Using Mobile Tools in Immersive Environments to Support Science Inquiry

Michelle Lui
OISE / University of Toronto
252 Bloor Street West
Toronto, ON M5S 1V6 Canada
michelle.lui@utoronto.ca

Alex Kuhn
School of Education
University of Michigan
610 East University
Ann Arbor, MI 48109 USA
kuhnalex@umich.edu

Alisa Acosta
OISE / University of Toronto
252 Bloor Street West
Toronto, ON M5S 1V6 Canada
alisa.acosta@utoronto.ca

María I. Niño-Soto
University of Toronto Schools
371 Bloor Street West
Toronto, ON M5S 2R7 Canada
maria.nino@utschools.ca

Chris Quintana
School of Education
University of Michigan
610 East University
Ann Arbor, MI 48109 USA
quintana@umich.edu

James D. Slotta
OISE / University of Toronto
252 Bloor Street West
Toronto, ON M5S 1V6 Canada
jslotta@oise.utoronto.ca

CHI 2014, Apr 26 - May 01 2014, Toronto, ON, Canada
ACM 978-1-4503-2474-8/14/04.
http://dx.doi.org/10.1145/2559206.2574796

Please Note: *This is an Extended Abstracts entry for an Interactivity exhibit at CHI 2014.*
It accompanies a fully refereed article that can be found in the CHI 2014 Main Proceedings.

Abstract
Digitally augmented physical spaces (e.g. smart classrooms) offer opportunities to engage students in novel and potentially transformative learning experiences. This paper presents an immersive rainforest simulation and a mobile inquiry platform where co-located students collect observational data from the environment and explore their peers' data using large visualizations displayed at the front of the room. This is relevant to the design of educational experiences, immersive and physical-digital spaces.

Author Keywords
Digitally augmented physical space, smart classroom, science inquiry, visualizations, mobile computing.

ACM Classification Keywords
H.5.2 [Information Interfaces and Presentation]: User Interfaces - Interaction styles; K.3.1 [Computer Uses in Education].

Introduction
The design and research of new technologies, guided by our understanding of how people learn, offers a wealth of new opportunities for learning and instruction in K-12 classrooms. This is particularly relevant to science disciplines, where students must develop deep understanding of complex concepts while also learning scientific reasoning and inquiry, and acquiring 21st century skills, for critical thinking, collaboration, and communication [6]. Many contemporary science

standards [5] call for students to learn these skills by actively engaging in substantive science inquiry where they investigate a natural phenomenon and draw conclusions about it. Instead of mastering disconnected facts, the inquiry approach emphasizes posing questions, gathering and analyzing data, and constructing evidence-based arguments [3]. However, many classroom attempts at traditional and technology-enhanced inquiry-based learning constrain students to work autonomously as individuals, pairs or—at most—in small groups in a small number of locations (e.g. classrooms, field trip, etc.), often confining them to work together on single desktop computers.

In recent years, researchers have begun to reconsider how to expand the inquiry settings and experiences to enrich students' inquiry activities. This includes exploring the role and breadth of the physical learning environment, and the design of learning activities for digitally augmented physical spaces (i.e. mixed-reality environments). These spaces offer new ways of engaging students with sophisticated science concepts that have traditionally been taught or addressed through more abstract forms of interaction [8]. Early efforts of digitally augmenting physical learning spaces have shown positive outcomes in facilitating creativity and reflection [e.g. 1, 2].

Figure 2. Students examining projected displays of EvoRoom.

This paper explores how new technologies and media can potentially enhance inquiry-based learning by integrating immersive simulations and interactive visualizations in a "smart classroom", with a mobile learning environment that enables co-located students to collect observations from both the smart classroom itself and out-of-class settings. Specifically, this work integrates EvoRoom, an immersive, cave-like rainforest simulation, and Zydeco, a mobile tool for collecting and sharing observations during inquiry learning. The resulting immersive environment is responsive to student observations, producing real-time emergent visualizations that aggregate student observations for purposes of knowledge building and discourse.

