Social as Interface *the conceptual design for a mobile learning environment for a museum*

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My thesis is dedicated to my children, *Nicholas Alexander Baeza Hochmuth*, and *Julian Andreas Baeza Hochmuth*. For them, I would climb the tallest mountain and do the unimaginable. They are my proudest joy and my deepest inspiration in life.

To my dear parents, *Maria Eujenia Baeza Rosales* and *Dr. Oscar Renato Baeza*, who have taught me the value of life and learning.

"We must remember that everything depends on how we use the material, not on the material itself….

We must be as familiar with the functions of our buildings as with our materials.

We must learn what a building can be, what it should be, and also what it must not be….

And just as we acquaint ourselves with materials, just as we must understanding functions,

so we must become familiar with the psychological and spiritual factors of our day.

No cultural activity is possible otherwise; for we are dependent on the spirit of our time."

Mies van der Rohe

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Abstract

This thesis explores how handheld mobile devices expand and augment the informal learning opportunities present inside museum spaces. By using constructivist-learning pedagogy as the guiding principle for fostering high level thinking dispositions, my work brings together characteristics of museum environments, wireless technology and learning theory to create user centered learning tools, which are participatory, experiential and interactive.

Introduction

When I graduated high school, my parents took me on a tour of Italy's three main cities; Venice, Florence and Rome. For the first time, I experienced ancient architecture; art by the great Renaissance masters, and the wonder of being in a foreign country robust with art and culture. I was awe struck by the magnitude of cultural beauty on this trip. Stemming from this wonderful experience with my family, I became enamored with the aesthetics of space, art, and it's history. This experience would have a great impact on my life. In the early eighties, I was excited to start my career as an undergraduate student in art history at Boston College, in Massachusetts. Boston seemed like the ideal city to pursue my art history studies and appreciation for learning and culture. Visits to local museums, lectures and musical recitals were weekly departures from my routine at Boston College. Institutions like the Isabella Stewart Gardner Museum, the Boston Museum of Fine Arts, and the old Boston Public Library were invitations to enter into a poetic space created for learning where interaction and dialogue were a vital part of the experience. My passion for learning and art would converge from these early experiences inside these wonderful informal learning environments. I appreciated the opportunity for enlightenment and passion that would emerge inside these museum spaces, which is what inspired me to pursue museum learning for my thesis project. Mobile learning in museums is a natural progression of my passions for learning and culture in my graduate studies, incorporating my interests in design, learning and museum environments.

Teaching close to home When my first son was born in 1993, I wanted to learn all that I could about child development, early cognition, and the emergence of knowledge. I immersed myself in this intellectual pursuit to help my baby engage proactively in the physical world around him. Shortly after my second son was born in 1995 this became my sole focus for the following 6 years. I read the classics in child psychology and mental development; learned about multiple intelligences, cognitive and psychological development in children birth to 7 years old, and made a commitment to introduce the richness of their environment to them. I tested many of the theories I read about on them. As I observed their progress during these wonderful years, I noticed trends and patterns in how they made sense of the physical world. When the boys got a little older, I made them frequent visitors to the Museum of Science, The Children's Museum of Acton, and the Museum of Fine Arts in Boston. Physical objects played a central role in their explorations, our discussions and their deeper understanding. Our social interaction lead to age appropriate dialogue which enabled learning to occur inside the museum context. They were 'sponging up' enormous amounts of information in these informal learning situations. Later at home, I could see this new information put to use. Their use of Legos™ was slightly adjusted to incorporate the structure that they had seen at the science museum the previous day, or their bath became a testing ground for water experiments seen at the museum of science. These early years with my children were the building blocks from which my passion for learning would evolved. I am so thankful for my boys for this gift.

Shortly after the boys entered preschool, I became interested in graphic design. I began my course of study for a BFA in design at the Art Institute of Boston (AIB), at Lesley University. I was amazed how my knowledge and appreciation for art history was directly applicable to my new design pursuits. My love for learning re-emerged in this new context as I made connections between classic historical concepts like the golden section, and modern design. I was astonished how this primordial concept, used both in Ancient Greece and during the Renaissance could be the very same concept being used to size paper, create poster design, and to size screens on handheld devices. My studies in design were a launching pad for many years of growth and appreciation for the aesthetics in communication design.

During my BFA studies at Lesley University, I became involved with the *American Institute of Graphic Arts* (AIGA) for the first time. I was immediately attracted to their educational mission and volunteered as my university's student representative. I frequently attended events offered in the Boston area during the academic year. I participated in the annual student portfolio review, which I would later organize for students as the *AIGA Boston Education Chair*. I held this post for two years with the primary responsibility of hosting the annual Boston student portfolio day held annually in the spring. Again, my love for learning was renewed in this capacity. This experience enabled me to learn the educational goals associated with a leading non-profit design organization dedicated to promoting an appreciation for design and visual culture.

In 2004, I had the great honor to teach at the *Boston University* summer term. I, along with a Dynamic Media Institute (DMI) colleague, taught web design to thirty students at the College of Fine Arts campus. That Fall I was asked to join the teaching team as an adjunct teaching instructor in design. I taught principles of Design to college juniors, web design, and a design elective to non-majors. I was able to put many of my skills to a test: communication, teaching, learning, along with helping others appreciate design and visual culture. Following my graduation in May 2005 from the Dynamic Media Institute (DMI) at the Massachusetts College of Art, I will join the summer term faculty for another wonderful summer of learning, which I anticipate, will be a wonderful experience.

At the DMI Graduate Program, my view of learning inside a cultural institution was transformed yet again. I found the perfect niche to deepen my understanding of learning, which incorporates my passion for design. Naturally, I chose to delve into the world of learning inside the museum mediated by mobile technology as the focus of my research. My experience with my first cell phone directly influenced my interest in mobile technology for museum interpretation. My cell phone was the first new media object I owned. My early adoption was primarily for emergencies; to get in touch with a family member or childcare provider. Today, I own a PDA phone which is an essential part of my day. It holds all my contacts and phone numbers, along with my daily schedule, my children's schedules, and notes. It enables me to keep track of my family's changing daily routine, along with giving me immediate access to information on the 'fly.' I cannot imagine my life without this device today. In addition, the phone has instant Internet access, giving me information when and where I need it. This device has transformed my expectation and demand for instant access, mobility, freedom, and ubiquity of information.

Bird's eye view of my research My research explores how the world of learning, mobility, handheld technology and museum learning intersect. Later, I will explain how prior knowledge enables learners to give meaning to personal experiences enabling reformulation and reorganization of newly acquired information. Current learning theories based on constructivist learning pedagogy form the foundation upon which my conceptual prototype for mobile learning is based. Three primary foci are the foundation for high level learning faculties inside the museum space: First, collaboration and participation; second, experience; and third, social interaction. Each of these elements will be further analyzed in the context of user scenarios, prototypes, and interface in my research. The goal is to develop learning tools for children in middle school, during a visit to the Museum of Fine Arts (MFA) in Boston. Further, my explorations will focus exclusively on the Egyptian galleries at the MFA in order to use specifically designed curriculum developed by the MFA educational staff.

This evaluation will take issues of space, object, architectural location, and audience as well as the appropriate means of mediating the museum experience via a handheld mobile device into account. My overriding objective is to develop technologically mediated experience, which is integral, both architecturally and conceptually, to the exhibition narrative in an age appropriate manner for school age children. Later, I will discuss museum technology and the advent of wireless and digital multimedia technology, including a brief history of museum technology, and handheld technology more specifically by looking into recent pilot programs around the world. The core of my thinking lies in making connections between the fundamental allowances in mobile technology and the convergence of constructivist learning pedagogy. I will show how technology and theory merge making mobile technology ideally positioned for optimal learning opportunities inside the museum. Further, the unique characteristics of museum environments such as mobility, physical space, and thinking dispositions are also well positioned to take full advance of mobile technology's affordances.

Background research and development My background research is based on real life ethnographic studies at the Massachusetts College of Art, *Looking to Learn Program* directed by Sandy Weisman at the Arnheim Gallery. By looking at the traditional museum/gallery visit, I was able to make observations and assessments of how school children behave inside the museum, what their needs are, and what the learning objectives of a school visit are. Experiments like *Rear View Window* explore issues of perception and physical space, and cognitive mapping as an interface for orientation to an information space. *The Isabella Stewart Gardner Museum Project*, looks at issues of database and how information can be individualized or personalized for particular user needs. This background research provided me with valuable information, which is directly applicable to my research in mobile learning inside a museum. Later, I will discuss the specific lessons learned in each project and how it is incorporated into my conceptual interfaces.

User scenarios My thesis project centers around teaching curriculum for the Egyptian collection at the Museum of Fine Arts, Boston. It delves into the convergence of technology, constructivist learning pedagogy and the inherent characteristics of museums. The learning tools have three foci: (i) an emphasis on participation and collaboration; (ii) dedication to experiential learning; and finally (iii) fostering social interaction between students.

The first user scenario: *An example of Interaction and Way-finding inside a Museum* will introduce students to three Egyptian artifacts previously analyzed in the classroom introductory session at school. An interactive map will show their location, along with the artifact they choose to look at inside the museum space. Museum content is made cognitively accessible inside a vast architectural space which can be intimidating and confusing. I propose using location based technologies, where a student is made aware of context rich information, based on his/her physical location inside the museum. As a corollary, this type of road-mapping encourages a student to see the museum as a macrocosm of information, where further exploration is at their finger tips. This cases-study will also look at ways in which an archiving tool can help students accumulate, modify and share acquired information during their school visit.

The second user scenario, *An example of Collaboration and Cooperation*, asks students to work with a partner inside the museum, enabling them to communicate from disparate locations on a PDA enabled chat space. The purpose of this exercise is to have students compare and contrast images of power from different periods in history with the Egyptian examples in the previous exercise. The focus of this exercise is to enable students to make connections using multiple points of view, thereby deepening their understanding of Egyptian art.

Theoretical Research

Constructivist learning pedagogy provides the theoretical foundation for a valuable learning experience which holds the belief that each learner constructs his/her personal understanding based on individual mental models, personal experiences, and a base of prior knowledge.

The three guiding principles of constructivist learning pedagogy are: (i) participation/collaboration (Piaget), (ii) experience (Dewey), and (iii) social interaction (Vygotsky). These principles merge seamlessly with the characteristics of mobile multimedia devices, and informal learning environments, such as museums.

How the student learns is at the forefront of constructivist thought, both in the epistemology of knowledge and how knowledge is obtained. Both developmental and cognitive psychology support the theory that knowledge is constructed as the learner learns, which is in a constant state of evolution and reformulation. Knowledge, in essence, is being reassembled and reorganized to assimilate newly acquired understanding from the basis of previously acquired knowledge. Thus the active learner evolves as he/she interacts with others in the physical world. Prior knowledge is the foundation upon which this cycle is predicated, for without it epiphanies would be unattainable. When talking about a museum experience for school children, we need to take into account a states' department of education (DOE)* teaching standards, along with specified school curriculum, which meets those teaching goals. Many museum interpretive programs create school programs to meet these educational requirements. The self-guided tour of Egyptian and Nubian Art material prepared by the interpretive staff at the Museum of Fine Arts, Boston states that 'it is designed to support interdisciplinary connections among subject areas such as visual arts, English language arts, math, science, history and social science.' Specifically, the curriculum supports the following standards from the Massachusetts Curriculum Frameworks.*

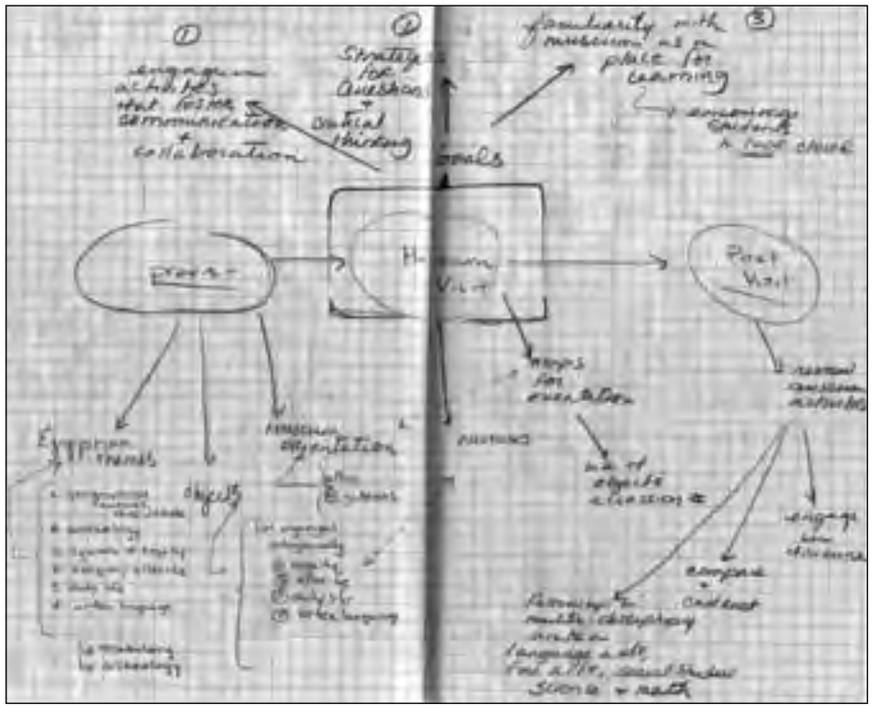
Also, equally important, a museum visit sits in the middle of a three step-learning continuum which, in order to be successful, must be well designed and fully integrated. That includes the pre-museum visit, the museum experience, and post-museum follow-up. For example, a school visit to the Egyptian galleries at the Museum of Fine Arts, in Boston should include a multidisciplinary school unit on Egypt and it's culture as preparatory information for the students. Also, a schools' curriculum is often supplemented by a tailored presentation made at the school by the museum's teaching professional prior to the museum visit, speaking specifically on the museum, it's collection, and the expectations of the museum visit. By having a solid background in Egyptian art and history, the school children come well equipped with prior knowledge to take full advantage of the informal learning opportunities in the Egyptian galleries. Equally important are the post-visit learning opportunities which the various school disciplines could take advantage of. A robust museum visit, well supported by contextual information, can be followed up with exercises across multiple subjects at school. The importance lies in creating an environment for learners to share their points of view in ways that will challenge their thinking; to integrate the parts that make of the 'whole' picture through continual refinement and reformulation and active participatory discourse.

* Massachusetts Teaching Standards

Massachusetts History and Social Science Framework–

Standard 7.14 – Describe the role of the pharaoh as god/king, the concept of dynasties, the importance of at least one Egyptian ruler, the relationship of pharaohs to peasants, and the role of slaves in ancient Egypt.
Standard 7.15 – Describe the polytheistic religion of ancient Egypt with respect to beliefs about death, the afterlife, mummification, and the roles of different deities; further connections to beliefs in divinity and the natural world (animal deities, flooding of the Nile, afterlife-daily life relationships)
Standard 7.16 – Summarize the important achievements of Egyptian civilization: Egyptian monumental architecture and art, hieroglyphic writing.

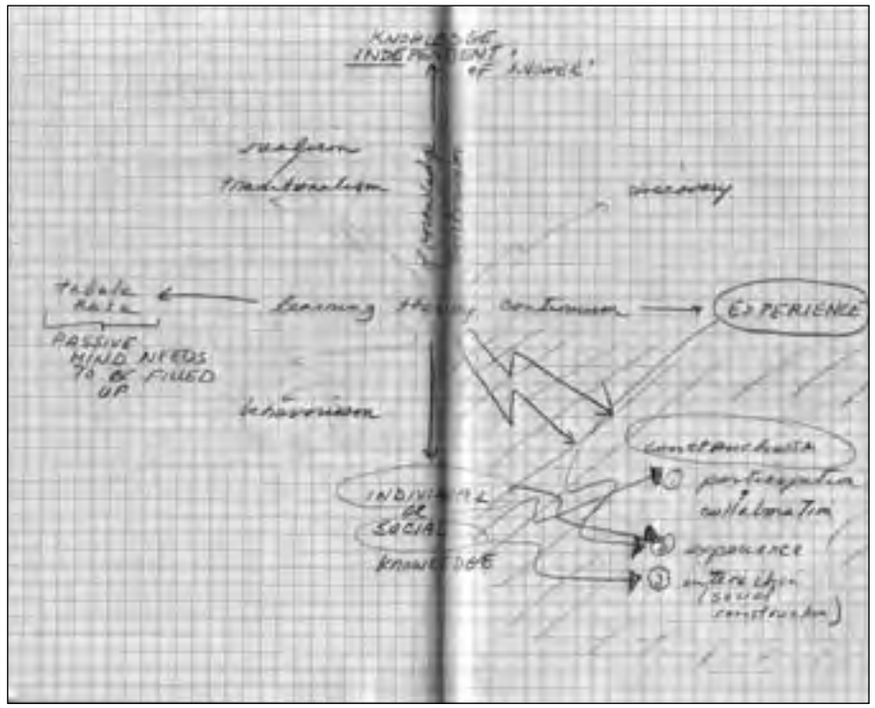
Massachusetts English Language Arts Curriculum Framework–
Standard 1 Discussion – Students will use agreed upon rules for informal and formal discussions in large and small groups.
Standard 2 Questioning – Listening and Contributing – Students will pose questions, listen to ideas from others, and contribute their own information or ideas in group discussions or interviews in order to acquire new knowledge.
Standard 3 Oral Presentation – Students will make oral presentations that demonstrate appropriate consideration of audience, purpose and information to be conveyed.



