

Museums in Transition: Emerging Technologies as Tools for Free-Choice Learning



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SCIENCE MUSEUM OF VIRGINIA



GYROSCOPE INC.

Museums in Transition: Emerging Technologies as Tools for Free-Choice Learning

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Contents

I. Introduction	3
II. Trend 1: Instant Information Access	4
III. Trend 2: Customization	8
IV. Trend 3: New Communication Networks	14
V. Trend 4: Participation and Personal Expression	15
VI. Trend 5: Making Science Accessible	20
VII. Trend 6: Technology as a Tool	23
VIII. Trend 7: Learning About Learning	24
IX. Technological Downsides	24
X. General Recommendations	25
XI. Notes	28
XII. Bibliography	32
XIII. Interview Sources	38

I. INTRODUCTION

The new communications technologies popularized in the last decade—from the Internet to cell phones to iPods—are transforming our world. They are fundamentally altering the way we access information and how we interact with one another. Today, thanks to new applications of these technologies and to pervasive low-cost broadband access in the home, we are able to easily find information about almost any topic from almost anywhere in the world. And blogs, wikis, podcasts and other social networking technologies are enhancing interaction among individuals—enabling people from wildly diverse backgrounds to share their opinions and their expertise with thousands of others.

These trends have not gone unnoticed in the museum field, and museums of every discipline—art, science, and history—and from every corner of the globe are responding with efforts to use new technologies to engage visitors in new and different ways. From providing visitors with handheld devices to instantly access more information about a work of art to using cards tagged with RFID chips to automatically create a personal website based on the visitors' interests, museums are experimenting with ways these new technologies can enhance the visitor experience on site and at home.

As it plans to open a new facility in Northern Virginia, the Science Museum of Virginia (SMV) seeks a leadership role in implementing the use of new communications technologies—using them to customize and personalize the museum experience to visitors' interests, to take visitors to places and engage them in ways not otherwise possible, to help forge lifelong relationships with visitors, and to better understand how visitors use the museum and how learning takes place while they are there.

With this goal in mind, the Science Museum of Virginia hired Gyroscope, Inc. to conduct a study to understand how museums are responding to the technology trends that are changing our world, to explore what has been successful and where the challenges remain, and to make recommendations for how SMV should incorporate technology into its visitor experience plan for its newest science center.

As part of its research, Gyroscope conducted an extensive literature review on the topics of technology-based societal trends and museum technology implementations. The Gyroscope team conducted 24 interviews with museum professionals, individuals working in the technology field, and technology researchers. These efforts have provided us with a picture of how technology is changing the way we gather information and interact with one another outside the museum and how museums are responding to these trends. While by no means an exhaustive study, this report outlines some of the many ways museums are adapting to changes in the culture by using new communication technologies and highlights some innovative projects seeking to extend and expand the way visitors interact with the museum and with one another.

II. TREND 1: INSTANT INFORMATION ACCESS

...just for a moment, marvel at how incredibly addicted consumers have become to getting instant access to any kind of useful and relevant information. In fact, consumers are experiencing nothing short of an all-encompassing INFOLUST.

– www.trendwatching.com¹

Since its public debut in the early 1990s, the Internet has become *the* source for instant, up-to-date information. Special-event photos are available on photo sharing websites like Flickr minutes after the event has ended. Travelers post hotel reviews on sites like TripAdvisor.com from their hotel rooms. When buying an airline ticket, we have instant access to price information from hundreds of airlines and quality-of-service information on the airlines themselves. And, websites have become richer, deeper and more complex, featuring live and pre-recorded video and audio content as well as text and images.

Today, the public has become more and more accustomed to having the Internet available wherever and whenever they want it—at the airport, in Starbucks, even at McDonalds. And carrying a heavy laptop is no longer a requirement; more and more mobile phones can access the Internet. Although less common in the United States, Internet-enabled phones are popular in Asia. (Seventy-six percent of cell phone users in Japan use their phone to access the Internet, versus only 12 percent of American users.²)

According to the website Trendwatching.com, the “addiction to instant access to any kind of useful and relevant information”³ is moving out of the virtual world and into the real world as well. Codes attached to physical objects can be used to gain more information about the object while standing in front of it—through text messaging, cell phones with barcode and other code readers, and voice recognition services. Now, when walking by a “For Rent” sign, you can send a text message to receive additional information about the apartment or house. Curious about a bottle of wine? Take a photo with your phone and e-mail it to get more details. As the boundary between the real and online worlds is blurring, every location and object can be “digitally augmented” and learned about at the moment of need.

The Museum Response: Handhelds, Cell Phones, and Podcasts

Multimedia Handhelds

With a public hungry for information, museums are seeking to provide it—when visitors want it and where they can most easily access it. That means putting it at their fingertips. Peter Samis, director of new media and technology at the San Francisco Museum of Modern Art, describes his goal for using any new technology in the gallery as “being able to deliver messages just in time. Visitors want to know about an artwork when they are standing in front of it. If they leave the gallery, you’ve lost them. So, we want to have the information as close to the object as possible.”⁴

One of the primary ways that museums are providing instant information access is through multimedia handheld devices—typically personal digital assistants (PDAs) or custom-designed devices—that visitors carry with them as they go through the museum. These devices typically provide enhanced content through text and images, audio, and video. But these devices can do much more than provide additional content. Other features include serving as wayfinding devices that can direct visitors to specific sites or exhibits at the museum, providing e-mail updates of

special events as they are taking place, offering visitors opportunities to send messages to one another, and collecting feedback from visitors through surveys. Many of these devices include a bookmarking feature where visitors can identify objects or exhibits they are particularly interested in and have information about those objects e-mailed to them or stored on a personal web page that they can access at a later date. These devices can also serve non-traditional or hard to reach audiences—as content can be provided in multiple languages, including American Sign Language.

Several museums are using multimedia handhelds to offer information that is customized to the visitors' needs or interests. The Singapore Science Center's ScienceAlive handheld device asks visitors what topics they are interested in and how much time they have, and then offers them a personalized tour based on that information.⁵

Museums report multiple reasons for implementing handheld projects. The Getty Museum, for example, wanted to support more in-depth interaction with the works of art, to improve wayfinding, to offer visitors a more personalized experience, and to help visitors make better use of pre-visit planning (as part of the project, visitors can go on-line in advance, select works of art they are particularly interested in seeing, and have a personalized handheld-based tour ready for them when they arrive at the museum).⁶ Other museums cite the ability to easily update content or to record user activity (including what they viewed and for how long) as benefits to these projects.⁷

But these projects have challenges as well. Practical challenges include developing content for devices that quickly go out of date, maintenance concerns, and getting visitors accustomed to using a new and unfamiliar technology. SFMOMA's Peter Samis reports that he's seen handhelds "become a budgetary sink for every institution that's tried to roll them out."⁸ These devices also create visitor experience challenges as well—from reducing social interaction to distracting visitors from the experience at the museum itself. After several years of experimenting with handheld devices, the Exploratorium in San Francisco (see sidebar page 6) determined that these devices worked best for specialized, rather than general audiences. According to Rob Semper, Executive Associate Director of the Exploratorium, "There is a lot to do in a science center and having another device is not that helpful. So, it works for more specialized groups, like teachers and school groups."⁹ Others indicate that handheld devices might work best for temporary, rather than permanent exhibits in a science center so visitors don't feel saddled by carrying a large device through their full visit. Chris Tellis, founder of Antenna Audio, offers that a temporary experience "lends itself to an interpretive media overlay. It's not a random experience. It's easier to do handheld material on that."¹⁰

Case Study: Exploratorium, San Francisco, CA

San Francisco's Exploratorium was an early experimenter with utilizing handheld devices within the science center to enhance the visitor experience, conducting several proof-of-concept studies. The museum began experimenting with a product it called the Exploratorium Electronic Guidebook. The guidebook consisted of a handheld device that visitors carried with them as they went through the science center. The guidebook offered visitors access to additional information about the exhibits, offered suggestions of activities to try at each exhibit, allowed visitors to enter their own questions and observations (which other visitors could access), and invited visitors to use a bookmarking feature to create a record of their visit. An article describing the project explained that "electronic guides, enhanced via interactive technology, can not only serve as reference information, but also provide expert guidance, dynamic advice, recommendations for further inquiry, and other learning supports no paper-based travel guide can provide."¹¹

