NMC | **Horizon Report >** 2015 Museum Edition

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The *NMC Horizon Report: 2015 Museum Edition*
is a collaboration between The NEW MEDIA CONSORTIUM and Balboa Park
Online Collaborative.

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Executive Summary

What is on the five-year horizon for museums? Which trends and important developments in technology will drive changes to museum education and interpretation? What are the challenges that we consider as solvable or difficult to overcome, and how can we strategize effective solutions? These questions and similar inquiries regarding technology adoption and educational change steered the collaborative research and discussions of a body of 54 experts to produce the *NMC Horizon Report: 2015 Museum Edition*, in partnership with the Balboa Park Online Collaborative (BPOC). The *NMC Horizon Report* series charts the five-year horizon for the impact of developments in technology on education and interpretation in museums across the globe. With more than 13 years of research and publications, it can be regarded as the world's longest-running exploration of emerging technology trends and uptake in education.

The experts agreed on two mid-term impact trends: increasing the collaboration that takes place between museums, as well as focusing on the power of data analytics to inform museum operations. These are just two of the 18 topics analyzed in the *NMC Horizon Report: 2015 Museum Edition*, indicating the key trends, significant challenges, and important technological developments that are very likely to impact changes in museums across the world over the next five years.

Regarding the challenges for museums, developing digital strategies is considered to be solvable. It is already being addressed by actions at individual museums. At the Metropolitan Museum of Art, they rethought their organizational strategy to integrate a digital presence more seamlessly into their operations. They created a new digital department, recruited a new chief digital officer, and allocated resources and facilities to advance innovation.[1] On the other hand, the experts identified privacy concerns as a wicked challenge — one that they consider complex to define, let alone solve. Compounding this challenge are the shifting expectations of privacy in light of a rapidly advancing digital world.

With more than 13 years of research and publications, the NMC Horizon Project can be regarded as the world's longest-running exploration of emerging technology trends and uptake in education.

In view of the trends and challenges observed, the panel also signalled the technological developments that could support these drivers of innovation and change. Bring Your Own Device (BYOD) and games and gamification are expected to be increasingly adopted by museums in one year's time or less to make use of mobile and online engagement. The time-to-adoption for location-based services and makerspaces are estimated within two to three years, while natural user interfaces and the Internet of Things are expected to be mainstream in museums within four to five years.

The three key sections of this report constitute a reference and straightforward technology-planning guide for a full range of museum professionals, including staff, leaders, board members, and policy-makers. It is our hope that this research will help to inform the choices that institutions are making about technology to improve, support, or extend education and interpretation in museums across the globe. Museum and education leaders worldwide look to the NMC Horizon Project and both its global and regional reports as key strategic technology planning references, and it is for that purpose that the *NMC Horizon Report: 2015 Museum Edition* is presented.

Topics from the *NMC Horizon Report > 2015 Museum Edition*

CHALLENGES

TRENDS, CHALLENGES, AND DEVELOPMENTS IN TECHNOLOGY FOR MUSEUMS

SOLVABLE
> Developing Digital Strategies
> Improving Digital Literacy of Museum Professionals

DIFFICULT
> Balancing Our Connected and Unconnected Lives
> Measuring the Impact of New Technologies

WICKED
> Privacy Concerns
> Maintaining Progress in Technology, Workflows, and Infrastructure

TRENDS

SHORT-TERM IMPACT
> Expanding the Concept of Visitors
> Increasing Focus on Participatory Experiences

MID-TERM IMPACT
> Increasing Cross-Institutional Collaboration
> Increasing Focus on Data Analytics for Museum Operations

LONG-TERM IMPACT
> Expanding the Boundaries of Creativity
> Rise of Private Companies in Museum Education
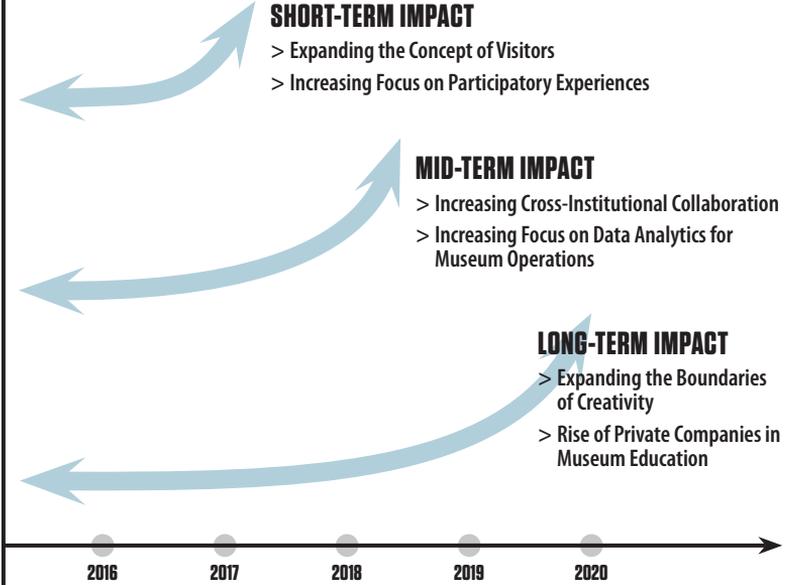
2016   2017   2018   2019   2020

NEAR-TERM
1 year or less
> Bring Your Own Device
> Games and Gamification

MID-TERM
2-3 years
> Location-Based Services
> Makerspaces

FAR-TERM
4-5 years
> Natural User Interface
> The Internet of Things

DEVELOPMENTS IN TECHNOLOGY

Introduction

I n the pages that follow, 18 topics carefully selected by the 2015 NMC Horizon Project Museum Expert Panel related to the applications of technology are examined, all of them areas very likely to impact technology planning and decision-making over the next five years (2015-2019). Six key trends, six significant challenges, and six important developments in educational and interpretive technology are placed directly in the context of their likely impact on the core missions of museums, and detailed in succinct, non-technical, and unbiased presentations. Each has been tied to essential questions of relevance, policy, leadership, and practice.

The *NMC Horizon Report: 2015 Museum Edition*, the fifth in the annual museum series of reports, was produced by the NMC in collaboration with the Balboa Park Online Collaborative. The internationally recognized *NMC Horizon Report* series and regional *NMC Technology Outlooks* are part of the NMC Horizon Project, a comprehensive effort established in 2002 by the NMC that identifies and describes important developments in technology likely to have a large impact over the coming five years in various education sectors around the globe.

Key trends, challenges, and technological developments that are detailed here will directly inform policy, leadership, and practice at all levels within the museum environment. This report aims to help museums, museum boards, and education leaders to strategically approach the further evolution of museum education and interpretation. Each topic has been carefully researched and framed in the context of its potential impact on global museum education and interpretation.

The report's first two sections focus on an analysis of trends driving technology decision-making and planning, and the challenges likely to impede the adoption of new technologies, respectively. Each includes an explicit discussion of the trend or challenge's implications for policy, leadership, and practice in museums, along with examples and relevant readings.

The third section, in which six important developments in technology are described, is ultimately framed by these trends and challenges. The adoption or abandonment of these technologies by museums

will be very much determined by the responses taken across the globe to these drivers of and obstacles to innovation and change.

Each of the four global editions of the *NMC Horizon Report* — higher education, primary and secondary education (K-12), museum, and library — highlights six important developments in technology or practices that are likely to enter mainstream use within their focus sectors over the next five years. Key trends and challenges that will affect current practice over the same period frame these discussions. The discussions of trends and technologies have been organized into three time-related categories; challenges are discussed within a similar three-part framework related to the scope of the challenge.

> ## Key trends, challenges, and technological developments that are detailed here will directly inform policy, leadership, and practice at all levels within the museum environment.

The process used to research and create the *NMC Horizon Report: 2015 Museum Edition* is rooted in the methods used across all the research conducted within the NMC Horizon Project. All editions of the *NMC Horizon Report* are informed by both primary and secondary research. Dozens of meaningful trends, challenges, and important developments in technology are examined for possible inclusion in the report for each edition.

Every report draws on the considerable expertise of an international panel that first considers a broad set of important trends, challenges, and developments in technology, and then examines each of them in progressively more detail, reducing the set until the final listing of trends, challenges, and technologies is selected. This process takes place online, where it is

captured in the NMC Horizon Project wiki. The wiki is intended to be a completely transparent window into the work of the project, one that not only provides a real-time view of the work as it happens, but also contains the entire record of the process for each of the various editions published since 2006. The wiki used for the *NMC Horizon Report: 2015 Museum Edition* can be found at museum.wiki.nmc.org.

The panel was composed of 54 technology experts from ten countries on four continents this year; their names and affiliations are listed at the end of this report. Despite their diversity of backgrounds and experience, they share a consensus view that each of the profiled technologies will have a significant relevance to museum education and interpretation around the globe over the next five years. The key trends driving interest in their adoption, and the significant challenges museums will need to address if they are to reach their potential, also represent their perspective.

