Museum As Ecology: A Case Study Analysis Of An Ambient Intelligent Museum Guide

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Abstract

This paper explores the usefulness of the ecology concept as an analytical framework for designing interactive technology in museums. We aim to describe and evaluate an ecological approach to understanding museums and to examine information and cultural ecologies as analytical tools for guiding the design of interactive systems. We focus on two related concepts of ecology, *cultural ecology* (Bell 2002) and *information ecology* (Nardi and O'Day 1999). Utilizing each of the two frameworks, we analyze observational and interview data we collected during the research for an ambient intelligent museum guide. We also discuss the design implications of our analysis. In this paper we found that an ecology framework is highly appropriate for representing the complexities of activities, relationships, technologies and people connected to museums. We also found the information ecologies framework to guide design decisions in the creating of our interactive prototype.

Keywords: ecology, information ecology, cultural ecology, design ethnography, ambient intelligence, design.

Introduction

This paper explores the usefulness of the ecology concept as an analytical framework for designing interactive technology in museums. We aim to describe and evaluate an ecological approach to understanding museums and to examine information and cultural ecologies as analytical tools for guiding the design of interactive systems. The paper will be of potential benefit for designers, researchers, developers, and museum administrators with an interest in interactive museum guides.

We focus on two related concepts of ecology, *cultural ecology* (Bell 2002) and *information ecology* (Nardi and O'Day 1999). We begin by providing an overview of the role of ecologies in helping designers better understand museums, and an overview of the case study, an ambient intelligence museum guide. The paper then discusses each ecology concept separately. In each case we provide an introduction to the concepts, the relevancy of the concepts to our case study, and an analysis of our design ethnography data or design process based on the ecology frameworks. This is followed by a discussion of design implications of the ecology analysis and its usefulness in describing museums for the design of technology.

Ambient intelligence computing is the embedding of sensor and display technologies in architectural environments that are supported by artificial intelligence such that the overall system responds and 'reasons' about the human actions and behaviours within the environment. The aim is to distribute technology away from people into the surrounding environment in order to better support interactivity.

The idea of an ecology framework emerged from the research and development of the case study project. Our design was guided by an understanding of information ecologies as an approach to understand appropriate interventions through design in existing social systems such as museums. We had not yet encountered the concept of cultural ecologies but have since found it to be an applicable schema for our design ethnography. In this paper we found that an ecology framework is highly appropriate for representing the complexities of activities, relationships, technologies and people connected to museums. We also found the frameworks support appropriate and localized design decisions in creating interactive systems.

Ecologies, Museums and Design

Nardi and O'Day's notion of *information ecologies* describes a system of people, practices, values, and technologies in a local environment (Nardi and O'Day 1999). They argue that the ecology metaphor shifts the focus to human activity from technology. For example, a library is an ecology for accessing information. It is a space with books, magazines, tapes, films, computers, databases and librarians to help find information. The technology components of the ecology are balanced to shape the environment around human action in accessing information. From the perspective of sociology, Bell has described museums in terms of *cultural ecologies* (Bell 2002). Both the museum space and museum visit experience are bound by interrelated ecological components.

Why Is This Relevant?

Our design choices were strongly influenced by the awareness of museums as deeply complex and dynamic spaces. Von Lehn, Heath and Hindmarsh have described museum experiences as *multivariate*; that is, they cannot be assessed by a single factor such as exhibit design, signage, or time spent in front of an artifact (Lehn, Heath et al. 2001). Instead, the museum experience is subject to multiple influences and results in multiple outcomes. Our design aimed to limit the degree to which we *intervened* in what is already a complex situation. We attempted to leverage existing actions, localized knowledge, and attributes of a museum. In support of these aims, we chose to develop an ambient intelligent system that utilized an audio display interface, a tangible interface, and a user-model and adaptive information retrieval system.

The audio display allowed us to provide a virtual context without having to explicitly impose a new visual interface on the museum visitor. We viewed the exhibition space to be made up of existing layers of visual interfaces from the objects themselves, to the didactics, the display cases, and the architecture of the space. The use of a tangible interface allowed us to move between the physical space and the virtual information space. We wanted to minimize the degree to which visitors had to learn something new in an environment where they were already learning interface conventions such as display cases, didactics and the exhibition itself. We aimed for the information the visitors received to be both responsive to them as well as specific to the knowledge and practices of museums – the locale of the experience.