Evaluation of the project showed mixed results. Visitors enjoyed using the devices and many were willing to commit the time to try out the suggested activities at the exhibits. At the same time, however, the devices were shown to cause social isolation and to interfere with visitors' use of the exhibits. Rakhi Rajani, a researcher with HP Labs in Palo Alto, a partner in the proof-of-concept studies, indicated that the video screen was distracting, the devices were cumbersome and the small screens not compelling, and there were problems with training visitors in how to use the devices. According to Rajani, "Fundamentally, the problem was that you don't want visitors to a hands-on science museum to have one hand limited by holding a device."¹² As was the case with other museums, the Exploratorium recognized that handheld devices "are designed to support users who observe and learn about artifacts rather than interact with them."¹³

The ability to bookmark content and information to look at later was one of the most popular features of the Electronic Guidebook. With its next proof-of-concept study, the Exploratorium chose to highlight this feature. Through its Rememberer project, the Exploratorium offered visitors an RFID tag (embedded in a card or watch), which visitors could use to record their interactions to a personal website that they could access at a later time. A camera was incorporated into many of the exhibits so visitors could take a photo of themselves using the exhibit and store it on their website. The Exploratorium's floor staff was provided with handheld devices they could use to answer visitors questions or to prompt new exhibit interactions on the floor. This project proved to be more successful at accomplishing the Exploratorium's goal of increasing "visitor engagement while preserving the interactive exhibit experience."¹⁴ According to Rajani, the simple gesture of tagging an RFID chip to a sensor was not too much of an imposition to visitors and visitors found the opportunity to bookmark to be a powerful experience for recording their personal interactions.¹⁵ While never fully implemented at the Exploratorium, several other museums have developed and implemented similar projects (see page 10). Rajani offers this simple advice based on the results of these proof-of-concept studies: "For any piece of technology that might come into the museum space, how it changes the experience must be considered. To begin, simply ask, 'Does this get in the way?' It shouldn't."¹⁶

Cell Phone Tours

Within the gallery walls, many museums are experimenting with using the visitor's own cell phone to offer audio content. Cell phone tours offer the ability to easily and cheaply change content (museum staff members can simply record the tour content over the telephone). Using the visitor's own device eliminates many of the concerns with maintenance and familiarity of handhelds. David Asheim, president of Guide by Cell, a San Francisco-based company that helps museums offer cell phone tours, reports that 60 museums have active cell phone programs through his company and another 35 are expected to come on-line in the next few months.¹⁷ Asheim expects to see between 200 and 500 museum clients in the next few years.

Cell phone tours are also extending outside of the walls of the museum—through city tours or tours linked to historical markers. Eugene Huang, Visiting Scholar at Stanford University and former Secretary of Technology for the Commonwealth of Virginia, reports that there are several efforts underway in Virginia to “marry different types of technologies so individuals can get a holistic experience wherever they are.”¹⁸ Projects include a cell phone tour linked to historical markers around the state and wifi hotspots on buoys in the James River and Chesapeake Bay. The Boston Museum of Science has developed a cell phone tour of green buildings around the city of Boston, utilizing community-contributed content.¹⁹ Huang describes these efforts as “a way to extend the museum experience outside of the traditional bounds of the museum.”²⁰

Cell phone tour companies are also expanding the range of experiences in which visitors can engage beyond listening to audio commentary. Guide by Cell offers features that allow visitors to leave audio or text messaging comments (the museum can then make these comments available to other visitors). The company is also working on a feature where museum visitors can visit a website after their visit and see a record of their visit complete with audio, images, and even museum store purchase recommendations.²¹

Cell phone tours offer their own challenges. Chris Tellis, founder of Antenna Audio, feels that the challenges of cell phone tours—the continuing digital divide, confusion about when it is okay to use a cell phone in the museum, and complications of dealing with multiple carriers—outweigh the benefits in many cases.²² In addition, questions remain about the value of a traditional audio tour in a hands-on science museum without artifacts or traditional collections. Yet, these technologies do have the potential to enhance the visitor experience in certain cases—when targeted at specialized audiences, when visitors want information about a limited selection of objects rather than a full tour, or when tour stops are widely distributed outside of the museum environment, such as markers along miles of highway. Some museums are also experimenting with using cell phones to offer services other than audio tours (see page 14).

Podcasts

Museums are also turning to podcasts as a way of providing relevant, up-to-date information to their audiences on an ongoing basis. While many museums have experimented with providing traditional museum audio tours through the podcast format, this use presents a range of challenges. The linear format of a podcast offers visitors less opportunity for choice and control than the current audio tour format (although this can be overcome by designing the tour as multiple audio tracks), and the tour must be downloaded from the visitors' home computer rather than at the museum.

Instead, museums are finding podcasts are an effective way to reach their audience outside of the museum environment—as well as a way of inviting new voices into the museum (see page 19). The Museum of Science in Boston, for example, is recording interviews with all of the museum’s guest lecturers and making them available as podcasts on the museum’s website and through iTunes and other online music stores. The museum is currently undertaking an effort to build a constantly updated audio library on the topic of breast cancer. “We want to provide up-to-date, accurate, and understandable medical and scientific content that we can translate into other languages,” said the museum’s Vice President for Technologies David Rabkin. “Podcasts create opportunities for global reach and customized content.”²³

The San Francisco Museum of Modern Art is also developing podcasts primarily as a tool to reach outside of the museum’s walls. The museum monthly ArtCast is composed as an audio zine with interviews with artists or curators, recordings of an artist’s writings, and interviews with visitors as they are looking at the works of art. The goal of the podcasts is to bring “listeners the voices of ‘people who have something interesting and insightful to say about the art that’s on view here at the Museum.’”²⁴

While feedback on podcasts has been positive, this remains a relatively new tool for communicating with visitors, and museum professionals continue to debate the best ways to produce and offer podcasts. While many museums are producing their own content using simple recording devices, others feel that maintaining the high production values that visitors have come to expect from museum audio tours is important. SFMOMA is working with audio tour production company Antenna Audio to produce its podcasts. Even while maintaining high production values, SFMOMA seeks to offer an informal, spontaneous tone and to include dialogue and multiple voices, which are defining characteristics of this new medium. Museums must also reach beyond their traditional marketing avenues to promote podcasts. Using the on-line community—or blogosphere—is the best way to reach the audiences most interested in podcasts.

The concept of providing museum content outside of the museum’s walls can extend beyond podcasts and cell phone tours. Many museum professionals envision museums putting their content into existing on-line communities or virtual worlds. Antenna Audio’s Chris Tellis said, “When you are producing a museum, communication doesn’t end at the walls of the museum. Putting stuff on YouTube or having a presence on MySpace means you are using technology not just in the walls of the museum. You are making it part of people’s lives.”²⁵

III. TREND 2: CUSTOMIZATION

Long Tail businesses can treat consumers as individuals, offering mass customization as an alternative to mass-market fare.

– Chris Anderson, *The Long Tail*²⁶

New technologies are not merely transforming where and when we are able to access information, but also the types of information we receive. Increasingly, sites like MyYahoo, Microsoft MSN, and the Wall Street Journal offer users the opportunity to control the content that appears on their homepage, tailoring it to the interests they have specified.

And technology is transforming our economy as well. Until recent years, the products offered to consumers were “hit-driven,” according to Wired Magazine editor Chris Anderson in his book *The Long Tail*. Products were only offered if there were a significant number of consumers in one place to purchase them; that is, if they were “hits.”²⁷ With the Internet’s capability to aggregate individuals from diverse parts of the globe, the range of available products has increased dramatically. Niche markets are now a realistic consumer base, resulting in products that are customized to specific tastes and interests.