The procedure for selecting the topics in the report is based on a modified Delphi process refined over the now 13 years of producing the *NMC Horizon Report* series, and began with the assembly of the panel. The panel represents a wide range of backgrounds, nationalities, and interests, yet each member brings a relevant expertise. Over the decade of the NMC Horizon Project research, more than 1,500 internationally recognized practitioners and experts have participated on the panels; in any given year, a third of panel members are new, ensuring a flow of fresh perspectives each year. Nominations to serve on the expert panel are encouraged; see go.nmc.org/horizon-nominate.

Once the panel for a particular edition is constituted, their work begins with a systematic review of the literature — press clippings, reports, essays, and other materials — that pertains to important developments in technology. Members are provided with an extensive set of background materials when the project begins, and are then asked to comment on them, identify those that seem especially worthwhile, and add to the set. The group discusses existing applications of important developments in technology and brainstorms new ones. A key criterion for the inclusion of a topic in this edition is its potential relevance to education and interpretation in museums. A carefully selected set of RSS feeds from hundreds of relevant publications ensures that background resources stay current as the project progresses. They are used to inform the thinking of the participants.

Following the review of the literature, the expert panel engages in the central focus of the research — the research questions that are at the core of the NMC

Horizon Project. These questions were designed to elicit a comprehensive listing of interesting technologies, challenges, and trends from the panel:

1 **Which of the important developments in technology catalogued in the NMC Horizon Project Listing will be most important to museum education and interpretation within the next five years?**

2 **What important developments in technology are missing from our list? Consider these related questions:**

> **What would you list among the established technologies that some museums are using today that arguably *all* museums should be using broadly to support education and interpretation?**

> **What technologies that have a solid user base in consumer, entertainment, or other industries should museums be actively looking for ways to apply?**

> **What are the key emerging technologies you see developing to the point that museums should begin to take notice during the next four to five years?**

3 **What trends do you expect to accelerate technology adoption to impact the ways in which museums approach their core missions of education and interpretation?**

4 **What do you see as the key challenges impeding technology adoption and acting as a barrier to museum education and interpretation?**

In the first step of this approach, the responses to the research questions are systematically ranked and placed into adoption horizons by each expert panel member using a multi-vote system that allows members to weight and categorize their selections. These are compiled into a collective ranking, and inevitably, the ones around which there is the most agreement are quickly apparent.

From the comprehensive list of trends, challenges, and important developments in technology originally considered for any report, the group explores the ways in which these topics impact education and interpretation in museums. A significant amount of time is spent researching real and potential applications for each of the topics that would be of interest to practitioners. For every edition, when that work is done, each topic is written up in the format of the *NMC Horizon Report*. With the benefit of the full picture of how the topic will look

in the report, the topics in the interim results are then ranked yet again, this time in reverse. The final topics selected by the expert panel are those detailed here in the *NMC Horizon Report: 2015 Museum Edition*.

Key Trends Accelerating Technology Adoption in Museums

The six trends described in the following pages were selected by the project's expert panel in a series of Delphi-based voting cycles, each accompanied by rounds of desktop research, discussions, and further refinements of the topics. These trends, which the members of the expert panel agreed are very likely to drive technology planning and decision-making over the next five years, are sorted into three impact-related categories — short-term impacts that typically have already been impacting decision-making, and will continue to be important for more than five years; mid-term impacts that will likely continue to be a factor in decision-making for the next three to five years; and long-term impacts that are driving technology adoption in museums now, but will likely remain important for only one to two years, becoming commonplace or fading away in that time.

While long-term impact trends have already been the topic of many museum education leaders' discussions and extensive research, short-term impact trends often do not have an abundance of concrete evidence pointing to their effectiveness and future directions. All of the trends listed here were explored for their implications for museums in a series of online discussions that can be viewed at museum.wiki.nmc.org/Trends.

The NMC Horizon Project model derived three meta-dimensions that were used to focus the discussions of each trend and challenge: policy, leadership, and practice. Policy, in this context, refers to the formal laws, regulations, rules, and guidelines that govern museums; leadership is the product of experts' visions of the future of learning, based on research and deep consideration; and practice is where new ideas take action, in museums and related settings.

Policy. While all of the identified trends had policy implications, two trends in particular are expected to have a strong impact on policy decisions in the next five years. Data analytics has emerged as a major topic of interest to national governments and museums, as strategic funding decisions often hinge on quantifying activity. The ENUMERATE project is conducting an analysis of statistical data about digitization and digital preservation across Europe to determine needs within the area.[2]

Likewise, the movement towards more participatory experiences, currently on the rise in museums, will reach its maximum impact in the next one to two years, calling for the development of more institutional policies. "Museum Selfie Day," held in museums across the globe, generated much debate about to what extent photography should be allowed in the museums.[3]

> **While long-term impact trends have already been the topic of many museum education leaders' discussions and extensive research, short-term impact trends often do not have an abundance of concrete evidence pointing to their effectiveness and future directions.**

Leadership. There are leadership implications for all the identified trends that are discussed in the following pages, but two trends stand out as unique opportunities for vision and leadership. Advancing linked open data initiatives requires museum professionals to form cross-institutional collaborations to share best practices and standards. Linked Open Data in Libraries Archives and Museums (LODLAM) is a hub for the sharing of semantic applications across the field.[4]

A short-term impact trend that is being emphasized in leadership discussions is how museums can better engage with online visitors. This movement reflects the growing notion that museums can develop programs and strategies that appeal to virtual patrons. Crystal Bridges Museum of American Art has emerged as a leader in the field, having created a distance-learning program that is available to every high school student across Arkansas.[5]

Practice. Each of the six trends identified by the expert panel has numerous implications for museum education and interpretation, and current examples are easy to find. The expansion of creativity, highlighted as one of two developing long-term impact trends in the following pages, is materializing in new types of artistic output. Artist Laurie Frick, for example, connects the quantified self with data visualization to create colorful abstract sculptures and drawings.[6]

All over the world, private companies are developing educational programs that augment and supplement traditional museum education programs. The idea is to offer programs that may not be funded through a museum's operating budget. The Ontario Science Centre has partnered with Cisco Systems to provide advanced network technologies, as well as fund a Cisco Science Fellowship, which facilitates the exchange of research and best practices.[7]

The following pages provide a discussion of each of the trends highlighted by this year's expert panel that includes an overview of the trend, its implications, and a set of curated recommendations for further reading on the topic.

Expanding the Boundaries of Creativity
Long-Term Impact: Driving technology adoption in museums for five or more years

Museums have long been considered beacons of creative expression within their communities. According to the American Alliance of Museum's "Trends and Potential Futures Report," museums "play a vital role in nurturing, documenting, organizing, interpreting and making accessible the new realm of creative output."[8] Emerging technologies have added new dimensions to what artists are capable of creating, in addition to making possible innovative ways for museums to display their work. Using lasers like paint brushes to generate digital strokes and programming robots to interact with patrons are just a couple examples of how the definition of art has expanded, moving far beyond traditional techniques.[9] As such, age-old perspectives of the artist as a drawer, painter, or sculptor have broadened vastly, and technology has unleashed seemingly limitless possibilities for different types of talents to enter the field. Museums are uniquely suited to maximize the emotional impact of these creative works by configuring custom, technology-enhanced spaces to enhance and personalize the visitor experience.

Overview

As the landscape of technology evolves, people have come to expect the places they frequent to keep pace. Over the last few years, museums have become more mobile-friendly and more integrated with patrons' favorite apps and social networks.[10] Guided by the core value of creativity, leveraging emerging tools has enabled museums to foster more interactive experiences — a trend that only continues to grow in importance. The director of University of Southern California's International Museum Institute and Fisher Museum of Art asserted, "the adoption of creativity and experimentation as an ongoing value implies the acceptance of constant vision and re-vision as standard rather than exceptional behavior." There are two converging dimensions of this trend: the natural evolution of the artist profession as new tools and technologies become available, and the desire for museums to continuously engage their patrons on a deeper level through interactive features.

