

# Collaborative Hypothesis-Building Using Immersive Virtual Environments for Ecosystems Science

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**Abstract:** EcoMUVE is a middle school science curriculum in which students explore an immersive virtual ecosystem and learn its causal dynamics through collaborative inquiry activities. Students work in teams of four to construct hypotheses about the relationships in the virtual ecosystem, using as evidence the data and observations collected through their virtual experiences. An analysis of the audio files of four teams demonstrates the ways in which their learning processes are situated within the virtual world.

## Introduction

EcoMUVE (<http://ecomuve.gse.harvard.edu>) is a curriculum for middle school students to learn about complex causal relationships in ecosystems simulated by Multi-User Virtual Environments (MUVES). EcoMUVE supports situated learning, in which students learn through being immersed in a richly represented ecological setting. Students work in teams to observe the environment, collect physical, chemical, and population data, and talk to digital characters, in order to solve a virtual mystery. This study articulates how students' experiences in this context aid in their collaborative concept mapping activities.

Student engagement in scientific practices is a central theme in the Next Generation Science Standards. Integral aspects of scientific practice include understanding the nature of evidence, using scientific arguments, and interpreting data related to scientific claims (Achieve 2013). The literature on collaborative concept mapping has found that this representational structure shows promise as an effective mechanism to support students constructing representations of their conceptual understanding, as well as fostering sustained small-group discussion about scientific ideas and deeper understanding through discourse and evidence-based arguments (Novak, 1990; Roth et al., 1994; Sizmur & Osborne, 1997).

Multi-user virtual environments (MUVES) have been demonstrated to be useful tools for science education (e.g., Barab et al., 2005; Clark et al., 2009; Ketelhut et al., 2010). In the design of EcoMUVE, we draw on Reiser's (2004) characterization of scaffolding by software tools, which can support learning by structuring the learning task, and drawing student attention to important aspects of the phenomena being represented and key questions to solve. MUVES can provide scaffolding through visualizations that highlight salient features, can simulate data collection and analysis tools, and can display multiple representations of phenomena (for example, scientific processes represented at both macro and micro levels). These design features are intended to facilitate student learning and to draw attention to important aspects of the phenomena being represented.

## Methods

EcoMUVE Pond is a two week, inquiry-based curriculum unit centered on a virtual pond and the surrounding watershed. Students explore the pond and its biodiversity, and travel in time to see changes over the course of a virtual summer. They discover a fish kill, and are tasked with figuring out why it happened. Students make observations, shrink to view microscopic organisms, and track individual atoms. They collaborate in teams to collect and share water, weather, and population data, as well as to graph changes in the data over time. They construct and present to the class an evidence-based concept map that represents their hypotheses of the ecosystem relationships. To look at students' collaborative hypothesis-building, we conducted a case study of a teacher and four classes of 7th grade students, ages 12-13, while they used the module. One team in each class was randomly selected to be audiotaped for 4 days during their collaborative activities (N=16).

## Findings

### Facilitated Observations and Inferences via Situated Learning in the Virtual World

Students perform observation and data collection tasks while immersed in the MUVE. In this example, students easily travel in time, and attend to salient visual features of the ecosystem:

S3: Guys, on July 6th it's raining. I don't know if that has to do with anything, about like the nitrates and phosphates.

S1: Record that. Record it was raining. Cause that makes things grow. And the water, just by looking at it, it looks green.

S2: Yeah, it got disgusting.

S1: On August 15, too, it's pretty bad.  
 S3: Yeah, it has a lot of chlorophyll.

### Multiple Forms of MUVE-Based Evidence Used in Constructing Hypotheses

Types of evidence students used from the MUVE included *perceptual information* (e.g., noticing the pond turning green, above), *data* viewed in tables and graphs, *reference* tools such as the atom tracker or online field guide, and *testimony* from characters in the world. In this example, students draw from all of these:

S5: Oh you guys! When I was tracking carbon... On the 10th, there was a lot of bacteria, and on then 16th they took in oxygen. So I think that's also why some of the fish died because if there is an increase number of bacteria on the 28th they're taking in even more oxygen which is also making the fish die. And also the minnows eat a lot and so that was a lot of oxygen and they're giving out a lot of carbon dioxide and minnows tend to eat small things like bacteria and algae so ...

S6: Yeah. What about the guy with the fertilizer? Do you think it could have run off the golf course? Wait, the day before the 28th - I think it was the 25th, the day before the 28th that you were allowed to measure - it was raining and that guy had the fertilizer and was putting it on the golf course and maybe the rain washed the fertilizer down into the lake and that killed all the fish!

### Collaborative Hypotheses with Concept Maps and MUVE-Based Evidence

Students' final concept maps were part of a group poster that included a written description of their hypothesis, and printouts of evidence from the world. Figure 1 shows one group's poster, which includes printouts of graphs and tables, as well as "our key piece of evidence" printed from the in-world field guide.

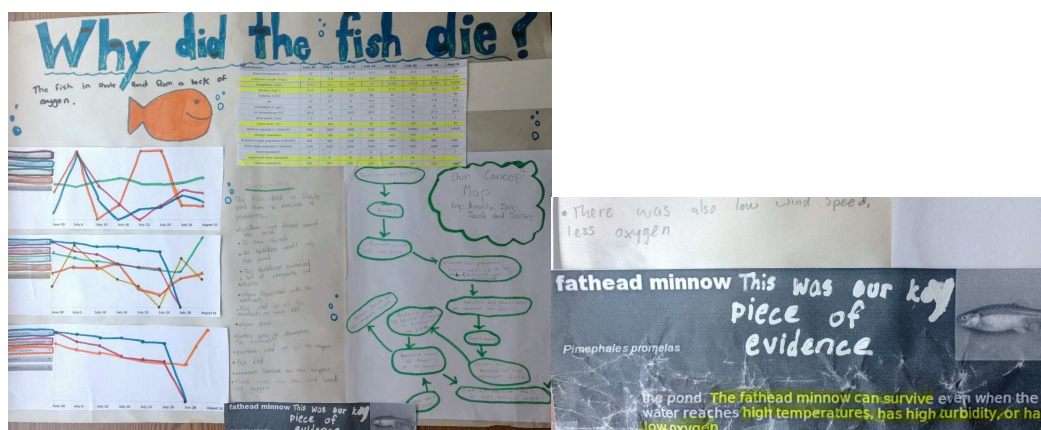


Figure 1. Student poster and example of evidence.

### Discussion

EcoMUVE places students in a richly immersive context with many learning resources. Findings presented here suggest EcoMUVE scaffolds student use of perceptual information, data, reference materials, and testimony in service of building collaborative explanations of ecosystems phenomena represented in the virtual environment.

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