Three Step Museum Experience

Massachusetts History and Social Science Framework~

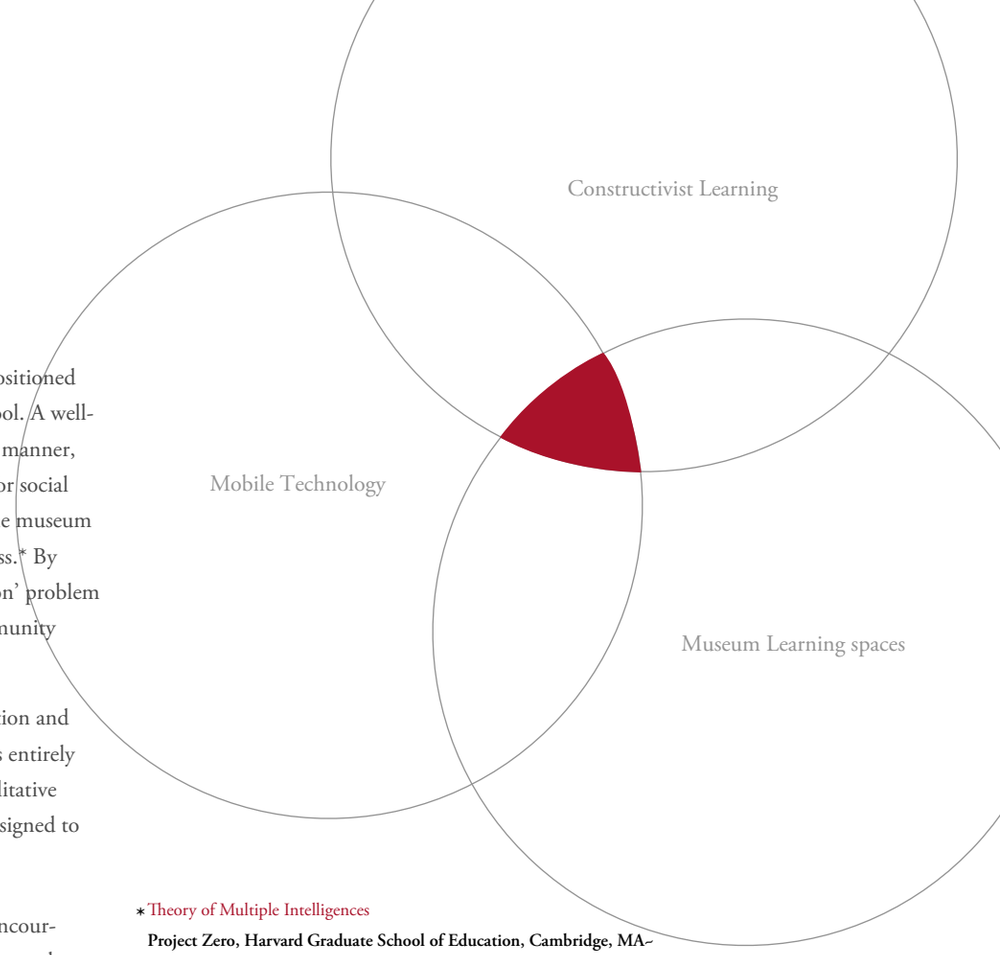
Pre-Visit – In school introduction to gallery visit and expectations.
Museum Visit – Museum exercises provided via a handheld device.
Post-visit follow-up – Multi-disciplinary exercises enabling discourse on subjects covered in museum visit.



Classic Learning Theories Matrix

Constructivist Thought relies on Experience and Social Knowledge~

Participation and Collaboration –
Experience –
Interaction –



Convergence of learning theory, mobile technology and museum interpretation Museums are uniquely positioned to take advantage of constructivist learning principles for the intelligent integration of mobile technology as a learning tool. A well-designed curriculum encourages students to interact directly with objects, collaborate voluntarily in a socially interactive manner, and produce rich experiences for conceptual and cognitive enrichment. Focusing on social discourse and opportunities for social interaction, technologically mediated communication enhances informal learning opportunities already present inside the museum space. Ideally, allowances for different learning styles and *multiple intelligences* are taken into account in the design process.* By enabling students to communicate, challenge and share their thoughts, they are given the opportunity to have a 'hands-on' problem solving experience with other participants. Synchronous communication gives students the opportunity to create a community within which to safely share disparate points of view and promote dialogue affecting their interpretation.

In addition to the affordances for collaboration, communication and interactivity, mobile technology enables customization and personalization of tailored content for unique collections and curricula. The effectiveness of this type of learning depends entirely on the appropriateness of the technology, and the design and implementation of the content. Both quantitative and qualitative advantages can be met with the use of wireless technology in the museum context as long as the content is specifically designed to meet specified curricular goals.

Importance of prior knowledge A constructivist approach would expand upon the students' prior knowledge and encourage them to actively make sense of their experience during the museum visit. It would allow for contextual links to further and deepen their understanding. It would provide ample opportunities for social interactions with other students as an integral part of the curriculum, so that learners can express what they think and have it challenged by others. There are three primary goals in this approach to learning: first, to encourage active discourse between students in a technologically mediated environment; second, to foster negotiation between students by implementing projects necessitating several participants; and finally, to encourage students to compare 'notes,' in order to challenge individual interpretation and understanding. Implementation of a handheld device under this strategy creates opportunities for students to accumulate a database of information for later reflection at school or at home. This database is immediately useful during the museum visit for in-group discussions, but more importantly, after the museum visits for further reflection and analysis. Additionally, the museum visit, can be 'recorded' by the device, and later used as a 'semantic' road map for students to learn from personal associations and connections made during their brief visit to the museum.

Characteristics of Wireless Technology Handheld wireless technology is well positioned to enhance the learning opportunities in museum using constructivist-learning theory as its foundation. The four main benefits of interactive mobile devices are:

(i) the opportunity to provide information in a non-sequential/linear manner which enables the learner to make decisions based on his personal inquiries;

(ii) the availability of multiple learning modalities (i.e. text, image, video, sound) providing information in a manner which is most meaningful to the learner;

(iii) the opportunity for the learner to make connections to pre-existing information in order to accommodate new concepts within this framework, and

(iv) ability to interact and share with others to come to a global understanding of the material in the process, along with connectivity.

These four elements acknowledge and hold that knowledge is created inside the mind of the learner using personal mental models, which converged directly with constructivist learning pedagogy.

* Theory of Multiple Intelligences

Project Zero, Harvard Graduate School of Education, Cambridge, MA~

The theory of multiple intelligences suggests that there are a number of distinct forms of intelligence that each individual possess in varying degrees. Howard Gardner proposes seven primary forms: linguistic, musical, logical-mathematical, spatial, body-kinesthetic, intrapersonal (i.e. insight, metacognition) and interpersonal (social skills). Emphasis is placed on the presentation of information from multipleperspectives and in multiple forms, such as audio, visual, textual, kinetic.

The Museum Visit The use of wireless technology can further the educational goals of a museum experience, which are to promote high level thinking and other critical student faculties during the museum visit. Firstly, the disposition to explore multiple perspectives supports problem solving and flexibility, the disposition to reason and evaluate are central to individual interpretation and interaction, and finally the disposition to make connections between disparate pieces of information promotes interdisciplinary thinking and discourse. *Professor Shari Tishman, Professor at Harvard Graduate School of Education*, stated in November of 1993*, that the goal for museum educators is to understand how high level thinking dispositions can be enhanced by existing affordances inside the museum environment. The motivation must start with the personal connections a student makes with his/her visual environment. I would further state that previous knowledge is directly connected to a learner's motivation and interest in a subject matter. Wireless handheld technology can be used to enhance and expand upon existing affordances as an appropriate mediator between a museum learning experience and participating students. Situated exercises with varying conditions, foster adaptability, and through conversation and 'verbalization' of personal ideas, integrate prior knowledge.

There is much research which points to the importance of 'place' in the process of learning. The question before us is what are the particular elements of the museum environment, which make it a place for active learning to occur. What are the stimuli in the environment and how are they presented to the learner. What is missing for them to get a full picture of an exhibit? What about the social interactions within the museum allowing for multiple points of view? How are the spaces curated and the exhibition pieces presented to the student? Is this helpful to the learner/student or a hindrance to deeper understanding? What type of mediated experience would foster communication, collaboration and social interaction? How can a students problem solving be visualized, shared, and used for the community of learners within the museum space?

Museums offer the student an object oriented learning experience. This environment is a perfect place for social interaction, contemplation and inquiry because of the inherent 'choices' a student has for self-guided inquiry. There are situations in which such opportunities are hindered by architectural barriers, such as bad lighting, sound, or overwhelming spaces, which are confusing and intimidating to a student. Such shortcomings are a fertile ground for the integration of mobile devices, because many of these problems can be minimized or completely eliminated by their appropriate integration. By anticipating the informational supports needed by a student, museums can provide solutions for conceptual struggles encountered during the museum visit. For this to be successful, the program must be developed from the student's point of view. What are the student's specific needs during a visit to the Egyptian galleries at the Museum of Fine Arts, Boston? These specific questions are addressed in the ethnographic investigations at the Arnheim Gallery, at the Massachusetts College of Art and at Museum of Fine Arts, Boston. Later in this thesis, I will discuss those findings and the lessons, which are directly applicable to my theories regarding museum interpretive programs.

* Professor Shari Tishman

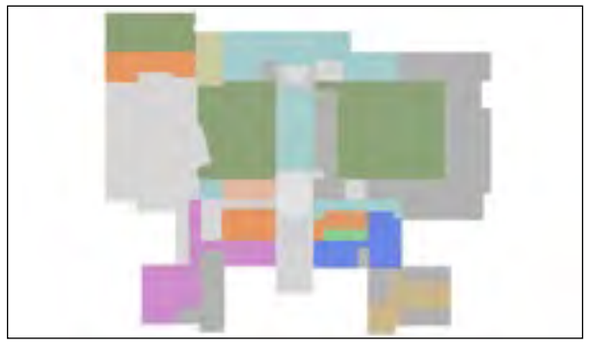
Research Associate, Project Zero, HGSE, Cambridge, MA~
Shari Tishman is a Lecturer in the Arts in Education program at Harvard Graduate School of Education. She was very generous in providing me with her expertise in museum learning. I enthusiastically agreed to sit in her classes at the HGSE and learned a great deal about learning dispositions inside a museum space.

Learning Space as Cognitive Mapping When a museum has a set structure and permanent exhibition, such as the Egyptian Galleries at the Museum of Fine Arts, reconstruction of the architectural space is not a reality, even if the design lacks educational efficacy. When the formal architectural features do not allow for the curatorial narrative to speak for the exhibition, using the fundamental elements of 'space', fundamental to the learning experience as a metaphor, can provide an important theoretical foundation for interface design. There is no doubt, architectural design affects navigational behavior inside the museum, by either limiting it or expanding it. What makes a space architecturally engaging is the associations between spaces and the objects contained therein. The learner must be able to *see the tree through the forest* in order for mental orientation to occur; this idea I call cognitive mapping.

The curriculum designed specifically for an architecturally engaging environment, would embrace constructivist pedagogy and allow for learners to make connections and observations between disparate physical spaces. A mapping interface feature would allow for the curriculum to cue the learner as to where he/she is and where he/she needs to visit to follow his/her personal lines of inquiry. Ideally, both the spatial design, exhibit design and the interface design would all support such flexibility, but if one is missing; the mobile device can mediate such limitations and create opportunities for self-directed inquiry.

The collective wisdom from environmental psychology, behavioral anthropology, environmental architects, and urban designers acknowledges that people utilize 'space' in order to be able, active participants in an interactive environment, in a way that allows him/her to achieve certain predefined goals. As a corollary, such an environment must be organized in such a way so as to provide meaningful choices and access to the overall scope in order to know 'where' one is. Visual access can be designed as a standard feature of the interface and curriculum so as to help the learner organize his/her path through the learning environment where one does not exist architecturally and structurally.

Having a better understanding of the dynamics of physical spaces and the socio-physical nature of museums and its connection to learning can provide a valuable metaphor for digital representations. There is an undeniable connection between dynamic systems of space, both virtual and real, and learning. Both require movement and orientation to move. Exhibitions are part of a knowledge system with disparate and codependent parts within physical and virtual space. Both have allowances for spatial, visual and information densities or granularities, which shift time, speed and information transfer, allowing for the internal reconfiguration of information. Other metaphors which translate seamlessly into the conceptual design of a learning interface are *legibility of space*; that is the coherence with which a learner can understand the organizational structure or patterns defining such a space. If the learner is able to decipher major benchmarks as orienting beacons, then he/she will be unafraid to explore its boundaries. The goal of a ubiquitous learning environment is to provide this information in a seamless and meaningful manner.



History of Museum Technology M-learning refers to learning and teaching using mobile technology such as a personal digital assistant (PDA), a handheld computer (HHC) or a mobile phone. The ubiquity and pervasiveness of this technology in our environment has created enormous opportunities for its use in educational institutions, such as museums and libraries.

My thesis exploration on the integration of this technology for museum learning involves the complex question of how a museum learning experience can be mediated for the middle school audience at the Museum of Fine Arts Egyptian Galleries. Arguably, with the advent of wireless technology, real-time content can be delivered to the student, while he/she is interacting within the museum space with others. At first glance this is the overriding reason to integrate this type of technology into any learning space. But there is a more important and pervasive reason why this technology is ideally positioned to enhance the learning opportunities in the museum scenario, which I will explain later.

Museum technology developed over the past 35 years with two major technological breakthroughs: First, audio guides using compact cassettes were introduced in 1980 and, second the transition from analogue to digital recording devices in 1994 introduced the idea of nonlinearity for the first time. Prior to the advent of digital technology, audio tours were limited to 45 minutes in duration and users were forced to follow a prescribed linear path developed by the museum curatorial staff. The rigidity of the technology had a direct impact on and interfered with the free-roaming nature of the museum experience, and arguably with educational opportunities inside the museum as well. With digital technology, non-linear content is available to the user for a richer, more personalized experience.

Notwithstanding these benefits, within the museum learning community, a debate on whether technology enhances or detracts from the museum learning experience lingers on. The question, of how mobile technology can be integrated into this experience without interfering with it, is my primary concern. Regardless of this hesitancy, museum technology continues to evolve and engage the learner in new ways. There is no doubt that museums will continue to invest in new technologies in the future, notwithstanding these debates because of audience need and demand for ubiquitous content.

Recent programs in interactive mobile devices have attempted to connect handheld computers (HHC) and personal digital assistants (PDA) to internal wireless network within the walls of a cultural institution to provide multimedia content, communication capabilities with others, and accessibility to contextual information on objects in the collection. HHCs and PDAs have become ubiquitous devices, which are ever present in our daily lives. Cutting edge mobile devices are extending beyond the architectural confines of 'place' into our environments, making information accessible in real time and at any place. William Mitchell, author of *Me++ The Cyborg Self and the Networked City*, points out that our entire system of communication and way of life has been reconfigured by the interactivity of networked spaces and will continue to do so in the future. I would further argue that teaching and learning paradigms are evolving to incorporate these new areas of connectivity with enormous teaching potential.*

* **Me++ The Cyborg Self and the Networked City**

"I am inseparable from my ever-expanding, ever-changing networks. Not only are these networks essential for my survival they also constitute and structure my channels of perception and agency - my means of knowing and acting on the world. They continuously and inescapably mediate my entire social, economic, and cultural existence. And they are as crucial to cognition as my neurons."

William J. Mitchell 2003

The development of mobile learning (m-learning) in museums dates to 1993, where a company named *Visible Interactive* (VI), developed the first known interactive audio tour known as iGo. This was the first device to break out of the linearity confines of the past. It had access to multimedia, text, and audio within the exhibit space using a modified Apple Newton® computer. This early experiment was followed by several pilots, focusing on elements of personalization, interactivity, and overall user experience within the museum environment. Notably, the first major project VI undertook was the iGo interactive guide for the Smithsonian Museum's 150th anniversary tour, providing information on 97 out of the 300 objects exhibited plus 2.5 hours of audio, text and graphics. VI also created tours for the Smithsonian's National Museum of Natural History, and the Air and Space Museum in Washington, D.C. In addition to the museum tours, VI produced an audio walking tour of San Francisco's Chinatown.

