Promises and Perils of Using Digital Tools in Informal Science Learning Environments: Design Considerations for Learning

Susan Yoon, University of Pennsylvania, 3700 Walnut Street, Philadelphia, PA 19104, yoonsa@gse.upenn.edu
Chris Quintana, University of Michigan, 610 East University Ave, Ann Arbor, MI, 48108, quintana@umich.edu
Leilah Lyons, University of Illinois at Chicago, 51 S. Morgan, Chicago, IL 60607, llyons@uic.edu
Judy Perry, MIT, 20 Ames Street, Cambridge MA, 02139, jperry@mit.edu
Scot Osterweil, MIT, 77 Mass. Ave., Bldg. E15-315, Cambridge, MA 02139, scot_o@mit.edu
Robb Lindgren, University of Central Florida, 12461 Research Parkway, Orlando, FL 32826, robb.lindgren@ucf.edu

Abstract: In this panel, six informal science projects discuss how instructional and technological design elements interact with the unique affordances and constraints of informal environments to impact learning. A central goal of the panel is to engage colleagues in examples that illustrate design decisions that inform research trajectories to move the field of CSCL forward in the design of informal learning environments.

Panel Topic

The National Research Council report on learning science in informal environments (NRC, 2009) examines the potential that non-school settings such as zoos and museums, have for engaging large portions of the population in scientific investigation. These experiences often stand in contrast to those typically found in traditional school science. The voluntary nature of participation often satisfies a sense of identity; fulfills individual social, emotional, and intellectual needs; and provides a degree of personal control over learning activities (Falk & Dierking, 2000). As informal activities have increasingly included digital tools, the NRC report also calls for more research on how digital platforms improve the learning experience. However, before we can study any impacts on learning, we need to construct good interventions and investigate how the designs do or do not optimally engage learners. In this panel discussion, we include six informal science projects that have gone through this critical design phase. We use the lens of design research due to its emphasis on a wide range of variables that may have contextual importance (Confrey, 2006) and the grounded-in-practice nature of the research, which increases the likelihood that interventions will be successful in the real world (Bielaczyc & Collins, 2007). An additional goal of the panel is to engage colleagues in examples of research that Puntambekar and Sandoval (2009) suggest can illustrate design decisions that inform research trajectories to move the CSCL field forward in the design of informal learning environments.

Panel Focus and Format

Panel contributors will focus on how instructional and technological design elements interact with the unique affordances and constraints of informal environments and will address factors that impact learning. Each presentation will introduce the context and learning goals, describe the design elements of the technology and associated activity, and provide an analysis of the design considerations in light of improving the learning goals. The panel incorporates perspectives from several different informal settings and a variety of digital tools. As we expect the topic of the panel to have a high degree of saliency in the CSCL community and would like to learn from other design researchers who conduct similar research in informal science environments, we would like to leave ample room for interactive dialogue with panel attendees. Thus, panelists will speak for 12 minutes about their project and 30 minutes will be devoted to community exchange. The five panel projects are listed below.

Doing Augmented Reality and Knowledge-Building in a Science Museum: Formalizing an Informal Learning Experience

Susan Yoon, University of Pennsylvania & Karen Elinich, The Franklin Institute Science Museum

The project *Augmented Reality for Interpretive and Experiential Learning (ARIEL)*, seeks to create digital augmentations of science museum devices that provide hidden information to visitors to develop deeper understanding of scientific phenomenon. In this presentation, we will report on a series of quasi-experimental studies in which increasing scaffolds were used in different conditions to support learning (Yoon et al., 2012). Building on the success of knowledge-building communities in formal classrooms, several conditions were constructed to encourage increased peer-to-peer collaboration, access to community knowledge and greater abstractions from interacting with the device. Results showed that students in the knowledge-building condition were better able to theorize about the scientific phenomena than students in other conditions. They demonstrated greater time on task, and discussed ideas with others in their group in more goal directed, intentional ways. However, in observations of device interactions, students in the knowledge-building conditions also behaved in ways that were more like in-school behaviors, less playful, inquisitive, and self-directed—which are hallmark characteristics of learning and participation that make informal environments unique and engaging. We discuss the trade-offs of what we have termed formalizing an informal learning experience and implications for structuring learning for deeper understanding.