The ecological model allows us to look further into the design process, past the interface, for guidance in our design intervention. Our aim is to examine the degree to which we as designers understand the museum as an existing ecology, thus capturing it in its *multivariate* state. A second goal is to examine how integral our design decisions were to the ecology or ecology inhabitants, thus developing appropriate design responses.

Case Study

The case-study is of the design process for an ambient intelligent museum guide known as *ec(h)o* (Wakkary, Newby et al. 2003; Hatala, Kalantari et al. 2004). The prototype is an integrated audio, vision and location tracking system installed as an augmentation of an existing exhibition installation. *ec(h)o* is designed to create a museum experience that consists of a physical installation and an interactive layer of three-dimensional soundscapes physically mapped to museum displays and the exhibition installation. Each soundscape consists of zones of ambient sound and *soundmarks* generated by dynamic audio data that relate to the artifacts the visitor is experiencing. The soundscapes change based on the position of the visitor in the space, the visitor's history with viewing the artifacts, and their individual interests in relation to the museum collection. Through a tangible interface, a wooden cube, the visitor can interact with a single artifact or multiple artifacts in order to listen to related audio information. The audio delivery is dynamic and generated by agent-assisted searches inferred by past interactions, histories and individual interests (Hatala, Kalantari et al. 2004). The prototype was installed and tested in the *Finders Keepers* exhibition at the Canadian Museum of Nature. The exhibition theme was collecting natural history artifacts in Canada.

In this paper we discuss aspects of the design process behind the development of the prototype. Many of the design choices for implementation were driven by a series of participatory design workshops and scenarios, details of which have been written in another paper (Wakkary 2005). Our particular attention here is on our design ethnography data and an analysis of our collaborative design with the staff members of the museum. We examine the data we retrieved and the documentation of the process through the ecological frameworks.

Fig 1: Museum visitor testing the ec(h)o system. The wooden cube held in her hand is the prototype's tangible interface

The Museum as Cultural Ecology

The anthropologist Genevieve Bell has described museums in terms of *cultural ecologies* (Bell 2002). As an ecology, the museum space and experience are bound by interrelated components and attributes of the given museum ecology. For example, Bell identifies three significant components of all museum ecologies, *liminality*, *engagement* and *sociality*. **Liminality** defines museums as places that embody an experience apart from everyday life – as such, the experience can be transforming. **Engagement** defines museums as places where people go to learn, often in an entertaining and exploratory way. **Sociality** defines museums as social places for groups such as pairs and families:

- **Liminality:** A museum visit is liminal in that it is experientially set apart from everyday life. Positive museum experiences are transformative, spiritual, and moving. A museum visitor should be inclined to pause and reflect. Liminality permits a deeper engagement.
- **Sociality**: People attend museums in groups such as couples, families, classes, friends, and dates. Museums have become social spaces; for example, supporting elements of this include cafes, gift shops, and lobby spaces. Museums are seen as safe places for families. They often include games and are designed to guide supported activities that increase the interaction between parents, children and artifacts.
- **Engagement:** People go to museums to learn. This engagement is often packaged in an entertaining way; for example, museums are increasingly viewed as tourist destinations. Museums are a balance between learning and entertainment spaces.

Bell sees the museum visit as a ritual determined by space, people and design. She decomposes the visiting ritual into three observational categories: space, visitors, and interactions and rituals. Altogether the ritual has design implications in relation to technology. Among the different museum ecologies Bell has described, she outlines two museum ecologies: *art museum ecologies* and *science museum ecologies*. These ecologies are seen to be distinct and supportive of very different kinds of museum visits. In order to better understand the specific nature and differences among the ecologies, we've compared Bell's analysis of the two museum ecologies (see Table 1).

