Environmental Probes




678k
TALK
INFO
Beds: 4 Baths: 2.5
Floors: Hardwood, Carpet
Walkable Rating: 98
(Zonkio.com)


BLACK'S NOOK
C
GOLF COURSE
EXISTING PINE GROVE
C
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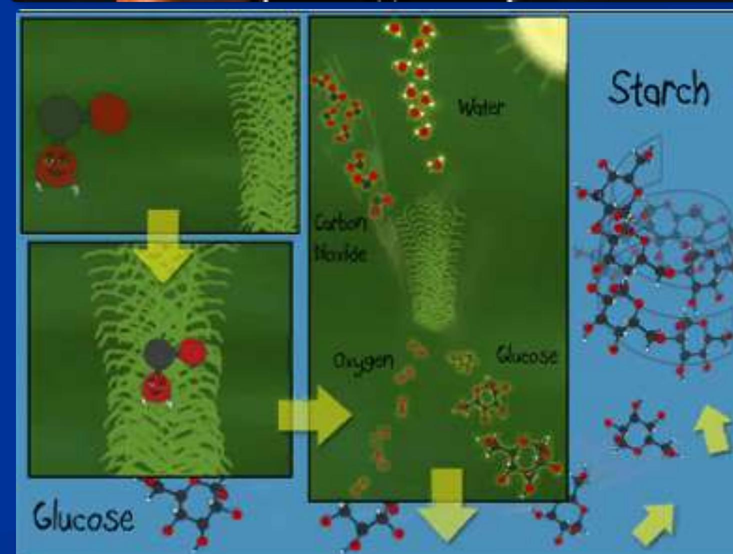
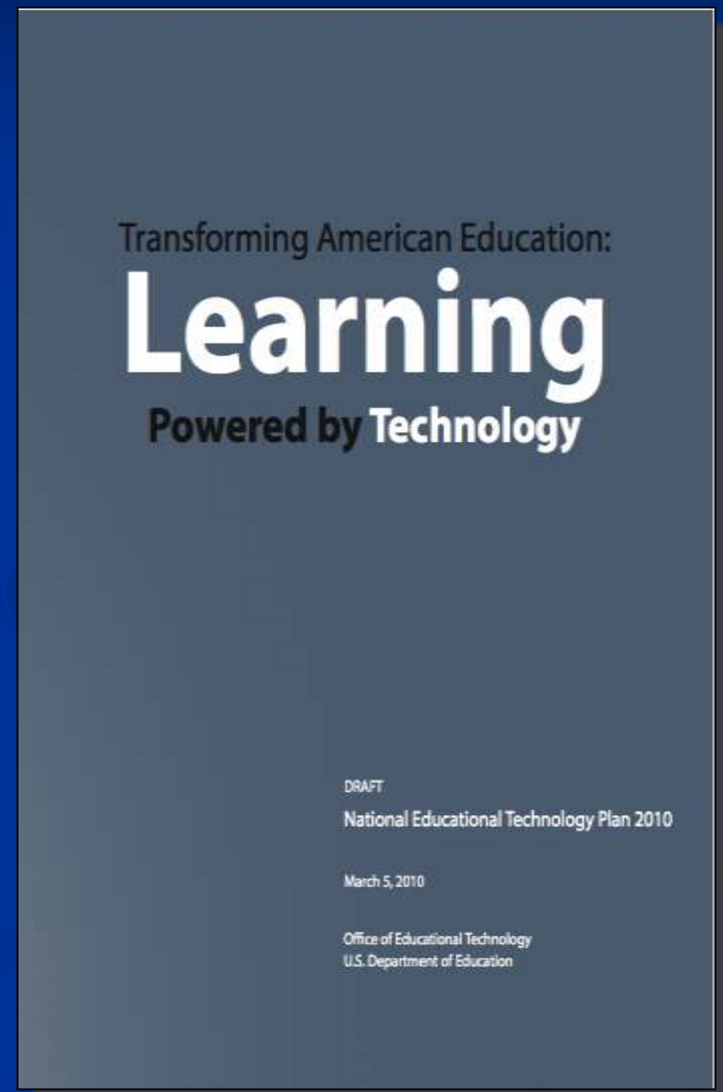

Water
Carbon Dioxide
Oxygen
Glucose
Starch
Glucose

The 2010 NETP

- Response to Congressional mandate for five-year plan for educational uses of technology
- Plan for *transforming* education with technology in response to urgent need to remain competitive in a global economy
- Reflection of increased understanding of how to support learning and of growing capabilities enabled by technology