VI's work on Apple Newton later inspired German researchers Stefan Gessler and Andreas Kotulla to engineer them as mobile Web browsers. Although these projects disappeared when the Apple Newton was discontinued, the concept of a wireless information environment was an accurate forecast of things to come and the ubiquity of mobile technology in our society today.

Following up on the VI projects, the Smithsonian Museum continued to be at the cutting edge of museum technology, it experimented with another handheld device know as the Rocket eBook in 1999, to support it's On Time exhibit . This introduced a touch screen, supported hypertext files, sound, as well as black and white graphics. The devices were pulled from the exhibit due to technical problems, but its legacy lies in the positive user adoption of these devices in the museum environment. Other early experiments were followed in Europe and the US respectively. Among the leaders in the US, Flavia Sparacino at the MIT Media Lab looked into 'perceptual intelligence' whereby museum displays would be adaptive to user interaction.*

More recently, at the Cannes Film Festival (2001) Palm Inc. developed an electronic guide that provided real-time information such as schedules, exhibitors, hotel and restaurant information as an alternative to its festival guide. Starbucks coffee houses installed wireless environments and provided IPaqs for customers at some of their nationwide locations. Clearly corporations and advertisers alike are aware of the enormous marketing opportunities with the availability of ubiquitous mobile devices at their reach. For the consumer, unfortunately this means a relentless barrage of unwanted mobile spam to come. This is the price users will have to pay for access to information 'on the fly.'

Museums along with cultural centers are finding audiences eager to participate in new experiments with hand held computing. The Field Museum in Chicago created a simple guide for a Palm®, which visitors used during their visit. Colonial Williamsburg has investigated the use of wireless technology as a tool for guiding visitors around its 175-acre site. The Discovery Museum in Connecticut has a Palm® initiative to provide exhibit information as well as access to outside resources via the Internet. The American Museum of the Moving Image developed the "eDocent" hand-held guide in a wireless, device aware environment, enabling users to bookmark content for later use on the Web. The San Francisco Museum of Modern Art (SFMOMA) has developed a visitor guide using Compaq® Ipaq handhelds in their galleries. The Museum's Interactive Educational Technologies program introduced the SFMOMA prototype using an Ipaq® with a touch screen and headphone capabilities. Curators were excited about the possibilities of expanding the available contextual information to users.*

* Other Museum Technology Experiments

The *Hyper Interaction with Physical Space* (HIPS) project involves the participation of three universities: The University of Edinburgh , University College of Dublin, and the Universita degli Studi di Siena that lead the project. Deutschen Museum München partnered with the Fraunhofer Institute for Graphic Data (IGD) creating the *MoBIS*, mobile visitor system for a special exhibition. University involvement in designing the future of mobile computing included the University of Glasgow, Scotland, who sponsored the *First Workshop on Human Computer Interaction with Mobile Devices in 1998*. In the U.S., the MIT Media Lab, known for its interest in wearable computing, experimented with interactive exhibit design through the work of Flavia Sparacino. Her work with *perceptual intelligence* integrates multiple sensor modalities to explore the expressive abilities of digital text, photographs, movie clips, music, and audio. *The Cornell University Human Computer Interaction* (HCI) group research led by Geri Gay included mobile and ubiquitous computing in library, museum and educational applications.

* "Ideally, a visitor could watch a video of an artist in the process of making his or her work while in the presence of the finished piece."

Deborah Larence, SFMOMA Interactive Technologies

The Exploratorium in San Francisco, with the help of the Concord Consortium, in Concord Massachusetts developed a mobile device, which enabled bookmarked material to download to a personal web page for later use, a concept much like the eDocent. The idea of recording a museum visit chronologically has great potential for the student because it acts as a reminder of all the concepts and experiences during the short scholastic visit. Other projects, which have explored content delivery through a web browser, include: The Whitney Museum project for The American, and the Experience Music Project in Seattle.

Many universities are conducting current research in the area of ubiquitous computing such as the delivery of automated audio to a patron's cell phone within the museum premises. Simon Fraser University in Canada has analyzed the concept of interpreting the museum as an informational and cultural ecology as an analytical framework for designing interactive museum experiences. This project involves the concept of ambient intelligence with architecturally placed sensor and display technologies, which are supported by artificial intelligence responsive to human action and behaviors within the museum-learning environment.

Pilot Programs using Mobile Technology *Tate Modern Multimedia Program, England 2002-2004.* This pilot program developed a variety of tours including: (i) a multimedia highlights tour specifically designed for the 16-25 age group; (ii) a British Sign Language tour for the hearing impaired; (iii) and a collections tour. Tate Modern's (MMT) pilot was open to the public in July 2002, with follow-up pilots in 2003 and 2004. Antenna Audio developed a 45-minute multimedia tour of the *Still Life/Object/ Real Life* galleries, in which visitors could experience audio, video, still images and a variety of interactive applications using a handheld iPAQ computer loaned to the museum by Hewlett Packard Corporation. The content of the multimedia tour was delivered to the visitor through the museum's wireless network, using location-based technologies, which identified the location of the handheld devices inside the gallery space. The wireless network extended over fourteen galleries, defining sixteen unique content zones by means of seven access points. In each gallery, a different approach to content design was applied to the presentation of a selected object.

A combination of location-based and interactive applications made a variety of functionalities available. Interactive surveys recorded visitors' opinions and involved users' points of view. A jukebox feature allowed visitors to mix their own soundtracks to visual collages. Location specific content made the information relevant and appropriate according to location and object. Tracked visitor location in the galleries alerted staff of technical failures and enabled dual communication. Special features include full screen content mode, direct contact capability with visitors (page service), automatic prompting of visitors (alert service) before the start of programming relating to location/exhibit, and a bookmark feature allowing for email.

This project required very sophisticated wireless network enabling a 802.11b protocol for the transmission of information. This is now considered old technology, for 802.11a and 802.11g protocols are now the standard. Both 'Client Side' Software (CSS) stored locally on the PDA (Internet Explorer and Macromedia Flash) and 'Server Side' Software (SSS) stored on the network server, made formats such as HTML and Flash deliverable. The content was delivered using a content delivery engine developed by PanGo's Museum Docent™. Another important component of the program was the location-based service (LBS) provider making location-sensitive content and interactive maps of the gallery available in real time. PanGo's Proximity Platform™ calculated the location of the user by taking signal strength readings from a number of access points in the user's vicinity and effectively 'triangulating' the user's position within the gallery space. The Tate also explored a highlights tour for the death and hard of hearing in which content was translated into British Sign Language (BSL) and distributed by the handheld device.*

The Royal Institute. The *Science Navigator* (SN) multimedia tour and information resource stands out for being the first to integrate personalization technologies along with location-based services for a multimedia tour inside a cultural institution. Although the program was tested for a few months in 2004, the goal is to make it part of a permanent installation by 2006. The system relies on location information services as well as user profiling for a customized user experience, which updates as the system extrapolates dynamic information from the learner's behavior. The SN automatically makes suggestions on possible routes and artifacts to see during the visit based on this dynamic information. This project stands as a strong testament to the exciting possibilities for artificial intelligence (AI) in the museum context.

iTour at the Jack S. Blanton Museum of Art, University of Texas at Austin. The *iTour* at the Blanton Museum is another example of implementation of a handheld device for interpretive purposes. Handheld pocket PCs held video content showing the artists and their work, and curatorial discussions.

This pilot used a limited exhibition, *Visualizing Identity*, for the mobile project, showcasing four works of art that explore issues of personal, racial and cultural identity. Once the user has engaged the device with a stylus, a variety of options are available, including: (i) video, audio or text; (ii) a watch and listen feature, and (iii) individually selected themes of study . The device allowed users to create poems, ask questions, or match their skin tone to those in one of the art exhibits: a very compelling way to involve the visitor directly with the work.*

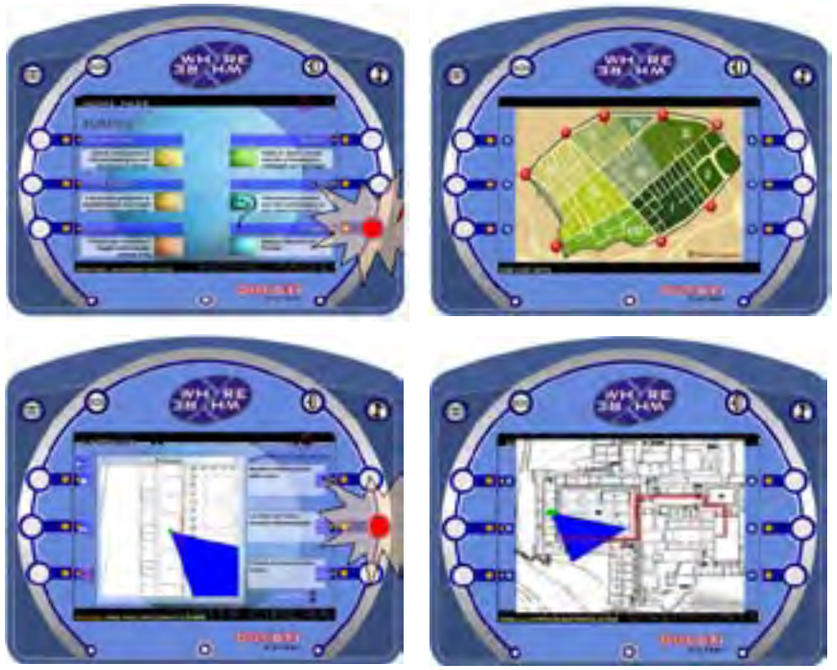
* "The iTour is a portal directly into the work of art...Nothing can replace the experience of standing in front of the work of art, but capturing the treasured knowledge of the artist, curator and docents in a handhled interactive computer gives visitors an opportunity to step into the work and explore, for as much or as little time as they wish. Ideally, we're trying to open the door to more 'ah-ha' moments, when the visitor makes a personal connection to the work of art."

Glanda Sims, ITS senior systems analyst and project leader.

MUSE Project and the WHYRE® museum guide at San Martino Museum, Italy. The MUSE project built a context-aware wearable device called WHYRE® for the purpose of cultural tourism in three sites in Italy: (i) Il Museo e Certosa di San Martino in Naples, (ii) the Institute and Museum of the History of Science in Florence, and finally (iii) the archeological site in Pompeii. The MUSE project is a joint project between Ducati Sistemi in Bologna, and the Italian National Research Program on Cultural Heritage. Although this project had complimentary stationary devices, the on-site interactive, the context-aware multimedia guide is the only portion of this project, which is directly applicable to my research.

This device is considered multimodal because the user can switch between a free navigation mode, a context mode and a guided tour mode. The user is dynamically prompted with multimedia content based on location inside the cultural institution. Location detection is made possible by multiple sensors, which detect a user's location using a positioning algorithm received by WLAN access points. This is referred to as *triangulation of a visitor's location* mentioned earlier in this paper. One of the interesting features of this project is the 'memories' channel, which creates a personalized CD during a museum visit. This is useful for the post-visit exercise which refresh a visitor's memory of his experience inside the museum.

One of the features, which I found most interesting in this pilot, was the interactive three-dimensional content delivery interface, where a visitor could explore parts of objects not visible to the eye at the museum. Use of a device to delve into the hidden interior of objects expands upon user experience inside the museum and has added learning value. For example, the ability to see inside of an Egyptian sarcophagus is a valuable experience for a learner where entire sections of hieroglyphic material are hidden from view due to the physical characteristics of the artifact or its presentation inside the museum. Without the intervention of a multimedia device, this valuable information would be inaccessible.



* *Virtual entrance of Pompeii Site Map* ~ the first screen is the entry point of the Pompeii application on the on-site mobile channel. The following interactions are available: (i) introductory presentation on site; (ii) site map; (iii) selection of navigation mode; (iv) get help on current screen. By pressing on the *Site Map* button, the archeological map of the site reveals content organized into 'insulas'.

MUSE Project and the WHYRE®, the insula del Centenario at the Pompeii archaeological site, Italy. The MUSE project at the insula del Centenario at Pompeii stands as a powerful example of deliverable content to provide the end user with a ubiquitous information environment. The virtual reconstruction of interior spaces brings this archaeological site to life and enables visitors to have full appreciation of the artistic splendor of Pompeii as it existed prior to its destruction.

* *La Casa del Centenario in Pompeii* ~ when the use enters this site, their position is detected by the application. A virtual reconstruction appears and a sound commentary automatically begins. Users can obtain more information by pressing the mid left button. Visitors are, thereby, able to visualize the atrium as it existed prior to the eruption of Mount Vesuvius in 79 A.D.

Other Projects Related to Mobile Technology in Cultural Institutions. The *m-ToGuide* (mobile tourist guide) explores similar features as the MMT pilot at the Tate Modern museum. This project was specifically designed to develop tourist content and services for handheld devices using a 2.5 and 3G telephone network intended for European use only. The aim of the *m-ToGuide* is to provide tourists with content and services (including m-commerce features enabling purchases) from a variety of providers, on handheld devices. It provides interactive navigation services and personalized information, according to criteria established by the users, on places of interest, monuments, stores, restaurants, hotels, and museums in real time. There are specifically designed features for cultural institutions such as: (i) visual and textual messaging alerting user of main points of interest, (ii) a 'highlights' tour for a destination city, (iii) museum tours and current exhibitions, (iv) navigational supports, (v) and finally visitor information on commerce in the area. Although this project is beyond the scope of my thesis in curriculum-based m-learning inside museums, it is a strong testament to the ubiquity and wide acceptance of wireless technology in the tourist sector.

Still closeup from *Earthly Delights Show* at Doran Gallery, Massachusetts College of Art 2004

Thesis Explorations

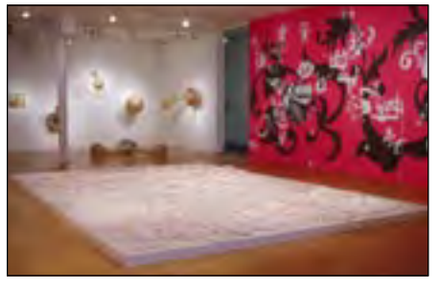
In 2004 I had the opportunity to observe a group of middle school students visit to the *Earthly Delights* exhibit. The questions I set out to answer were:

(i) how do students and teachers use museum spaces as informal learning environments and
(ii) what are the elements of user experience which transfer into digital functionalities?

Looking to Learn (LTL) is Massachusetts College of Art's gallery education program created to introduce students in grades four through twelve to contemporary art.

The LTL program uses inquiry-based activities which aim to:

(i) help students develop visual awareness,
(ii) stimulate high level thinking abilities,
(iii) nurture imaginative responses to the visual arts,
(iv) encourage curiosity, imagination and interpretation,
(v) value participation and articulation, and
(vi) to pursue visual expression.



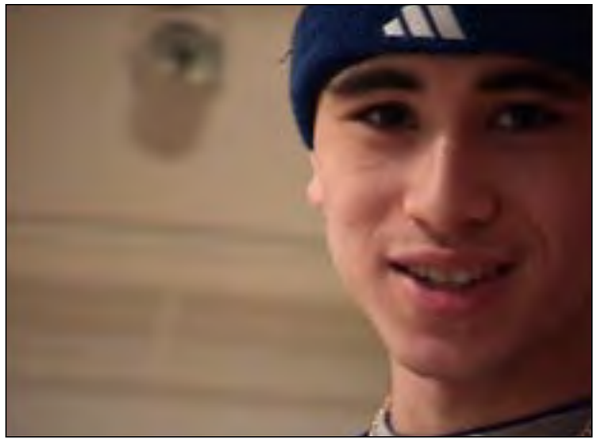
These goals are standard for museum interpretation programs and are consistently endorsed in the museum learning community. The LTL program approaches student learning as a three-part continuum. The pre-visit classroom orientation program introduces the children to the important themes and topics in the collection. Following the gallery visit, students engage in art-making exercises to incorporate what they have learned into their art.

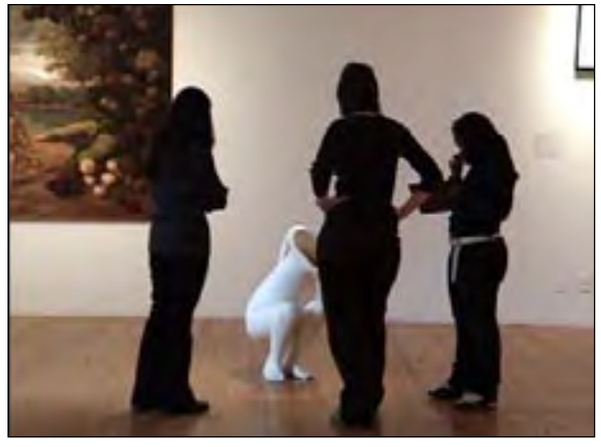
During the school orientation program, students are introduced to the concept of what it means to actively look at art. Topics include 'group show versus individual show,' mediums used by artists, and Hieronymus Bosch's *Garden of Delights* triptych and how it relates to the show. Emphasis is placed on the importance of how art is used to express multiple points of view.