The former component reflects a larger movement in society where technology is more ingrained in formal education. The Art Institute, for example, is among many education institutions to offer an entire program devoted to media arts, which includes specializations in game design and programming, animation, and digital film.[11] Whether formally or informally trained, more artists who may not be painters or sculptors in the conventional sense are using technology to create works that resonate deeply with people. In the Netherlands, artists Job, Joris, and Marieke used an Ultimaker 2 3D printer to squeeze cells from an animation into a single scene that appears as if it is set in motion. The intent is for viewers to feel as if they are inside of a computer world where there is no sense of time. This work is currently being displayed at Amersfoort's Kunsthal Museum.[12]

While artists create stories, museums are tasked with discerning the most provocative way to share them at scale. Moreover, they are often the gatekeepers of artifacts that cannot survive hands-on interactions — and ancient worlds that can never be experienced. As such, museums have been turning to creative tools such as augmented and virtual reality to allow people to experience the objects or the moments in history. The National Museum of Natural History, for example, launched the AR-enabled "Walk Among Dinosaurs" exhibit so that patrons can experience life alongside of Tyrannosaurus Rex and other creatures from the Late Cretaceous period, thanks to motion-tracking.[13] The American Museum of Natural History's "Fly Like a Pterosaur" interactive installation employs similar technology; visitors can flap their "wings" to control an on-screen Pterosaur's movements. The use of this technology has also enhanced learning experiences through simulations. The Smithsonian National Air and Space Museum's 2014 "Interstellar" exhibit featured Oculus Rift, which enabled visitors to explore a spacecraft as a crewmember, feeling weightlessness and seeing different views of the Milky Way.[14]

Implications for Policy, Leadership, or Practice

The concept of creativity may pose challenges to policy-making as it is, by definition, a product of imagination and artistry. However, governments have increasingly recognized the importance of fostering creativity in education and view museums as incubators for breeding more innovation in cultural and learning exchanges. UNESCO's "Museums for Intercultural Dialogue" initiative created an international network of museums that contribute historical and cultural objects to UNESCO's virtual museum with encouragement

to build upon collaborative narratives.[15] Because deploying new technologies in museums can be costly, there is a need for governments to continuously and publicly demonstrate support for them. The European Commission's recently published report, "Towards an Integrated Approach to Cultural Heritage for Europe," addresses the value of museums as creative educational forces in the economy, making the case that they should not be overlooked for funding.[16]

Creativity is at the forefront of many leadership discussions as museums continue to push the boundaries of what is possible. The theme for the most recent UK's Museum Computer Group Conference was the future of museums, post-web technology.[17] By brainstorming how emerging consumer devices, such as wearable technology and the quantified self, can potentially be used in museums, there is an opportunity to develop forward-thinking programs and supporting infrastructure. Due to budget constraints, small museums could be easily left behind in the design of creative technology-enabled experiences; fortunately, the Collaborative Arts Triple Helix (CATH) project in the UK is making it possible for these institutions to innovate. CATH convenes academic institutions, technology firms, and small cultural organizations to fund the co-creation of digital prototypes that solve pressing issues for fostering creative exhibits and programs in museums, such as visitor flow and the 3D printing of artifact replicas.[18] Museums are also using technology to increase accessibility. Spain's Prado Museum recently created the first exhibit for the visually-impaired that leverages 3D printing. Aspects of famous paintings from their collections, including their textures, were selected for rapid prototyping.[19]

This trend has materialized in compelling ways in practice, particularly around how art is made. Artist Laurie Frick, for example, tracked her time, sleep, and movements each day for one year; she turned the data into visualizations that reveal organic patterns in behavior, showcasing how data collection through wearable devices can give someone a better sense of their body.[20] At Köllnischer Park in Berlin, Germany, an abstract artwork is changing in appearance every day, with the help of a wall-climbing robot that is programmed to paint. Named "Vertwalker," the robot will even overwrite its own work for the sake of constantly creating something new. [21] Museums are also changing the way they engage with patrons through new devices — shifting creative control to their audiences. Cuseum is a start-up that is leveraging Beacon technology to personalize tours. In pilots conducted at Boston Athenaeum, MIT's List Visual Arts Center, and New York's Neue Galerie, visitors used Cuseum's smartphone app to design their own paths, including stops at artworks bookmarked by their Facebook friends.[22]

For Further Reading

The following resources are recommended for those who wish to learn more about expanding the boundaries of creativity:

How Do You Define Creativity? More than 600 People Answer that Question in the DAM's New Report (Video)
go.nmc.org/define
(Heather Nielsen, Denver Art Museum, 15 October 2014.) Denver Art Museum leveraged a literature review, three focus group sessions, 38 interviews with visitors, and a survey of more than 600 people in an 18-month investigation to understand how their programs impact visitors' creative lives. **>** *Policy*

From Smartphones to Museum Walls
go.nmc.org/fromsma
(Rena Silveran, *The New York Times*, 10 February 2015.) The Columbus Museum of Art in Ohio engaged modern smart device users in a historical movement with its exhibit entitled Mobile Photo Now. The museum crowdsourced images of specific themes via Instagram for a pop-up exhibit, in the same manner that the New York City movement, the Photo League, brought together artists in the 1930s to photograph specific themes to promote social and street photography.
> *Leadership*

New Museum's Incubator Will Help Artists Explore Emerging Technologies
go.nmc.org/newinc
(Rachel Oliner, *PSFK*, 17 March 2014.) The New Museum has developed an incubator called NEW INC to support artists as they experiment with the rapidly expanding landscape of production methods including 3D printing and devices like the Arduino microcontroller and Oculus Rift. Recognizing that more artists and designers are thinking and working entrepreneurially, the collaborative space offers professional development training, a mentorship program, and access to a network of advisors and experts. **>** *Leadership*

LACMA's Art and Technology Lab
go.nmc.org/lacm
(LACMA, accessed 4 March 2015.) LACMA's Art and Technology Lab issues an open call to artists working on projects that leverage emerging technologies and provides several grants and in-kind support from technology companies to help develop the prototype projects. The lab also presents demonstrations, works in progress, and workshops for the public. **>** *Practice*

Rise of Private Companies in Museum Education
Long-Term Impact: Driving technology adoption in museums for five or more years

*A*pproaches to museum education have changed with the tide of technology, aligning with the digital paradigms that are continuously shaping museum operation and interpretation. While many museums have enjoyed increased capacity and streamlined processes as a result of this shift, there is much discussion about how to leverage these developments to strengthen educational engagement. In recent years, a number of companies and startups have been working directly with or alongside museums on education-centric goals. This trend is exemplified through Museum Hack, a private company that provides interactive, highly personalized tours of the Metropolitan Museum of Art, taking visitors off of the beaten path and engaging them in alternative interpretations of world famous artworks.[23] Attitudes vary about how third-party involvement can help accomplish the museum's mission; some museum professionals believe that private companies can improve museums by holding up a mirror to their institutions, illuminating areas for improvement. Whatever the case, a range of enterprises and outside efforts from the private sector are increasingly shaping the future of museums with the primary goal of deepening the public's interest in cultural heritage.

Overview
The ever-changing digital landscape has affected the basis for financial decisions regarding human resources, technological infrastructure, and programming, among others in the museum world. Programs focused on education and interpretation are similarly being transformed as technology has introduced new tools for engaging visitors where they are, through their smartphones, apps, and social media networks. A number of museums detailed in this report are updating their overall strategies by restructuring their budgets to fund digital enhancement and its ongoing support. Yet, small and mid-size institutions are often constrained by limited capacity and lack of funds that challenge their ability to deliver on visions of transformational interpretation and robust education programs.[24] This trend is paving the way for more abundant and productive partnerships between museums and for-profit enterprises, which are being established with parallel missions of leading people's discovery and understanding of cultural heritage and art.

Third-party projects that bring cultural discovery to the public are taking place inside and beyond institutional walls. The Ingress app, for example, is a mobile massively multiplayer online game created by a Google startup that encourages players to explore the world and take interest in cultural sites. As a "Capture the Flag"-style game, the player must find clues and points that are hidden in active spots, which are geo-located in historical markers in neighborhoods and cities worldwide.[25] Designed by the creator of Google Earth, John Hanke, Ingress is being played in 200 countries, and has resulted in global in-person meet-ups of gamers in foreign locales with sightseeing, or "portal-capturing," as the primary mission.[26] Onsite, companies such as Museum Hack are offering visitors new opportunities to personally learn about the treasures within the Met, an institution that covers more than 2.3 million square feet and 13 acres of Central Park. From its launch in 2011, the company expanded rapidly to meet the demand for the experience offered by Nick Gray, the founder and CEO, who began by giving these types of tours on his own.[27]

Another dimension of this trend is related to how museums are leveraging educational products offered by outside private companies and embedding them into infrastructure or using them for interpretation. For example, a number of museums have outsourced their need for mobile tours to STQRY (pronounced "story"), a startup that has developed an online storytelling platform targeted to cultural heritage institutions that want to improve opportunities for discovery.[28] Anyone with the STQRY app can find stories of interest from museums in their area, see their operating hours and ticket prices, and get directions to visit in-person. Currently, there are 16 museums featured on STQRY's homepage, including the Seattle Art Museum, which features stories about cultural objects from native tribes of the Pacific Northwest within the institution, complete with images, audio clips, and transcripts.[29] Meanwhile, Google has recently announced the release of a museum-specific platform to develop apps that allows museums to use existing services including Street View and YouTube, requiring very little technical knowhow to accomplish.[30]

