I-Guides in Progress: Two Prototype Applications for Museum Educators and Visitors Using Wireless Technologies to Support Informal Science Learning

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Abstract

We describe I-Guides, an information technology research project in progress at the Exploratorium, a hands-on museum of science, art, and human perception. Building upon the findings from the Electronic Guidebook Project [Hsi, 2003], various configurations of RFID technologies, handheld computers, and network-based applications are being developed to support nomadic inquiry and extend the museum experience for two different audiences: museum visitors and museum educators. For museum visitors, this project is exploring ways to enable visitors to intentionally capture one's museum experiences for later reflection and investigation of personally relevant science ideas via the Web. For museum educators, this project is designing a wireless handheld Web resource and digital library infrastructure to support educators in making effective uses of exhibits and exhibit-based content for inquiry-based teaching. An overview of research as well as planned design studies, working prototypes, and evaluation activities are described.

Background and Context for Research

Wireless electronic devices such as audio tour guides have been used to promote deeper appreciation of exhibit artifacts and enhance onsite museums experiences [Woodruff et al., 2001]. These museum-based experiences can be extended beyond the physical location of museum-based learning using technologies that enable one to bookmark an exhibit for later reflection [Fleck et al., 2002]. Similarly, handheld computer applications have been configured to enhance and extend formal classroom education into informal learning settings such as zoos, aquaria, and the outdoors using probeware and GPS to enable real-time data collection and data interpretation. [Chang and Sheu, 2002; Klopfer et al., 2002; Tinker and Krajcik, 2001].

The I-Guides project takes place at the Exploratorium, an interactive, hands-on museum of science, art, and human perception in San Francisco, California. Our goals are to create a wireless infrastructure and test bed at the museum to support nomadic inquiry: an approach to learning in which the learner is mobile, asks and investigates personally relevant problems, builds on their own scientific ideas, critiques information, and creates explanations by drawing upon cognitive supports and knowledge resources from both virtual and physical landscapes. This model of learning in informal environments assumes learners are not passive recipients of knowledge but rather are self-motivated and make their own choices about what to learn and when to request facilitation (provided by either technology or humans). This work draws upon pragmatic pedagogical principles and instructional framework from the Scaffolded Knowledge Integration for science education [Linn and Hsi, 2000].

Our long-range vision is to support continuous, lifelong science inquiry at the museum as well as extend visitors' primary informal experiences across other learning spaces encountered after their visit to the Exploratorium or other partner museum. Via a wireless network, digital library, and personalized Web museum services, this future cyberinfrastructure will enable user interactions to be audited and longitudinal studies of museum visitor behaviors to be conducted towards building a model of learning in informal environments.

Application for Museum Visitors

Visitor Needs and Interactions

At any given time in the museum, there are live demonstrations, hands-on construction activities, and as many as 600 interactive exhibits to explore. Many exhibits involve one-handed manipulation to move a disk, knob, or lever, while others involve two hands and other participants. The museum is noisy, and exhibits often involve things that can interfere with the handheld's function, such as sand, water, or electricity. Visitors find this free-choice, multi-sensory environment exciting yet overwhelming, making it difficult to engage visitors for any length of time at a single exhibit. Visitors also consist of family groups who have multiple, competing interests and agendas [Dierking and Falk, 1994]. Older members of a family group may want more time to explore the scientific phenomena being presented by one exhibit but are pulled away by children to the next exhibit or event, requiring the older family members to switch their attention from moment to moment. The hands-on museum setting poses a challenging but potentially rich context for studying ways in which museum visitors might use wireless technologies to improve visitor experiences and address deeper understanding of the science phenomena beyond fleeting encounters with exhibits.

Our first design, the Electronic Guidebook, was used to make the science behind the exhibit more explicit. This guidebook contained multimedia content of ways to play with exhibits, exhibit history, and content to show examples of the same science phenomena found in everyday life. However, our research with the Electronic Guidebook has established that individual visitors found it difficult and cumbersome to carry handheld devices while operating the museum exhibits. Ironically, visitors also found that a handheld promoted a sense of isolation in a museum whose goal is to promote learning conversations [Hsi, 2003]. Unlike audio tours in art museums, the audio portion of the multimedia content was difficult to hear in the Exploratorium's noisy environment. While the nomadic Web content motivated users to try new ways to interact with exhibits, they preferred having their hands free to manipulate exhibits [Fleck et al., 2002]. Thus, the redesigned visitor application for I-Guides aims to remove bulky technology from the hands of the visitor and provide alternative forms of recording and capturing user experiences at the museum for later reflection. Using an RFID package such as an electronic watch, a card, a yo-yo, or a remote clicker, a visitor could bookmark the exhibit he/she is visiting (which sends his/her unique ID to the network via an RFID transceiver mounted on the exhibit), capture a memorable photo of himself/herself at or near an exhibit by activating a camera, and/or trigger a printer to create a souvenir of a visit. An RFID transceiver records and sends the visitor identification number to the network and database system while also tracking a visitor's conceptual pathway through the museum. After the museum visit, the visitor later reviews additional science articles, conducts personally relevant science investigations, explores online exhibits, and downloads hands-on kits and other science activities at home via a personalized Web page (Figure 1).

Figure 1: The I-Guide Digital Notepad prototype showing an image that a visitor family group has captured during their museum visit and access to more after-museum, Web-based, science-inquiry activities.