Comparison of cultural ecologies		
Components	**Art Museum Ecologies**	**Science Museum Ecologies**
Space	• Neutral gallery spaces, bland floors, minimal signage and little text. • Creation of a contemplative space for appreciation of the artifacts • Space remains surprisingly still and quiet…visitors talk in hushed tones	• Buildings tend to be newer or at least built in the last century • Many museums are housed in structures built for entirely different purposes • The spaces are deliberately provocative or playful • Displays predominately interactive, demanding, and commanding of the visitor's attention • Most installations are meant to be instructive rather then interpretive • Signage has an explicit educational function
Visitors	• Predominately older (55-75 yrs old), female, couple, groups of females, few solitary men • Well dressed	• Younger and more diverse, more children, broader range of ethnic minorities • Teems with social activity and noise. • People talk loudly and move in more dynamic ways • Diversity of ritual: Adults speak in regular tones, people laugh and clown around, visitors are engaged and engrossed, and at times even bored
Interactions and rituals	• Pervasive sense that museums are the arbiters of culture, you need special knowledge. • Popularity of docent tours, and audio tours (though they interrupt the ritual by impeding the social side) • Strong presence of visitor feedback mechanisms • Experience is inclusive of a visit to the gift shop, café thus facilitating the sense of a cultural outing	• The bulk of installations within the science and technology museum ecology are predicated on the notion of visitors interacting, as a result, these ecological niches have been a lot quicker to adopt in-museum technology—e.g., multi-media installations, computer stations, hands-on experiments. • These museums seem to understand the fact that people learn and absorb information in variety of different ways.

Design implications	Technology mediated tours (audio, PDA, etc) need to take advantage of visitors desire to be educated and entertained, but also encourages social interaction and contemplation.	For science and technology museums there are fewer barriers to technology adoption. This translates into different considerations for intervening in the ecology with new technology. Technology needs to support (sit well with in the existing model) existing interactions and fulfill visitors based on a conditioned expectation.

Table 1. A comparison between art museum and science museum ecologies.

In our case study, a natural history museum, it became evident that it closely followed the science museum ecologies. For example, the attributes of space were explicitly instructional, provoked play, and often demanded interaction.

Relevant Aspects Of A Cultural Ecology For Our Case-Study

Not unlike Bell, we observed the Canadian Nature Museum visitors through traditional ethnographic techniques. While we had a different and more descriptive schema for analysis, we found that all our data fit well in Bell's ecology components. The design implications of the science museum ecology are directly in line with our own assumptions coming in to the project. Yet we had not systematically connected these assumptions to our observations as Bell's framework does.

Analysis Of Our Case Utilizing Cultural Ecologies

What follows is a summary analysis of some of the observational data we collected based on the cultural Bell's science museum ecologies' framework.

Visitors

Many examples of diversity in visitors and visit rituals reported by Bell were indeed observed in our own study. For example, the cultural diversity of visitors noted in the science museum ecologies was found in our observations, particularly across student and tourist visitors. Bell states that in contrast to art museums, "science museum ecologies seem to teem with activity and noise" (Bell 2002 p. 11). It is clear from both Bell's observations and our own that this can be attributed to the large number of children and teenaged visitors to science museums. Bell observes a strong presence of middle school and high school students. This was in keeping with our own analysis; however visitors were typically on the younger end of the range (between 8 -14 years of age), and often as groups on school field trips. Though visiting as part of a large group, these visitors often fragmented into smaller groups and clearly enjoyed a level of autonomy - running, jumping, speaking loudly, laughing, and exploring the space as if it were a playground, despite the accompaniment of adult teachers; for example see figure 2 (below). This speaks to the safe social spaces that museums have become. Similarly aged visitors were observed as members of families. Despite parental supervision, the playful nature of the visit ritual was only slightly more tempered.

Most of the adults observed in the museum space were younger or middle aged, with few instances of elderly visitors. Most adults were observed as couples or parents, with their typical visitation ritual being a quiet, semi-absorbed inspection of the space. This contrast between the adult ritual and the youth ritual was noted both by Bell and ourselves.

Like Bell, we observed very few instances of individual visitors. Although visitor groups dominated, we did note many instances of individual exploration. In these instances members of a group would venture off, explore the space for experiences of interest, and then report back to the group their discoveries. The younger visitors in particular seemed to enjoy this pattern of interaction. We made note of numerous instances where groups of students would disperse and come back together, or younger members of a family would explore and report back to their parents.