The ability to sell niche product by aggregating disparate buyers is only one way in which technology is enabling increased customization of products. Collaborative filtering and recommendation systems, such as those used by Amazon.com, are another. With these systems, sellers can introduce buyers to products they may not even know they want. For example, buying concert tickets on the TicketMaster website will result in a follow-up e-mail listing other bands the buyer might like and providing links to related websites and blogs. According to Eugene Huang, visiting scholar at Stanford University, these technologies provide “a way to go beyond the traditional producer-consumer model.”²⁸

Wayne LaBar, vice president for exhibits at Liberty Science Center, describes the increase in product customization as follows:

Consumers no longer have to accept pre-packaged music produced solely by well-known commercial artists. Other expressions of the nearly limitless set of choices new technology is offering consumers include radio wave body scanners that allow people to be measured for custom-made jeans; the ability to rent movies-on-demand at home anytime; and even the ability to create personalized coffee table books using their own photographs.²⁹

The Museum Response: Customized Websites and RFID

Customized Websites

Museums, too, are making use of technology to tailor their offerings to their visitors’ specific needs and interests. Many museums have developed customizable websites, which can be modified to offer users only content they are interested in receiving. Museum websites can be customized in multiple ways. Users might explicitly enter information about themselves and their interests; the website can track what the user does and pays attention to and provide recommendations based on use; or software can compare one user to multiple other users and provide recommendations based on what similar users have expressed interest in.³⁰ In any case, the result is a website that reflects the visitors’ interests and offers products and services that are customized to the user. The Metropolitan Museum of Art’s MyMetMuseum website is an excellent example of a customizable website. Each individual’s website includes an on-line gallery of works they are interested in, a customized calendar of events, and a customized newsletter offering information about subjects of interest to the user.³¹ Museum can also offer customized e-mails with links to materials or information about special events of interest to the visitor.

In a recent article on customized websites, authors Jonathan Bowen and Silvia Filippini-Fantoni explain the transformation from one-size-fits-all museum websites to customized sites as follows:

Museums' traditional communication paradigms often share the characteristics of mass communication experiences, where one of the parties is present and the other absent. With personalization, these can be modified into more natural forms of communications based on interaction and exchange.³²

RFID

As outlined above, many museums are using handheld devices as far more than on-the-spot information sources; another primary use of these devices is to collect information about the visitor and to offer a customized experience based on that information. For a variety of reasons, however, many science museums have elected to move away from handhelds and instead are turning to other technologies, such as RFID, barcodes, or even thumbprints that can serve the same purpose.

The Tech Museum of Innovation in San Jose, CA, began experimenting with RFID as a tool to connect one exhibit to another within the museum, to extend the visitor experience beyond the museum visit itself, and to personalize and customize the experience. The museum's TechTag consists of an RFID chip embedded in a bracelet that visitors wear. As visitors go through the museum, they can tag their bracelet to readers at various exhibits to both activate the exhibits and create a customized web record of their visit (including content about the exhibits they visited and the results of their interactions or experiments at the exhibit). The TechTags are only used to a limited degree to create a customized experience at the exhibit (by remembering the language preferences of the visitors), but are primarily used as a tool to create a personalized website that can be explored after the visitor has left the museum.

RFID can be an exciting tool for creating customized experience both within and outside the museum. However, the Tech Museum has seen a variety of challenges arise as well. The primary challenge has been educating visitors about the purpose of the TechTag. An evaluation of the project by the University of Pittsburgh Center for Learning in Out of School Environments found that most visitors (53 percent) did not know that the TechTag was creating a web record of their visit.³³ Once they were aware of the personalized website, most visitors (65 percent) expressed interest in visiting it, but making visitors aware of this feature in the first place was challenging. The study also revealed some concerns among visitors about privacy, and the evaluation team recommended using aliases and unidentifiable photos, while avoiding other personal information.

As part of its next steps, the Tech plans to add additional orientation for visitors, including a component at the exhibits that explains how the TechTag works. The museum is also planning to develop group tags, so that classroom or family groups can all have access to one another's results. Finally, the museum is exploring options to have visitors add information to their personal website and post portions of them to a public site to share their results with other visitors.³⁴

Still in the planning stages, the University of Arizona Science Center in Tucson, AZ, is planning to use technology to offer a far more customized experience than that provided by the TechTags. Through its Pathways to Learning program, the museum plans to use technology (most likely RFID tags) to track visitors, exploring where they go in the museum, what they do with the exhibits, what selections and choices they make, and how much time they spend in each interaction. Then, building on research in cognition and brain science, the museum plans to develop a system that can provide customized experiences and recommendations for the visitor. The goal, according to Giovanni Battistini, Vice President of Technology at the University of Arizona Science Center, is to “understand from the behavior of the visitor what type of individual characteristics they have and use that knowledge to make intelligent recommendations about the learning opportunities.”³⁵ Experiences can be customized in numerous ways, including the content delivery interface. According to a report on the project:

By asking a few well-placed questions, Pathways will be able to deliver information based on the user’s science literacy level and on their specific interests. Because it is now also possible to build multiple interfaces for a single database, the information can be presented by an interface that appeals to a specific user. If the user is a 2nd grade student, they might receive an interface with a virtual guide to assist them in moving through the pages, whereas a faculty member at a university would receive a typical academic- or research-oriented interface.³⁶

The program is intended to guide visitors’ electronic interactions over the web, guide them through the physical exhibits, and even provide them with a list of additional activities or resources in the Tucson area that might be interesting to them. The goal, according to Battistini, is to make people better self-directed learners. “Learning how to learn has become critical to the citizens of the 21st Century,” Battistini said.³⁷ The project will also include a research component that will make use of the data collected on visitor behavior. According to Battistini, the museum’s research arm will “use the data that Pathways will provide for research on issues that relate to cognitive science and learning.”³⁸

The multi-million dollar Pathways project will be a significant experience in the new University of Arizona Science Center, which is expected to open in 2009. The project is currently in the research phase and the museum is building prototypes, monitoring visitor behavior, and determining different approaches to the project. Once the project is fully developed, the science center hopes to offer the technology to other science centers that may be interested in offering similar experiences to their visitors—allowing the science center to implement this project on a much larger scale.

There are a variety of challenges to offering meaningful technology-based customized experiences to museum visitors. Rob Semper, Executive Associate Director of the Exploratorium, said that several museums have tried unsuccessfully to offer customized tours based on visitor interests. “The experience at a science museum is so browsing and so affected by everybody else in the museum that you end up off track from your carefully planned visit.”³⁹

Steven Allison-Bunnell, Senior Producer & Writer for EduWeb, a developer of online learning experiences, indicated that EduWeb’s research has shown that there are multiple factors—learning style, age, subject, motivation—that influence people’s preferences for certain experiences or activities, and it can be challenging to draw clear links between those factors and specific experiences. “People are idiosyncratic and will respond to particular aspects of any given activity in ways that reflect their interests and prior knowledge, as well as their learning style,” he said. “In a sense, they customize the experience internally.”⁴⁰

There are also privacy concerns surrounding the collection of people's individual data, though many museum professionals indicate that these concerns are usually easily overcome once visitors understand the type of information the museum needs. Institute for Learning Innovation Researcher Kate Haley Goldman indicated:

People are less cautious with this than we expect them to be. The things you want to be asking kids are not things parents would be concerned about.... It's not the demographic information that museums should be most concerned about; it's the psychographic information. It's more relevant, but less identifying. In the abstract, people get scared, but when they see what needs to be collected, they couldn't care less.⁴¹

Case Study: Technisches Museum, Vienna, Austria

When the Technisches Museum in Vienna, Austria, opened its new permanent exhibit on the history of media in 2003, they sought to have not only content that reflected technological innovation, but also to add a digital overlay that would use technology to enhance the visitor experience. The concept they implemented consisted of a plastic card embedded with an RFID tag that visitors could purchase for 2 Euros and use to enhance their experience in the exhibition. The card originally offered a wide range of features, including:

- **Content storage:** The visitor can organize and collect content on topics of interest to them. Visitors use the card to access information at approximately 30 terminals, which are distributed throughout the exhibition area. The card essentially creates a digital catalogue with information from selected topic areas. These are accessible to the visitor on their personalized website after their visit.
- **Personal experience record:** The card is also used to store the visitors' personal interactions to a website. For example, visitors can act out a television news report in front of a green screen and have a movie of their interaction saved on their personal website.
- **Recommendation system:** Visitors using the cards had access to several recommendation systems: (1) a list of the exhibits that are used most often; (2) access to the results of a visitor voting system; and (3) an adaptive recommendation system that would notice where the visitor spent a lot of time and recommend similar exhibits or related topics.
- **Communication between card users:** Visitors could select a nickname and send messages to one another. This was primarily used among school groups.

