Learning Complex Systems
Some core challenges

A curriculum for teaching complex systems

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Preview of the Next Hour

- Introduction and A Few Prototypical Examples (Mini-Lecture) (~15 min.)

- Generating Examples of Each Complex Causal Pattern or Feature (Small Groups) (~20 min.)

- Applying the Concepts to Teaching and Learning: Two Examples (~20 min.)

- Connecting Forward (~2 min.)

We make hundreds of decisions everyday that hinge on our notions of how cause and effect behaves.

Most of the time we do fairly well….

Back to the 1950s…
People in Borneo were suffering from malaria. The World Health Organization sprayed DDT to kill the mosquitoes that carried the malaria. The mosquitoes died and malaria declined. Soon, the thatched roofs of the houses began to cave in. The DDT also killed a parasitic wasp that had controlled thatch-eating caterpillars. DDT-poisoned insects were eaten by geckoes which in turn were eaten by cats. The cats died, rats flourished, and there were outbreaks of sylvatic plague and typhus. In response, the World Health Organization parachuted live cats into Borneo.

“If you want to understand nature, you must be conversant with the language in which nature speaks to us.”

-Richard Feynman


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Environmental justice will be one of the defining issues of our time.

Default assumptions about the patterns and features of causality limit our ability to perceive, attend to, and reason about causal complexity.

Causal Default Assumptions

1. linear (vs. non-linear)
2. direct (vs. indirect)
3. unidirectional (vs. bi-directional)
4. sequential (vs. simultaneous)
5. obvious (vs. non-obvious)
6. active or intentional agents (vs. non-agentive)
7. event-based (vs. processes or steady states)
8. deterministic (vs. probabilistic)
9. local (vs. spatially distant)
10. immediate (vs. delayed)
11. centralized (vs. decentralized/distributed)

Chernobyl: An Interaction Between Reactor Design and Human Reasoning About Causal Complexity

- Managing events as opposed to the state of the system.
- Monitoring the moment rather than the dynamic.
- Overriding safety features- Deterministic vs. Probabilistic Causality
- Extended domino patterns
- Immediate and delayed effects
- Obvious and nonobvious causes and effects.
- Far and long reaching impact

Action at a Distance Research

- Infants expect physical contact between causes and effects and show puzzlement to "action at a distance" --Shadow Research by Spelke and colleagues.

- Students tend to expect causes and effects that are close together in space and time (but knowledge of mechanisms also plays a role.)

Action at an Attentional Distance

Even if we realize that causes and effects can be separate in space and time, we have to overcome the attentional gap.

We tend to miss effects that happen at a distance from their causes. We may not realize that they are linked and even if we do, we find it difficult to attend to them.

Working with two classmates, consider three of the causal features on the sheet.

- Try to generate two examples of each.

- Try to make the examples as different as possible.

- Track any puzzles that arise as you are generating examples.