Figure 2. The Finders Keepers exhibition at the Canadian Nature Museum.

Space

Strong similarities between Bell's ecologies and our observations occur in other categories as well. For example, Bell's discussions of space and displays matched our observations. Bell argues that displays and installations tend to be demanding of the visitors' attention. We found these characteristics in the four exhibitions we analyzed. For example, in the mammals exhibit was a series of dioramas depicting animals in their natural habitat. In addition to the visual scene, the dioramas were accompanied by ambient sound effects, a detailed didactic, and at least two tactile artifacts; such as fur samples, hoof imprints, and horns busts, relevant to the mammal on display.

Another key characteristic of Bell's ecologies is that installations in science museums are explicitly educational. Bell reminds us that this differs from art museum ecologies where information tends to be sparse and the aim is to facilitate interpretation over education. Our observations noted numerous instances of explicit educational and instructional approaches to the information design of the displays. For example, in the *Creepy Critters* exhibit, living specimens in terrariums and aquariums were supported by graphical representations on didactics coupled with a short paragraph on each species. This information was further supported by a collection of nearby reading materials (books, magazines, species sheets) related to the display.

Interactions and Rituals

The displays and installations revealed diverse forms of interaction: microscopes with adjustable slide wheels that could be turned to explore different specimens; wooden puzzles which, once completed, would fall apart at the pull of a handle, creating a loud crashing sound that captured the attention of others; a collecting game called *The Rat Pack Challenge* which tasked visitors to search the room and discern collectable artifacts from non-collectable ones; discovery drawers filled with objects like fossils, fur pelts, and minerals which visitors could touch and inspect at close range; push button audio and video installations; scale models and artist recreations of dinosaurs that people could walk up to and touch; terrariums and aquariums filled with living specimens; magazines, coloring books, and a small library of natural history artifacts that were lent to students.

Fig 3: Full-scale wooden puzzle that, once completed, would create loud crashing sounds at the pull of a lever (on the left)

Bell notes that an attribute of science museum ecologies is to support the fact that people learn in a variety of ways. Alternative approaches to learning turned up throughout our observations. Examples include interactive puzzles, quizzes, and games that require visitors to explore and think about the artifacts being displayed; multimedia stations provided for deeper investigation into a topic or subject area; and dioramas and immersive displays allowing visitors to imagine through visual simulations of historical periods.

Museum as Information Ecology

Bell's ethnographic efforts focused on observational experiences of the museum visit. Anthropologists Bonnie Nardi and Vicki O'Day draw on activity theory (Vygotsky 1925/1982; Nardi 1996) and field studies of technology libraries, virtual worlds, an architectural firm, high schools and a teaching hospital in order to develop their concept *information ecologies*. The concept they describe strives for a more systematic view of organizations, based on the relationships among people, practices, technology, values and locale.

Nardi and O'Day use the concept of ecology to critique current understandings of technology as autonomous. The authors aim to reframe the metaphoric underpinnings of certain views of technology such as *technology as a tool*, *technology as text*, and *technology as system*. They argue for a more complex understanding of interdependent elements and influences of which technology is only one part; a view that holds a sense of urgency due to opposing possible outcomes of entropy and failure or growth and dynamism. Constituent elements of information ecologies include system, diversity, co-evolution, keystone species, and locality:

- **System:** Information ecologies are distinct through their strong relationships and dependencies among the different parts. The parts may be different, yet they are complimentary and extend each other in capabilities. Change can also be seen to be systemic; when one part changes, it affects all others.
- **Diversity:** As in a biological ecology, different species thrive in different niches in the ecology. The complex interdependencies ensure that many different kinds of roles and functions exist. An information ecology contains a diverse set of people, activities and technologies. It in fact relies on diversity in order to successfully respond to change and potential chaos.
- **Co-evolution:** Parts of the information ecology adapt to each other or co-evolve as change occurs, only to be reintegrated later. The ecology is always balancing the

various toeholds of co-evolving parts.