Immersive Simulation

EvoRoom is an immersive simulation of the rainforest ecosystem of Borneo and Sumatra (Figure 1). Implemented within a "smart classroom" research environment [4, 9], the room is equipped with computers, servers, projection displays, and customized software to coordinate the flow of participants and content materials, as well as to collect data during the exploratory science activity that is being conducted in the room.

Figure 1. EvoRoom's projected displays, showing one side of the room.

In order to support a common, shared experience for students, the room is set up with two sets of large projected "walls" (achieved by stitching together three projected displays) that students examine in small groups (Figure 2). Two interactive whiteboards are

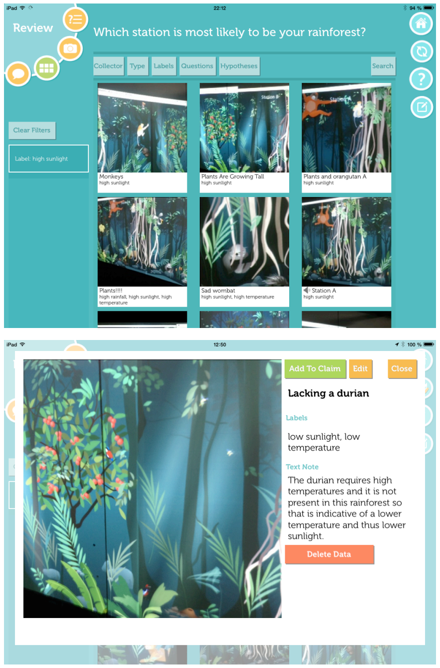

Figure 3. Reviewing shared observations collected in Zydeco (top) and reviewing a single data object (bottom).

located at the front of the room. The simulation is controlled with a custom application that allows the teacher to manage the time spent on each activity phase, controlling the pedagogical flow.

The inquiry activities that accompany the immersive simulation are co-designed with a teacher to fit within a broader high school biology curriculum, covering topics of evolution and biodiversity. With the fully integrated curriculum running for approximately 10 to 12 weeks, the full set of activities includes in-class collaborative activities, homework, a field trip to the zoo, as well as two inquiry activities within the EvoRoom environment.

Observation Collection and Sharing

While EvoRoom provides a mechanism for situating students in a phenomenon to complete an inquiry activity, it lacks extensive features to help students capture observations from the immersive experience, or to capture and use observations from the outside world within the immersive space. In order to explore how such additional functionality could enhance the science learning experience, EvoRoom was integrated with Zydeco, a mobile (e.g. iOS devices) and web-based tool that enables students to pose questions, collect, share, and review data and observations, and then use that data to construct evidence-based explanations [7]. Thus, EvoRoom provides students with a range of rich locales to explore, and Zydeco provides tools to capture and use aspects of the simulated locales to further address the questions they are investigating (and potentially augment this with data they collect outside of the classroom with Zydeco, such as observations from a park or museum). For example, after completing a homework activity where students investigate environmental and climatological factors (e.g. low rainfall, tsunami, earthquake), they visited EvoRoom where the projected displays were divided into four different simulations (or "stations"), each showing visibly distinct rainforest scenarios. Students were prompted to capture and collect observations and evidence about which rainforest scenario reflects the impact of the different environmental factors (e.g. "Which station is most likely to be your rainforest?", referring to the rainforest that has the assigned environmental factor for the group). Using Zydeco, students collected these observations to address this question by capturing photos, audio recordings, video, and text notes in EvoRoom. Students also used Zydeco to title and tag these captured observations for later use using a set of tags developed by the teacher.

The student observations captured with Zydeco were then shared amongst all members of the investigation, who could review the data on their tablets (Figure 3), apply search filters to explore their data, and then construct scientific explanations consisting of: (1) a claim that addressed the driving question, (2) evidence in the observations they or their peers had collected, and (3) their reasoning for why the selected evidence supported their claim.

