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The free-choice learning and Cyberlaboratory: using cutting-edge technology to build capacity at the edge of science and science communication

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Abstract

A fully-automated video-based data collection system has been installed in a public museum/aquarium for research on life-long free-choice learning in an everyday context. The system links video observation tools, interactive computer-based kiosks, and face detection and recognition software with a research control and content management system that allows for data collection as well as customization of visitor experiences. This paper provides a brief overview of the system as well as some of the initial research projects being carried out by study staff. Researchers are studying family interaction with and learning from physical interactives, digital display platforms, live animal interactions, and staff facilitation. Initial findings from the early phases of this four-year, nationally funded project are presented including data on understanding of complex scientific visualizations projected on digital spheres as well as findings from video observation of volunteer docent practice. Three current research projects involving the use of multi-touch tables, interactive wave tanks and live animal touching experiences are also described in the context of the larger informal science education field.

Introduction: A laboratory for studying learning

The Oregon Sea Grant's Free-Choice Learning (FCL) Laboratory is situated at Hatfield Marine Science Center (HMSC), an Oregon State University marine science research facility on the west coast of the United States housing a Visitor Center (VC) that functions both as a public science museum and aquarium and as a laboratory for studying self-paced, leisure-time lifelong learning. It refers to learning activities that often take place outside classrooms, are self-motivated, and guided by the needs and interests of the learner. Our FCL lab studies how people learn through these activities. Findings can inform better educational and research practices in informal science education venues.

The HMSC campus houses university, state and federal agency researchers, educators, and outreach specialists. The VC serves a public audience of approximately 150,000 people a year as a donation-only interactive science center and aquarium, highlighting the research of scientists on site through a combination of computer-based, physical interactive, and live animal exhibits. Since 2004, a research initiative involving informal science education (ISE) has worked to develop a culture of evaluation and research surrounding informal science learning in the VC.

In recent years, the US National Science Foundation has funded the installation of a research infrastructure within the VC, using emergent technologies to study behavior, capture responses and adapt content to visitor needs. The "*Cyberlaboratory*" (NSF-ESI 1114741) was established to exploit emerging technologies in a museum setting and across related learning contexts.

The need for new tools for studying learning in everyday settings is evident both in the ISE literature and in practice. Hein (1998) argues for the museum as a forum for eliciting and building on visitors' prior knowledge and experiences in everday ways to build science knowledge and literacy. This constructivist perspective is widespread in the ISE field (Rowe, 1998) and within the published research literature (Phipps, 2008). It is taken as a given within the ISE field that such customization also requires tapping into visitors' interests in ways that honor their choice and control in learning activity. More recently, the ISE field has recognized the need to create continuity across the myriad places and times learners' engage in science learning (NRC, 2009), and cyberlearning opportunities have been advanced as one of the best ways to create that continuity (NSF, 2008). Yet, very few interactive exhibits incorporate tools that allow for visitor input about the experience or methods of customizing their experience, much less help form connections among museum-based, environmental-based, and school, home or afterschool based experiences.

In practice at museums, parks, and afterschool venues, a variety of technologies (including augmented reality, handheld computers, and human recognition systems) have caught the attention of exhibit and program developers interested in supporting the kind of free-choice learning that Hein and other researchers in the field envision. ISE professionals are looking to find ways to utilize these new technologies to engage learners and visitors, to improve free-choice learning experiences and to onduct research and evaluation without violating what makes these experiences unique.

Tools for studying learning

The cyberlab's current research tools and technology platforms are comprised of three separate but interrelated systems: a video-based observation system, an observational control system, and a database. Fully automated observation systems are the core tools to record visitor interactions in varied levels of researcher-controlled detail. These observation systems can work independently or in conjunction with the control systems (described below), which can be configured to trigger exhibit content changes based on output results from the observation systems.

Facial detection and recognition engines built into new exhibits utilize cameras to detect faces, and further, map a visitor's face and store the pattern in a database. Once the unique data-print pattern for a particular face has been stored, the system recognizes the same person at other exhibits. Face recognition makes it possible to create a unique user

ID and associated database for every visitor. An Observation Control System allows researchers and evaluators to alter response parameters of adaptive exhibit content. Customizable conditional filters applied to visitor data can trigger content change in an exhibit or handheld application based on a given researcher's line of inquiry. A database contains two primary areas: 1) information about the museum itself and 2) information about visitors. A simple floor map divides the VC into cells. Each cell is pre-loaded with particular attributes describing physical properties, learning affordances, and ideas that are associated with that place in the museum. Thus, for instance, a data base cell that corresponds to an aquarium tank contains information about the fact that the cell area includes live animals, signage, water, and if appropriate artifacts or biofacts as well as basic information about the type of content of the signage (e.g., biology, nutrituion, geology, etc).

Additionally, the face recognition system is used to assign a unique, anonymous user ID to all visitors, and that ID is then associated with data about all user movements, user selections from various interactive opportunities, audio comments made to learning partners, relationship links, and time spent at each learning station/exhibit. The longer the user spends at the facility, the more data is compiled on choices, learning styles and understanding. The adaptive exhibits can be configured to respond to user data, and alter content to suit individual user needs and learning preferences and experiences.

Research areas

The Cyberlab project team has undertaken a variety of research efforts over the last three years exploring the range of traditional museum-based ISE experiences: Physical interactives, digital interactives, live animal interactions, and staff interactions.

Physical interactives: There is a large body of research on interactive science exhibits as rich places for learning (e.g. Allen, 2004; Gutwill and Allen, 2010). Much of this work (e.g., Dierking, 1987; Bitgood,1993; Borun, et. al.,1996) has explored the link between family behaviors and types of exhibits. However, theories directing both the design and evaluation of interactive exhibits have traditionally drawn from cognitive and developmental psychology, which focuses on individuals rather than small groups of learners. Learning in the museum context may be better viewed as a social endeavor.