Implications for Policy, Leadership, or Practice
While this trend may not be apparent in institutional policy, there are efforts at the national level to support

the interaction of private companies and museums to help accomplish the common goal of innovation. As part of the European Agenda for Culture, the Open Method of Coordination (OMC) Working Group on Promotion of Creative Partnerships has published a policy handbook that defines creative partnerships and offers real-world case studies to demonstrate what they offer in opportunities to develop personal and professional skills, enhance innovation, and achieve cross-pollination between sectors.[31] Similarly, the Northern Ireland Museums Council (NIMC), a government agency that supports local museums in the region, has developed the Museums and Creative Industries Toolkit, a document that delineates how and why museums should partner with outside companies in order to expand their audiences, increase the use of their collections, and educate the public about the cultural heritage sector.[32]

There are a number of agencies and organizations in the cultural sector that are leading the way by establishing models for how museums can partner with companies from other industries. The current Vice President of Private Sector Initiatives for Americans for the Arts has outlined the need for businesses to support museums, highlighting the success of the pARTnership Movement, an initiative that joined 25 businesses with 25 cultural institutions to demonstrate how creative transfer can help both institutions maintain a competitive advantage.[33] The UK-based charity Nesta partnered with the Arts Council of England and the Arts and Humanities Research Council to form the Digital R&D Fund for the Arts, a program that joins together companies and organizations, and funds ideas that promote new business models or proposes innovative approaches to expanding reach and engagement.[34] Since 2012, the program has funded 52 projects focused on interpreting cultural heritage, and has been making grants of up to £125,000 with plans to allocate a cumulative total of £7million by 2015.[35]

In practice, there are some museums that are augmenting their educational offerings with products a la carte, while others are engaged with private companies on a much deeper level. The Samsung Digital Discovery Centre at the British Museum is one model for how cultural heritage institutions are collaborating with for-profit third parties in a mutually beneficial partnership that enhances museum education. Opened in 2009, the Samsung Digital Discovery Centre hosts free workshops, sessions, and activities for families and schools, and the space is equipped with state-of-the-art digital equipment to facilitate exploration.[36] Moreover, the center has become the hub of a number of in-depth research studies on digital learning used by researchers from all over the world.[37] The Ontario Science Centre has embarked on a similar partnership with Cisco Systems,

which will provide the institution with the latest network technologies and fund the Cisco Science Fellow for Innovative Learning Technologies. The fellowship is the first museum-focused position of its kind supported by Cisco, and it appoints a liaison between the science center and schools to facilitate the exchange of research and best practices of using integrated technologies for learning.[38]

For Further Reading
The following resources are recommended for those who wish to learn more about the rise of private companies in museum education:

Children Who Visit Museums Have Higher Achievement in Reading, Math, and Science
go.nmc.org/achie
(Deanne W. Swan, IMLS, 21 April 2014.) Data from the Early Childhood Longitudinal Study, was used to examine the influence of children's museum visitation during kindergarten on academic achievement later in third grade. Those who have visited museums had higher achievement scores in reading, mathematics, and science than children who did not, proving the important role museums should have in early education. *> Policy*

Applause for the Education Mission of Museums
go.nmc.org/appla
(John M. Eger, *The Huffington Post*, 18 February 2014.) Museums are transforming education through partnerships like the California Academy of Sciences in San Francisco who joined with the San Francisco Public Library, KQED, and the Bay Area Video Coalition to create a digital learning lab and a regional youth program network to equip young people with the 21st century skills they need in the new economy. *> Leadership*

A+UP
go.nmc.org/aup
(A+Up, accessed 25 February 2015.) A+UP is a tuition-free, open application middle school in Houston's Museum District that holds classes on-site at a range of Houston's cultural and learning institutions including The Health Museum, The Museum of Fine Arts, The Houston Zoo, The Children's Museum, and The Holocaust Museum. Students use these collections and resources for in-depth, hands-on learning projects. *> Leadership*

Working with Museums and Galleries to Connect Learning for K-6 Future Teachers
go.nmc.org/teachers
(La Trobe University, 2015.) A partnership between the School of Education of La Trobe University, Melbourne Museum, and the National Gallery of Victoria, and others has developed an accredited online postgraduate teacher education course that showcases how museums and galleries are public learning spaces for everyone. *> Practice*

Increasing Cross-Institution Collaboration
Mid-Term Impact: Driving technology adoption in museums for three to five years

Collective action among museums is growing in importance to drive best practices in technology use across the sector. More and more, museums are joining consortia or alliances — associations of two or more organizations[39] — to combine resources or to align themselves strategically with innovative initiatives. Today's global environment is allowing museums to unite across international borders and work toward common goals concerning technology use, and the sharing and co-creation of collections and exhibitions. Support behind technology-enabled learning in museums has reinforced the trend toward museum communities and consortia, as leaders in the space recognize collective action as a sustainable method of supporting upgrades in museums' technological infrastructures and digital offerings. Furthermore, many museums reside on university campuses, affording them greater opportunities to leverage the resources of the universities in addition to their academic libraries.[40]

Overview

The idea of formal partnerships between learning-focused institutions is not new, but the added dimension of joint technology-enabled initiatives is spurring creative collaborations. The root of this trend is reflected in UK's Museums Association's "Museums 2020" initiative, which invited professionals in the field to contribute their ideas online for shaping the future of museums.[41] An overwhelming amount of participants' feedback focused on the need for more collaboration between institutions for sharing expertise and building upon each other's communities.[42] Additionally, a joint study conducted by the University of Toronto and the University of Quebec at Montreal explored the motivations and outcomes of such collaborations. Researchers noted that partnerships between museums correlate with key themes, which include taking advantage of each other's technological developments.[43]

Museums can also look to AAM's "TrendsWatch 2015" report to begin developing standards for working together around common goals in the digital arena, such as generating more open data and incorporating wearable technology in exhibit design.[44] The report provides specific recommendations for how museums can respond to these growing areas of interest. In addition to sharing recommendations and bolstering staff learning, museum partnerships often revolve around solving a major global issue that cannot be alleviated on a large scale by a single institution. The volunteer-based Museum Access Consortium (MAC) in New York consists of 100 cultural institutions from the metropolitan area that advocates for improved accessibility in cultural facilities for patrons with disabilities. MAC convenes members for networking opportunities and museum outings, and has created an online database of exemplary resources and guidelines on accessibility.[45]

An important component of this trend is a spirit of openness. As part of the Google Cultural Institute, the Google Art Project joins together 150 museums from all over the world — including the Australian National Maritime Museum and Museum of the Sakitama Ancient Burial Mounds — with the common goal of making their collections accessible online to anyone, anywhere.[46] Collection objects across different museums and exhibits can be viewed side-by-side, illuminating clearer connections between specific artists and periods of history. Run by the Open Knowledge Foundation, OpenGLAM is another initiative that convenes galleries, libraries, archives, and museums around the mission of open access to digital cultural heritage works.[47] The network behind OpenGLAM includes the Wikimedia Foundation, The Internet Archive, and Europeana.[48]

Implications for Policy, Leadership, or Practice

Governments have long been concerned with developing policies that stimulate relationships among cultural institutions. The Network of European Museum Organizations (NEMO) is a partnership that facilitates networking opportunities along with the sharing of best practices among museums across the continent, enabling them to collaborate on multilateral and international projects.[49] One of their focuses is disseminating relevant information on EU policy to museums.[50] NEMO makes related policies more accessible for museum staffs, curating critical resources for understanding the impact of cultural policy and developing learning opportunities around them. In terms of policy around technology-focused museum collaborations, there is still much work to be done. Reputable government organizations such as IMLS have emphasized the need for museum spaces that better accommodate people with physical

and mental disabilities, setting a precedent for focused collaborations around technology-enhanced accessibility.[51]

Advancing cross-museum collaboration requires leaders to design programs that convene museums around technology-centric purposes. Linked Open Data in Libraries Archives and Museums (LODLAM) is a network of technicians and professionals who are working with linked data in the field. LODLAM's website is a hub for the sharing of resources and collaboration between participants.[52] Frequent face-to-face events are also key to disseminating best practices and shaping the future of museum technology. In 2014, the Metropolitan Museum of Art hosted the inaugural Global Museum Leaders Colloquium (GMLC) in which museum leaders from 14 countries participated in the program "Museums in an Interconnected World." Directors convened in small workshop groups to develop ideas for museum collaboration around harnessing the potential of digital media and tools. Proposals included the creation of new communications channels, joint strategic approaches to emerging technology, and the design of a new single-object exhibition platform.[53]