Contextual Fit between Formal and Informal Contexts for Middle School Science Inquiry

Chris Quintana, Wan-Tzu Lo, & Shannon Schmoll, University of Michigan

Our *Zydeco* project is exploring the coordinated, integrated use of mobile devices (e.g., smartphones and tablets), web applications, and the cloud to support middle school science practices across formal classroom and informal out-of-class (e.g., museums and parks) contexts (Quintana, 2012). Zydeco helps students plan their inquiry in classrooms, collect different data artifacts (e.g., photos, videos, audios and texts) outside the classroom, and analyze those artifacts to build a scientific explanation, thus framing an activity structure that integrates different contexts into a larger educational setting. As we develop projects with middle school teachers and museum educators, we are identifying different issues when trying to create a more cohesive fit between formal and informal contexts: (1) *resource fit*, or the challenge teachers face in understanding what resources are available in out-of-class contexts and how those resources connect to their curricula and current science standards, (2) *supportive fit*, or the scaffolding features that need to be developed and embedded in the mobile tools, museum exhibits, and other resources to support students with the reflective and analytic activity needed for sensemaking with respect to their science questions and goals, and (3) *cultural fit*, or the potential mismatch between the goals of structured and free-choice contexts, the way these different goals impact exploratory activity, and the anxieties about technology that arise in many informal contexts.

Embodying Data: Using Performative Embodied Interaction Experiences to Engage Visitors in Data Interpretation in Zoos and Museums

Leilah Lyons, UIC & the New York Hall of Science

Informal Science Institutions (ISIs) have traditionally played an educational role by either hosting the curated *products* of scientific endeavor (e.g., pottery, animals) or providing access to the *processes* of scientific inquiry via hands-on exhibits (e.g., light tables, heat cameras). What does it mean for ILIs now that the *products* of science have evolved to be large data sets, and the *processes* involve the interpretation of those data sets? In two projects we explored the use of embodied interaction as a low-threshold, personalized entry point for data interpretation. One, with the Brookfield Zoo, asks visitors to role-play as polar bears in a game that plots their effort expenditures on a graph, co-constructing a visualized *product* illustrating the accelerating impact of climate change (Lyons et al., 2012). In a second project with the Jane Addams Hull House Museum and the New York Hall of Science, we allow visitors to "embody" subsets of georeferenced data, animating them with bodily motions, to transform inter- and intra-subset comparisons into an active social *process* of data interpretation. In the former case, we find that participation leads to better learning, but audiences also need opportunities to learn. In the latter, we find that visitors generate good questions about the data, but need further support (with representational fluency or background knowledge, or both) to then answer those questions. We are now exploring how docents might be incorporated dynamic digital exhibits to address these challenges.

Race Against Time: Leveraging an Augmented Reality Game to Engage Students with Global Climate Change Issues in a Zoo Setting

Judy Perry & Eric Klopfer, MIT Scheller Teacher Education Program

For the past decade, MIT's Scheller Teacher Education Program (STEP) Lab has been developing augmented reality (AR) games as well as toolkits to make AR games. These location-based AR experiences utilize the player's mobile device to provide a digital layer of information enhancing the real-world experience. MIT and the Columbus Zoo and Aquarium (Columbus, OH) partnered to develop new AR games to enhance visitor experiences by engaging players with the Zoo's physical space employing a narrative, game-like experience. In Fall 2011, a mixed methods study was conducted comparing the experiences between (a) students visiting the Columbus Zoo playing an AR game, and (b) students freely exploring the same physical areas of the Zoo. Findings suggest that playing the AR game impacted students' beliefs and ideas about global climate change (the theme of the AR game) more than the control group. Observations of students also provide data comparing the movement, discussion and gaze patterns between AR and control students. Findings here also suggest trade-offs in terms of students' time looking at animals and exhibits, versus time engaging with AR game elements.