After a period of evaluation, the museum decided to reduce the number of features available to visitors. Otmar Moritsch, Curator for Information and Communication Technology at the museum, reported, "The freedom was too much for many people... They didn't want an endless number of features. The visitors want an intuitive tool for easy use."⁴² For example, the museum found that most visitors didn't make use of the recommendation system in a small exhibit hall and that communication between card users was limited, so these features were eliminated. Other features were added, such as interactive simulations that can be stored with the card and explored at home.

The museum has considered the card a prototype and has not been heavily promoting its use. As a result, only about 10 percent of visitors use the card. However, of those that use it, 60 percent return to visit the website, revealing that visitors are aware of the purpose of the card. The museum's future plans include increased promotion, a link with the museum's membership program, and the creation of a networked system with other museums in Europe and America.

IV. TREND 3: NEW COMMUNICATION NETWORKS

Communication networks, whether organized by the mobile phone or the Internet, are changing the scale, national boundaries, institutional rules, scope and dynamic of kids' social worlds.

– Peter Lyman, U.C. Berkeley Professor⁴³

For today's teenagers in particular, technology is changing the way communication takes place. Instant messaging on computers or cell phones (IM or texting) has become a primary mode of communication among teenagers.⁴⁴ According to the Pew Internet and American Life Project, 87 percent of youth ages 12-17 use the Internet (compared to 66 percent of adults). Of these on-line youth, 75 percent use instant messaging and 48 percent of those use it every day.⁴⁵ Similarly 45 percent of teens own a cell phone and 33 percent use their phone for text messaging.⁴⁶ These numbers are growing every day. Teenage girls are leading the way, perhaps because, according to U.C. Berkeley Professor Peter Lyman, "girls are generally more interested in the social functionality of the mobile phone, while boys are more focused on the device itself and its use as a status symbol."⁴⁷

There are a variety of reasons why this transformation in communication modes is taking place. For many teens it is an issue of economics—text communication is simply cheaper than voice communication. But, text messaging also offers teens a sense of independence—an ability to communicate with one other out of the eye of parents or other authority figures—and an ability to communicate at any time and in any place. These new methods of communication are expanding the scope of teens' social worlds—allowing them to communicate with individuals that they might not otherwise come in contact with.⁴⁸

Organizations attempting to reach these *millennials* ("kids for whom digital technology has been a persistent part of most of their lives"⁴⁹) recognize the need to use the communication tools their audience uses in order to reach them. The San Francisco Department of Public Health, for example, has begun a program to deliver sex education information to teens via text messaging.⁵⁰

The Museum Response: Cell Phones

Museums too have recognized that new technologies such as cell phones and iPods may offer a new way to reach teenagers—an audience that has not traditionally made extensive use of museums. Greg Brown, Vice President of Operations and Technology at the Tech Museum of Innovation, recognizes the "potential that using these kinds of access tools could attract [teenagers]. All of a sudden, the museum becomes a cool place to use your cell phone or iPod. Our dream is to become a hangout. If you become a communications hub—with exhibits, activities, things on the web, and game environments—that could happen."⁵¹ But, other museum professionals caution against relying on new technologies to reach new audiences. Peter Samis, Associate Curator of Education and Program Manager for Interactive Educational Technologies at SFMOMA, indicates that his museum "is getting a younger, hipper, smarter audience in general. This is a way of communicating with them, but this alone isn't necessarily going to attract them."⁵²

Liberty Science Center in New Jersey is attempting to test whether cell phone-based programs will provide an improved way of reaching teenagers with its Science Now, Science Everywhere (SNSE) project. The SNSE project, which is funded by the National Science Foundation and will be rolled out in 2007, will use cell phones as far more

than an audio tour device. Rather, the museum plans to build activities around the multiple ways that the audience uses their phones. Visitors will be able to hear audio commentary, receive and store data (maps, information, and images) to their phones, use their phones to create things (ring tones, animations, or video clips), interact with displays (voting, contributing information), communicate with other visitors, or download games to play.⁵³ The experience may even extend outside the museum's walls through camera phone challenges that send visitors on scavenger hunts to capture photos of science-related objects.

In addition to efforts to attract a teen audience, the SNSE project has several other potential benefits for the museum. The museum's initial goal was to teach visitors about cell phone technology. According to Director of Exhibitions and Theaters Wayne LaBar, the museum determined that "the best way to explain these things is to let people use them and get more proficient in their use."⁵⁴ Having visitors bring and use their own devices (rather than devices provided by the museum) eliminates maintenance concerns and also overcomes interface issues that arise when visitors use unfamiliar devices. In addition, according to Exhibit Developer and Project Manager Denise Bressler, "We believe that by using their phones, visitors will have more ownership over their learning experience as well as access to the content after their visit."⁵⁵

V. TREND 4: PARTICIPATION AND PERSONAL EXPRESSION

What makes the Web alive is, quite simply, us. Our presence, most often conducted at the speed of broadband, is constant and mandatory.

– Steven Levy and Brad Stone, *Newsweek*⁵⁶

The dot.com boom of the late 1990s and bust of the early 2000s has given rise to a new manifestation of the Web—focused far less on commerce and far more on user participation and personal expression. Dubbed Web 2.0, the new Web is brought to life by the individuals who use it, rather than by people paid to create it. Kevin Kelly, former editor of *Wired Magazine*, cites a study that indicates that "only 40 percent of the web is commercial. The rest runs on duty or passion."⁵⁷ According to a recent article in *Newsweek*, the characteristics of the new Web are that it builds on the intelligence of countless users, that it is user-created and user-organized with content for websites coming from their users, that it brings people together as a community rather than an audience, and that it is "not a place to go, but things to do, ways to express yourself, means to connect with others."⁵⁸ While digital technology in the past tended to separate people by making them focus on a screen, today's technologies enhance interaction among people. The ideas and software dubbed "Web 2.0" are all about social networking—bringing people together in a community conversation.

From blogs to wikis to user reviews, today's web users not only expect but also demand to play a role in content creation. Once again, youth—particularly teenage girls—are leading the way in the creation of the new Web. Fifty-seven percent of teenagers have created content for the Internet, ranging from contributing to blogs or web pages to sharing original content to remixing content found on the Internet.⁵⁹ According to Exploratorium researcher Sherry Hsi, "New media enable a broader variety of personal expression by youth and enable youth to share these expressions with a wider audience, who in turn, may interact with the original creators to promote shared expression in variety of new and unexpected ways."⁶⁰ Researchers have noted how digital technology can reinvigorate kids' imaginations as they find ways to re-appropriate existing content in new and different ways.⁶¹

Some of the most well-known examples of user-created websites are Wikipedia, www.wikipedia.com, an on-line encyclopedia that anyone can contribute to or edit; Flickr, www.flickr.com, a photo-sharing website whose photos are contributed by the website's 2.5 million users; and MySpace, www.myspace.com, a social website where 65 million people have created personal websites complete with blogs, photos, music rankings, and more. But many youth-focused educational websites are also joining the user-created bandwagon. Backyard Jungle, <http://pbskids.org/backyardjungle>, a website geared at children between the ages of 8 and 13 has kids creating almost all the content for the website. Kids create virtual backyards, in which they can post drawings and photos of their real or imagined backyards. Similarly, Whyville, www.Whyville.net, an educational website targeted at children between the ages of 8 and 15, incorporates opportunities for user participation by having kids write and publish newspaper articles or providing opportunities for peer-to-peer tutoring.