These collaborations can also have a profound effect on learning, especially when museums are creatively incorporated into formal education. In Fall 2014, students enrolled in the Master's Program in Public History at Carleton University co-developed the Canadian Museum of History's signature gallery, the "Canadian History Hall." During this process, students interacted with the museum's curators and staff, conducted key research, and submitted proposals for exhibition requirements.[54] Cross-institution collaboration can be especially critical for small museums that may have significantly smaller budgets to innovate. The Chattanooga Museums Collaborative, for example, joined together the Creative Discovery Museum, Tennessee Aquarium, and the Hunter Museum of American Art; the Aquarium was able to share their expertise on developing an effective IT network with the other two museums, and both benefited from wide-scale technology improvements.[55]

For Further Reading
The following resources are recommended for those who wish to learn more about increasing cross-institution collaboration:

LEM - The Learning Museum Network Project
go.nmc.org/lem
(LEM, accessed 17 February 2015.) The LEM - Learning Museum Network, funded by the European Commission, is a permanent network of museums and cultural heritage organizations who work to address challenges of the EU 2020 Strategy and actively contribute to lifelong learning. > *Policy*

The Artstor Digital Library
go.nmc.org/artstor
(Artstor, accessed 4 March 2015.) The Artstor Digital Library collaborates with museums like Harvard University's Peabody Museum of Archaeology and Ethnology and the Carnegie Institution of Washington to distribute digital images from museum collections in the arts, architecture, humanities, and sciences with an accessible suite of software tools for teaching and research. > *Leadership*

Museum Momentum
go.nmc.org/univmus
(Ian Wylie, *Times Higher Education*, 13 February 2015.) This article points to growing trends for university museums who are beginning to show their willingness to network and share best practices through national groupings like the Coordination Center for Scientific University Collections (CCSUC) in Germany and the Museum Association of Kyoto, a network of 14 university museums in the Japanese city. > *Leadership*

Smithsonian Joins Forces with 14 Museums to Pool Data on American Art
go.nmc.org/lod
(Laura C. Mallonee, *Hyperallergic*, 6 February 2015.) The Smithsonian American Art Museum (SAAM) has launched the American Art Collaborative (AAC), a consortium of 14 museums across the country that will connect their collections in a searchable manner through tagging their content with Linked Open Data (LOD). This allows users to find connections and relationships between works, artists, materials, and styles across collections. > *Leadership*

DigitalNZ
go.nmc.org/dnz
(DigitalNZ, accessed 16 February 2015.) DigitalNZ, based in Wellington at the National Library of New Zealand, has partnered with Te Papa, the Alexander Turnbull Library, Auckland Art Gallery, Te Ara, NZ On Screen and more to aggregate and provide access to more than 27 million digital items from New Zealand heritage collections including photos, posters and memorabilia, newspaper clippings, artworks, and publications. > *Practice*

Variety the Key to Making Ends Meet for Arts Groups
go.nmc.org/variety
(Millicent Martin Emery, *My SA*, 1 February 2015.) Arts and culture organizations in small communities are often able to better operate through collaboration and partnerships like Richmond Art Museum's annual Art to Heart gala which works in conjunction with Reid Hospital to draw diners interested in supporting both health and art. Shaun Dingwerth, Richmond Art Museum's executive director, explains how the museum seeks to include as many partners as possible to make grant proposals more appealing to funders. > *Practice*

Increasing Focus on Data Analytics for Museum Operations
Mid-Term Impact: Driving technology adoption in museums for three to five years

Ninety percent of the world's data has been generated in the last two years, and through the exponential growth of hardware, software, and networking, every day we add 2.5 quintillion bytes.[56] In recent years, companies such as Macy's, Netflix, and Wal-Mart have been analyzing data to boost their sales and track customer behavior.[57] Until recently, museums gathered behavioral analysis of visitors primarily through attendance statistics and staff-administered surveys — tools that are now often considered crude and inefficient.[58] Museums are increasingly employing strategies similar to those of major retailers for analyzing visitor information to generate more revenue and improve the efficiency of their operations in areas such as food service, marketing, retail, development, and program and exhibition design.[59] The benefits are becoming clearer as museums dive into data analytics and begin to learn more about their visitors; these analytics offer more targeted retail and focused information on the collections, as well as a greater understanding of an audience's interests and needs.[60]

Overview
A major shift is occurring in cultural organizations as they begin leveraging new data analysis techniques to inform their operations. From the moment a visitor enters a museum, there are a number of ways that their data is being collected to discern patterns and meanings in their behaviors and interests. A typical museum encounter used to include a guard with a clicker counting the visitors at the entrance, and then visitors paying admission fees and providing their zip code to the person at the front desk. This type of data collection provided very little insight into the visitor experience. Now organizations forgo these traditional procedures in exchange for sophisticated digital data collection methods. Indeed, more museums are eliminating their admission and membership fees altogether in favor of strategies that provide free access and incentives in exchange for personal information.

The Dallas Museum of Art's (DMA) Friends program is influencing museums to consider what is more valuable — admission revenue or knowledge of a visitor's behavior. Inspired by airline rewards programs, DMA implemented data analytics to encourage more repeat visitation and strengthen relationships with their patronage. Members receive a card that they use to collect points while engaging in programs or exhibitions – perks range from gift shop discounts to free parking. Since the launch of the program in 2013, the museum has registered over 50,000 new members.[61] While projects like the DMA Friends program are employed at large institutions, smaller organizations are also enjoying the benefits of data analysis. The History Colorado Center's new point-of-sale system was able to provide valuable insights into their visitors' demographics and visitor patterns; they learned that 40% of their visitors were families, a statistic that led to the creation of a new position to develop programming expressly for this audience. Since deploying the strategy, their attendance and memberships have doubled.[62]

Once inside the museum, data analytics are being employed to understand visitors' foot traffic. While much of this work in the past was done through direct staff observations, noninvasive Bluetooth sensors are being used at the Louvre, for example, to analyze the visitation patterns of short-stay patrons (less than one and a half hours) and long-stay visitors (more than six hours). Their recent study disproved an initial hypothesis that short-stay visitors explore fewer of the museum's popular areas due to time constraints.[63] While these innovative projects are showing the potential of data analytics, not every museum or cultural organization has the requisite staffing needed to build their own systems, so it will be important in the coming years for institutions to become educated on the vendors that can provide turn-key solutions.[64]

Implications for Policy, Leadership, or Practice
To guide the creation of museum-related data policy, government entities are employing data analytics to understand the make-up of cultural institutions and the breadth of museum digitization projects. In the United States, the Institute of Museum and Library Services (IMLS), is a federally funded organization that advances innovation, lifelong learning, and cultural and civic engagement through research, policy development, and grant-making.[65] Recently, IMLS has undertaken a massive data research project called the "Museum Universe Data File," to create a list of 35,000 museums and related organizations in the United States — the first ever of its kind.[66] This large-scale analysis will enable IMLS to better serve the museum community. In Europe, the European Commission-funded ENUMERATE

project is creating a baseline of statistical data about digitization and digital preservation initiatives in cultural organizations across the continent. A consortium of ten European-wide partners is developing a consistent set of evidence for guiding digitization funding decisions.[67]

The success of the aforementioned DMA Friends program at encouraging deeper engagement and repeat visitation has positioned the museum as a leader in the field. Their audience engagement initiative was awarded a National Leadership Grant to support the expansion of their platform to three partners: the Denver Art Museum, Los Angeles County Museum of Art, and Minneapolis Institute of Arts. The museums will undergo a year of research to establish a dataset about the program's strengths and weaknesses, with the goal of determining what activities and tools could be scaled across the field.[68] To support the growing need for data analysts in cultural organizations, university training programs are beginning to emerge, as well. While most big data projects have focused on economics or healthcare data, the City University of New York's (CUNY) Graduate Center is opening the Center for Digital Scholarship and Data Visualization for training museum professionals. CUNY will work with datasets provided by partnering organizations such as the Museum of Modern Art, New York Public Library, and Brooklyn Historical Society.[69]

Experimentation with data analytics in museums is growing in size and type, from dashboards that visualize datasets and measure performance at the Indianapolis Museum of Art[70] and Cleveland Museum of Art[71] to point-of-sale software that predicts what a customer of a gift shop will likely purchase on their next visit, as they are doing at the Norman Rockwell Museum.[72] Indeed, predictive analytics can have a substantial impact on how weather conditions can guide daily staffing decisions at a sculpture garden or zoo. The Point Defiance Zoo & Aquarium combines real-time weather data from the National Oceanic and Atmospheric Administration, ticket sales, mobile check-ins, and past attendance data to understand and adapt to fluctuations in attendance.[73] On the other side of the globe, mobile app tour analytics are being used at the Museum of Old and New Art in Australia to provide daily reports on the number of visitors, how many works were viewed, which were the most visited collection objects, and how long a visitor remained in front of an object.[74] As these experiments mature, it is argued that the next phase of data analytics should include sharing insight through linked big data across a network of museums. The insights derived from this sharing of information could prove extremely beneficial to small museums with limited budgets.[75]