- **Keystone Species:** Ecologies are marked by the presence of certain keystone species whose presence is crucial to the survival of the ecology itself. Often such species take the role of mediators who bridge institutional boundaries and translate across disciplines. Introduction of new technologies in an ecology is often reliant on mediators who shape tools to fit local circumstances.
- **Locality**: The participants within the ecology aid in giving identity and place to things. For example, the *habitation* of technology provides us with a set of relationships within the ecology: to whom a machine belongs determines the family of relationships connected to the technology. We all have special knowledge about our own local ecologies; it is inaccessible to anyone outside, thus giving us local influence on change. Only those who are integral to the ecology can provide a local habitation and name to technology.

Relevant Aspects Of An Information Ecology For Our Case-Study

Can an information ecology understanding of a museum positively inform our design process and outcome? In our design approach, we contextualized our efforts within the concept of information ecologies. That is, we looked at the Canadian Nature Museum as an information ecology, and even further, actively sought out keystone species for localized knowledge. One assumption of ours was that we were intervening at the level of the individual museum visitor at a scale and form that was appropriate. Nardi and O'Day argue that information ecologies are scaled to individuals, and through considering the issue at this scale we can find individual points of leverage, ways into the system, and avenues of intervention.

What follows is a summative reflection, through the lens of information ecologies, of our collaboration in the design of our prototype with the Canadian Nature Museum and its staff.

Analysis Of Our Case Utilizing An Information Ecology Framework

Our observations within the museum and the formal and informal sessions with museum staff were guided by our understanding of information ecologies. Our design goals lead us to this process and in many respects the experience validated for us the applicability of the framework to an organization like a museum. In table 2 (see below), we have provided a matrix analysis of our observations. In order to provide more detail to our findings we've summarized a few key dimensions of the ecology including *diversity, co-evolution*, and *locality*.

Analysis of the Canadian Nature Museum as an Information Ecology				
	Diversity	**Locality**	**Co-evolution**	**Keystone Species**
People	Students, children, tourists, parents, scientists, designers, archivists, administrative support personnel, security guards, researchers, management, volunteers, construction workers, technologists, archivists, educators, food preparation staff, building maintenance personnel.	*Specialized knowledge:* Quaternary Zoologist, Ichthyologist, Vascular Botanist, Chief Collection Manager - Botany, Chief Collection Manager - Invertebrates, Conservator, Library Production Assistant, Archivist, Exhibit Designer, Manager Of Information Services, Director Of Collection Services, Security Guard, Administrative Assistant.	Senior Web Development Officer, Senior Technician of 3D Imaging, Producer -Broadcast & Multimedia, Intellectual Property Manager, filmmakers.	*Scientists*: botany, arctic science, vascular plants, crustaceans, entomology, ichthyology, fossil reptiles, gemology, mammal evolution, materials science.
Practices	*Services:* corporate collection, communications, community relations, fundraising, exhibitions, finance, human resources, information technology, library services, research.	*Specialized types of knowledge***:** conservation strategies for plants and other organic artifacts, affordable approaches to humidity management, dietary analysis of the Siglit people, affordable exhibit design strategies balancing education and entertainment.	Architecture and engineering, 3D imaging, web development, interaction design, research, construction, media production, archiving, conservation, animal management, construction, high-definition video production.	Collecting, studying, analyzing, storing, drying, exhibiting, recording, carbon dating, classifying.
Values	Credibility, safety, security, entertainment, accessibility, education,	Security of resources; appropriate usage, balance between education and	Diversity of the visitation ritual, support for alternative learning styles,	Collecting, scientific research, history, knowledge sharing, validity, diversity, accuracy.

	extensibility, "revisitability", affordability, recounting and sharing of experience, collaborative learning, preservation, diversity of the visitation ritual, accurate natural record.	entertainment, conservation, diversity, knowledge sharing, communication.	accessibility, safety, entertainment, education, accessibility, high-resolution film presentation, immersive engagement.	
Technology	Acid-free storage containers, humidity monitors, pest management, artifact cleaners, taxidermy, microscopes, 3D modeling software, office technology, exhibit design tools, lighting, media production tools, facilities and construction tools, audio/video equipment, terrariums, aquariums, safety/ security equipment, video surveillance, card access control, archiving and library technologies, communication technologies, 3D modeling, website, digitized collection, accessibility - elevators, wheelchair lifts.	Affordable display technologies – cases, audio-visual, interactives (electronic and non-electronic), humidity controls, lighting, preservation.	Internet, computing technology, wireless networks, database, 3D scanners, CAD modeling tools, image and video editing tools, High-Definition Cinema displays and projectors, audio.	Acid-free storage containers, collection cabinets, hygrothermographs, microscopes, plant press, DNA analysis technology, brushes, electron microprobes, exhibit displays.