During the gallery visit, students are encouraged to discuss artifacts, which they find personally meaningful. In the picture to the right an artist depicts white pig fetuses on a large white platform. This display engendered much discussion about life and death, the color white and the immediate visual impact of this large-scale project. Most students described it as disgusting and repulsive until they looked deeper into it.

The documentary film and observations made during the LTL program helped me make conclusions regarding user needs, problems, goals and interactions inside museum space. This information relates to human factors affecting participation, collaboration and interaction and gave me first hand knowledge in the following areas:

(i) the roles students play,
(ii) how are these roles translate into participation,
(iii) and the interpersonal relationships contributing to effective communication.

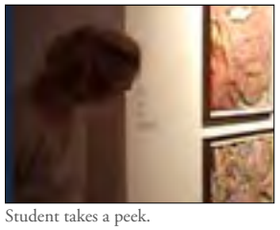


This ethnographic documentation provided useful information for human, social and organizational tools used to accomplish educational exercises. The pictures above are stills from the film taken during a school visit to the Earthly Delights show in 2004.

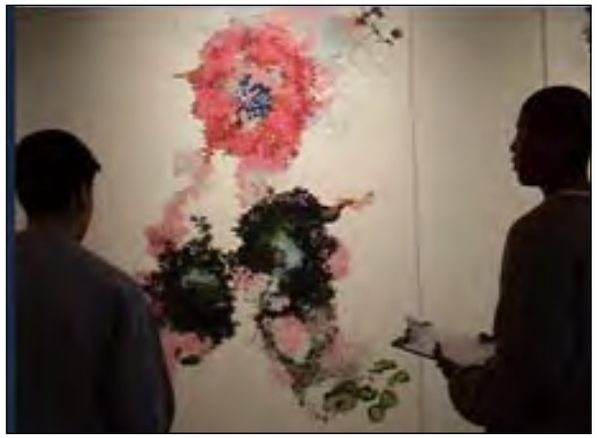
Social interaction, cooperation and dialogue are fundamental for a valuable learning experience in this scenario. The goal of the gallery/museum visit is to enable students to make connections between introductory material, and gallery content in order to create personal meaning and knowledge, while expanding upon information they already know. This requires that they feel comfortable participating within a group inside the gallery space. In *Earthly Delights,* students were asked to react to the piece by sharing their first impressions with the group. Sandy Weisman, director of LTL, lead the discussion and tried to include as many points of view as possible. I observed that many students were not comfortable expressing their opinions and stayed quiet during this session. It was clear that many students wanted to remain anonymous during this process. Perhaps they were embarrassed or too shy to speak up. Later students were asked to work in small groups. I noticed that many were created along gender and ethnically lines limiting their exposure to multiple points of view. Many boys were embarrassed to look 'too interested' in front of the girls. All of these behaviors are developmentally appropriate for children in the middle school age group. These explorations culminated in a shared group presentation about the exhibition. Students were asked to answer the following questions in order to *decode* its meaning.

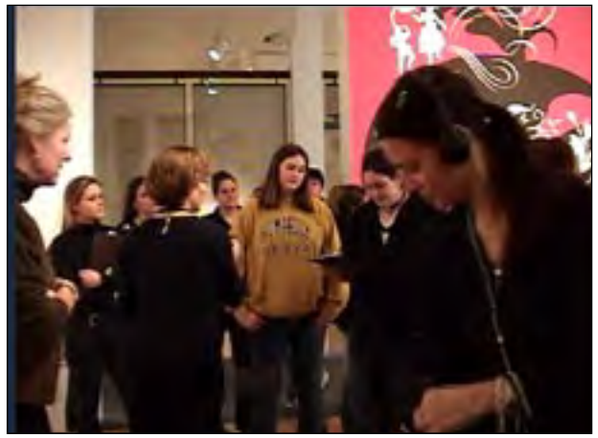
(i) What was your first reaction to the piece? What associations do you make when you look closer?
(ii) What feelings are generated when you look closer?
(iii) What ideas does the work suggest to you and your partner? How has the artist made you respond to the work? What kind of world is the artist is representing?


Student takes a peek.


Boys feeling silly in gallery.


Groups defined by gender.






My observations of the student's behavior inside the gallery space enable me to create a list of user needs for more fluid communication during a gallery visit. The group presentation was the biggest challenge because of students' reluctance to participate. It was difficult for them to make references to pieces of art located in other rooms or behind walls.

Translation into needs:

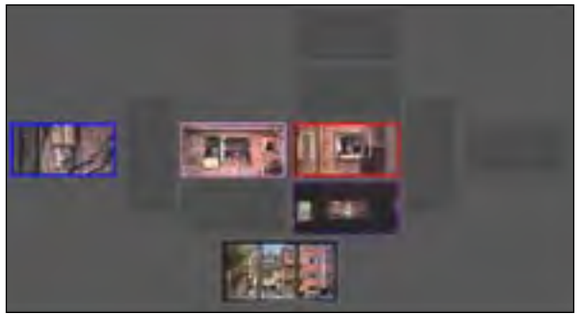
(i) anonymity
(ii) book marking or archiving information for presentation
(iii) breaking out of ethnic grouping and gender grouping
(iv) helping boys and girls feel like creators feel more comfortable being creative
(vi) helping girls interact with boys (and vice versa)
(vii) accessibility to information on the fly

The primary lesson I learned from my observations of the LTL was that effective social communication forms the basis of a valuable museum leaning experience. Technologically mediated communication can be used to break down the barriers to effective communication and to expand upon the existing characteristics, which positively affect learning inside a gallery space.

Rear View Window Interface Project ~ A cognitive Roadmap. The film set was amazing, depicting a city apartment complex, the center courtyard, and it's residents. I was amazed how the view from one apartment could set the stage for the entire film in such a captivating way. The opening scene introduces the viewer to the inhabitants of a New York apartment complex: Ms. Torso, the beautifully attractive dancer, the sad and lonely woman, Mr. Lonely Hearts, the unfulfilled piano player, and the newly-weds who slept on an exterior fire escape facing the courtyard. The viewer is allowed to peek into these apartments from the vantage point of L.B. Jeffries' apartment, the main protagonist in the story.

James Stewart, plays L.B. Jeffries, an adventure photographer known for his high risky photo shoots. As a result of a dangerous assignment, Jeffries is relegated to a wheelchair with a broken leg for seven weeks in the middle of a hot summer in New York City. The viewer is well aware of Jeffries' psychological frustration, his inability to move, and the need to get out of this situation. The viewer feels his frustration, his boredom and the personal escape realized by his binoculars. The movie forces us, the viewer, to become voyeurs like Jeffries into the events in his courtyard. Through his binoculars we share his suspicion of Lars Thorwald's and his murderous act against his wife.

Jeffries' girlfriend Lisa is a character worthy of modern day admiration. Hitchcock breaks out of the traditional female beauty stereotype, with a woman who is brave, able and willing to take risks. As the story unfolds, we are able to glean commonalities between Jeffries and Lisa, their convictions and fears. She, like Jeffries, is drawn into the developing mystery unfolding before her eyes. She, like Jeffries, faces the challenge and puts herself at risk for the sake of finding out the truth. We, like Jeffries, are terrified by Lisa's ability to put herself at risk as she steps into Jeffries shoes and shows him that she can handle a dangerous and precarious mission. Jeffries is amazed her willingness to find out the truth. I believe she undeniably impresses him.



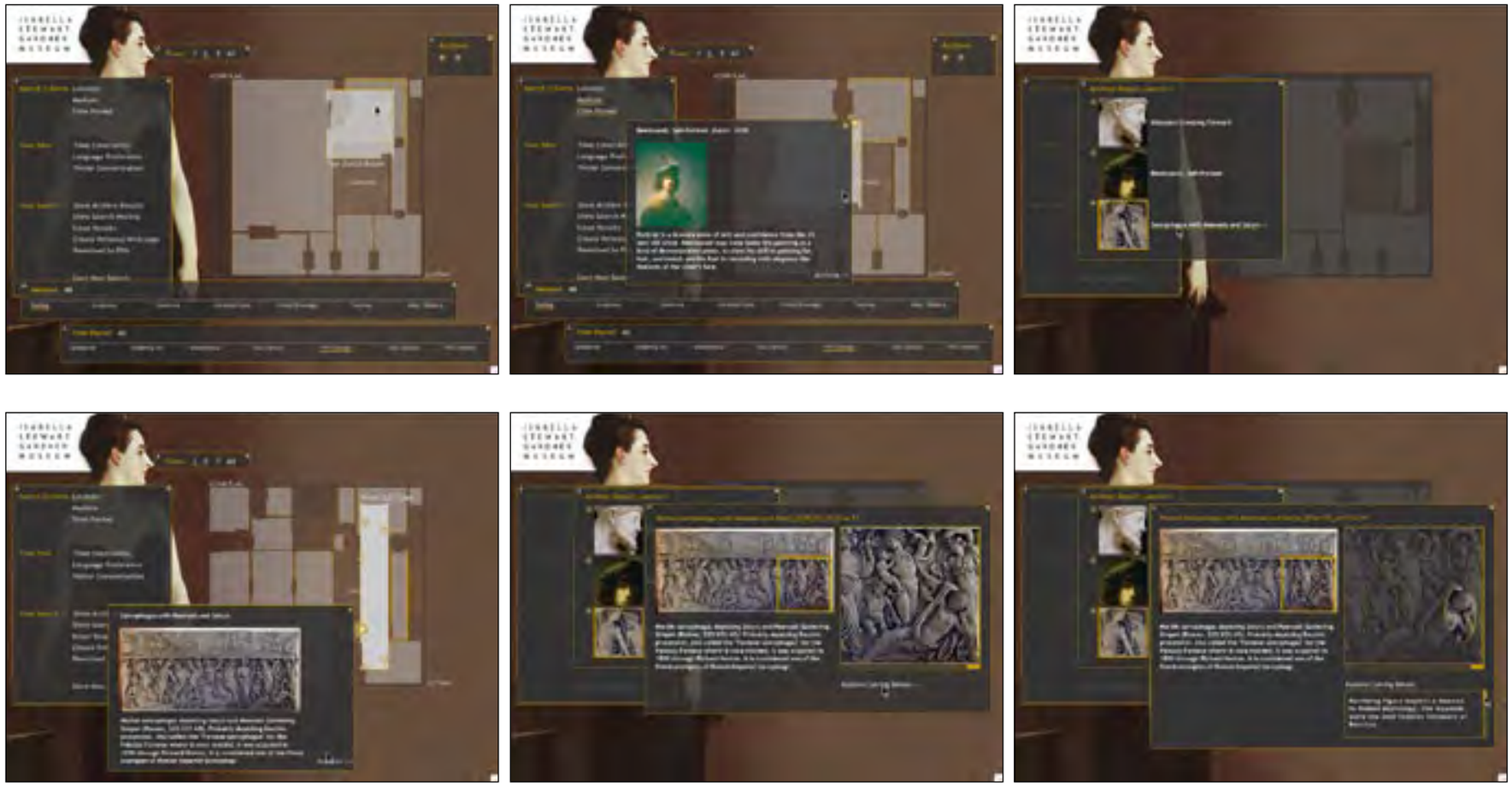
Alfred Hitchcock's genius is seen in his ability to make us feel like we are part of this developing mystery. We are voyeurs as Jeffries observes the various events in the apartments in front of his window. This is most evident when the tables' turn in the movie at the height of the drama; when Lars Thorwald becomes aware of Jeffries' observations and turns off his lights. This action immediately turns Lars into our observer. At the height of this developing drama, Lisa breaks into Lars' apartment and confirms our suspicion that he killed his wife by showing us her wedding ring. Lars' eyes are lead back to Jeffries apartment by a dramatic change of position of the camera, which draws the viewer back into Jeffries' apartment. The drama is further heightened by Jeffries' solitary confinement in the apartment. We are fearful for his safety.

Apart from the enormous suspense felt during the movie, what was most evident to me was seeing the apartment complex as a metaphor for a map of information. This map being able to provide private information into the lives of it's inhabitants. As I looked at this movie with an eye for interactive design and information, Jeffries' window became a metaphor for a navigable space from which he could seek out information contained within. Jeffries was given clues, perceivable through the windows into the space within, much like a well-designed interface. The different windows in the apartment building acted much like informational containers or categories.

Although Hitchcock used multi-sensory clues to give the viewer context on the story, the prevailing organizational tool employed by him was the architectural map of the apartment building and the corresponding apartments. This metaphor was very influential to me in my thinking for the pda museum project. The apartment building, depicted by an accurate map of the architectural layout, orients the user to the information contained therein.

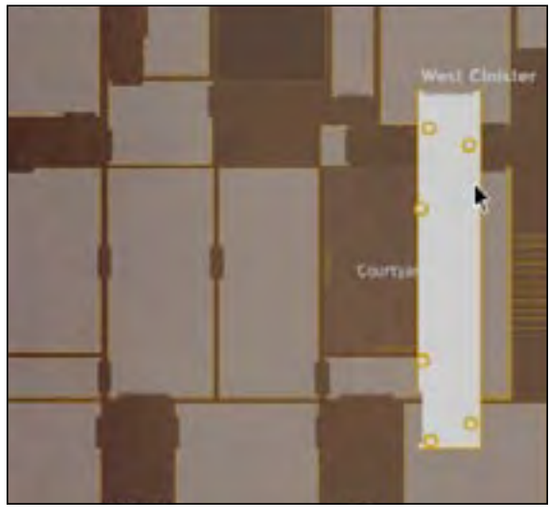
In my thesis project, this visual device forms the organizational foundation upon which other functionalities, like the archiving tool, are based. I chose a two-dimensional representation of the apartment building in order to simplify the information and distill it for the user. By simplifying the visual information into its most important elements, you eliminate confusion and 'clutter' for the viewer. The map is a cognitive representation of the story.

Other organization features of the Hitchcock project include the use of logical categories, namely separating information in ways that relate to the content. We are interested in Jeffries perception of his girlfriend Lisa over a period of time in the movie. A timeline is a logical metaphor to explain this transition. The timeline contains content relating to which events and characters influenced his attitude towards Lisa during the movie.



Isabella Stewart Gardner Project – individualization and Resolution. The focus of this project is to analyze how information can be individualized or personalized for particular user needs through filtering devices in the interface. I was confronted with a database of over 2,500 objects ranging from paintings, sculpture, furniture, textiles, drawings, silver, ceramics, illuminated manuscripts, rare books, photographs and letters, from ancient Rome, Medieval Europe, Renaissance Italy, Asia, the Islamic world and 19th-century France and America. The curatorial aim at the Isabella Stewart Gardner Museum (ISGM) is to explain the collection in context to Ms. Gardner's era in order to encourage alternative ways of understanding art. The unique setting evocative of a 15th century Venetian Palace which houses the collection is a very provocative setting in which to explore.

The first three screen shots above aim to show the ways in which a database system can organize information for the user in a manner which is both understandable and accessible. The collection is organized according to era and medium, from which the user can set filtering criteria in order to show corresponding artwork on the map. The user can continue to filter the information until he/she is able to reach one particular artifact. Once this artifact is found on the map, the user can then archive it and explore a deeper level of content relating to it. The top left image shows the exact room where Rembrandt's 1629 Self-Portrait is located. Once the artifact icon is clicked, a description of the painting appears on the screen with the choice for archiving and in the top center screen. The archived artifacts create an opportunity to add media features for further resolution of the information. For instance, in the example above, the visitor has archived a Roman Sarcophagus of the Satyrs and Maenads dating to 222 A.D. This piece has enormous detail in the carving and a story which would be imperceptible to the individual without the enhancement of higher resolution features in the interface. In the bottom row, the user has selected the artifact for deeper exploration. The second screen shows a scrolling mechanism which zooms into the sculpture and shows the sections of the piece. The scrolling device can be stopped at any point to highlight a specific part of the artifact, as seen in the last screen shot on the right.