User Requirements for Individual Visitors

Based on a front-end evaluation with visitors and museum staff, we found that the packaging's design needs to be lightweight, waterproof, drop-proof, and inexpensive, and that it should not interfere with exhibit interaction. The overall system configuration of packaging and user has to necessarily be both easy to maintain and low-powered or requiring no power outlets (because of the nature of some exhibit locations). In addition, the ID capture system must be created and installed to be obvious enough for visitors to trigger, and yet not detract from the aesthetic of the exhibit design. The packaging also has to be easy to distribute at the admission ticket desk or at a vending machine.

Based on several group design meetings, three general classes of bookmarking devices that house the RFID tag[1] were prototyped: retractables, wearables, and cards (Figure 2). These configurations are currently being studied and evaluated by visitors at the museum.

Figure 2: Prototypes for RFID tokens: yo-yo, cards, table coaster, necklace, and watch.

Application for Museum Educators (Explainers)

A second I-Guides application is designed for museum educators, called Explainers. This application was motivated by positive feedback from the Explainers who enjoyed learning from the explanations provided in the Electronic Guidebook, our first research prototype, and their high level of fluency in using technology and attention switching between exhibits and the handheld made them ideal candidates for testing the I-Guide [Hsi, 2003]. Explainers are museum staff who are apprenticed into helping others experience and become skilled at inquiry-based approaches to learning and teaching science. Explainers prompt

[1] The RFID tag, developed by Texas Instruments, uses a passive inductive couple to capture user ID information. The RFID wireless transceiver is a proprietary technology under development at Intel Research Labs, Seattle, Washington, USA.

visitors, children on field trips, and visiting teachers to engage more deeply with exhibits without answering questions directly or giving lengthy explanations. Explainers also perform demonstrations, shepherd field trip groups, and help maintain exhibits. Because new Explainers continually join the museum staff and new exhibits are featured at the Exploratorium on a regular basis, Explainers' background knowledge about any particular exhibit and the content behind that exhibit varies. Also, Explainers gain pedagogical expertise in using exhibits for teaching with visitors, yet this expertise is lost when they leave the museum. Thus, the handheld could be used as device to capture and share Explainer knowledge with future trainees. Explainers could use a wireless handheld in the presence of visitors to remotely control a larger exhibit, to send addition information via e-mail to a visitor, or to collect data about the interesting phenomena. The handheld could also serve as a mobile tutorial or training tool, or as a workflow organizer for the Explainer. We predict that this same application could also by useful by the adult in a family group to support facilitation and explanation with their children.

Our overarching purpose in focusing our efforts on a museum-educator application is to synthesize an instructional design framework for tiny displays, to apply this framework to the design of nomadic Web content, and to study its effects in the facilitation of learning with exhibits in a hands-on science museum. To support content delivery via the handhelds (whether the content be rich media animations, narratives, guiding questions, or simple prompts), we are developing a digital library infrastructure to organize media and develop search tools to support ubiquitous access of exhibit-based content resources. The broader context for this work is to understand both the role of IT technologies in supporting explanation and facilitation with exhibits, and the derivation and refinement of an instructional design framework specific for handheld/mobile display devices.

Planned Research and Evaluation

We have been following a design-based research approach to creating educationally relevant interventions in which design for learning requires iterative refinement and study [Collins, Joseph, and Bielaczyc, 2000; DBRC, 2003]. Rather than attempting to isolate particular variables for study in the context of a museum, we are identifying salient variables that arise and their interrelationships. Drawing upon Collins et al.'s model, we plan to design and study both the RFID visitor application and museum educator handheld application along three dimensions: cognitive level, social level, and interaction with artifacts. However, one additional dimension is added that takes into consideration the institutional context and the influences that institutional policies place upon educational design, learner experiences, and expected learning outcomes.

Wireless RFID Studies with Visitors

To test whether visitors are able to make use of RFID tags and readers, we are testing two basic configurations: one scenario in which the user carries the transceiver, and the exhibit contains a tag, and the inverse: The visitor carries the tag and the RFID transceiver is mounted on the exhibit. In both cases, the RFID transceiver captures and sends in real time a unique visitor ID to a user database. We will assess whether or not visitors are able to use this system at the museum, trace the visitor's path through the museum, and measure how many visitors conduct post-visit investigations. In addition, we will interview visitors about their post-museum activities and evaluate their online activity and work created in their I-Guides Digital Notepads. Eight visitors have been interviewed and have critiqued paper prototypes of post-visit activities. These critiques are being incorporated into the current, working design and will be used in larger evaluation studies.

Inquiry-Based Teaching and Instructional Design Studies with Explainers

To better understand the influence of nomadic Web content on Explainers' mediation skills and inquiry-based teaching with exhibits, we are designing and comparing three media conditions for the handheld (e.g., narrative, guided inquiry prompts, and mixed media) to better understand its usefulness as a facilitation training tool and its influence on promoting self-guided inquiry. In addition, we are developing an interface that will allow Explainers to enter and archive new pedagogical insights and tips on explaining scientific phenomena and ways to play with exhibits. Explainer focus groups have been conducted to identify training issues and knowledge needs. Exhibit-based content and guided inquiry prompts that will provide insight into the design of handheld multimedia for inquiry are currently being designed and evaluated.

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