The Web is just one manifestation of the user-created trend. Corporations are inviting users to submit ideas for new products, designs, and even commercials. A recent *New York Times* article cited examples such as designer John Fluevog soliciting shoe design ideas from customers, Jones Soda utilizing customer-submitted photographs on its soda bottles, and on-line t-shirt company Threadless, which exclusively produces t-shirts based on customer designs.⁶² And, Yahoo News is launching a site to invite citizens to submit video footage from newsworthy events.⁶³ Scientists, too, see the value of broader participation. Several on-line scientific journals, such as the *Public Library of Science*, are adding open comment or review areas and even rating schemes for their scientific papers, which has the effect of "not only continuing peer review after publication, but also of making it easier to find important work in a blizzard of papers."⁶⁴

The Museum Response: User-Generated Websites, Blogs, Cell Phones & Podcasts, Open-Source Exhibits

User-Generated Websites

Museums, too, are seeking to offer visitors ways to participate and contribute in the making of the museum experience. One way to do this is through user-generated websites where visitors can feel that they have made a meaningful contribution that is publicly recognized. Several museums have experimented with these efforts. The Fine Arts Museums of San Francisco, for example, offered a Virtual Gallery program from 2001 to 2005. Visitors could choose works from the museums' collection and create a virtual exhibition with their own title and introductory text. These galleries were then posted publicly on the website so others could view them. During the time the program was offered, over 2,000 galleries were created and curators indicated that they had no problem with offensive comments being posted on the site.⁶⁵

Building on this experience, the Art Gallery of New South Wales operated a six-month pilot program called My Virtual Gallery, in which visitors could create their own virtual exhibitions and then submit them for approval to be publicly posted. Interestingly, while 250 virtual galleries were created over the six-month period, only 45 were actually submitted for approval (17 were approved).⁶⁶ The limited interest in approval may reflect the fact that, for many visitors, it is the process of creation that is important. Kate Haley Goldman, Senior Research Associate at the Institute for Learning Innovation, indicates that with experiences like these, "people are interested in creating it, not revisiting it."⁶⁷ Others feel that there is value in public recognition. Jonathan Cooper, Manager of Information at the Art Gallery of New South Wales, wrote:

Participation and recognition are strong motivating factors: people usually feel more positively towards an activity if they feel they have contributed something meaningful towards a tangible outcome, and even more so if their contributions are publicly recognized in some way.⁶⁸

The Smithsonian Institution's Cooper-Hewitt National Design Museum will soon be launching a new website which offers visitors a range of different ways to participate, including creating their own virtual exhibitions, communicating with one another, sharing digital photos, creating search tags for artworks, and even adding information to the museum's database of knowledge about works in their collection.⁶⁹

Blogs

Blogs, or web logs, offer another way for visitors to make meaningful contributions to the museum experience. Some blogs, such as the Walker Art Museum's six blogs, available at <http://blogs.walkerart.org/index.wac>, have staff and curators posting the entries—offering a behind-the-scenes view of the museum—while visitors are allowed to add comments or questions. Others, such as the Science Museum of Minnesota's Science Buzz, <http://www.smm.org/buzz> (see sidebar page 18), allow any user to register and post entries to the blog, regardless of whether they are a museum staff member or community member.

Blogs offer museums opportunities to respond to current issues in the news, to allow visitors to share their opinions and views, and to do continuous topic testing (blog entries that spur a flurry of responses could make for very interesting exhibit topics). While there are many benefits to blogs, museums should not assume that if they post it, visitors will come. It takes time to build up a community that is interested in participating in your blog. Institute for Learning Innovation Researcher Kate Haley Goldman said:

I often see assumptions of automatic community build up. The concern should be whether anyone will bother to post on your site, especially for the target age ranges. We are trying to get young adults who are going to have a huge sniffer on to see if this is legitimate enough, cool enough for them to spend time on. It takes time to build that up. It isn't something you can roll out quickly.⁷⁰

One lesson learned by the British Columbia Botanical Garden and Centre for Plant Research is the importance of promoting the blog on-line as a tool for building community. After launching its first three blogs with only moderate success, the Botanical Garden decided to extend its on-line promotion efforts with the launch of its fourth blog—Botany Photo of the Day, <http://www.ubcbotanicalgarden.org/potd/>, a photoblog of daily plant related images contributed by staff and readers. The Botanical Garden listed its blog in weblog carnivals (which compile links to blog entries on related topics), submitted their entries to popular blogs not affiliated with the museum, included links on its blog to other websites to supplement content, and even created a Flickr group where visitors could contribute photos for the blog. The Botanical Garden's unique website visitors more than doubled year-over-year with the launch of Botany Photo of the Day.⁷¹

Case Study: Science Museum of Minnesota, St. Paul, MN

The Science Museum of Minnesota launched its blog, Science Buzz, in 2004 as part of a National Science Foundation-funded project to address current science in the museum. The goal was to find ways to rapidly get current science content on the web and onto the museum's floor. In addition to the website, the museum has several exhibit areas throughout the museum that offer rapidly changing science content. The stations consist of a computer terminal (driven off the website), a graphic panel, and a phone with changing audio content. Depending on their topic, stations may also include a vitrine, activity table, post-it note board, and a space for a roll-up cart.

According to Exhibit Developer Bryan Kennedy, the goal for the project was not only to be able to rapidly change exhibit content, but also to "open up that authoritative structure"⁷² by allowing anyone to post blog entries. Entries are contributed by museum floor staff, museum volunteers, graduate students interested in science outreach, and even museum visitors.

Science Buzz also offers the museum a format for constant formative evaluation. Particularly engaging blog entries can be turned into physical graphics for the changing stations in about an hour, and eventually some topics may turn into full-fledged exhibitions. As Kennedy said:

If I put a story on and no comments come and then 16 come on the next story, I know what's interesting to people. We're not going to be ruled by popularity, but it is interesting to see. For example, we posted something about vaccines, and a lot of people came out with a lot of misconceptions about vaccines. It might be a really interesting thing to engage people on.⁷³

The museum does moderate the anonymous comments on the blog, but rarely censors them. Kennedy indicated that the museum tries to make a distinction between visitors with an agenda to promote and visitors with valid questions and misunderstanding. When comments are posted with scientifically inaccurate information, the museum responds to them.

Science Buzz currently has about 500 registered users, and many more visitors who are reading, but not contributing (between 30,000 and 50,000 unique visitors each month). But, it took time to build the on-line community. With limited marketing, most people's introduction to the blog comes from the exhibit floor, where people can leave comments at kiosks. Today, Kennedy describes Science Buzz as "more than a blog; it's an on-line community."⁷⁴

Cell Phones and Podcasts

Several museums are experimenting with inviting visitors to contribute content for cell phone tours or podcasts. Perhaps the most well known example of this occurred outside the museum community. Through ArtMobs, a class at Marymount Manhattan College created unofficial audio guides of the Museum of Modern Art (MOMA) in New York and invited the community to contribute their own podcasts as well. Now, museums are embracing this movement. Both MOMA in New York and the San Francisco Museum of Modern Art have invited their visitors to contribute content for the museum's official podcasts. Both museums, however, have reported a limited response from the community. With only a few submissions to its ArtCast Invitational, SFMOMA is pursuing other methods of including visitor voices in its podcasts. Each podcast has a VoxPop feature, where the museum staff interviews visitors in the gallery as they are looking at the artwork. Additionally, the museum is partnering with a local writing workshop for middle school kids to have them write about art for inclusion in the museum's podcasts.⁷⁵

Open Source Exhibits

Even exhibits can be opened up to visitor contributions. As part of its large-scale renovation project, Liberty Science Center in New Jersey is making various pieces of exhibit software available for community members to re-engineer. As with the Science Now, Science Everywhere cell phone project, the goal for this project was to find a way to educate people about hacking, re-engineering, and the open-source software movement, and the team at Liberty felt that the best way to do this was to have visitors engage in these activities. At the same time, the team felt that this could "exponentially expand the creative base"—involving a significantly larger number of people in making the museum's software-based exhibits the best that they could be.⁷⁶ The museum recently launched its Exhibit Commons website, <http://www.exhibitcommons.org>, where it will be posting a variety of open-source software programs with which visitors can experiment. Wayne LaBar, Vice President for Exhibits, recognizes that the people who participate in re-engineering the museum's software may be a small group, but says these may be "people who never come to the science center now—people who have a technology and science background, but are not necessarily parents."⁷⁷

Acknowledging that only a limited number of visitors will have the technical expertise to modify software, the museum has also found ways for less technically inclined visitors to contribute—suggesting experiment activities to be offered in a staffed lab space, contributing audio recordings of sentences in various languages, or contributing video showing rivers or skyscrapers throughout the world. There is a museum approval process in place for determining which software programs or content make it out to the exhibit floor.