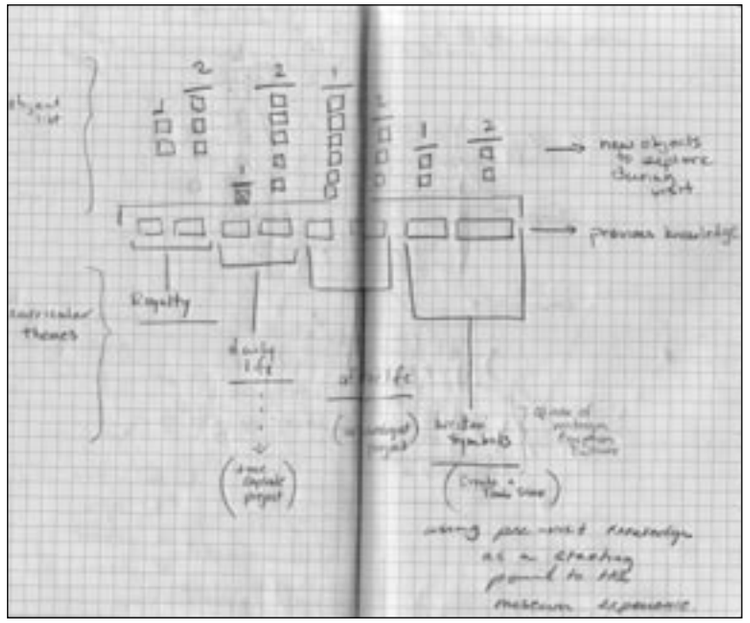
Thesis Project ~ Mobile Learning insdie the Egyptian Galleries at the MFA, Boston

The Department of Education and Public Programs at the MFA offers extensive resources dedicated to the museum's Egyptian and Nubian Art collection. Useful publications include, *Exploring Egyptian Art at the Museum of Fine Arts, Boston, Digging up Egypt's Past, and Preparing for a Self-Guided Visit to the Permanent Collection at the Museum of Fine Arts, Boston*. The extensive written materials surrounding the Egyptian and Nubian Art collection, were a wonderful resource upon which to base my curricular exercises. These resources are specifically designed to work with the extensive Egyptian collection at the MFA and are categorized into to four themes. These include symbols of royalty, daily life, the afterlife, and written symbols.

The core curricular goals in the MFA's interpretive program for children fall inline with the pedagogical objectives stated earlier in this thesis. These docent goals are commonly held standards in the museum learning community, and include:

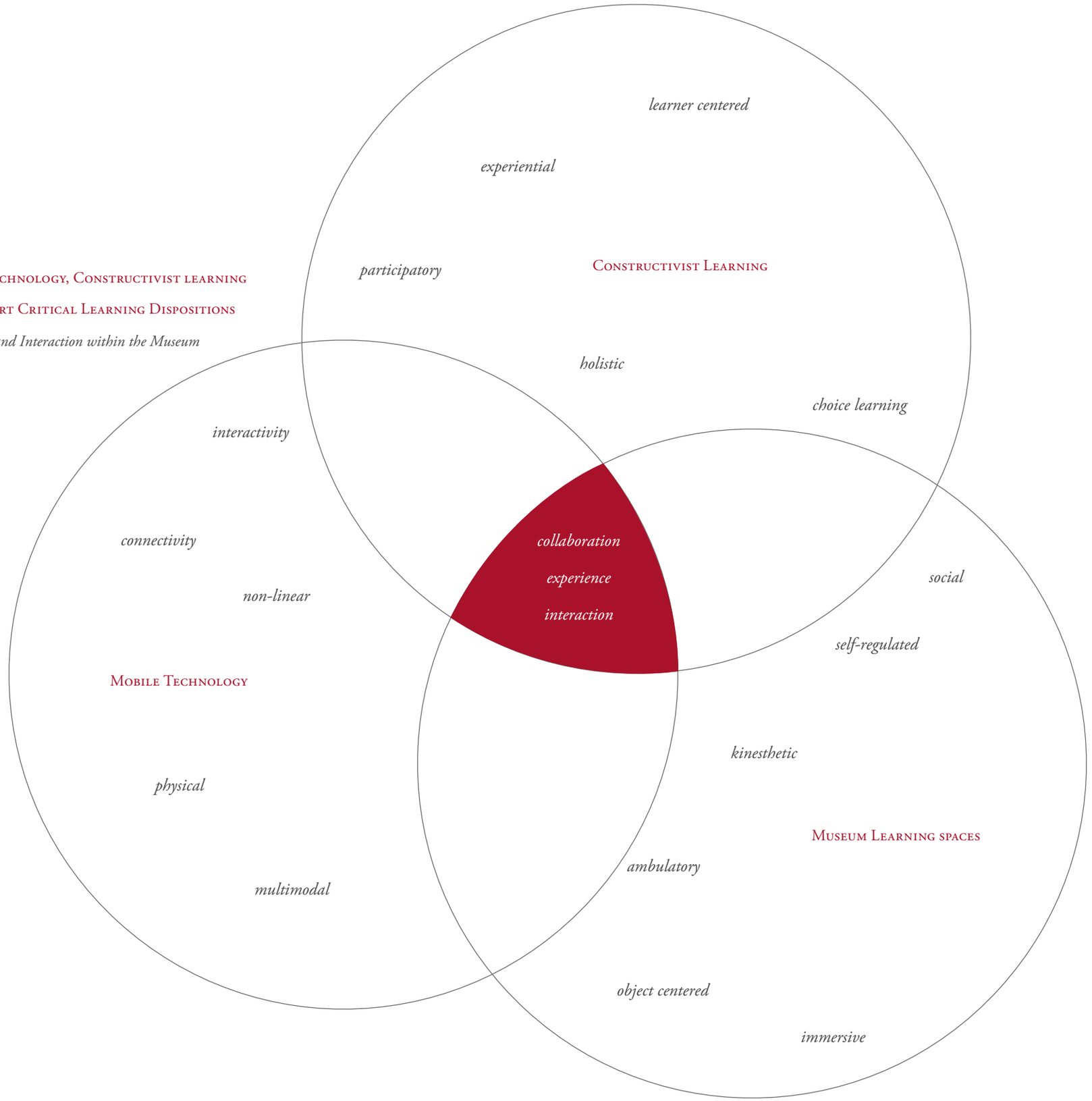
(i) to explore the Egyptian Galleries,
(ii) to become comfortable inside the museum space,
(iii) to look closely at art and to make inferences from what you see,
(iv) to compare and contrast what you see,
(v) to collect and record what you see,
(vi) and to share and discuss what you see with others.

There is a direct connection between these stated goals and the tenants of constructivist learning theory, focusing on collaboration, experiential learning, and social interaction inside the museum. In addition to these objectives, the affordances of a handheld digital multimedia device support the commonalities found in constructivist learning pedagogy and museum learning spaces, striking a perfect balance for critical learning dispositions. It's focus on collaboration, experience and interactivity between individual classmates and the network within the museum, in addition to tailored content for unique collections and curricula, enable targeted learning to take place.



Convergence of Mobile Technology, Constructivist learning theory and Museums support Critical Learning Dispositions

Collaboration, Experience and Interaction within the Museum



Synchronicity and multimodality – a usability paradigm shift The Muse project mentioned earlier in this thesis spoke about unique usability paradigms applicable to mobile devices in cultural institutions. Multimodality, offering a variety of interactive modes, and synchronicity* dealing with issues of location based content delivery are directly impacted by the user's movement inside the physical space. This fact makes the following issues important to consider:

(i) the user's position inside the gallery space;
(ii) the dynamic nature of user's position 'pushes' information relative to person's location, thus changing the nature of the information; and
(iii) the linearity of time based media, such as video, audio and animation, present with a beginning and an end.

For example, if a student is viewing a time based element on the screen and then moves prior to its conclusion, then an asynchronous situation in created where the content does not match the user's new location. The content will not conform unless the user has control over the stream of content and can stop it or he has a choice to resynchronize the mobile device. In either of these scenarios, the user must know what is going on in order to control his/her experience and he/she must be aware of his choices at that time.

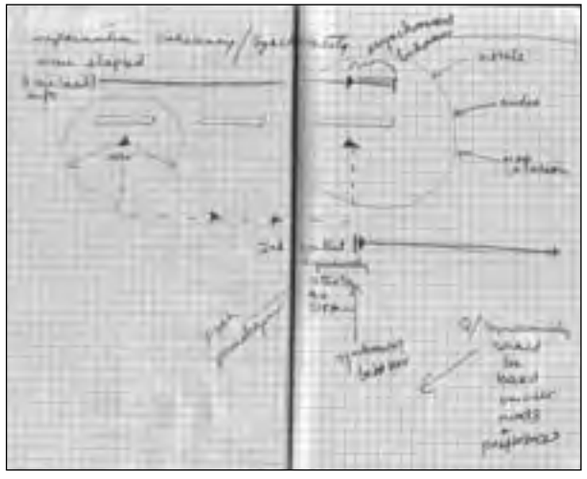
The usability of context-aware 'behavior', the success of 'push' paradigm, and the use of a multi-modal interactive model all depend on the level of intuitiveness and adaptability of the interface. Impacting such criteria will be the following:

(i) does the user know when he/she is in control of the interaction,
(ii) does the user set the limits of each interactive mode, and
(iii) are transitions between modes clearly communicated to the user?

Lessons from the Muse project point to a need for clear communication of multimodal features and interactivity by use of color, icons or text and, multiple prompting cues which I have taken into consideration in my conceptual prototype.

* *Definition* – syn·chro·nic·i·ty

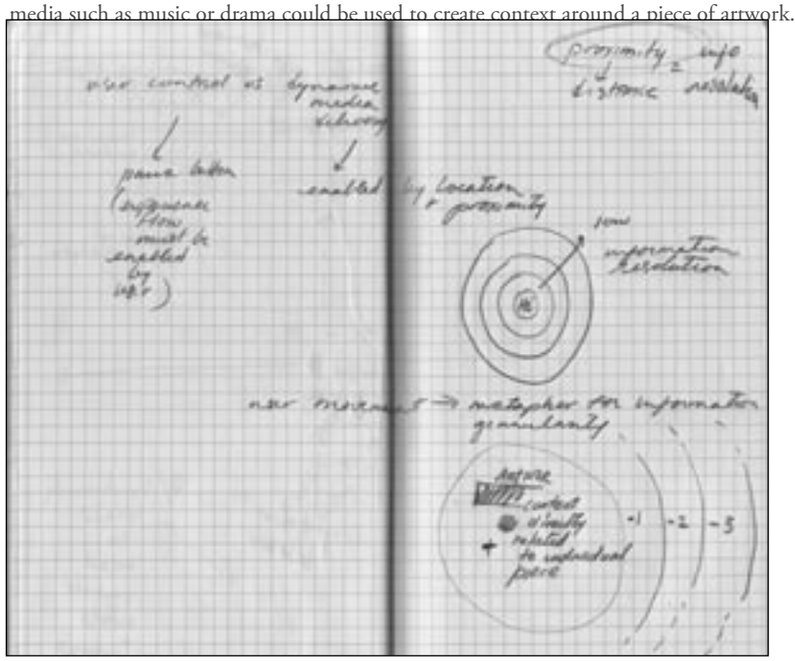
Function: noun, 1 : the quality or fact of being synchronous, 2 : the coincidental occurrence of events and especially psychic events (as similar thoughts in widely separated persons or a mental image of an unexpected event before it happens) that seem related but are not explained by conventional mechanisms of causality -- used especially in the psychology of C. G. Jung



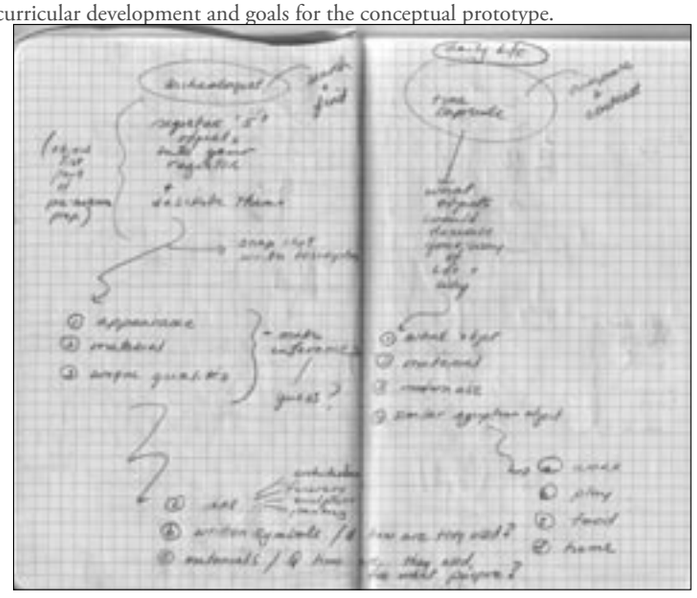
IT network structure inside the museum. Content is stored on a central computer server and channeled to the visitor's handheld device via a wireless local area network (WLAN). Content can be automatically triggered by a software-based system, like the one used at the Tate Modern developed by PanGo Networks mentioned earlier in this thesis, or small infrared tags which are read when the PDA comes close to it's proximity.

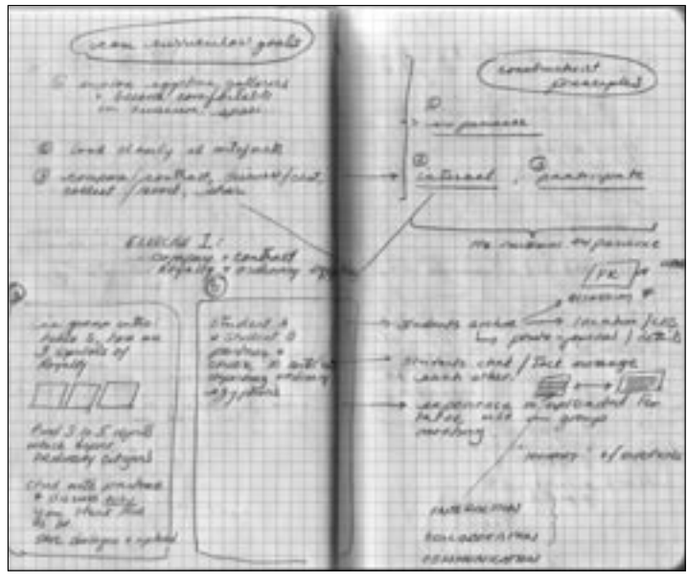
Infrared triggers (IR) or radio tags (RFID) attached to walls are picked up by the PDA upon entering its range or 'line-of-site.' For location detection throughout an institution, a server-side software positioning system works best. The system 'triangulates' the location of a device from three different access points to establish a user's location. This is especially useful for location-specific content delivery. Another benefit is the ability for the user to have an updated interactive map for ambient orientation and cognitive mapping.

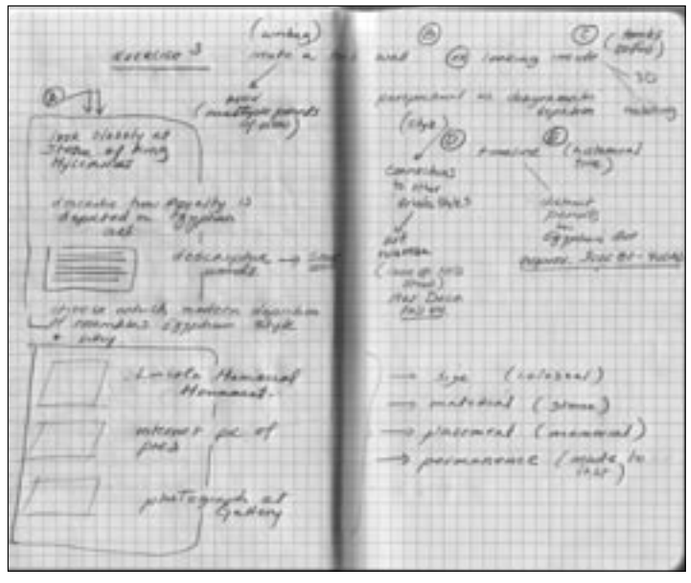
An augmented museum experience. Use of interpretive technology in the museum context is a controversial issue because of the concern for its interference with a learner's direct observation and interaction with a museum object. A screen-based handheld device, which draws attention away from the object, is in direct conflict with this goal. Therefore, it must enhance the interpretive process in order to be a viable solution worthy of financial and intellectual investment. The goal for interpretive technology, therefore, is to augment, enhance and increase accessibility by its implementation. Direct application of this stated goal is to include content which makes the 'invisible' visible; meaning it depicts hidden parts of an object, such as a sculpture or piece of furniture, or a virtual reconstruction of an archaeological site no longer existing. Further, other supporting media such as video clips would be used to show an artist's technique, studio and conceptual process while the user is in front of the art piece, in addition to an artists rough sketches or previous studies, expanding upon what the learner is able to glean from an object. For visitors with special needs, a handheld device would offer tailored content addressing the requirements of a particular disability. For instance, the hearing-impaired could enable a video guide with all explanations given in American/British sign language or captioned video. For the visually impaired, control over size of font and contrast can alleviate many of the hindrances encountered inside the museum. Finally, other media such as music or drama could be used to create context around a piece of artwork.