Harnessing Imagination in Fostering Scientific Identity in Curated Games

Scot Osterweil, MIT Education Arcade

In collaboration with the Smithsonian Institution, the MIT Education Arcade developed a new form of informal activity, the *Curated Game*. Staged as an eight-week long event, played on-line by middle-schoolers across the country, the first curated game, titled *Vanished*, engaged players in a mystery quest that resulted in thousands of players collaborating on a nested series of scientific investigations. In the course of the game players investigated topics such as cryptography, geology, forensic anthropology, archaeology and climatology. In the process they participated in data collection, investigations in museums and science centers, hypothesis formation, scientific argumentation and calibration. They collaborated with fellow players while being mentored daily by MIT undergraduates on-line, and weekly by Smithsonian Scientists through videoconferences. The goal of the game was not to develop expertise in any particular scientific domain, but rather to expose players to scientific processes and to increase student identity with scientists and scientific practice. Analysis of the thousands of forum posts generated in the game show solid evidence of this effect, as well as new findings about the role of imagination in fostering serious scientific thinking and disciplined scientific practice. We will discuss these findings both in the context of the completed game *Vanished*, and how they are influencing the design of our follow-on curated game project devoted to engineering practice, *Gadgets*.

Supporting Body Cueing with Immersive Technology to Promote Science Learning in Informal Spaces

Robb Lindgren, Michael Tscholl, Eileen Smith, and J. Michael Moshell, University of Central Florida

Informal learning frequently occurs in spacious environments that afford physical exploration and engaging one's body in the process of conceptual development. The *MEteor* project leverages these features of informal learning spaces to build middle school students' intuitions about physics in an interactive mixed reality simulation of planetary astronomy (Lindgren, Aakre, & Moshell, 2012). Working with two Science Centers in Central Florida we have designed the room-sized immersive simulation game to support a type of embodied interaction where a learner moves in specific ways as a means of understanding the functionality of a target domain. In the case of *MEteor*, a learner uses their body to enact predictions of an asteroid's trajectory as it encounters planets and other entities in space. Different configurations of audio, visual, and physical cues guide learner movements and scaffold their understanding of important physics concepts such as Newton's and Kepler's laws. *MEteor* participants have shown greater engagement, self-efficacy, and more adaptive knowledge structures compared to learners who use a desktop computer version of the same simulation. We are currently investigating the effects of *social feedback* in *MEteo*r—harnessing the input of visitors "on the sidelines" who assist in guiding participant movements.

References

Bielaczyc, K. & Collins, A. (2007). Design research: Foundational perspectives, critical tensions, and arenas for action. In J. Campione, K. Metz, & A. M. Palincsar (Eds.), *Children"s learning in and out of school: Essays in honor of Ann Brown* (pp. 89-111). Hillsdale, NJ: Lawrence Erlbaum Associates.

Confrey, J. (2006). The evolution of design studies as methodology. In Keith Sawyer (Ed.), *The Cambridge handbook of the learning sciences* (pp. 135-150). New York, NY: Cambridge University Press.

Puntambekar, S., & Sandoval, W. (2009). Design research: Moving forward. *Journal of the Learning Sciences*, *18*, 323-326.

Falk, J. H. (2001). *Free-choice science education: How we learn science outside of school*. New York, NY: Teachers College Press.

Falk, J. H., & Dierking, L. D. (2000). *Learning from museums: Visitor experiences and the making of meaning.* Walnut Creek, CA: AltaMira Press

Lindgren, R., Aakre, A., Moshell, J. M. (2012). You're the asteroid! Body-based metaphors in a mixed reality simulation of planetary astronomy. *Proceedings of the International Conference of the Learning Sciences*, Sydney, Australia.

Lyons, L., Slattery, B., Jimenez, P., Lopez, B., and Moher, T. (2012). Don't Forget about the Sweat: Effortful Embodied Interaction in Support of Learning. In *Sixth International Conference on Tangible, Embedded, and Embodied Interaction (TEI '12)*, ACM, 77-84.

Quintana, C. (2012). Pervasive science: Using mobile devices and the cloud to support science education. *Interactions*, 19, 4, 76-80.

Yoon, S., Elinich, K., Wang, J., Steinmeier, C., & Tucker, S. (2012). Using Augmented Reality and Knowledge-Building Scaffolds to Improve Learning in a Science Museum. *International Journal of Computer Supported Collaborative Learning*, *7*(4), 519-541.

Acknowledgments

This research is supported by grants from the U.S. National Science Foundation: 0741659 (ARIEL); 1020027 (Zydeco); 0917442 (Vanished); 1114621 (MEteor); 1043284 (CliZEN); 1248052 (CoCensus); and support from the U.S. National Endowment for the Humanities HD 51357 (CoCensus).