LaBar envisions that these "open source exhibits" will engage visitors in deeper and more meaningful ways, and likely lead to more innovative exhibits. "Once they are educated to their role in the museum, visitors can be part of exhibit teams in a much fuller way," LaBar said. "Eventually, there might be whole exhibits designed not by the science center, but by the public."⁷⁸

A primary concern with experiences that invite visitor participation is the accuracy and appropriateness of the visitor contributions. David Rabkin, Vice President for Technologies at the Museum of Science in Boston offers, "When you draw on the community as expertise and as a resource, you lose some control. We need to gauge if we can let loose or if it needs more moderation."⁷⁹ Many museums do moderate their visitor contributions, while others feel that changes in society will eventually lead to changes in what we are willing to allow in the museum.

Liberty Science Center’s Wayne LaBar says, “As museums start to use blogging—having people converse about science and technology live—it is going to change our parameters about what we allow on our floor.”⁸⁰ Jim Spadaccini, Founder and Creative Director of web design firm Ideum, adds, “People are savvy enough to know the difference between visitor comments and things that are directed by the museum.”⁸¹ Some museums are developing community conversation zones that are identified as being outside the museum’s sphere of influence. For their Mathew Barney show, SFMOMA has created a blog at www.whatsyours.org where visitors can post their opinions about the show. SFMOMA’s Peter Samis notes, “As long as the responses are articulate and thoughtful—or even emotional with reasons given for the strong feelings—that’s going to make it interesting. It means you’ve made an impact.”⁸²

Many museum professionals feel that incorporating visitor participation and personal expression into museum exhibits has benefits that far outweigh the potential challenges. Ideum’s Spadaccini describes the benefits as follows:

You are going to have visitors who are more engaged, who are very plugged into the institution. They are the alpha-bloggers or super-users. That’s a group that can do a lot of things for you as an institution, the same way you have volunteers or active members at the physical museum... . The more engaged they are, the deeper experience they will have.⁸³

VI. TREND 5: MAKING SCIENCE ACCESSIBLE

What I am trying to do... is show the world how ordinary citizens can shape a whole scientific discipline and participate in it.

– Rick Bonney, Cornell Laboratory of Ornithology⁸⁴

The Web was born as a tool for scientists—allowing scientific teams with members in disparate parts of the globe to share information, images, and data with one another.⁸⁵ Today, with the Web broadly accessible to nearly everyone, nearly everywhere, the potential exists for scientific endeavors that make use of thousands of eyes and ears. Technology not only makes it easier for a broad range of individuals to participate in research; it also makes it easier for them to see scientific research in action and communicate with scientists throughout the world. Remote sensing, videoconferencing, webcasts, and virtual environments can easily take people to places that they would not otherwise be able to go.

The Museum Response: Citizen Science, Simulations, Web Cams, Webcasts & Videoconferencing, Immersive Technologies

Citizen Science

From the Denver Museum of Nature & Science’s Colorado Spider Survey project to the many museum-led BioBlitz projects (which attempt to count as many different species as possible in one area over 24 hours), many museums and other educational institutions have initiated citizen science projects that invite the general public to play a role in collecting scientific data that can be used for real research studies. The Cornell Laboratory of Ornithology is a leader in the citizen science arena with 12 distinct citizen science projects, such as the Great Backyard Bird Count, which engages citizens in counting birds over a four-day period. As with most citizen science projects, the Cornell Laboratory of Ornithology makes extensive use of the web—both to recruit and train participants and as the place

for visitors to contribute their data. Reported data show up on the Cornell website within two hours, and the raw data are made available for citizens to interpret and analyze. The lab not only seeks to help visitors learn science by doing science, it also wants to “have ordinary bird watchers take the science of ornithology under their control to some extent and to shape it, participate in it, and help us come up with future knowledge in the field.”⁸⁶

Technology also enables the collection of ever more sophisticated scientific data. Handheld devices equipped with sensors, probes, and GPS software can be used to gather detailed, location-based measurements of the physical world. Environmental Detectives, an educational program developed by MIT, for example, sends students out to collect environmental data—such as sampling chemical concentrations in groundwater—and enter it into location-aware Pocket PCs that they carry with them.

Simulations

Technology can also enable museum visitors to interact with real scientific data through real-world simulations. According to Steve Allison-Bunnell, Senior Producer & Writer at EduWeb, the complexity of the scientific process means that it is very difficult for a museum visitor to participate in meaningful scientific research. Instead, they are often placed in the position of being “casual consumers of science facts.”⁸⁷ At the same time, despite there being a wealth of scientific data available on the web, few sites are actually interpreting this data for visitors.⁸⁸ (One notable exception is NASA’s Earth Observatory, <http://earthobservatory.nasa.gov>, which allows visitors to create animations from a wide range of scientific datasets.)

However, according to Allison-Bunnell, digital visualization and simulation tools can play a significant role in helping visitors understand data and participate in meaningful science experiences. “If an institution puts resources into creating visualization and simulation, it is possible for people to really change how they see the world,” Allison-Bunnell said.⁸⁹ Christopher Stapleton, Professor of Film and Digital Media at the University of Central Florida who has created simulated environments for a range of museums, reports, “Real-time, scientific-data-driven exhibits can now be done at a reasonable cost, and visitors can be enabled to adjust scenarios on that data to explore consequences and real-world complexities in ways they can understand.”⁹⁰

Ilan Chabay, Professor of Public Learning and Understanding of Science at Göteborg University, emphasized the power of electronic simulations and real devices operating in parallel—such as a bay water flow model with a graphic simulation that allows changes in scale or terrain. According to Chabay, “the combination offers visitors open-ended investigation, means to record their experiments, and the often crucial connection between real objects and their electronic representations.”⁹¹

Simulations fit well with the educational mission of most science centers for several reasons. First, they are inherently open to shared exploration, or social learning. Second, the exploration of the simulated system is the goal, rather than having a goal of reaching a predetermined answer. Simulations support “what if” learning strategies. Simulations can be created to function at any scale and any degree of complexity, to suit a wide demographic range of visitors, and they can be readily accessed at home, though on a reduced scale, extending the visitor experience beyond the museum.