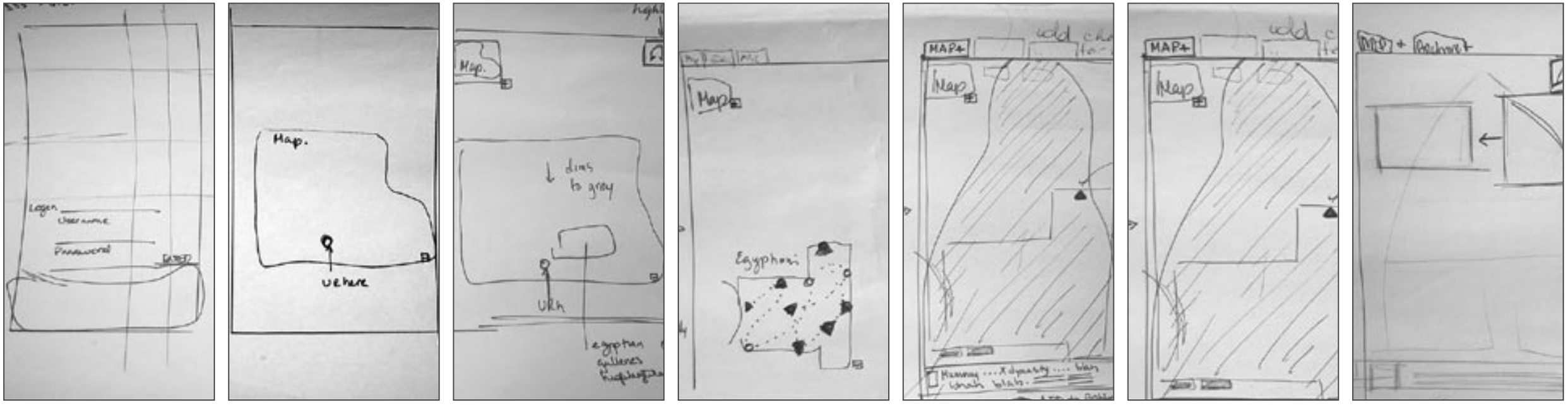


Finally, in this conceptual prototype, the narrative and visual presentation of learning interfaces, for the middle school audience, are directly derived from the specific interpretive and curricular guidelines developed by the museum staff. The goal is to augment the existing learning opportunities inside the museum space with the integration of specifically design learning interfaces. The figures below show my original thoughts regarding curricular development and goals for the conceptual prototype.









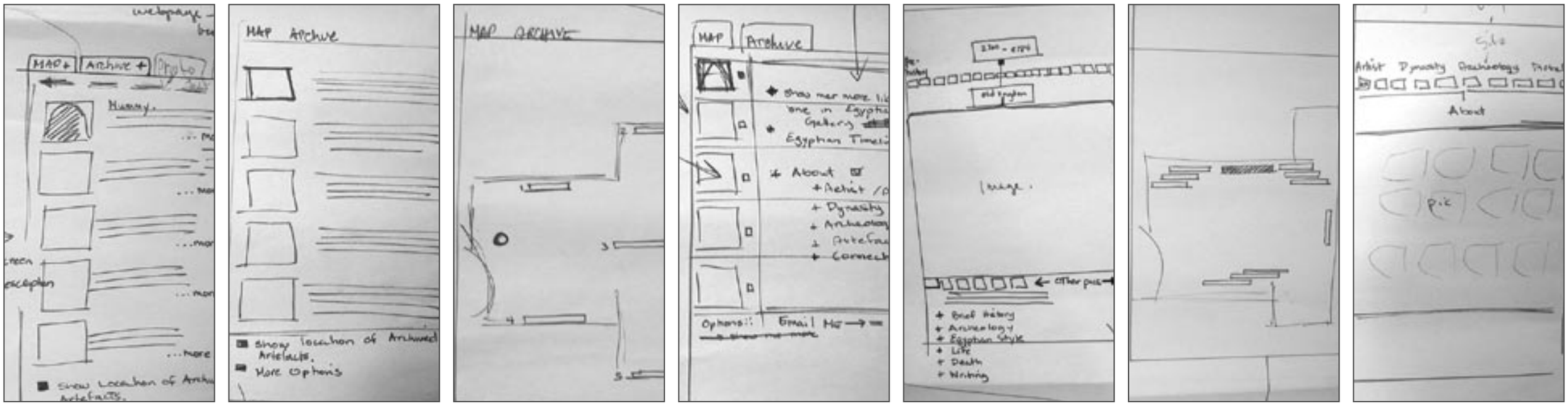
Paper Prototyping–refinements towards a Usability Paradigm/location aware applications inside the museum.

The aim in creating a paper prototype was to glean usability issues pertaining to context-aware/location aware systems, particularly the usefulness of context-aware behaviors, push/pull information models, and the usefulness of the multi-modal interaction paradigm for handheld devices.

Upon evaluation of the user-scenarios, conclusions about user behavior and needs, thereby clarifying the navigational and interaction design elements. Issues faced include heuristics or how well the navigation/interaction design conformed to established principles or industry standards and cognitive road-mapping, focusing on how well the user/student was able to solve problems within the information space. Although analysis of ergonomic efficacy affecting usability is not the focus of my research, this is a very important issue affecting the use of a handheld device. Ergonomic issues specific to a mobile technology include audio quality, screen resolution, shape, size and weight of handheld device, and interface design.

The usability factors which impact a mobile multimedia device inside a mobile cultural environment include:

(i) accessibility,
(ii) orientation,
(iii) user control vs. dynamic control,
(iv) consistency, and
(v) predictability.



Accessibility speaks to the ease with which a user can find a place/location or particular piece of artwork using the system. Orientation allows a user to know 'where' he/she is and 'how' to get to a place he/she wants to go. In terms of a navigational structure, this issue addresses how easily the user can understand his/her location in order to grasp larger contextual issues inside the cultural institution. User control stands in contrast to 'pushed' dynamic information, which appears on the device depending on the user's location inside the museum. Usability here is very critical since knowing when there is control enable full participation within the available applications and functions. Consistency of interface design addresses the need for predictability when a user is in a family conceptual space allowing familiarity and comfort of use. All of the aforementioned issues are applicable to predictability: once an environment becomes familiar or predictable in its behaviors and treatment, then a user can concentrate on the exploration of features rather than eliminating the obstructions to use. Issues identified in user testing will be analyzed later in the conceptual prototype:

(i) What techniques can be used to give the user understanding about the state of control?
- a. Audio cues
- b. 'vibration' cues
- c. interface design
- d. outer 'skin' of the device
- e. soft-interface features
  - i. color
  - ii. textual hierarchy
  - iii. proportions

(ii) Where are opportunities for clear communication:
- a. effects/behavior enabled usability;
- b. visual/interface enabled usability;
- c. device/behavior enabled usability

An example of Interaction and Way-finding inside a Museum

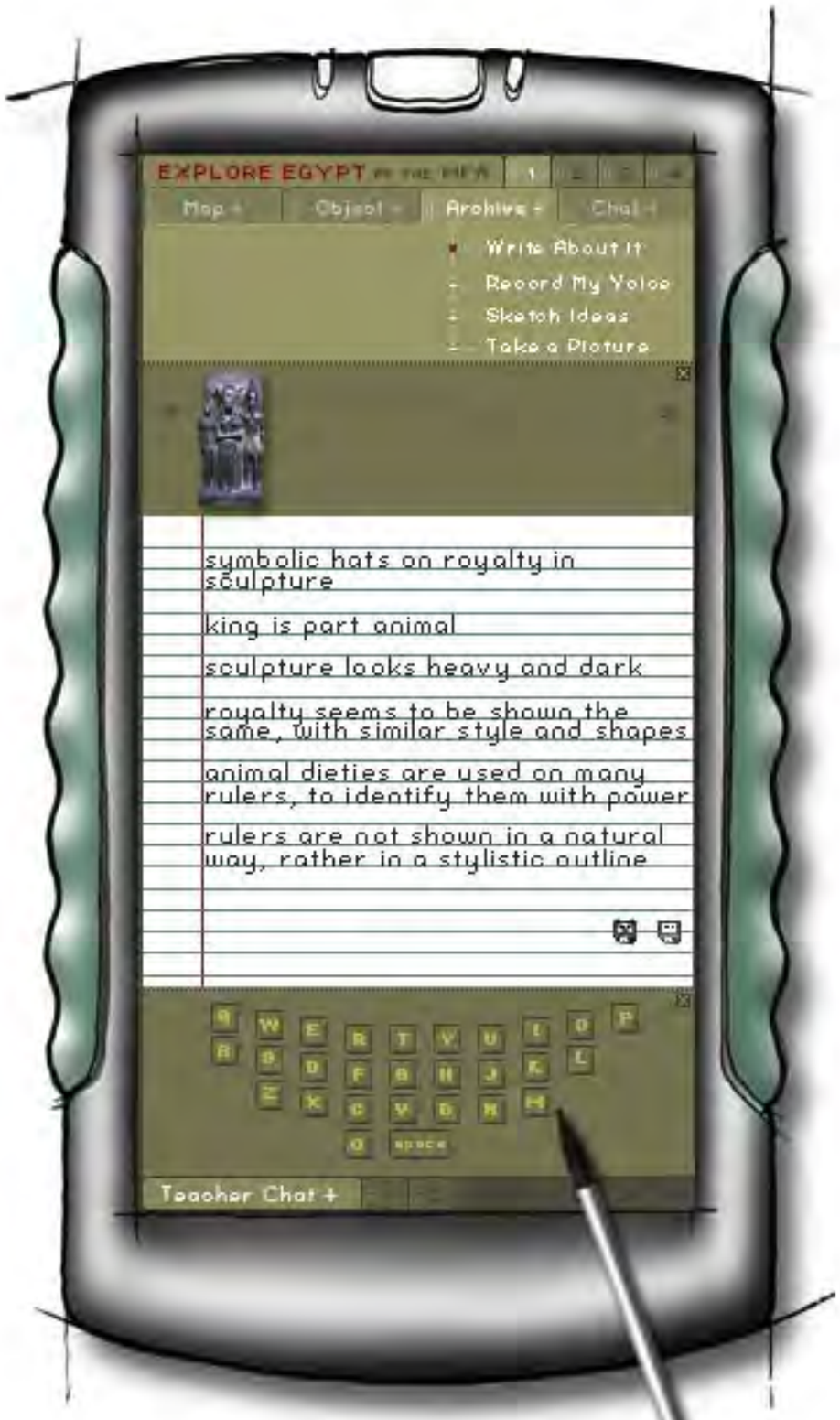

EXPLORE EGYPT
Map +
Object +
Archive +
Chat +
You are here
Teacher Chat +


EXPLORE EGYPT
Map +
Object +
Archive +
Chat +
You are here
Teacher Chat +


EXPLORE EGYPT BY THE MFA
Map +
Object +
Archive +
Chat +
Exercise 1 Images
King Menkaure and his Queen
Relief of Nofer
Triad of King Menkaure
Galleries and Collections
Triad of King Menkaure with goddess Hathor and the deified Hare nome
Egypt, Giza, Valley Temple of Myserinus more >>
Old Kingdom, dynasty 4 2532-2510 BC more >>
Teacher Chat +


EXPLORE EGYPT BY THE MFA
Map +
Object +
Archive +
Chat +
Exercise 1 Images
King Menkaure and his Queen
Relief of Nofer
Triad of King Menkaure
Galleries and Collections
Great Job. Now that you are in front of your chosen artifact, explain how royalty is depicted in Ecyptian Art. What do you see in your chosen artifact? Can you glean characteristics which recur in Egyptian Art? Click on chat tab above and selct write about it. -Ms. P
Teacher Chat +


EXPLORE EGYPT
Map +
Object +
Archive +
Chat +
Write About It
Record My Voice
Sketch Ideas
Take a Picture
Triad of King Menkaure with goddess Hathor and the deified Hare nome
Egypt, Giza, Valley Temple of Myoerinus more >>
Old Kingdom, dynasty 4 2532-2510 BC more >>
Teacher Chat +


EXPLORE EGYPT
Map +
Object +
Archive +
Chat +
Write About It
Record My Voice
Sketch Ideas
Take a Picture
symbolic hats on royalty in sculpture
king is part animal
sculpture looks heavy and dark
royalty seems to be shown the same, with similar style and shapes
animal dieties are used on many rulers, to identify them with power
rulers are not shown in a natural way, rather in a stylistic outline
space
Teacher Chat +


EXPLORE EGYPT
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Object +
Archive +
Chat +
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Record My Voice
Sketch Ideas
Take a Picture
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Map +
Object +
Archive +
Chat +
Write About It
Record My Voice
Sketch Ideas
Take a Picture
Teacher Chat +


EXPLORE EGYPT
Map +
Object +
Archive +
Chat +
Write About It
Record My Voice
Sketch Ideas
Take a Picture
royalty is often shown with very very expensive artifacts, like the second pic of the gold pectoral
many symbols are used, like the sun, and ankh, symbol for eternity
queen seems very important to the since she is nearly as big
the shiny surface of the Triad make the figures look very young
none of the artifacts depict an aging king or queen
Teacher Chat +


EXPLORE EGYPT
Map +
Object +
Archive +
Chat +
Write About It
Record My Voice
Sketch Ideas
Take a Picture
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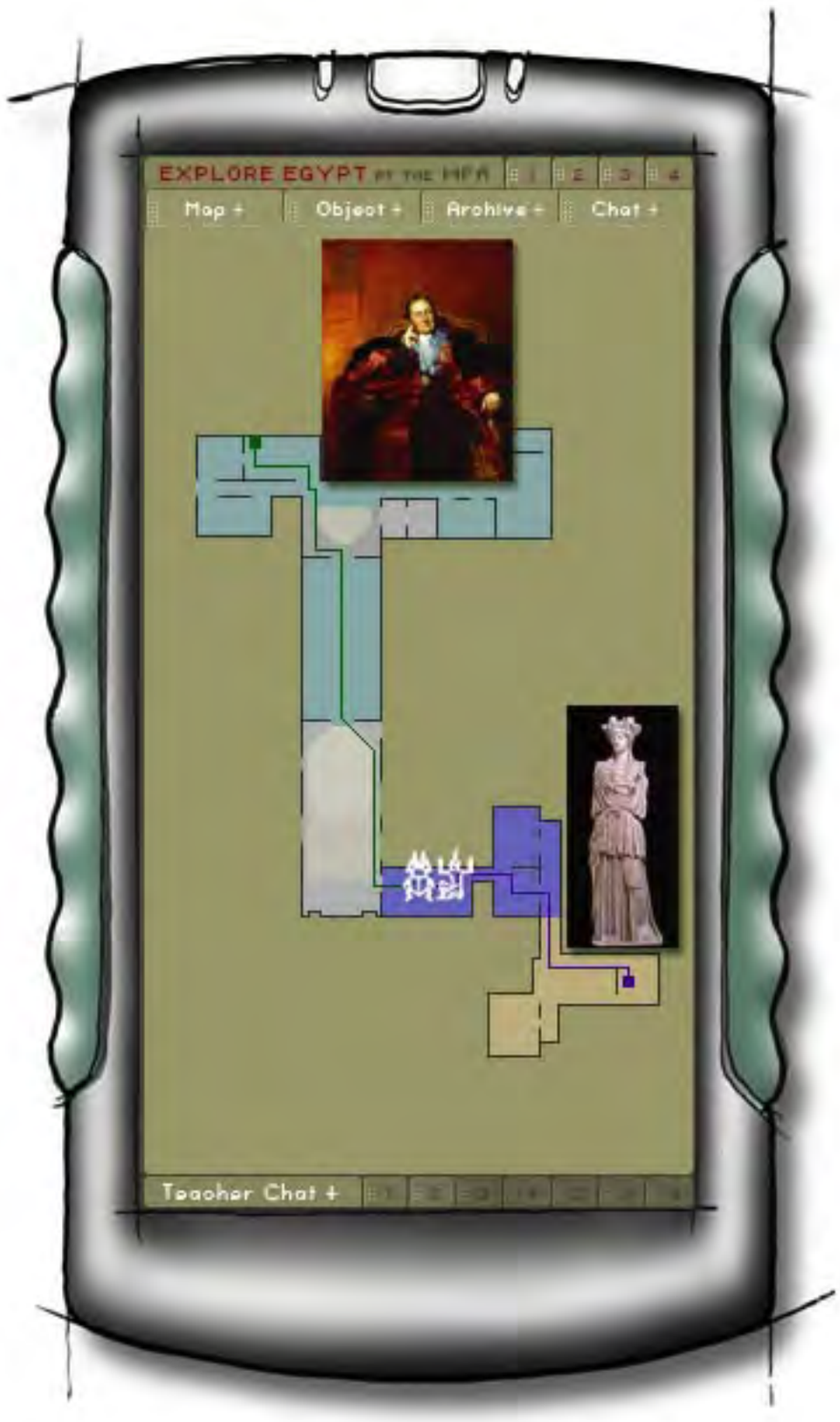
Teacher Chat +