Table 2: A matrix analysis of the Canadian Nature Museum as an information ecology

Diversity

Visits with the museum staff, as well as observations of the exhibition spaces, indicated a high level of diversity of people involved with the museum. The visitor population was clearly diverse. We observed a range across groupings, ages, ethnicity and gender, including young students with teachers, college students, middle-aged tourists, large and small families, and young couples. Among the staff, the range of roles and functions at the museum is broad, including scientists, security personnel, office administrators, cafeteria workers, finance and administration personnel, archivists, media producers, 3D modelers, designers, and facilities personnel.

An outgrowth of the museum's staffing needs is that the institution demonstrated an equally diverse set of practices. This is exemplified in the list of service departments found within the museum: corporate services, collection services, communication services, community services, exhibition services, finance, human resources, information services, library services, and research services.

Further support of our use of an information ecology framework was the different values that emerged from interviews with museum staff. These differences appeared across and within departments. For example, among the values we found were *scientific credibility, safety, security, entertainment, education, accessibility, affordability, preservation, longevity, bilingualism, community involvement, collaborative learning,* and *distance learning*.

Finally, it was clear from our observations, interviews and tour of the collections and exhibition facilities that a wide range of technologies was employed. The types of technology varied from highly specialized to general solutions, and from technically sophisticated to simple. Observed technologies ranged from advanced 3D scanning equipment used to digitize artifacts for Web exhibitions, to acid free collection boxes used to preserve beetle specimens, to motion detectors for artifact security within the exhibits, to a jar of water employed to maintain humidity in an elephant skull exhibit case.

Co-evolution

Nardi and O'Day describe co-evolution as an adaptive response to change:

> information ecologies evolve as new ideas, tools, activities, and forms of expertise arrive in them...parts of the system adapt to each other or co-evolve as newer, faster, and different tools, are integrated repeatedly . . . (p. 52).

In our work with the museum we observed numerous instances of co-evolution.

During one of our visits we were given a tour and demonstration of the museum's recently purchased 3D scanning technology. It was explained that this technology with an entirely new department was meant to support the museum's mandate to provide Internet access to the collection for the general public and research community. Such an investment in technology, as well as the staff to support it, exemplified the sort of co-evolution described by Nardi and O'Day. Clearly the Internet and changing imaging technologies impinged upon the museum, resulting in the decision to adopt new tools in order to respond to these changes.

During our formal and informal sessions with staff, we encountered great excitement over major renovations planned for the museum's exhibition facility. The museum's exhibition design team discussed upgrades to exhibits and possible new technologies to support the upgrades. Such future possibilities and a new mandate for interactive technology use seemed to genuinely increase the excitement and interest around the museum in new interactive technologies and, in particular, our project. The significant focus on future spaces and interactive exhibits resulted in lessening interest or attention to existing displays and exhibits.

While parts of the system change and create new momentum, other parts find themselves in stasis. For example, we observed significant disparities in the adoption of new technologies across the ecology. Use and adoption of new technologies and supporting practices appeared to flourish behind the public face of the museum in areas such as the administration offices, research facilities, and collections/storage facilities. Conversely, there was a noticeable lack of new technology adoption in the public exhibition spaces. Similarly, the archives department of the museum had yet to respond through new practices or technologies to issues of access and media format. For example, it was very difficult to access in any indexical form the vast collection of field recordings the archive held. The outmoded and heterogeneous types of analog media of the archival objects further complicated things.