Web Cams

Web cams are another technology that museums and other educational institutions are utilizing to engage visitors in scientific observation. The Cornell Laboratory of Ornithology's nest cams—which provide live feeds of 10 bird nests—are “using real-time Internet technology to observe and interpret the nesting behavior of cavity nesting birds and promote understanding of their breeding behavior.”⁹² Scientists provide daily commentary, and viewers can add their own comments or questions. Cornell is also moving into doing virtual citizen science projects, where they ask web viewers to mine the images for information and data useful to scientific research. Other museums have incorporated web cams into their exhibits. At the EcoTarium in Worcester, MA, a camera trained on their tide pool tanks records the movements and activities of their sea creatures. Visitors use a spin browser to view several days of animal activity. David Rabkin, Vice President of Technologies at the Museum of Science in Boston, recommends that to make a successful web cam exhibit, “you need to create a compelling experience, give the visitor control, and add a time element” so that visitors can see activity over time, as well as live views.⁹³

Webcasts & Videoconferencing

Museums are also making use of technology to take their visitors to events around the world, to bring them into scientists' labs, and to enable them to have personal interactions with scientists at remote sites. Liberty Science Center in New Jersey offers a popular “Live From” program, which uses two-way videoconferencing to take groups of visitors into operating rooms to witness live heart, brain, or kidney surgery. Visitors can interact with the doctors, asking them questions and watching them work. The program is so popular that the museum is designing a theater in their new facility to provide a home for the program, but Liberty's Vice President for Exhibitions and Theaters Wayne LaBar cautions that these programs can be challenging to pull off. “It's not a problem with the technology, but on the people side. You need a good doctor and the hospital has to agree.”⁹⁴

The Exploratorium in San Francisco is another leader in webcasts. Executive Associate Director Rob Semper explains, “There are certain stories you can tell with real science, but you need a fluid media connection between the museum and the world at large.”⁹⁵ Partnering with research organizations around the globe, the Exploratorium offers approximately 20 webcasts each year, from solar eclipses in Turkey to scientific crews working in Antarctica. The webcasts are broadcast over the Internet, as well as projected for museum visitors in the webcast studio on the museum floor. Semper has found that webcasts work best as mediated experiences, with “someone there to give people a sense of what they're seeing, what they're looking at.”⁹⁶

Information technology entrepreneur Duffy Mazan offers that on-demand replays of seminars and special events may expand the usefulness of webcasts. “Making the material available at the convenience of the viewer allows it to reach a much broader audience.”⁹⁷

Immersive Technologies

Gaming, simulations, visualizations, interactive virtual reality, and other immersive technologies are also used by a range of science centers to engage visitors with science. According to Arlene de Strulle, Program Director for Informal Science Education at the National Science Foundation, these advanced technologies bring learners into a single or multi-user environment where the fidelity of the virtual experience is so authentic that learners can

react and interact “as if” they are truly present in the virtual place. The state of presence afforded by immersive technologies is not provided through the more limited mobile communications technologies because the visual interface engages learners more effectively within contextually rich graphic environments, including environments not constrained by the laws of time and gravity. As an example, this can allow for deeper comprehension of physical science. Given the anticipated exponential expansion of visual technologies well into the future and its apparent promise as an effective teaching and learning modality, it would serve the field very well to investigate how to best exploit this technology in the service of improving education.⁹⁸

VII. TREND 6: TECHNOLOGY AS A TOOL

Computers will not live up to their potential until we start to think of them less like television and more like paint brushes. That is, we need to start seeing computers not simply as information machines, but also as a new medium for creative design and expression.

– Mitchel Resnick, MIT Media Laboratory⁹⁹

While the focus in this report is on technology as a communications medium, technology also represents the tools we use to solve problems and develop the products that we need. Yet, today, so many of the technologies that we use are hidden away. Few of the users of everyday technologies have an understanding of how they work. Mitchel Resnick, researcher at the MIT Media Laboratory, offers the following observation:

Today’s black box instruments are highly effective in making measurements and collecting data—enabling even novices to perform advanced scientific experiments. But, at the same time, these black boxes are “opaque” (in that their inner workings are often hidden and thus poorly understood by their users) and they are bland in appearance (making it difficult for users to feel a sense of personal connection with scientific activity).¹⁰⁰

Resnick and his colleagues have been working on a project entitled Beyond Black Boxes, which seeks to engage children in designing their own scientific instruments and using them to conduct scientific investigations of their own choosing. Resnick’s team has developed a small, programmable computer called a “Cricket” that can be connected to a range of sensors, control motors and lights, and communicate with other “Crickets” through infrared light.¹⁰¹ From building a bird feeder that snaps photos of birds when they land to collecting temperature data on a walk around town, the project has engaged children in a wide range of scientific investigations. Resnick’s research has found that students who build their own scientific instruments feel a strong sense of personal investment, can be more creative in their scientific investigations, and develop critical thinking skills.¹⁰²

The Museum Response: Making Things

Many museums offer workshops and programs that engage children in using technology to design things, make tools, and express their creativity. DesignIt Studios, a National Science Foundation-funded project at the Fort Worth Museum of Science and History, for example, engaged children in two-week technology-based summer workshops at the museum and at community sites. Children made movement-tracking sensors to collect data, built musical robots, and created their own animations.¹⁰³ Resnick has also been working with a group of museums on a project entitled Playful Invention and Exploration (PIE) Network, which makes use of Resnick’s “Crickets” in museum workshops and programs.

VIII. TREND 7: LEARNING ABOUT LEARNING

On-line visitors leave a trail of all their interactions on-line. So, you are not only able to see the paths that people take through your site, but you are also able to see what they are thinking and saying as they go through.

– Jim Spadaccini, Ideum¹⁰⁴

The multiple types of technologies described in this paper—from handheld devices to RFID tags—all offer museums the opportunity to track visitors and understand what they are doing both on-site in the museum and in the virtual environment on-line. While none of the museums we spoke with are using technology exclusively for this purpose, it is a clear side benefit for many of their projects. At the Tech Museum of Innovation, for example, the museum has been able to plot the trajectories of TechTag users to see how they move through the museum and which exhibits they utilize. Greg Brown, the Tech’s Vice President for Operations and Technology, reported that, as a result of this information, the museum removed exhibits that did not receive a significant amount of use and moved exhibits that were creating bottlenecks in the space.¹⁰⁵ Many museums have incorporated surveys or feedback mechanisms into their technology devices as well.

Finally, many of these technology efforts are engaging visitors in deeper and more meaningful ways than more traditional exhibits. According to Institute of Learning Innovation Researcher Kate Haley Goldman, these more invested users can give more useful evaluation information. “If people are invested, you can talk to them,” Haley Goldman said.¹⁰⁶

IX. TECHNOLOGICAL DOWNSIDES

Individuals both within and outside the museum field caution against an over-reliance on technology to accomplish goals. The Boston Museum of Science’s David Rabkin warns against getting into a “technology push situation when what you need is a programmatic pull. You need to figure out the visitor experience first.”¹⁰⁷ Many of the overarching goals outlined in this paper—from providing just-in-time information to offering customized experiences to offering opportunities for personal expression—could be accomplished without technology, perhaps through interaction with highly qualified and trained staff members. Chris Tellis, founder of audio tour production company Antenna Audio, offers the following advice:

I think the biggest mistake anybody makes in technology in museums is to lead with the technology. You have to sit down and say, ‘What do we want our visitors to learn?’ The second thing you say is ‘What are the sources?’ ... The last thing you do is go to the technology.¹⁰⁸

When considering a technology project, it is important to remember that the digital divide is still very real. There are significant differences in access to and understanding of technologies between people of different races, genders, and socioeconomic groups.¹⁰⁹ Not only do minority and low-income youth have less access to technology, but they also have less familiarity with using it. Several technology researchers have called for the development of public spaces that allow disadvantaged youth to not only access technology, but also have opportunities to gain the skills they need to take advantage of it. Exploratorium researcher Sherry Hsi advocates for new initiatives that “explore the potential development of new hybrid spaces that blend physical and virtual environments and digital tools where youth-centered activities can share power with competent adults to encourage all youth to learn.”¹¹⁰

Because technology changes so quickly and, as Eugene Huang states, “the web and globalization of the economy has made technology available anywhere and at any time,” it becomes easy for museums to get out of date. Huang added, “If you go to [a science center], it would be neat to see how an iPod does its magic, but it needs to be relevant to today. Otherwise, people think, ‘Been there, done that.’”¹¹¹

Technology has other downsides as well. Paul Saffo notes that the high level of customization offered by technology means that “individuals can select from a vast cyber-sea of media and utterly saturate their information space exclusively with information and sources that reinforce existing world-views.”¹¹² Saffo argues the need for an intellectual commons that will continue to introduce individuals to the new ideas and perspectives needed in a democratic society.