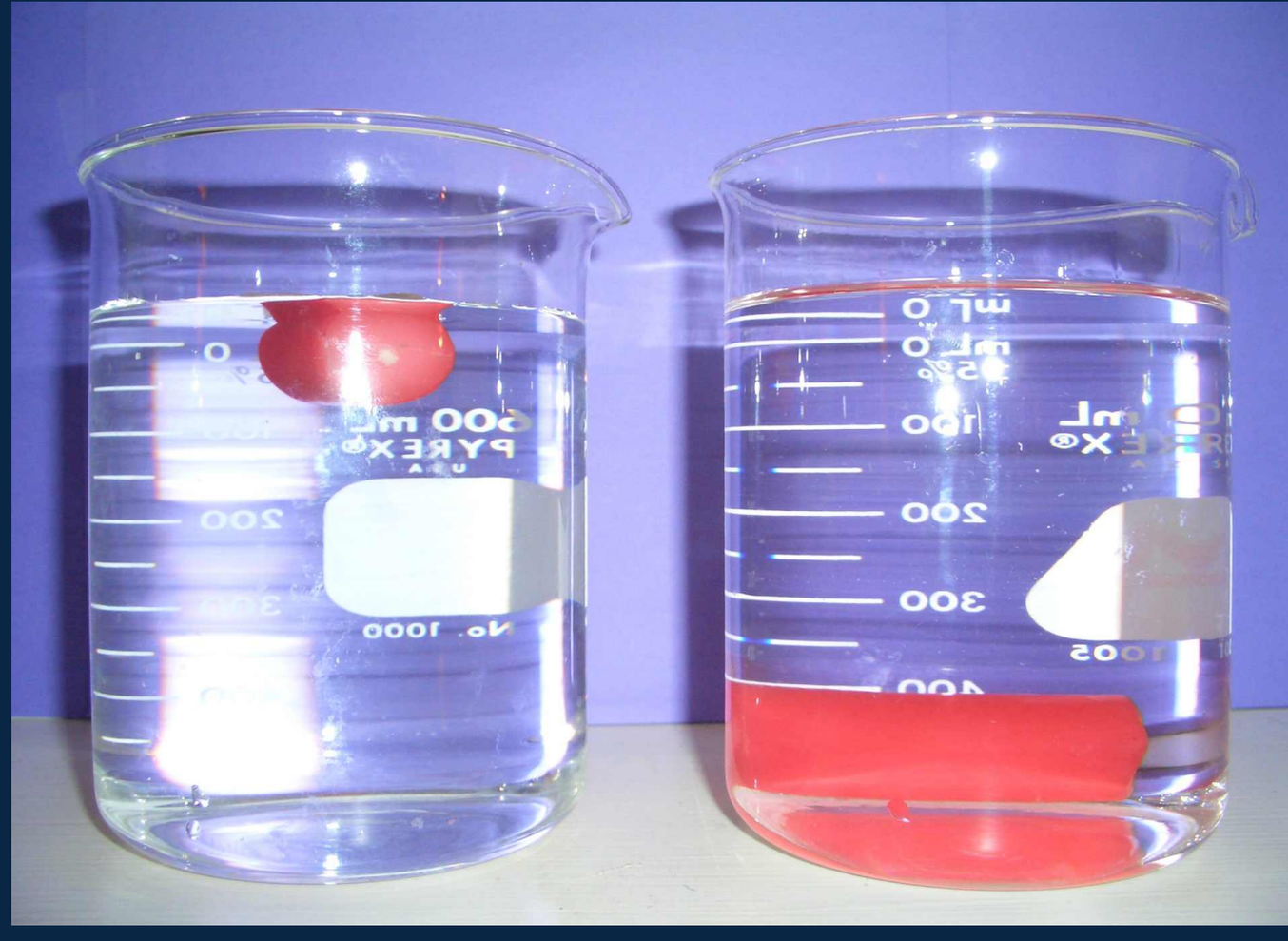
>We will jigsaw so the groups are focused on different sets.

Applying the Concepts to Examples of Learning and Teaching

How do we help learners perceive, attend to, and reason well about complex causal features?

Examples of Learning and Teaching

What is going on when an object sinks or floats?




200
No. 1000
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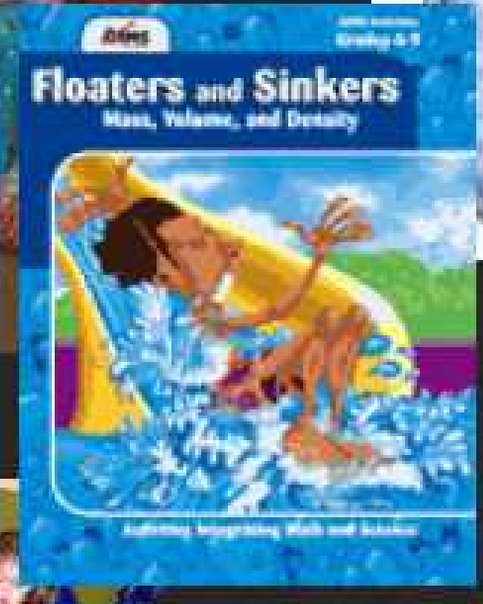
400

Relational Causality

A relationship (typically one of balance or imbalance) between two things causes the outcome.

"Sinkers and Floaters"



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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.
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- causes that can be non-obvious or act in concert with obvious causes.
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- processes and steady states in addition to eventbased reasoning.