Policy Barriers and Enablers

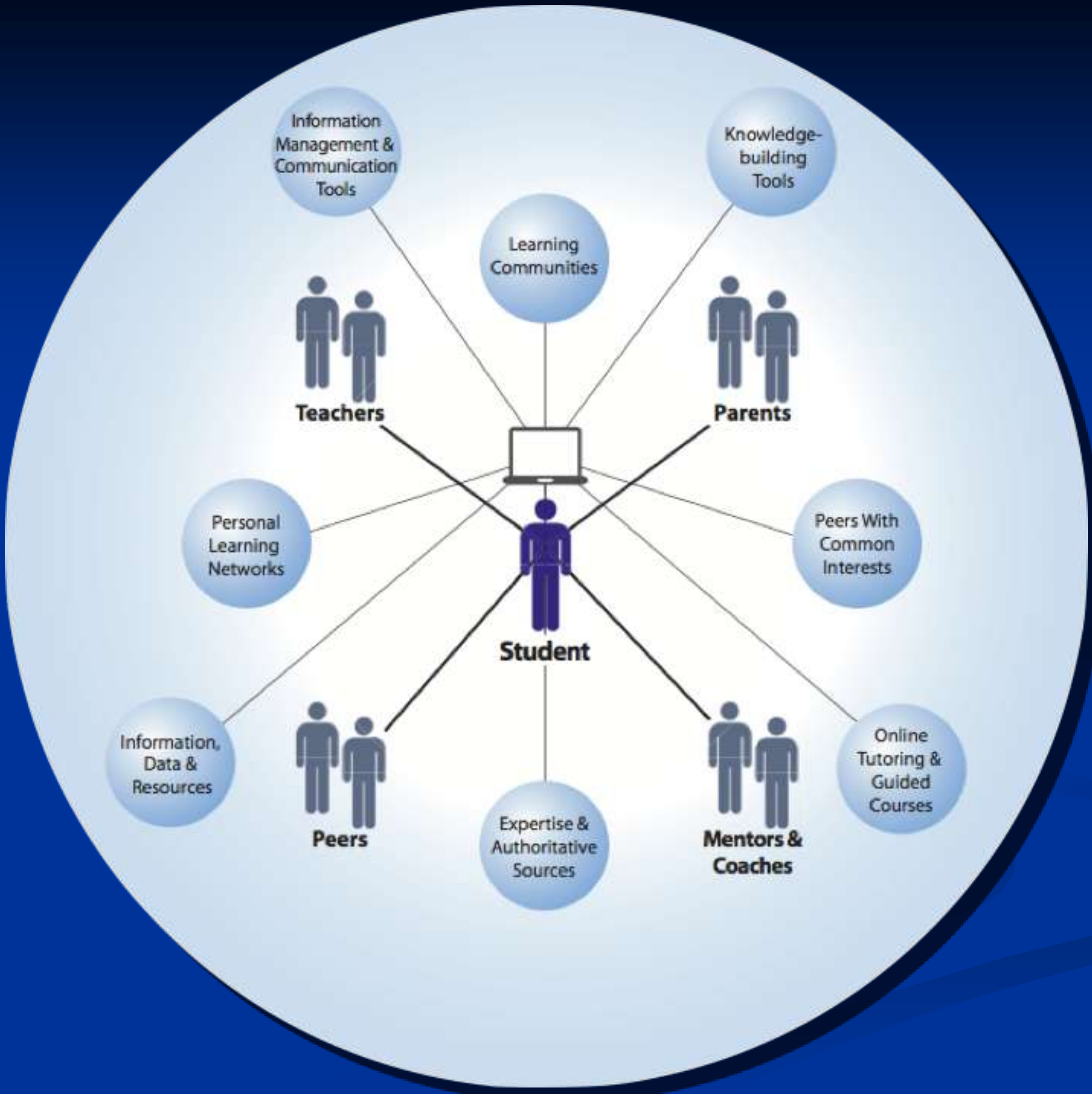
Teaching

Assessment

Infrastructure

Productivity

Learning


Information Management & Communication Tools
Knowledge-building Tools
Learning Communities
Teachers
Parents
Personal Learning Networks
Peers With Common Interests
Student
Information, Data & Resources
Peers
Expertise & Authoritative Sources
Mentors & Coaches
Online Tutoring & Guided Courses