X. GENERAL RECOMMENDATIONS

The specific technology projects that any individual museum pursues will depend on the museum’s goals for the visitor experience. However, museum professionals who have implemented technology-based projects offer a range of recommendations applicable to a broad spectrum of potential projects.

Technology is a Means, Not an End: Whatever technology-based projects a museum chooses to implement must truly add value to the visitor experience—allowing visitors to interact with the museum or with one another in ways that would not otherwise be possible. And this value must be overtly apparent to visitors. The Tech Museum of Innovation’s Greg Brown suggests, “Don’t use technology for technology’s sake. You need to really add value with technology. We can’t just add technology for the gee-whiz-ness. We need to make the benefit really obvious and clear so people get it.”¹¹³ Information technology entrepreneur Duffy Mazan adds that a big challenge is “not getting too far outside of the core mission of the museum. The resources devoted to technology should be measured against how much the technology adds to the core educational mission.”¹¹⁴

Choose Wisely: With a multitude of potential technology implementations available, it will be impossible for any one museum to stay on the leading edge of all of them. Rather, most of the museums highlighted in this report have chosen a specific area or a small number of areas of technology in which to experiment. Museums must choose the specific technology or technologies that best support their program and visitor experience goals, rather than trying to be all things to all people.

Know Your Audience: Understanding your audience—the ways in which they use technology in their daily lives and the specific technologies that they use—is essential to creating an experience that appeals to them and resonates with them. Research into the museum’s target audience will be essential to creating a successful technology program and, once the program is implemented, a continued focus on staying aware of the audience’s interests, needs, and goals is essential.

Educate Your Users: Several technology projects have struggled to succeed simply because visitors do not clearly understand how to interact with the technology or what it can do for them. For example, several bookmarking projects—where visitors identify objects or topics they are interested in learning more about later—have resulted in low uptake of this feature in large part because visitors simply aren’t educated about what the feature does. Alisa Barry, Head of Interactive Media at the Natural History Museum in London, offers, “Museums need not only

to offer these opportunities, but also to educate their visitors that these information technologies exist within the museum environment and can enrich the user experience."¹¹⁵

Equally important in solving this issue is providing technology in a configuration that needs as little education as possible. The goal is to provide technology that is self-explanatory, functionally transparent, and designed to enhance learning. Arlene de Strulle, Program Director for Informal Science Education at the National Science Foundation, commented that in a science center or museum, the learning environment is of such high intensity, infused with visual, audio, and textual stimulation, that when learners are required to master an overlay of complex technologies in order to participate in an exhibit experience, the cognitive load can create the antithesis of what is intended, often resulting in an ineffective learning experience and alienation of the learner. Although the goal of using technology should be to afford new opportunities for the exploration of phenomena via seamless immersion in the learning experience without adding much cognitive load, many technologies are not designed for education; rather they are adapted and repurposed for education. Accordingly, the instruction or activity is designed to fit the technology, as opposed to the technology being designed, from inception, for enhancing cognitive skills. The effects of color, interactivity, navigation, scaffolding, and other media or instructional strategies on learners should be highly considered because in reality, these do affect multigenerational learners in very different ways.¹¹⁶

Design For Experience, Not for Hardware: Technology is advancing at lightning speed; technologies that are cutting-edge today may be out-of-date tomorrow. As just one example, Hewlett-Packard Laboratories has recently developed a technology that can hold a significant amount of data in a tag the size of a shirt button. Once released commercially, analysts predict that these wireless “Memory Spots” may replace RFID tags.¹¹⁷ The baseline, going forward, is broadband infrastructure for fast and rich information delivery anywhere. Museums must strive to take maximum advantage of it. Any technologies that a visitor uses ride on top of it, and will keep changing.

As a result, any museum’s plans for technology projects must focus first on the visitor experience. Only when the desired visitor experience is firmly determined should the museum begin to look for technologies to implement and support it. The Tech Museum of Innovation’s Greg Brown indicates that this is a recommendation that his museum has tried to follow. “RFID is not a path,” he said. “The path is personalization and customization of the experience. RFID is one way of uniquely identifying visitors. There are a lot of other ways... We tried to design the interface so it’s almost independent of the device that’s used.”¹¹⁸ Projects should also be designed to be flexible enough to adapt when the technology changes. Mitzi Vernon, Associate Professor of Industrial Design at Virginia Tech suggests that one approach to flexibility is to develop a museum identity—such as a wearable device—but to have the product designed to allow the technology used within it to change over time.¹¹⁹

Provide Sufficient Resources: Museums seeking to stay on the cutting edge of technology must allocate significant resources toward this goal—both staff and funding. Having an in-house technology team to both produce and maintain these programs is essential—and museums may find that the skills that these individuals need may be very different from skills already available on staff. Celia Pearce, Professor of Social Technologies and Digital Media at Georgia Tech, offers, “Museums have to get over their technophobia and make finding the resources to incorporate technology much more of a priority than it has been. That includes finding the human resources who are comfortable with creating digital experiences, online and in the museum, for the visitors.”¹²⁰ The technology team—and museum as a whole—must have an outward-looking perspective, an awareness of and continual engagement in the online “daily conversation” of the museum’s community, local and global.

Allocating sufficient funding to these efforts is also essential. The Boston Museum of Science's David Rabkin recommends creating a research and development budget that will allow museum staff to conduct the exploration and experimentation they need to keep the museum on the cutting edge.¹²¹ Technology planning must be integrated, not thought of as "other" or as an add-on. It should be considered a normal element of most or all programs, departments, and initiatives.

First is Not Always Best: For resource-strained museums, it may not always be possible to be on the cutting edge, and some museum professionals say it's better that way. Many of the projects described in this paper still consider themselves prototypes—even after a few years of visitor use—and some are still in the early planning stages. Museums planning new technology projects should carefully watch as other projects are implemented to see what works well and what doesn't. Antenna Audio's Chris Tellis offers, "Visitors don't care if the museum is first. You're better off going around and amalgamating best practices."¹²² Similarly, standard, proven, off-the-shelf hardware and software can be thought of as "best practices"; they are cost-effective, well supported, and familiar to users. The museum's resource investment then goes into the content, where it has the most effect. Information technology entrepreneur Duffy Mazan recommends using "fixed, off-the-shelf hardware at the exhibits tied to a centralized content back-end. That lets you update content centrally and update hardware inexpensively."¹²³

This recommendation also underscores the importance of prototyping—testing things out with real visitors before they are fully implemented to gain a better understanding of how visitors make use of these devices, what features they like or don't like, and how much introduction or explanation they require.

Develop Strategic Partnerships: Implementing innovative new technology-based projects can be expensive and require lengthy development time. In addition to implementing best practices developed by others, Museums should seek out strategic partnerships with likeminded institutions in developing innovative, yet effective, new approaches. These partnerships can help the museum leverage its financial and staff resources and allow the project to have a broader and more significant impact in the educational community.

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XIII. Interview Sources

Steven Allison-Bunnell

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Educational Web Adventures

Dave Asheim

President
Guide By Cell

Giovanni Battistini

Vice President of Technology
University of Arizona Science Center

Greg Brown

Vice President, Operations and Technology
Tech Museum of Innovation

Ilan Chabay

Professor, Public Learning and Understanding of
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Göteborg University

Arlene de Strulle

Program Director, Informal Science Education
National Science Foundation

Clark Dodsworth

Director
Osage Associates

Kate Haley Goldman

Senior Research Associate
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Eugene Huang

Visiting Scholar
Stanford University

Bryan Kennedy

Exhibit Developer
Science Museum of Minnesota

Wayne LaBar

Vice President, Exhibitions and Theaters
Liberty Science Center

Denise Martinez

Exhibit Coordinator
Utah Science Center

Duffy Mazan

Information Technology Entrepreneur

Otmar Moritsch

Curator, Information and Communication Technology
Technisches Museum, Vienna

Celia Pearce

Assistant Professor, Social Technologies and Digital
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Georgia Tech

David Rabkin

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Museum of Science, Boston

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Jim Spadaccini

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Chris Tellis

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