For Further Reading

The following resources are recommended for those who wish to learn more about increasing focus on data analytics for museum operations:

Cultural Data Project
go.nmc.org/cdp
(Cultural Data, accessed 16 February 2015.) The Cultural Data Project is the emerging national standard for data collection in the arts and cultural sector. It provides a user-friendly online management tool designed to strengthen organizations by lessening the burden of preparing grant application materials and simplifying report-generation so museums can make an effective case to donors and policymakers for their support.
> *Policy*

Mobile Sensing, BYOD and Big Data Analytics: New Technologies for Audience Research in Museums
go.nmc.org/mobsen
(Theano Moussouri, George Roussos, *Participations*, May 2014.) This paper uses case studies to discuss methods of indoor visitor tracking, recommending ways to address the methodological, ethical, and practical challenges emerging from the use of these technologies. **>** *Policy*

The Nelson-Atkins Museum Gears Up For Big Data To Shape Visitor Experiences
go.nmc.org/shape
(Laura Spencer, *KCUR*, 5 February 2015.) This interview with Julián Zugazagoitia, the director and CEO of the Nelson-Atkins Museum of Art, delves into how tracking the way visitors interact with art can help museums understand how to create better experiences for each visitor. **>** *Leadership*

Art Traffic at the Louvre
go.nmc.org/artraff
(Art Traffic at the Louvre, accessed 16 February 2015.) The MIT Senseable City Lab worked with The Louvre Museum to deploy seven Bluetooth sensors with sufficient coverage to measure visiting sequences and duration at key representative locations in the museum so that they could use the data to better understand visitor behavior and experience. **>** *Leadership*

The Arts and Culture Sector Must Think About Data… but Differently
go.nmc.org/diff
(Abhay Adhikari, *The Guardian*, 28 March 2014.) Technologies that collect data present an opportunity for museums to open up their findings and create evidence-based stories that can highlight their scale and impact. **>** *Practice*

Expanding the Concept of Visitors
Short-Term Impact: Driving technology adoption in museums for the next one to two years

T*he dichotomy between the onsite and virtual museum visitor is blurring rapidly, and both audiences have high expectations for accessing services and information online. Visitors who are unable to visit a museum in person are now able to experience its collections and respond and contribute meaningfully to conversations about exhibitions and programming occurring in the physical space, redefining what it means to be a museum patron. Through emerging digital tools, museums are now able to develop long-term relationships with visitors that extend beyond the walls of the museum and the duration of an exhibition.[76] Acknowledging the needs of a global audience is also important in helping to keep museums relevant. Museum website traffic has quickly outpaced physical museum attendance. According to the Council of Australasian Museum Directors, 70% of the 51 million visits in the 2013-14 financial year were online.[77] This statistic underscores a major shift in how museums think about their patrons.*

Overview
The changing habits of museum audiences since the recession and rise of the digital age have contributed to a shift in the way museums view the concept of a museum visit. Recent trend reports by the National Endowment for the Arts have revealed a steady decline in experiencing art in person over the past two decades. One of their latest surveys of public participation in the arts shows that nearly 75% of Americans used electronic devices to view or listen to art while just 33.4% attended one of seven art events the same year.[78] With the introduction of new technologies, leaders in the field are questioning what defines a place during a museum visit. Social media platforms such as Twitter and Facebook, along with websites, are now being seen as surrogates for a physical museum experience.[79]

As museum websites and social media feeds create new kinds of spaces for connecting with patrons, some museums are expanding their geographical focus to deliver cultural experiences to audiences around the world. The Metropolitan Museum of Art created international social media accounts, such as Weibo in China, to engage with growing global audiences. They report that around 60 posts on Weibo have been viewed nearly three million times.[80] Indeed, museums in Europe are also leveraging social networks to see dramatic gains in viewership and engagement. The National Gallery of Denmark increased their Instagram reach by 2,500 percent between July and August 2014 through a social media strategy that encouraged visitors to share their personal photos of the museum.[81]

Online-only museum experiences are also growing and contributing to greater awareness and interest in museum collections and exhibitions. The Google Cultural Institute counts 500 partners from over 60 countries that have provided online access to more than six million objects and artifacts. The Institute had more than 19 million unique visitors and 200 million page views in one year. Museums are building their relevancy and reputations through this type of online access. After the first seven weeks of launching their online collection on Google Art Project, Hamburg's Archaeological Museum received more than 80,000 views with each user spending about eight minutes on the site.[82] Museums are also increasingly looking to the Internet for online-only exhibitions. The presentation space for the Museum of Modern Art's "Design and Violence" occurred not on their physical campus but on the web.[83]

Implications for Policy, Leadership, or Practice
The impact of decreased museum attendance, especially for art museums that saw physical visits fall by 58 million people between 2002 and 2012,[84] has stimulated investments in mobiles that could influence future policy. A consortium of pan-European academic, industrial, and cultural organizations recently banded together to develop the "Cultural-Heritage Experiences through Socio-personal interactions and Storytelling" (CHESS) app, which enables museum visitors to shape their museum experience from anywhere on the continent and beyond. The tool leverages mobiles, augmented reality, and geo-localization to create personal, interactive experiences.[85] Similarly, Bloomberg Connects will provide 17 million dollars in philanthropic funding over the next three years to support mobile technology in museums. The goals of this mobile-app initiative are to expose culture, increase visitation, and expand engagement both onsite and offsite.[86] Both initiatives hope to engage younger tech-savvy generations in particular because their engagement is seen as critical to keeping museums relevant in the future.

Museum leaders are developing new opportunities for online visitors to engage with their organizations when geography is a primary obstacle. Although a digital visit cannot replace the richness of an analog visit, individuals in rural areas often have limited travel opportunities to visit their nearest museum and can benefit through online access to a museum's collection. Crystal Bridges Museum of American Art in Arkansas is one organization building relationships with important student-aged patrons via a state-wide, distance-learning program. Through a partnership with Virtual Arkansas, Crystal Bridges has developed semester-long courses for high schools in the state of Arkansas, a state with a high number of students from low socio-economic and/or rural schools.[87] North Carolina Museum of Art is another museum developing online courses to engage with younger visitors. In collaboration with the North Carolina Virtual Public School, high school students can take courses such as Art of Advertising, Art of Game Design, or Art of Videography.[88]

When museums shutter their doors for renovations or expansions, visiting them is not an option. However, museums are responding with innovative projects that show the potential of online engagement. When the Rijksmuseum in the Netherlands recently underwent a renovation, the museum focused on making over 100,000 high-resolution collection objects available to the public through the Rijkstudio. This open design concept invites online visitors to create their own artworks by downloading images and manipulating them copyright-free.[89] San Francisco Museum of Modern Art's solution to keeping audiences interested during their temporary closure due to expansion is also noteworthy. Along with moving their collections to other Bay Area exhibition spaces, the museum is generating online traffic to their website through a number of projects.

For Further Reading
The following resources are recommended for those who wish to learn more about expanding the concept of visitors:

Using Social Media to Attract New Audiences to the Arts
go.nmc.org/toattract
(Elise Korolev, *UP London*, 2 October 2014.) This post discusses the importance of a strong social media strategy because social media platforms are also forums for visitors to share their experiences with each other and the world. Word of mouth advertising is now amplified through social media, and a "like" on Facebook, comment on Twitter, or photo on Instagram about a visit is a genuine endorsement for a museum that speaks volumes to potential visitors. > *Policy*

Harvard Art Museums Launch Redesigned and Expanded Website
go.nmc.org/harart
(Harvard Art Museums, 12 November 2014.) Harvardartmuseums.org is intended to be a resource for before, during, and after an in-person or virtual visit. The new site features high-resolution images, information about works in the collections, extensive educational and interpretive tools, and interactive navigation guides; all with responsive design and optimized for viewing on mobile devices. > *Leadership*

Museums Share Their Best Practices for Reaching Multilingual Audiences
go.nmc.org/lingual
(Rebecca Mir, Guggenheim, 25 April 2014.) As museums are able to virtually reach audiences all over the world, they must seek to connect to visitors who speak a range of languages. This article describes take-aways from an #EduTues chat facilitated by Queens Museum and the Guggenheim which brought together a number of institutions and individuals to discuss how their institutions are meeting linguistic challenges.
> *Leadership*

Museums Should Make Time for Slower Digital Experiences
go.nmc.org/slower
(Danny Birchall, *The Guardian*, 23 January 2015.) Inspired by recent developments in long-form journalism, Wellcome Collection launched a digital exhibit called "Mindcraft," which is an immersive and interactive digital story about madness, murder, and mental healing. The museum wanted to experiment with reaching visitors in unique ways and found digital to be the best way to create a space in which people could spend more time with the collections. > *Leadership*

Is the Future of Museums Really Online?
go.nmc.org/onlinefuture
(Bob Duggan, *Big Think*, 9 February 2015.) The author pulls findings from two recent reports to frame some impediments to visiting museums and then explains how museums can leverage their digital counterparts to reach those visitors who are unable to physically enter the building. > *Practice*

Increasing Focus on Participatory Experiences
Short-Term Impact: Driving technologyadoption in museums for the next one to two years

Expectations for civic and social engagement are profoundly changing museums' scope, reach, and relationships. More and more, museums are integrating important developments in technology and approaches such as social media, open content, and crowdsourcing as a means of engaging their communities both internally and externally on a continuum of participation. Museum professionals are embracing innovations that include mobile and network technology, which enable their institutions to provide patrons with more immersive opportunities that integrate visitor knowledge into exhibits and objects. Additionally, there is a need to recognize that niche visitor groups and individuals can provide museums with insights that enrich collections and enhance the interpretive value of an exhibit. Participatory experiences are becoming more valuable, on-site and online, and museums are increasingly seeking out ways to incorporate community contributions.