EXPLORE EGYPT
Map
Object
Archive
Chat
Great Job. In exercise 2 you will work with a partner.
Point PDAs at your partner in order to synchronize them.
Choose an icon from the choices below to enable the syncing process.
When a connection is established, you will see a red dot in the center of the arrows.
-Ms. Peach
Teacher Chat
EXPLORE EGYPT
Map
Object
Archive
Chat
Great Job. In exercise 2 you will work with a partner.
Point PDAs at your partner in order to synchronize them.
Choose an icon from the choices below to enable the syncing process.
When a connection is established, you will see a red dot in the center of the arrows.
-Ms. Peach
Teacher Chat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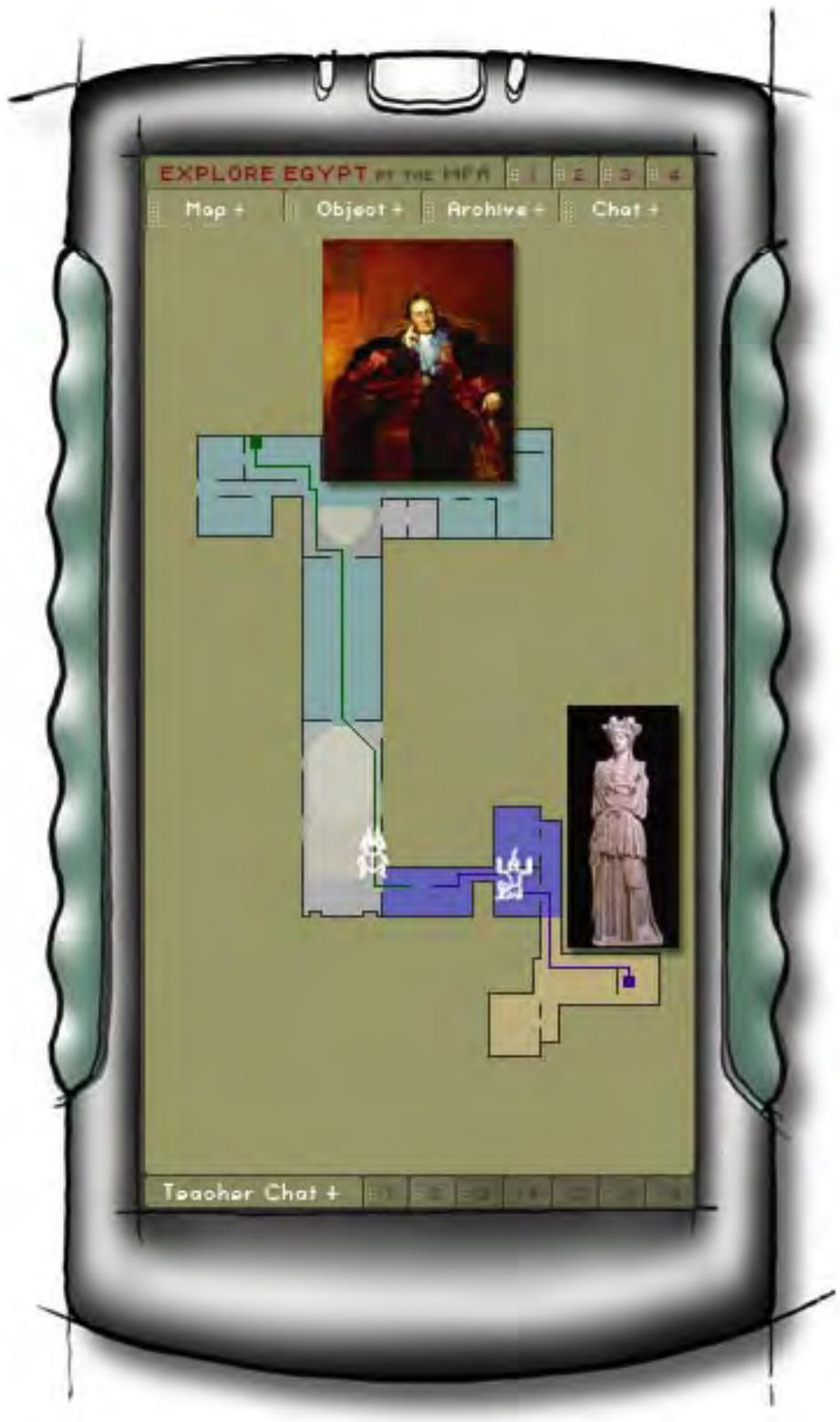
Chat +
Teacher Chat +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EXPLORE EGYPT
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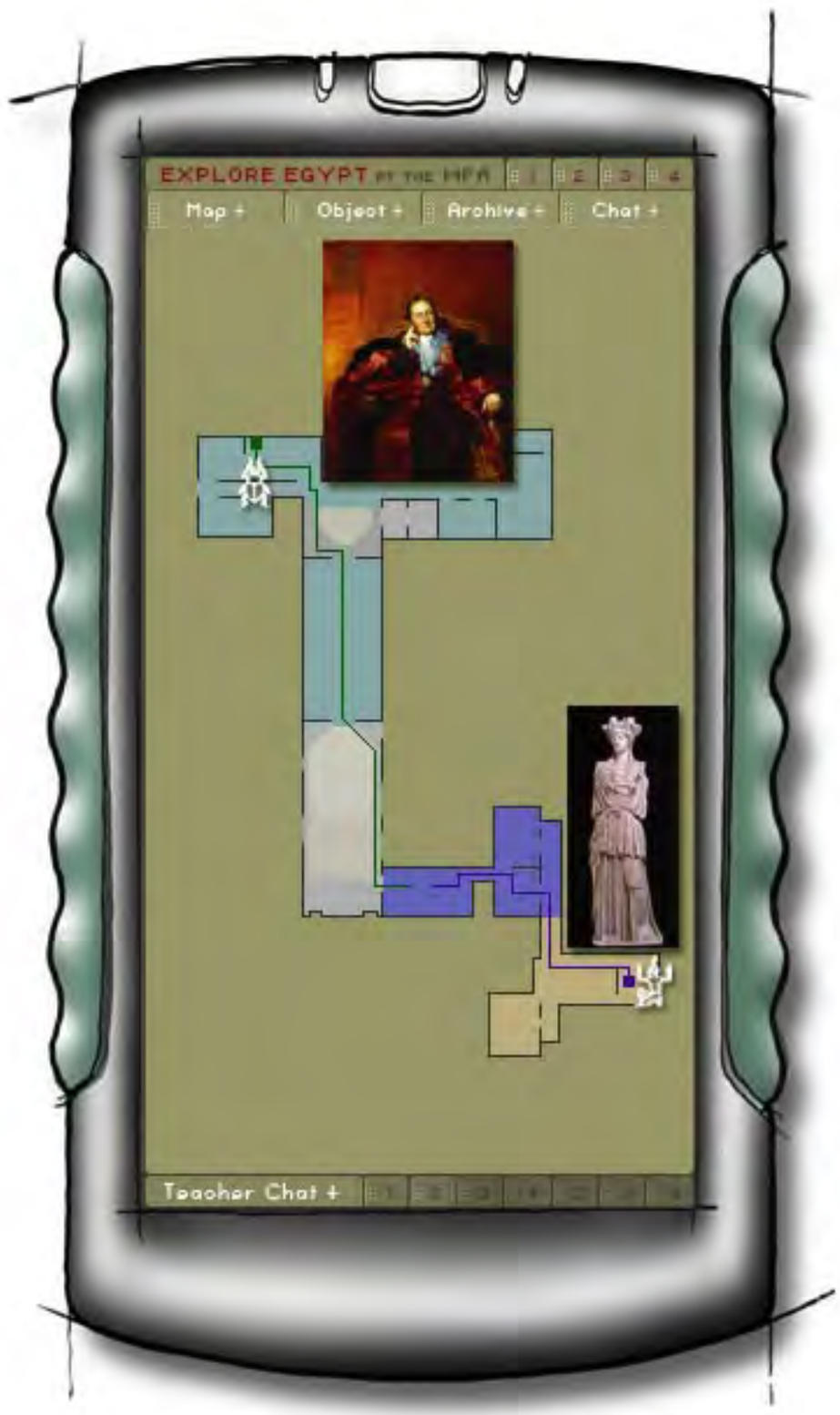
EXPLORE EGYPT
Map +
Object +
Archive +
Chat +
Teacher Chat +

An example of Collaboration and Cooperation


EXPLORE EGYPT AT THE MFA
1
2
3
4
Map +
Object +
Archive +
Chat +
Your partner is typing.
Hey, the marquies looks royal because of his cape,dress but he also looks very comfortable.
Teacher Chat +


EXPLORE EGYPT AT THE MFA
1
2
3
4
Map +
Object +
Archive +
Chat +
Hey, Julian the marquies looks royal because of his cape,dress but he also looks very comfortable.
Your partner is typing.
Hey the statue of Athena looks closer to Egyptian sculpture. She's god-like and magestic.
Teacher Chat +


EXPLORE EGYPT
Map +
Object +
Archive +
Chat +
Hey, Julian the marquies looks royal because of his cape,dress but he also looks very comfortable.
Hey the statue of Athena looks closer to Egyptian sculpture. She's god-like and magestic.
Your partner is typing.
The painting can break and be torn, where a sculpture is more permanent Athena looks more natural too.
Teacher Chat +


EXPLORE EGYPT
Map +
Object +
Archive +
Chat +
Hey, Julian the marquies looks royal because of his cape,dress but he also looks very comfortable.
Hey the statue of Athena looks closer to Egyptian sculpture. She's god-like and magestic.
The painting can break and be torn, where a sculpture is more permanent Athena looks more natural too.
Your partner is typing.
Twentieth century depiction of power shows a ruler in their own enviornment. Less idealized and true.
Teacher Chat +


EXPLORE EGYPT BY THE MFA
1
2
3
4
Map +
Object +
Archive +
Chat +
Hey, Julian the marquies looks royal because of his cape,dress but he also looks very comfortable.
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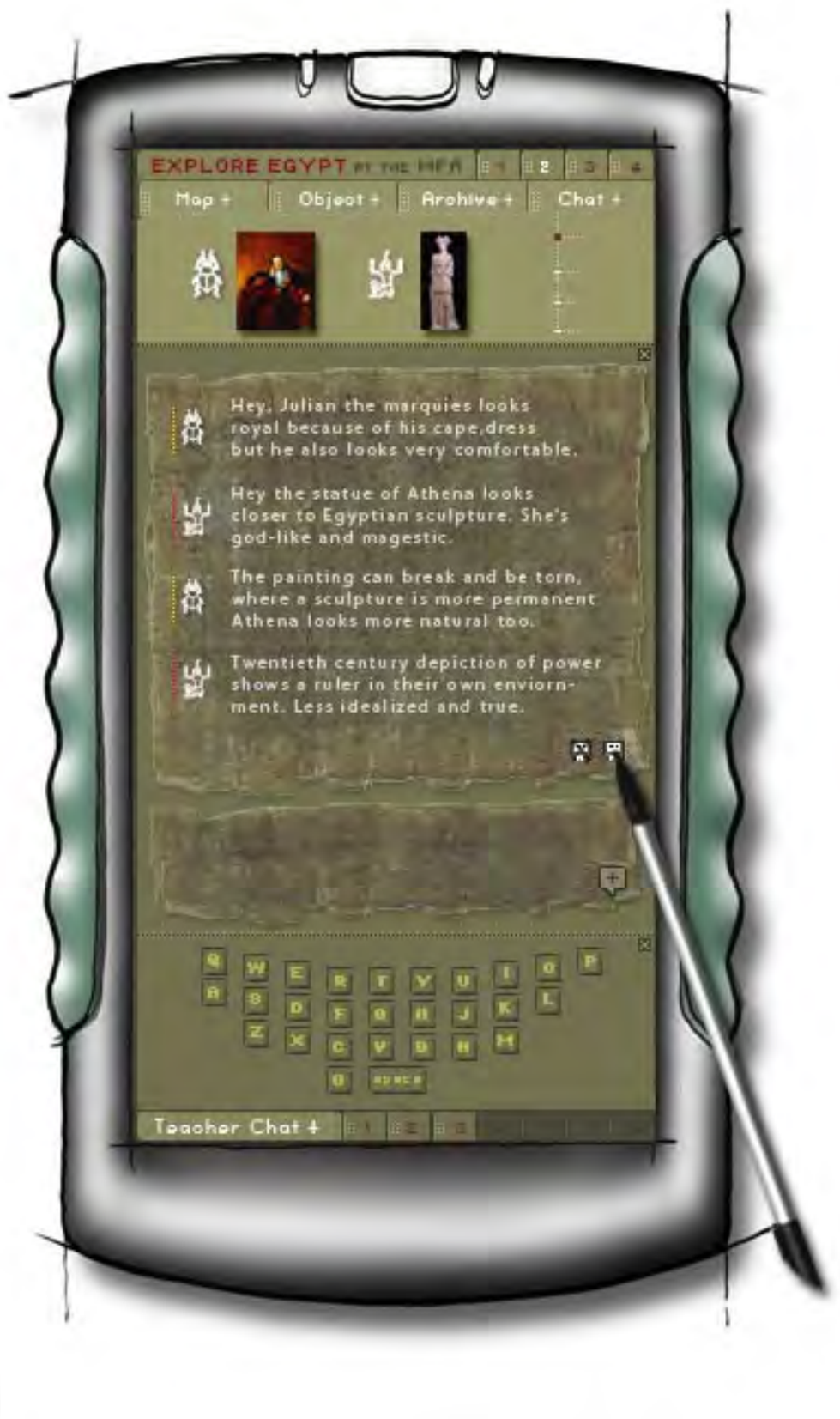
Teacher Chat +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Twentieth century depiction of power shows a ruler in their own enviorn-ment. Less idealized and true.
Teacher Chat +

Conclusion The goal of a valuable museum learning experience is to foster high level thinking dispositions while in the physical presence of art. A well-designed curriculum encourages students to interact directly with objects, in a participatory environment, enabling social discourse and opportunities for social interaction. The convergence of museum environments, wireless technology and constructivist learning theory creates a fertile ground for this type of scenario. The conceptual prototype for mobile learning inside the Egyptian Galleries at the Museum of Fine Arts Boston was a wonderful way to test the usefulness of interpretive technology for this stated purpose. I believe it encouraged students to interact directly with objects, and collaborate for a meaningful experience. I believe that technologically mediated communication enhances informal learning opportunities already present inside the museum space.

Many of the barriers to communication which were identified in the ethnographic studies were alleviated or eliminated completely by the mobile device, thereby creating a seamless communication environment. By integrating the curriculum with the available technology, information designers and interpretive staff are assured the experience will enable learners to share their points of view with other participants. Implementation of a interpretive technology under this strategy creates opportunities for meaningful data collection for later reflection.

Future Research and Directions With the advent of technological IT progress and change eclipsing every 12 to 24 months, this thesis does not attempt to address the needs of any particular platform, but rather conceptual issues relating to design and learning pedagogy inside the museum. My future research will focus on new paradigms for interactivity in adaptable environments; what this means for museum rights management and the future accessibility of museum interpretive content for youth audiences. My interests lie in innovative use of museum archives for personalization of information, which augments the museum experience. Also, the concept of a digital avatar borrowed from gaming could provide an important metaphor for conceptualization of smart museum agents or 'buddies.' Perhaps peer-to-peer interactions could be the basis of 'experientially' based collaboration and intelligence.

End Matter

Field Interviews Fall 2003 / I had the opportunity to interview the following experts in the field:

George Fifield, Director of the Boston CyberArts Festival and New Media Curator at the DeCordova Museum, Lincoln, Massachusetts.

Sharon Horrigan, Director of Curriculum Based Museum Education, Museum of Science, Boston, Massachusetts.

Stephen Bannasch, Director of Technology for the Concord Consortium, Concord, Massachusetts.

Shari Tishman, Harvard Graduate School of Education, Cambridge Massachusetts.

Laura Howick, Museum Education Expert and Guest Speaker at the HGSE November 2003, Cambridge, Massachusetts.

Claire Loughheed, Director of Education, DeCordova Museum, Lincoln Massachusetts.

Jennifer Audley, Youth Director, CyberArts Festival.

Sandy Weisman, Director of Looking to Learn Program at The Massachusetts College of Art and the Arnheim Gallery, Boston, Massachusetts.