Our wave lab exhibit serves as a platform facilitating research on learning as groups interact among themselves and with exhibit components using physical interactives. The wave lab exhibit utilizes three interactive flume tanks filled with water allowing to explore concepts relevant to coastal issues, from the physics of waves (especially tsunami waves), and beach erosion, to wave energy production. A substantial effort has been put into the prototyping phase as we design and implement exhibit components and interfaces where visitors can be hands-on minds-on as they interact with the exhibit and researchers can easily manipulate the user interfaces, materials, and tasks presented to visitors. The prototyping phase focused both on exhibit design, construction, and implementation and on effective methods of researching learning in such exhibits. Our current research with the wave lab platform focuses on tinkering and play as entryways to engineering concepts in a museum setting using video and audio of family interactions in iterative build and test activities.

Digital interactives: We also carry out research with two different digital platforms of interest to museums and other science learning venues, digital spheres and multi-touch tables. Digital spheres have allowed us to carry out research on how data visualizations designed for academic scientists might be made more meaningful to museum visitors. We have used interviews and eye-tracking to investigate academic scientific experts and novices as they attempt to make meaning from global visualizations of ocean data on spheres and flat surfaces (Stofer, 2013). Laboratory interviews revealed that non-science undergraduates struggled with decoding almost every part of unscaffolded visualizations, while experts had difficulty only in understanding the time of year and season represented. Novices did not always use supporting elements such as the title and key, could not understand jargon in unscaffolded titles, conflated the meaning of the rainbow color scale used across multiple topics, and could not always orient themselves geographically to the visualizations centered on the ocean. However, their understanding improved on scaffolded visualizations. Interviews with our public audience revealed further struggles with meaning-making; scores were lower than either laboratory participant group.

With the installation of a multi-touch interactive tabletop, we are interested in investigating the social interactions and collaborations occurring around this form of technology. We plan to explore how visitors engage with the content, each other, and how conversations, gesture and technological novelty mediate learning and interaction among family groups. We are also examining videoed interaction for evidence of modeling or apprenticeship between visitors when it comes to using this form of technology. Are users engaging with the content or merely attracted to the novelty of an interactive tabletop? We hope to install software that allows visitors to manipulate and visualize data to create personal meaning based on their own interpretations. This research may give insight to how the public uses this form of technology in a public science center while providing evidence of learning via social participation.

Live animal interactions: Many studies such as Falk et al. (2007) and Fraser & Sickler (2009) have demonstrated increasing efforts to justify the overall value of visitor experiences within zoos and aquariums in the U.S. There is limited research on the impact of live animal encounters and touch tank experiences in museums, but the few studies there are point out that such exhibits can be rich settings for learning science (Ash, 2003; Ash et al. 2008). Regardless, live animal encounters and animal touch experiences are commonly featured in many informal science education venues. The effort, time and money required for establishing and maintaining touch tanks and live animal exhibits within museum education programs is apparently motivated by the general belief that touching and interacting with live animals facilitate affective reactions of care, therefore helping create conservation awareness (Rowe & Kisiel, 2012).

HMSC features a large touch-tank containing marine invertebrates of the northeastern Pacific Ocean. Using the HMSC touch tanks as a focal point for data collection is allowing us to explore more deeply the impact of live animal interactions on visitors' conservation attitudes and/or behavior, a topic which has been investigated in many studies with inputs for research in education, psychology, sociology, cultural studies and tourism (e.g. Ballantyne et al., 2007; Falk et al., 2007; Hughes, 2011; Kisiel et al., 2012; Rowe & Kisiel, 2012;), most pointing to positive correlations, at least to some degree. Nevertheless, it can be difficult to document the outcomes and impacts of FCLexperiences with live animals. Quantitative results can be misleading; so much of the research in the area relies on qualitative data. Our current project allows us to combine both large-scale quantitative data on use of and interactions at touch tanks with deep qualitative analysis of videoed interactions as well as comparison between family experiences at the museum touch tanks and in nearby actual intertidal zones.

Staff interactions: Finally, our automated data collection system is being used in conjunction with cameras placed on visitors to explore the practices of volunteer docents and facilitators in the museum context (Dover, 2013). Museum settings including aquariums, zoos and science centers rely heavily on their volunteer docent populations to interact with and communicate science and conservation concepts to the visiting public. The interactions docents have with museum visitors are important to meeting the educational expectations of museums and improving public science literacy as a whole, yet research to date is limited around docent practice, docents' reflections on that practice and the sources for docents to learn that practice. Thus, we have little understanding of the interpretive practice docents actually undertake whilst interacting with visitors, why they choose to enact particular strategies, and how they came to learn those practices. Thematic analysis using constant comparative methods demonstrated four claims about docent practice: 1) docents view teaching in the museum as opportunities to spark interest with these new experiences; 2) docents utilize a shared repertoire of practice and information in their community developed from understanding visitor patterns of interest; 3) docents believe that being a docent means balancing potentially conflicting roles; and 4) docents use interpretation as a pedagogy to engage visitors with science and create personally meaningful experiences. Analysis of significant interactions between docents and visitors shows that such practices are mediated through a variety of discursive and physical tools and implemented by docents as a means of engaging visitors with science and conservation.

Conclusions

The projects briefly reported here build on the last 8 years of work by the FCL Lab at HMSC. Traditionally, those studies have employed video, observational, survey and interview tools that are time and effort intensive for data collectors and for participants. Through the use of built in observation systems, we can significantly decrease the amount of person time devoted to data collection allowing for more sustained focus on analysis. At the same time, from a participant perspective, data collection is more seamlessly woven into the leisure and learning experience and may even be able to help customize that experience.

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