Overview

The idea of the museum as a participatory institution has advanced with the tide of technology as tools to communicate and share have become more accessible to the general public. As a result, many artists and museum curators are embracing a paradigm shift that requires visitors to actively contribute to installations and exhibitions to create meaning. The participatory museum is both a philosophy and strategy that, while not requiring technology to implement, leverages new modes of communication to make cultural institutions a more relevant, constructive piece of society. The publication of *The Participatory Museum* by Nina Simon in 2010 was a major step to formalizing the movement, which has since gained significant traction with the broader museum community.[90] A freely licensed and shared online book, *The Participatory Museum* puts forth the vision of a cultural institution that is designed with the express purpose of engaging the community, and it includes techniques that encourage visitors to create and connect with each other around art.[91]

The increasing focus on participatory experiences has given rise to innovative approaches for creating and designing content for the cultural space. Crowdsourcing, for example, is a technique that solicits contributions from the community to influence the direction or meaning of a particular project. Many museums use crowdsourcing at the superficial level to organize communities via social media. Their expectation is that word-of-mouth news will boost their reputations and increase attendance levels of certain exhibits. On the other hand, there is a growing sense that participation from the community can enhance museums in a deeper way through establishing a reciprocal dialogue. PR strategies have been adapted by museums that want to build personal connections with their content via social media and public online forums. From a museum expert's perspective, radical trust is the ability to be open, transparent, and communicate personally from an institutional standpoint, which directly empowers online communities to reciprocate that openness and participate in meaningful exchange.[92]

Without a doubt, the ubiquity of smartphones with high-quality cameras and social apps has affected how museums are accommodating visitors who use these devices in the museum space. Social media management has become a high priority because of its catchall ability to tap into what visitors are thinking, how they are engaging with museum-specific content, and why they enjoy certain cultural experiences over others. Public relations experts working in the museum field are focused on how social media creates a channel for communication — before, during, and after a trip to the museum — which can be a useful tool for customer care.[93] Some museums are taking full advantage of mobile technology and social media to construct their exhibits through visitor participation. The New Museum in Manhattan organized an event in September 2014 called "AUNTSforcamera: BYOC! (Bring Your Own Camera—Where the Audience Controls the Frame)," which encouraged visitors to film 8-second videos of the live performances to be tagged and shared through a social media app designed by one of the artists.[94]

Implications for Policy, Leadership, or Practice

The momentum behind the participatory movement is causing many museum leaders to consider formulating policies that foster digital interaction via smartphones and social media inside museum walls. Invented by museum consultant and blogger, Mar Dixon, the first #MuseumSelfie day took place on January 22, 2014, demonstrating the power of social media outlets to open up access to collections all over the world. In 24 hours, 11,143 people had tweeted their #MuseumSelfie

and 5,591 photos had been shared as a result. In a reflection about #MuseumSelfie day, museum leader Lorna Cruikshanks considered how the activity increased visitor engagement around objects as many photos showed recreations and interactions with sculptures and portraits.[95] In Dixon's review of the event, she discussed the unintended effects of #MuseumSelfie day, which generated many political conversations about photography in museums as well as a backlash against selfies in cultural heritage institutions.[96]

Because participatory strategy involves innovative approaches, many projects are breaking ground in experimental territory, which is why it is especially important for museum leaders to evaluate the successes and failures of their projects. At the Museums and the Web 2014 conference, European researchers published their findings about crowdsourcing projects for the cultural institution using two case studies, "Red een Portret" (Save a Portrait) at the Amsterdam City Archives and a photo-tagging project of the Maria Austria Institute on the "Vele Handen" (Many Hands) crowdsourcing platform, to draw thorough conclusions about effective and ineffective models of implementation.[97] Other effective models of participatory practice, such as crowdfunding, are also gaining attention. At the Palazzo Madama in Turin, museum leaders implemented a crowdfunding campaign using social media in order to raise 80,000 Euros that would allow them to purchase an iconic collection of porcelain. In the process, the small museum was able to connect with over 1,500 people, raise 20,000 Euros more than their goal, and successfully make the acquisition. Museum leader Jasper Visser highlighted this particular project as an example of "the museum AD 2014," which is defined by value, community, engagement and co-creation.[98]

The participatory experience in practice can be seen in museums where exhibits are designed for visitors to learn about works of art by doing. At the Center for Creative Connections at the Dallas Museum of Art, for example, coordinators have installed a large worktable in the middle of the gallery where three hands-on activities are cycled on a monthly basis. Intended to engage adults, the museum educators have learned that children are not the only ones who enjoy making and sharing their creations and reflections with others.[99] Some museums are taking advantage of their most dedicated visitors to participate in ongoing, long-term projects. At the Children's Museum of Indianapolis, three families were recruited to participate in the Playscape 5, a community blog that catalogs their experiences in the museum over a period of six months. Organized by their unique hashtag, the families were able to contribute to the blog using Instagram, Vine videos, and other social media. Museum leader Lori Byrd Phillips reported that the community-blogging activity fostered authenticity, loyalty, and transparency in the museum environment, and gave the visitors a renewed sense of ownership.[100]

For Further Reading

The following resources are recommended for those who wish to learn more about increasing focus on participatory experiences:

Museums Morph Digitally
go.nmc.org/morph
(Steve Lohr, *The New York Times*, 23 October 2014.) Many museums like the Metropolitan Museum of Art have turned 180 degrees from asking visitors to stow their cellphones to encouraging them to use them while browsing collection objects. Such museum policy changes create an open environment that invites visitors to personalize their experience by exploring and saving content on their devices and sharing with their friends and networks. **>** *Policy*

Split Second Exhibit
go.nmc.org/split
(Brooklyn Museum, accessed 9 February 2015.) Split Second was an exhibit at the Brooklyn Museum that invited the museum's online community to participate in an experiment exploring how each viewer's initial reaction to a work of art is affected by what they know, what they are asked, and what they are told about the object in question. The online interaction connected to a physical installation within the museum of Indian paintings from the museum's permanent collection. **>** *Leadership*

What Will Museums Be Like in the Future? Short Essay Collection by Museum Leaders and Innovators From Around the World
go.nmc.org/infut
(Museum-iD, accessed 5 February 2015.) Museum-iD invited museum leaders to share their visions for the future of museums. Many of the responses focused on a more participatory museum that serves as a social agent or civic connector making use of co-production in a more democratic manner. **>** *Leadership*

Citizen Participation in Science at the Museum of Science in Boston
go.nmc.org/partic
(David Sittenfeld, *Scistarter Blog*, 11 December 2014.) The Museum of Science in Boston invites public collaboration through three citizen science projects: "Firefly Watch," "Planning for Healthier Cities," and its Forum project that includes over 50 citizen forums in which participants consider and make decisions about socio-scientific issues. **>** *Practice*

Significant Challenges Impeding Technology Adoption in Museums

The six challenges described on the following pages were selected by the project's expert panel in a series of Delphi-based cycles of discussion, refinement, and voting; the expert panel was in consensus that each is very likely to impede the adoption of one or more new technologies if unresolved. A complete record of the discussions and related materials were captured in the online work site used by the expert panel and archived at museum.wiki. nmc.org/Challenges.

Because not all challenges are of the same scope, the discussions here are sorted into three categories defined by the nature of the challenge. The NMC Horizon Project defines solvable challenges as those that we both understand and know how to solve; difficult challenges are ones that are more or less well-understood but for which solutions remain elusive; and wicked challenges, the most difficult, are categorized as complex to even define, and thus require additional data and insights before solutions will even be possible. Once the list of challenges was identified they were examined through three meta-expressions: their implications for policy, leadership, and practice for museums.

