How Immersion in Mobile-Enabled Augmented Realities Helps Students Learn

Amy Kamarainen
New York Hall of Science

Chris Dede
Harvard University

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”

*January 2009 issue of Science*
**EcoMOBILE – Blending Real and Virtual using Augmented Reality**

- **EcoMUVE - Multi-User Virtual Environments:** Supports ecosystems science learning in middle school classrooms
- **EcoMOBILE – Augmented Reality:** Support application and transfer of concepts and skills during field trip to a real ecosystem

**EcoMUVE Rationale**

- Ecosystems have complex causal dynamics that are hard to understand. Understandings of Consequence curriculum (Gotzair)
- Multi-User Virtual Environments (MUVEs) engage students in authentic science inquiry and aid deeper understanding through immersion.

---

**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.

http://ecomuve.gse.harvard.edu

---

**1976**

12:05

**2012**
Can mobile technologies make field trips more productive learning experiences?

Field trips involve learning challenges:

- Novelty of new environment can be positive and negative
- Single visit
- Difficult to measure learning outcomes

(Ways mobile technology can address these learning challenges:

- Novelty of new environment can be positive and negative
  - Highlight local features meaningful to students
  - Continue role from EcoMUVE
- Single visit
  - Capture artifacts to bring back to the classroom
  - Use technology to highlight changes over time
- Difficult to measure learning outcomes
  - Embed formative assessment in the experience
  - Tacit assessment based on student paths

Beyond “Old Wine”: Augmented Reality

Augmented realities utilize mobile, context-aware technologies that enable participants to interact with digital information, videos, visualizations, and simulations embedded within a physical setting.

- Location-aware AR presents digital media to learners as they move through a physical area with a GPS-enabled smartphone or similar mobile device
- Vision-based AR presents digital media to learners after they point the camera in their mobile device at an object (e.g., QR code, 2D target).
EcoMUVE is going Mobile

Does augmented reality enhance learning on a field trip?
Seeing the Unseen
• Taking on the role of a scientist
• Individual Pathways

Seeing the Unseen in EcoMOBILE: Changes in Scale

Seeing the Unseen in EcoMOBILE: Changes over Time

Taking on the role of a scientist in EcoMUVE
Students take on roles and gain expertise
Learning quests introduce important content
Pilot test of EcoMUVE + Field Trip

3 classes used EcoMUVE before going on the field trip, 3 went on the field trip first (n = 85)

Student survey assessing quality of experience and inquiry skills

Students who used EcoMUVE before the field trip performed better on inquiry-based items on the survey (ME = 5.2 ± 2.1, MF = 4.2 ± 2.3, p-value = 0.002)

Primed to make observations

• EcoMUVE students listed more organisms that they expected to see (ME = 1.4 ± 0.17, MF = 0.95 ± 0.13, p-value = 0.03)

• Organisms expected were ones present in the virtual environment (ME = 1.1 ± 0.15, MF = 0.4 ± 0.1, p-value = 0.001)

Using tools to extend the senses

Tool use did not differ among treatments

Students in both groups were equally surprised by the water measurements they had collected
Constructing explanations

“Were there measurements that surprised you? If so, tell us why?”

“Was the pond healthy? Explain why.”

Students exposed to EcoMUVE provided richer explanations

Explanations included:
- plausible scientific mechanisms
- connections to prior knowledge
- comparison among variables

Individual Pathways in EcoMUVE

ROLES in EcoMOBILE

Individual Pathways in EcoMUVE

Students with different roles collaborate to understand what caused the fish kill
Individual Pathways in EcoMOBILE

<table>
<thead>
<tr>
<th>Naturalist</th>
<th>Microscopic Specialist</th>
<th>Water Chemist</th>
<th>Private Investigator</th>
</tr>
</thead>
<tbody>
<tr>
<td>Observe pond for similarities to EcoMUVE</td>
<td>Observe duckweed</td>
<td>Observe pond for similarities to EcoMUVE</td>
<td>Talk to virtual golfer</td>
</tr>
<tr>
<td>Observe virtual fish</td>
<td>View 3D model of duck</td>
<td>Measure dissolved oxygen</td>
<td>Observe storm water pipe overlay</td>
</tr>
<tr>
<td>Calculate fish population size</td>
<td>Video of starch decomposition by bacteria</td>
<td>Video of how oxygen dissolves in water</td>
<td>Find inlet and outlet of pond</td>
</tr>
<tr>
<td>Collect macroinvertebrates</td>
<td>Observe virtual bacteria</td>
<td>Measure water temperature</td>
<td>Talk to young girl about what a watershed is</td>
</tr>
<tr>
<td>ID macroinverts and calculate tolerance index</td>
<td>Measure pH</td>
<td>Measure phosphates</td>
<td>Measure turbidity</td>
</tr>
</tbody>
</table>