Locality

Nardi and O'Day argue that we all have special knowledge about our own local ecologies and that this knowledge tends to be inaccessible to anyone who exists outside of that ecology. In addition, the habitation of a technology will always be an outgrowth of its location within a network of relationships. For example, understanding to whom an artifact is connected or belongs sheds light on other relationships and aspects of local participation, local engagement, or local conditions unique to specific settings.

During a formal interview session with one of the collection managers, we found that that an absorbent flooring and sheet plastic we had observed under a collection of invertebrate jars was in fact a low budget conservation technique. The action guarded against potential spills caused by temporary construction in an adjacent exhibit. In the same interview we discovered that a jar of water in an elephant skull case was a highly successful yet inexpensive solution for managing the humidity needs of that specimen.

We recorded numerous instances where a staff member's localized knowledge transformed a collection of artifacts from opaque and dull to interesting. For example, one of the scientists we interviewed was a paleo-anthropologist. Her knowledge was highly specialized; the information and insights she passed on during the interview were valuable in that they gave life to what was a static display of bones. She provided engaging stories that connected the archaeological artifacts (animal bones) to the history and living practices of an ancient Inuit people. In addition, she provided details and explanation of the forensic process of sorting and analyzing the artifacts that she herself had performed.

Discussion

The cultural ecologies framework validated many of our design goals. The fact that our observations fit nearly completely with Bell's description of science museum ecologies strongly validated our own assumptions. In addition, one of our key assumptions mapped directly to Bell's design implications, which are formally linked to the ecologies, e.g.;

> technologies need to support existing interactions and create the possibilities for others conditioned by the visitor expectation that this interaction will be engaging and dynamic" (Bell 2002 p.12).

We therefore aimed to integrate our solution within the wide range of low-technology interactive solutions, and to keep our prototype playful, and above all, accessible to the museum visitor. Our observations that fall within Bell's categorization of *interaction and ritual* emphasized that our system should be open to multiple forms of input, such as movement and physical interaction with the displays, and responsive to different learning styles. In many respects, our prototype became a virtual extension of the exhibition space and acted as an augmentation to the didactics and other learning materials.

Information ecologies informed early conceptualizing of the project and specifically guided design decisions at later points. For example, our understanding of the *co-evolution* dynamics of the ecology led us to consider our prototype as a complementary influence. Co-evolutionary trends that we identified included a strong investment in visual technologies to support access to the collection and new approaches to exhibition design. We saw the opportunity to contribute an alternative approach to interactive display based on audio. We also saw the chance to give form to the intellectual knowledge of the museum staff in addition to the embodied knowledge of the artifacts.

Another example of how the information ecology understanding guided a design decision arose out the issues of *locality* and *keystone species*. This led to a novel approach to content design and development. In our earlier discussion on *locality,* we commented on our numerous observations of informal yet engaging delivery of specialized knowledge on behalf of the museum researchers. The majority of these types of exchanges happened as we toured the collections and storage facility. Stories connected to artifacts ranged from anecdotes about where the artifact was found and how cold it was at the time or how difficult the terrain was, to stories of the difficulties of mold-making on site or humorous tales of transportation and objects temporarily getting lost, to what the objects tell us, or how their meaning has changed. Often these were first hand accounts and discussed in the most informal and wide-ranging manner. Factual or thesis driven accounts of artifacts were mixed with anecdotal and humorous tales related to the discovery, processing or research of the actual artifact. This experience deeply struck us since our shared perception of the public exhibition display space was quite the opposite. Not unlike many exhibitions, the artifacts and contextualizing information appeared static and lifeless. In locality terms, it was evident to us that once the artifacts were connected to people, the understanding of these artifacts became deeply connected to all aspects of the ecology and came out in the form of storytelling that covered activities related to the artifact, conservation, storage, research and display technologies, meaning and values associated with the artifacts – all situated in specific contexts of time and place.

The exhibition facility and the collections/storage facilities were geographically quite far apart. The collections/storage facilities also housed the research facilities. It was evident that on a large level, two distinct ecologies were forming. The ecologies of the research and collections facilities were more dynamic, involving present day practices and perhaps greater informational exchange around the artifacts and specimens. One goal in the design was to bridge the gap between the ecologies with the goal of bringing more life to the artifacts on display. We aimed to model our information delivery and audio experience on the informal storytelling manner we had experienced. We aimed to create a virtual cocktail party of natural history scientists to accompany the visitor through the museum.