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Thomas, Selma and Mintz, Ann, Editors. The Virtual and the Real: Media in the Museum. © 1999, Reprinted 2000 American Association of Museums.

This is a collection of articles about the nature of museology in the Information Age. The writers analyze the impact of new on museum environments and objects contained therein. Many of the articles explore the relationships between object, venue, audience, education and interpretation.

Gardner, Howard. Art Education and human development. © 1990, The Getty Center for Education in the Arts.

Falk, Dr. John and Dierking, Dr. Lynn. Learning from Museums. Alta Mira Press, Walnut Creek, CA. © 2000.

This volume is a practical guide for museum professionals on how to maximize the educational experience for visitors. It examines the history of education in public museums, different educational theories, and a range of research methods employed in visitor studies. It then shows how research and philosophy can be combined and applied.

Constructivism in Education, Opinions and Second Opinions on Controversial Issues. 99th Yearbook of the National Society for the Study of Education. Part 1. Edited by D.C. Phillips, Chicago University Press, © 2000.

Falk , John H. and Dierking , Lynn D. Learning from Museums: Visitor Experiences and the Making of Meaning. AltaMira Press, © 2000.

Why do people go to museums, and what do they learn there? What roles can museums serve in a learning community? How can museums facilitate more effective learning experiences? Synthesizing theories and research from a wide range of disciplines, including psychology, education, anthropology, neuroscience, and museum research, Falk and Dierking explain the nature and process of learning as it occurs within the museum context and provide advice on how museums can create better learning environments.

Hein, George and Alexander, Mary. Museums: Places of Learning. American Association of Museums, ©1998

This book talks about the value of museum learning. It reviews educational theory and museum education practice, and relates the educational contributions of museums to the wider educational issues of society and public service.

Pitman, Bonnie. Editor. Presence of Mind: Museums and the Spirit of Learning. American Association of Museums,© 1999.

A comprehensive look at the current state and future prospects of education within the museum at the beginning of the 21st century. Among the 17 essayists, all leaders in the field, are Sally Duensing, Tessa Bridal, Carolyn P. Blackmon, Susan Bernstein, Diane Frankel, Michael Spock, Mary Ellen Munley, Elaine Gurian, and Judith White.

Hirsh, Joanne and Silverman, Lois. Editors. Transforming Practice: Selections from the Journal of Museum Education, 1992-1999. Museum Education Roundtable,© 2000.

Drawing on nearly a decade of journal contributions, this anthology continues MER's tradition of helping museum professionals develop and sustain their effectiveness as educators, visitor advocates, and program and policy managers. Included are more than 40 contributions from such authors as David Anderson, Minda Borun, David Carr, Lynn D. Dierking, Janet A. Kamien, Randi Korn, Carol B. Stapp, and Stephen E. Weil.

Barrett, Edward. Editor. Sociomedia: Multimedia, Hypermedia and the Social Construction of Knowledge. MIT Press, Cambridge, Massachusetts. © 1992 3rd Edition 1995.

Paris, S. G. Editor. Children learning with objects in informal learning environments. In, Perspectives on object-centered learning in museums, pp. 37-54. Mahwah: New Jersey: Erlbaum. © 2002.

Paris, a developmental psychologist, argues for conducting developmental research in informal community settings such as museums, libraries, religious centers, and cultural festivals. He argues that informal contexts may inform our understanding of children's social and cognitive development. He states that research should be from a socio-cultural approach to learning and that theories should be contextualized with constructivist theories of meaning-making. Paris posits that the use of objects in informal settings provides an important context for this research.

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Roschelle, Jeremy. Learning in Interactive Environments: Prior knowledge and new experience. In Public Institutions for Personal Learning. American Association of Museums, © 1995.

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CIMI Consortium on Museum Intelligence
http://www.cimi.org/about.html

The DeCordova Museum and Sculpture Park
http://www.decordova.org

Project Zero, Harvard Graduate School of Education
http://www.pz.harvard.edu

MoMA's Visual Thinking Curriculum Project
http://www.pz.harvard.edu/Research/MoMA.htm

Archives & Museum Informatics
http://www.archimuse.com/

Institute of Museum and Library Services
http://www.imls.gov/

Palm. Inc. Education Division
http://www.palmone.com/us/education/

Center for Innovative Learning Technologies.
www.cilt.org

The Concord Consortium
www.concord.org

The Exploratorium Museum, San Francisco
www.exploratorium.org

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UnWired, Supplement to Wired. 'Get Wired: Everything you need to know about the WI-FI Revolution.' © 2003.

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Addendum – Educational Organizations of Interest

American Council on Education
One Dupont Circle
Washington, D.C. 20036
(202) 939-9300
ACE is a forum for the discussion of major issues related to higher education and its potential to contribute to the quality of American life. ACE publishes news and information about education issues through a biweekly newsletter, Higher Education & National Affairs and a quarterly magazine, Educational Record.

American Federation of Teachers
555 New Jersey Avenue, NW
Washington, D.C. 20001
(202) 879-4400
The AFT is a 940,000-member union of public and professional employees, including public and private school teachers, paraprofessionals and school-related personnel (PSRPs), higher education faculty and professionals, employees of state and local governments, nurses and health professionals.

American Library Association
50 East Huron Street
Chicago, IL 60611
1-800-545-2433
The ALA is the oldest library association in the world. Its mission is to advocate for free and open information; develop innovative programs that support libraries acquiring new information technology and training people in its use; supporting libraries as centers for culture, literacy and lifetime learning; and promoting excellence in libraries and librarianship.

American Society for Training and Development
1640 King Street
Alexandria, VA 22313-2043
(703) 683-8100
ASTD is a professional association for the field of workplace learning and performance. ASTD provides applied research, information on workplace learning and performance, networks, and professional development.

Association for the Advancement of Computers in Education (AACE)
P.O. Box 2966
Charlottesville, VA 22902
(804) 973-3987, (804) 978-7449 (fax)
AACE is an international, educational, and professional organization dedicated to the advancement of knowledge, theory, and quality of learning and teaching at all levels with information technology. AACE encourages scholarly inquiry related to information technology in education and the dissemination of research results and their applications.

Association for Educational Communications and Technology (AECT)
1025 Vermont Avenue, NW, Suite 820
Washington, D.C. 20005-3516
(202) 347-7834, (202) 347-7839(fax)
The mission of the Association for Educational Communications and Technology is to provide leadership in educational communications and technology by linking professionals holding a common interest in the use of educational technology and its application to the learning process.

Agency for Instructional Technology
Post Office Box A
Bloomington, IN 47402-0120
(812) 339-2203, (812) 333-4218 (fax)
The Agency for Instructional Technology is a nonprofit U.S.-Canadian education agency, founded in 1962, whose mission is to foster learning for pre-K through adult students. AIT develops, acquires, and distributes quality technology-based instructional resources and services. It also provides leadership to the educational technology policy community. AIT is the headquarters of TECHNOS Press, home of the annual AIT Distinguished Fellows Program and publisher of TECHNOS: Quarterly for Education and Technology.

Association for Supervision and Curriculum Development (ASCD)
1250 North Pitt Street
Alexandria, VA 22134
(703) 549-9110, 1-800-933-2723
ASCD is an international, nonprofit, nonpartisan education association committed to the mission of forging covenants in teaching and learning for the success of all learners. ASCD provides professional development in curriculum and supervision; initiates and supports activities to provide educational equity for all students; and serves as a world-class leader in education information services.

Center for Special Education Technology
Council for Exceptional children
1920 Association Drive
Reston, VA 22091
(703) 620-3660
The Council for Exceptional Children (CEC) is an international professional organization dedicated to improving educational outcomes for individuals with exceptionalities, students with disabilities, and/or the gifted. CEC advocates for appropriate governmental policies, sets professional standards, provides continual professional development, advocates for newly and historically underserved individuals with exceptionalities, and helps professionals obtain conditions and resources necessary for effective professional practice.

Council of Chief State School Officers
One Massachusetts Avenue, NW, Suite 700
Washington, D.C. 20001-1431
(202) 336-7000
The CCSSO is a nationwide, nonprofit organization composed of public officials who lead the departments responsible for elementary and secondary education in the United States and the Department of Defense Education Activity. The CCSSO works on behalf of the state agencies that have primary authority for education in each state.

Council of Great City Schools
1301 Pennsylvania Avenue, NW, Suite 702
Washington, D.C. 20004
(202) 393-2427, (202) 393-2400 (fax)
CGCS is an organization of the nation's largest urban public school systems, advocating K-12 education in inner-city schools, and governed by superintendents and board of education members from 50 cities across the country. Publications include the Urban Educator.

EDUCOM
1112 Sixteenth Street, NW, Suite 600
Washington, D.C. 20036
(202) 872-4200
EDUCOM is a nonprofit consortium of higher education institutions that facilitates the introduction, use, and access to and management of information resources in teaching, learning, scholarship, and research. EDUCOM also provides publications, conferences, and seminars.

Eisenhower National Clearinghouse for Math & Science Education
Ohio State University
1929 Kenny Road
Columbus, OH 43210-1079
(614) 292-7784, 1-800-621-5785
The ENC serves 10 regions of the country and works to disseminate effective materials and teaching methods related to math and science education. ENC Online offers teachers free publications, CD-ROMs, and professional development activities.

George Lucas Education Foundation
Post Office Box 3494
San Rafael, CA 94912
(415) 662-1600
The Foundation gathers, synthesizes, and disseminates information and other resources through various media to promote and share the latest strategies to change the K-12 educational system, especially those that integrate technology with teaching and learning.

Institute for Educational Leadership
1001 Connecticut Avenue, NW, Suite 310
Washington, D.C. 20036
(202) 822-8405
IEL seeks to establish broad-based educational leadership networks through projects such as the School Board Effectiveness Program and Superintendents Prepared.

Institute for Transfer of Technology to Education (ITTE)
National School Boards Association
1680 Duke Street
Alexandria, VA 22314
(703) 838-6722
The Institute for the Transfer of Technology to Education is a program of the National School Boards Association. ITTE works actively with school districts across North America that are exploring creative ways to teach and learn with technology.

International Communications Industries Association (ICIA), Inc.
11242 Waples Mill Road, Suite 200
Fairfax, VA 22030
(703) 273-7200, 1-800-659-7469
ICIA is a not-for-profit organization that supports the audio-visual/presentation industry, providing cutting-edge education, training and certification through the Institute for Professional Development and four advanced schools - Installation, Rental, Design and the new ICIA/Sony Sales School.

Instructional Materials Depot, Inc.
2323 S. 109th Street, Suite 350
West Allis, WI 53227-1911
(414) 329-9623 FAX: (414) 329-9624
IMD publishes reform tools and offers training and planning assistance to professionals charged with developing action plans for curriculum reform and School Improvement Plans. Technology-based planning tools published by the IMD, train-the-trainer workshops, and consultation services are available to reform leaders, principals, and curriculum developers. IMD publishes proactive professional development tools to help reform leaders; pioneers use of technology-based and Internet-based tools for formative assessment and systems management; publishes a free Internet-based journal on issues related to curriculum reform, the IMD Quarterly, journal of instructional design, available at: http://www.execpc.com/~imdepot/; tailors a toolbox of tools to local needs; serves public and private school reformers and charter school developers; supplies reform tools to reform programs and consultants.

International Interactive Communications Society (IICS)
10160 SW Nimbus Avenue, Suite F2
Portland, OR 97223
(505) 620-3604
The IICS was established for the advancement of interactive systems and the people who produce them. Members come from a wide variety of multimedia-related fields and applications.

International Society for Technology in Education (ISTE)
1787 Agate Street
Eugene, OR 97403-9905
(541) 346-4414
ISTE promotes appropriate uses of technology to support and improve teaching and learning. ISTE also provides curriculums for learning about technology and integrating it into the classroom; research results and project reports; leadership for policy affecting educational technology. ISTE publishes Learning and Leading With Technology and the Journal of Research on Computing in Education, as well as eight special interest periodicals and educator-developed books and courseware.

Mathematics & Science Center
2401 Hartman Street
Richmond, VA 23223
(804) 343-6525
The Center provides leadership and support in mathematics and science education to its participating school divisions, modeling effective uses of technology within these disciplines. The Center achieves its aims through enrichment experiences for students within and beyond the regular school day, parent-child programs, and professional development opportunities for educators.

National Alliance of Business
1201 New York Avenue, NW, Suite 700
Washington, D.C. 20036
(202) 289-2888, 1-800-787-2848
The National Alliance of Business was established to find innovative, long-term solutions to the challenge of improving workforce quality. One of their goals is to increase the capacity of America's education system to provide students with the knowledge and skills needed for personal fulfillment and career success in today's workplaces.

National Association of Independent Schools
1620 L Street, NW, 11th Floor
Washington, D.C. 20036
(202) 973-9700
The National Association of Independent Schools represents more than 1,100 independent schools and associations in the United States and abroad. NAIS also serves families and students interested in independent education, people interested in teaching in independent schools, and companies interested in marketing products and services to independent schools by providing information about member schools and by providing programs such as the financial aid needs analysis made available to families.

National Center on Adult Literacy
University of Pennsylvania
3910 Chestnut Street
Philadelphia, PA 19104-3111
(215) 898-2100, (215) 898-9804 (fax)
Focused primarily on North America, the mission of NCAL is to (a) improve understanding of adult learners and their learning, (b) foster innovation and increase effectiveness in adult basic education and literacy work, and (c) expand access to information and build capacity for adult literacy service provision.

National Center for Research on Teacher Learning
Michigan State University
116 Erickson Hall
East Lansing, MI 48824-1034
(517) 355-9302
The center examines various approaches to teacher education including pre-service, in service, alternative route, and induction programs to further knowledge and understanding of the purpose of teacher education, the character and quality of teacher education, and the role of teacher education in teacher learning.

National Education Association
National Center for Innovation
1201 Sixteenth Street, NW
Washington, D.C. 20036-3207
(202) 822-7350
NEA is committed to advancing the cause of public education by sponsoring activities at the local, state, and national levels.

National Foundation for the Improvement of Education
1201 Sixteenth Street, NW
Washington, D.C. 20036
(202) 822-7840
NFIE provides grants and technical assistance to teachers, education support personnel, and higher education faculty and staff to improve student learning in the nation's public schools.

National Institute for Health
The Learning Center for Interactive Technology, Cognitive Science Branch
8600 Rockville Pike
Bethesda, MD 20894
(301) 496-0508
The Branch conducts research and development in computer and information technologies, disseminates information about these technologies to the National Library of Medicine's various constituencies, and supports their application in health professions education.

National School Boards Association
(See Institute for the Transfer of Technology to Education)
Research for Better Schools
444 North 3rd Street
Philadelphia, PA 19123-4107
(215) 574-9300
RBS conducts research and development in computer and information technologies, disseminates information about these technologies to the National Library of Medicine's various constituencies, and supports their application in health professions education. RBS also offers educational technology, development, evaluation, technical assistance, and training services. RBS Publications provide R&D-based products for practitioners and policymakers.

Society for Applied Learning Technology (SALT)
50 Culpepper Street
Warrenton, VA 20186
(540) 347-0055
The Society is oriented to professionals whose work requires knowledge and communication in the field of instructional technology. SALT enables members to achieve knowledge for work in the field of applied learning technology by association with other professionals in conferences sponsored by the Society.

Stewart Publishing, Inc.
4706 Autumn Cove Court
Alexandria, VA 22312-1445
(707) 354-8155, (703) 354-2177 (fax)
Stewart Publishing is the site for Interactive Healthcare, which has a directory of nearly 2,000 software titles for Medicine, Nursing, Allied Health, Patient Education, and Health Promotion. Interactive Healthcare also sponsors a newsletter and conferences related to healthcare education.

Technical Education Research Center (TERC)
2067 Massachusetts Avenue
Cambridge, MA 02140
(617) 547-0430
TERC is a nonprofit research and development organization committed to improving mathematics and science learning and teaching. The organization is internationally recognized for creating innovative curricula, fostering teacher professional development, pioneering creative uses of technology in education, contributing to educators' understanding of learning and teaching, and developing equitable opportunities for underserved learners.

U.S. Department of Education
600 Independence Avenue, SW
Washington, D.C. 20202-0498
(202) 401-2000, 1-800-USA-LEARN
Ask Eric education clearinghouse: http://ericir.syr.edu

U.S. National Commission on Libraries and Information Science
1110 Vermont Avenue, NW, Suite 820
Washington, D.C. 20005-3522
(202) 606-9200
The NCLIS identifies the needs of the people of the U.S. for library and information services; translates those needs into recommended national policy; advises the President, the Congress, state and local governments and others on implementation of national and international policy. NCLIS conducts studies, surveys and analyses of the library and information needs of the nation; appraises the adequacies and deficiencies of current library and information resources; conducts hearings and issues publications.