Work together to create video that summarizes the health of the pond based on whole team's observations

Connections between classroom and real world
Teacher Feedback

“It helped structure their movement through space...so rather than having a whole group of kids clustered in one muddy, wobbly spot at the edge of the pond, they were all at sort of different spots going through it at their different paces and because they were moving independently through the different parts, I felt like it gave them a different ownership over the experience than if there had been just one teacher voice and a crowd of kids...”

~6th grade teacher using EcoMOBILE
Interface for Your Digital Life

IN THE FUTURE YOUR MOBILE PHONE WILL ACT AS YOUR DIGITAL "6TH SENSE"

**Why Immersion for Learning?**

- allow simulated experiences otherwise impossible to deliver.
- increase engagement in learning by allow students to immerse themselves in a virtual world.
- support new forms of interaction and collaboration
- enable embedded hints and tutoring delivered via situated, just-in-time processes.
- Increase – and assess – learner’s knowledge, skills, and self-efficacy.
- promote transfer to the real world more than other forms of instruction

**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
A Different Model of Pedagogy

- Experiences central, rather than information as pre-digested experience (for assimilation or synthesis)
- Knowledge is situated in a context and distributed across a community (rather than located within an individual: with vs. from)
- Reputation, experiences, and accomplishments as measures of quality (rather than tests, papers)

Transformation of Formal Education

Core Principles of Professional Development

- Teachers teach as they were taught.
- The important issue is not technology usage, but changes in content, pedagogy, assessment, and learning outside of school.
- Continuous peer learning is the best strategy for long-term improvement.

Professional Development: Communities of “Unlearning”

- Developing fluency in using emerging interactive media
- Complementing presentational instruction with collaborative inquiry-based learning
- Unlearning almost unconscious assumptions and beliefs and values about the nature of teaching, learning, and schooling

Crucial issue for professional development
NSTA Science Education Ed Tech Strand

• 10:30 am - 11:30 am
  Developing large scale effective teacher learning communities at NSTA (Al Byers, Darren Cambridge, and Flavio Mendez)

• 12:15 pm - 1:15 pm
  How Immersion in Mobile-Enabled Augmented Realities Helps Students Learning (Chris Dede and Amy Kamarainen)

• 2:00 pm - 3:00 pm
  Free STEM Resources for Mobile and Desktop Devices from the Concord Consortium Collection (Chad Dorsey and Carolyn Staudt)

• 3:45 pm - 4:45 pm
  Science Education and Mobile Technologies: A Happy Marriage (Elliot Soloway and Cathleen Norris)

Speaker Presentations: http://learningcenter.nsta.org/iste2012

Complementary Affordances of MUVEs and MBDs

MUVEs

- Highly engaging.
- Simulate experiences otherwise impossible in school settings.
- Exploration over time, place, size, and scale
- Opportunities to take on roles, work in teams, jigsaw pedagogy
- Shared immersive experience that contextualizes learning and supports inquiry.

Complementary Affordances of MBDs

MBDs:

- Usable in the real-world: greater fidelity and sensory richness, physical interactions with organisms and environments.
- Self-directed collection of real-world data and images.
- Technologies including cameras, recording devices, probes, GPS, mapping, graphing, augmented reality.

Acknowledgements

Project Team – Tina Grotzer and Shari Metcalf at the Harvard Graduate School of Education
Qualcomm – Michal Koenig, Edith Saldivar, Kristin Atkiks
National Science Foundation
US Department of Education – Institution for Education Sciences
FreshAir – MoGo Mobile – Matt Dunleavy, Daniel Burgess, Dave Payne
Texas Instruments – Rob Foshay, James Donatelli, Jackie Bonneau
Kajeet – Michael Flood and Wayne Periera
Wisdom Tools – Lyle Turner and Andrew Nelson
Harvard Graduate School of Education – Jody Clarke-Midura, Shane Tutwiler, Allison Browne, Diana Mazzuca, Yang Jiang
Susan Agger and Teachers from Cambridge, Lexington, Chappaqua
All our student participants
Seeing the unseen in EcoMOBILE