We identified the scientist collectors as our *keystone species*. Our content development process centered on formal interview sessions with staff, a majority of whom were scientist collectors, followed by a walkthrough of the exhibition space captured on video (Wakkary, Newby et al. 2004). In the first session, we asked that they speak generally about what they do and how it relates to artifacts at the museum. We aimed to elicit the range of storytelling we had encountered earlier. In the walkthrough sessions we asked them to speak to the artifacts as well as the exhibition display in the exhibition. These sessions became the basis for discrete audio objects that were categorized by topics and relationship to artifacts on display. In our prototype our system reasoned on possible objects the visitors might want to hear based on their previous interests, movement and interactions in the exhibition. In the end, it was very much like a virtual cocktail party, especially since we strove to maintain a diversity of delivery in language styles and voices.

We come to ecologies as designers who use ethnographic techniques and concepts to better our designs. Our aim is twofold: first, to best understand the complexity of the people and context that make up our design situation; second, to leverage the role of participant observer into a collaborative design relationship through direct collaboration or our informed representation of the stakeholders for whom we design. For our purposes, both ecological frameworks served our goals despite their strong differences. Bell's descriptive framework the *cultural ecologies* formally linked different actions and attributes of the museum visitor into a coherent system. As a descriptive tool it validated our assumptions and provided a clearer link between what we observed and the design implications. We could see it being useful at the early stages of the design process as an ethnographic schema and initial framing of the design situation. Nardi and O'Day's *information ecologies* framework was generative as well as descriptive. The framework helped generate design decisions such as the goal to make accessible the local knowledge within the organization, as well as supporting our design aim of developing a complementary approach to the organization's current use of technology.

More generally, our findings are that ecologies effectively capture in a formal and systematic manner the museum experience and the organization itself. The evidence for the information ecologies is tied to our design outcome and process as we've detailed extensively in this paper. Bell's cultural ecologies supported almost all of our observations and insights.

It is important to note, however, that although Bell's science museum ecologies mapped directly to our observations, some important characteristics did not. Despite Bell's observations of a high adoption rate of interactive technology, we found with the exception of video kiosks and push button audio stations, very few technology driven interactive elements were found in our analysis of the museum. Interactivity not mediated through computer technology was common and took the form of puzzles, games, microscopes, and touch-me artifacts. The distinction between a science museum and natural history museum may be a result of differing disciplines and therefore different levels of receptivity to technology; yet one might expect differences in other attributes of the ecology to occur as well.

Our analysis of the ecologies is only evidenced in a single sample of one institution. Our visitations and interviews occurred over three separate trips, each lasting between one to three days. We would like to pursue future research in other museums over slightly longer periods of time. In addition, we would eventually like to return to the Canadian Nature Museum after the renovations to the new space and perform another formal study to look for shifts in the ecologies.

Conclusion

At a time when museums are undergoing change and adopting new interactive technologies, the ecological frameworks we've discussed in this paper are deserving of greater evaluation. Both *cultural ecologies* and *information ecologies* focus on technology use within the ecologies and therefore have specialized functions in understanding museums today. As designers, we found these two approaches supported design goals and contributed to the making of key design decisions. The ecologies provided us an in-depth understanding of the museum visit experience and the organization.

The cultural ecologies framework validated many of our design goals. Our observations fit nearly completely with Bell's description of science museum ecologies with the exception of the museum's use of computer technology for interactive displays. We could see using the framework as an ethnographic schema in future museum projects.

As designers, the information ecology provided us with deep and multiple views of the organization and the people connected to it. Like ethnography in design, ecologies have a role in the design process, one that can guide design decisions in addition to systematically providing a descriptive understanding of the design situation. In our particular case, our design was guided by our findings of *locality*, *keystone species*, and *co-evolution*.

Our case-study analysis suggests that ecological frameworks can be effective descriptive tools, and in certain instances generative tools as well. Future research includes additional formal studies of museums as well as a study in the shift of ecologies over time.

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