Interactive Visualization

A key component of the smart classroom environment is the use of large-scale interactive visualizations of students-contributed artifacts to drive scientific discussions and debates. Artifacts such as observations, notes, or explanations that are written individually or in small groups are aggregated in an interactive visualization that can be projected on an EvoRoom wall. Taken together, these artifacts are organized in such a

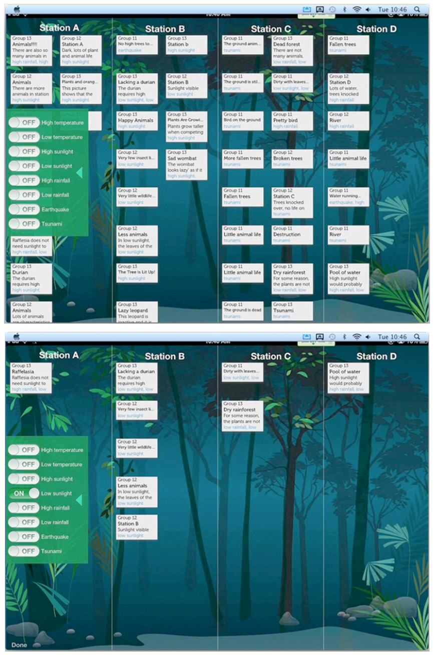

Figure 4. Image of visualization with all observations shown (top) and filtered by factor (bottom).

way that collective trends are shown. In our example, a visualization organized the student-contributions according to station ID and environmental factor. After the observation stage, the visualization showed which stations students believed to be impacted by different environmental impacts (Figure 4).

As ambient displays within the room, interactive visualizations support spontaneous discussions between students and the teacher and well as within student groups. When used in whole class discussions, the visualizations allow exploration of patterns within the shared observations.

Conclusion

This work is helping us see how to create such technology-supported environments for science education, not just from a technology standpoint, but also to think about the kinds of science education activities that are facilitated with these technologies. Other immersive environments may be created following similar design principles, for example simulations of the solar system or cities from ancient times (e.g. ancient Rome). Such simulations could draw from real-time data that is increasingly available online. For lessons in environmental science, for example, we could simulate the changing water levels, or water usage and quality at different locations over time.

While this immersive environment was conceived for classrooms, it may be easily redesigned for informal environments such as science centers, museums or other public spaces. This work is relevant for anyone who wishes to design interactive experiences working at the intersection of architecture, art, and communication.

References

[1] Bell, M., Chalmers, M., Barkhuus, L., Hall, M., Sherwood, S., Tennent, P., Brown. B., Rowland, D., Benford, S., Hampshire, A. and Captra, M. Interweaving mobile games with everyday life. In *Proc. CHI 2006*, ACM Press (2006), 417-426.

[2] Facer, K., Joiner, R., Stanton, D., Reid, J., Hull, R. and Kirk, D. Savannah: mobile gaming and learning. *Journal of Computer Assisted Learning, 20* (2004), 399-409.

[3] Krajcik, J. S. and Blumenfeld, P. Project-based learning. In R. K. Sawyer, ed. *The Cambridge handbook of the learning sciences,* Cambridge, New York, 2006, 317–334.

[4] Lui, M. and Slotta, J. D. Immersive simulations for smart classrooms: Exploring evolutionary concepts in secondary science. *Technology, Pedagogy & Education* (2013).

[5] National Research Council. Next Generation Science Standards: For States, By States. Washington, DC: The National Academies Press, 2013.

[6] National Science Foundation Task Force on Cyberlearning. Fostering learning in the networked world: The cyberlearning opportunity and challenge. A 21st Century Agenda for the National Science Foundation, 2008.

[7] Quintana, C. Pervasive science: Using mobile devices and the cloud to support science education. *Interactions, 19* (2012), 76-80.

[8] Price, S. and Rogers, Y. Let's get physical: the learning benefits of interacting in digitally augmented physical spaces. *Computers and Education 43*, 1-2 (2004), 137- 151.

[9] Slotta, J. D. Evolving the classrooms of the future: The interplay of pedagogy, technology and community. *Classroom of the Future. Orchestrating collaborative spaces*. Sense, Rotterdam (2010), 215-242.