Beyond teaching just ability…

- Sensitivity
- Ability
- Inclination

(A Triadic Notion of Thinking Dispositions, Work by Tishman, Perkins, and Jay)


EcoMUVE BetaTests
Population
Jul 25

Action at a Distance: Runoff From Housing Development

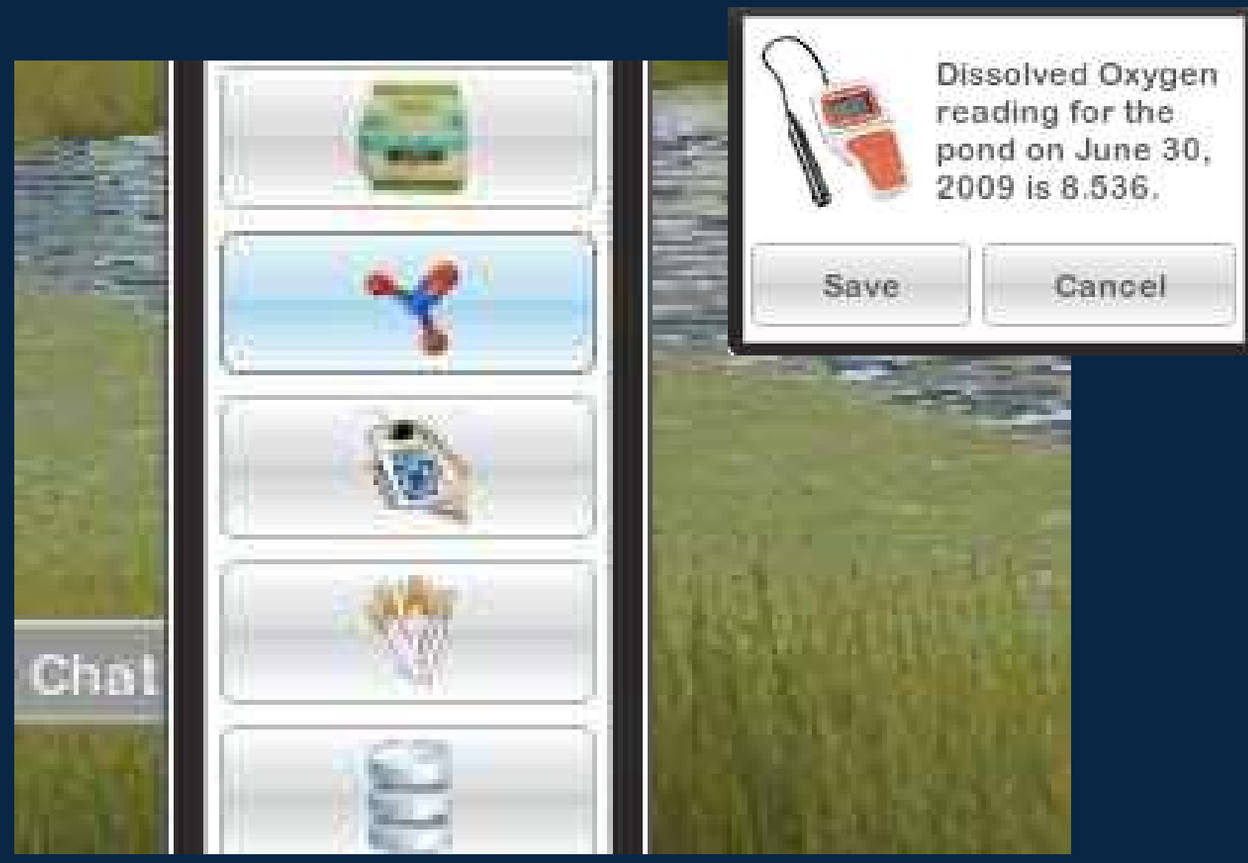
Non-Obvious Causes

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

Changes in Turbidity Over Time: Noticing Processes/ Change Over Time

One can move back and forth in time.

Measurement and Monitoring



Students collect physical, chemical, and population data over time, graphing patterns to see relationships between behaviors and outcomes.

Pedagogy of Session

• Offering multiple exemplars of complex causal dynamics helps learners abstract the underlying structures.

• Connecting back to your own experiences to generate examples engages you in backwards reaching transfer and active processing that should help you remember the concepts later.

• Connecting forward involves you in active search which helps you find applications of the concepts.