Policy. While all of the identified challenges had policy implications, two specific challenges are driving policy decisions at many museums at the moment. The easiest one to address is creating policies that better advance digital literacy. Governments and museum organizations are already making ample headway. The Institute of Museum and Library Services (IMLS), for example, has convened a Project Team and Taskforce for the development of 21st century common standards for museum staff skill sets — collaboration through technology and understanding how to assess the effectiveness of digital tools are just two of the skills being defined.[101]

A more challenging policy area is that there is a great deal of complexity involving data privacy. International organizations are currently developing policy to ensure privacy protection. Led by Brazil and Germany, the United Nations is developing a draft resolution titled "Right to Privacy in the Digital Age."[102]

Leadership. Again, while all the identified challenges have leadership implications that are discussed in the following pages, two pose roadblocks to employing effective visions. There is a major need for museums to develop benchmarks and standards before integrating new technologies, and some museums are already making progress. The Minneapolis Institute of Arts' "Dynamic New Approach" strategy brief, for example, requires that every adopted technology must meet the museum's goals and objectives, such as increasing audience engagement and globalizing efforts.[103]

The maintenance of progress in technology, workflows, and infrastructure is considered by the panel to be a wicked challenge requiring effective leadership. Some organizations are stepping up to develop potential solutions, such as the Digital Library Federation (DLF) that provides a Cross-Pollinator Fellowship for museum professionals involved in using digital collections and services to bring greater understanding to how cultural heritage institutions operate in a networked environment.[104]

> ## Because not all challenges are of the same scope, the discussions here are sorted into three categories defined by the nature of the challenge.

Practice. Each of the six challenges identified by the expert panel presents numerous impediments for advancing museum education and interpretation, but two in particular are presenting unique obstacles. The expert panel perceives the balancing of our connected and unconnected lives to be a difficult challenge. The Frye Art Museum's Mindful Meditation classes, for example, are helping visitors find analog methods for art appreciation such as applying present-moment awareness while exploring collection objects.[105]

Creating digital strategies has also been a challenge for museums, especially as technology advances at an accelerating rate. Tate Museum has developed a comprehensive plan called "Digital as a Dimension of Everything" that embraces digital activity and skills across their organization. It focuses on a number of interrelated activities such as use of online platforms and the development and fostering of an arts community.

The following pages provide a discussion of each of the challenges highlighted by this year's expert panel that includes an overview of the challenge, its implications, and a set of curated recommendations for further reading on the topic.

Developing Digital Strategies
Solvable Challenge: Those that we understand and know how to solve

The ubiquity of technology use in society has impacted how museums develop strategic plans and digital strategies. Such strategies should include hardware, software, and networks, as well as critical tasks like digitization. More importantly, these plans should help museums expand the meaning of digital to include the adoption of digital values such as agility, flexibility, and usability to keep pace with rapidly evolving societal changes that are increasingly inseparable from technology.[106] Digital strategies are more than the development of a website; they should include the multiple channels of technologies that provide unique opportunities for audience engagement.[107] A museum's digital presence today includes not only a website, but also a social media presence, mobile tools and apps, electronic fundraising, and much more. Additionally, it is clear that a museum cannot simply plan a web presence in the same manner as a brochure or catalog; they require the development of new workflows and staffing requirements.

Overview

As mirrors of contemporary society, which is increasingly participatory, networked, and open-source, museums are in the midst of a digital transformation that is impacting almost all areas of a museum's operations.[108] At the center of this challenge is the notion of museums needing to be more aware and responsive to their audiences' evolving behaviors to stay relevant. As a result, they are being urged to shift their attitudes to balance digital infrastructure and digital mindset in equal measure.[109] Leaders in the field believe that digital strategies are not about platforms, but about people; putting platforms first is seen as impeding organizations.[110] Furthermore, museums must create plans that engage two different but connected perspectives: that of the long-term that focuses on flexibility and digital values and that of the short-term that stimulates immediate action.[111]

Museums are digitizing components of their collections to increase access while creating greater audience engagement. A recent report by CSIRO analyzing Australia's galleries, libraries, archives, and museums cautioned that digital innovation is inconsistent and isolated in the continent, and only a few organizations place technology services at their core, rather than as an add-on activity.[112] The report recommends that museums specifically engage in digitization projects to increase relationships, to reach younger audiences, and to create greater interest in museum collections.[113] In the UK, the Natural History Museum is addressing this common refrain by embarking on a plan to digitize 80 million specimens from the museum's collections and provide access through an online data portal.[114]

Research groups and leading museums are exploring focused methods that use technology to create greater connections with visitors. Developed by Jasper Visser and Jim Richardson, the "Digital Engagement Framework" is helping museums think about how to identify their value creation opportunities, using digital means. The framework calls for developing strategies, processes, and technologies to maximize co-created value, that is, when value creation mutually benefits the museum and patron.[115] At the Metropolitan Museum of Art, their comprehensive engagement strategy focuses on three dimensions of interaction: before the visit, which involves the display of as many collection objects as possible online; during the visit, which develops solutions to enrich a visitor's experience; and after the visit, which uses guest-generated data to meet audience expectations and encourage return engagement.[116] Depending on the culture of the museum, developing a standalone digital strategy may be helpful for providing clarity and focus, or reviewing an existing strategic plan may be more appropriate. More importantly, museums need to ensure that digital is woven seamlessly into whatever solution is chosen.[117]

Implications for Policy, Leadership, or Practice

As governments coordinate efforts to develop arts and culture policies, some are focusing on technology initiatives that are impacting museum planning. In Australia, all federal and state arts jurisdictions have developed an Arts Accord, an agreement between federal, state, and territory governments to strengthen support for arts and culture and set principles for ongoing cooperation.[118] One of the areas of focus is on digital, and the Powerhouse Museum is part of a working party that is assessing existing data readiness for sharing and identifying digital engagement innovations across the sector to provide an agreed set of actions to be pursued by the Arts Accord.[119] Similarly, Europeana, part of the Digital Agenda for Europe's 2020 initiative, seeks to further the digitization and

networking of museum cultural heritage.[120] In the US, private foundation initiatives such as the Bloomberg Connects program, which provides funding for the development of technology to increase access to cultural institutions and enhance visitor experiences, may lead to greater policy action.[121]

Strong commitment and visionary leadership are required for an organization to understand how to effectively invest in technology initiatives. The Metropolitan Museum of Art recently implemented a plan that revealed several organizational implications that can be helpful to museums looking for guidance. It required the museum to rethink their organizational structure by establishing a digital department; rethinking which vital skills were needed to carry out the strategy by recruiting a new chief digital officer; allocating resources for social media managers, website managers, content teams, and an audio guide team; and, creating facilities dedicated to innovation.[122] Organizational leaders can also turn to an emerging body of research, such as recently published books *Digital Heritage and Culture: Strategy and Implementation* that is helping to establish best practices[123] and *The End of the Beginning: Normativity in the Postdigital Museum* that encourages the evolution of attitudes regarding how digital thinking is applied in museums.[124]

On the implementation level, the Tate Museum in the UK has developed a comprehensive plan that embraces digital activity and skills across their organization. Their approach, called "Digital as a Dimension of Everything," addresses the use of online platforms and channels for providing rich content for visitors, for the creation and nurturing of an arts community, and for maximizing revenue opportunities.[125] Thinking digitally should not fall within one department's scope of work, regardless of organizational structure; museums should move away from a one-off project mentality to a collaborative approach by investing in digital capacity and skill building among core museum staff.[126] The Royal Ontario Museum, for example, has a team of web content producers who help to train staff by holding monthly workshops and one-on-one mentoring sessions.[127]

For Further Reading

The following resources are recommended for those who wish to learn more about developing digital strategies:

An Introduction to Digital Strategies for Museums

go.nmc.org/introstrat

(Jack Ludden, Museums and the Web Asia 2014, 1 October 2014.) This article describes how museum strategies must stem from a goal of balancing cultural preservation with participation in a contemporary, fast-paced world. The three important objectives mentioned that will strengthen a museum's digital presence include managing data well, creating elegant responsive designs, and engaging in online conversations. **>** *Policy*

Towards an Integrated Approach to Cultural Heritage for Europe

go.nmc.org/integrated

(European Commission, 22 July 2014.) In line with the objectives of the European Agenda for Culture, this communication presents the EU's approach to cultural heritage across different policy areas and then describes the measures available to strengthen policy cooperation at different levels, citing projects being developed to support new models of cultural heritage governance. It highlights the importance of digitization and e-learning tools that promote online accessibility and wider access. **>** *Policy*

eCult Vademecum: A Guide for Museums to Develop a Technology Strategy

go.nmc.org/vadem

(eCult Observatory, accessed 18 February 2015.) The eCultValue project which consists of five partners from museums, technology, and research, with networks all over Europe, has confronted technology developers and cultural heritage institutions to identify opportunities and challenges of technology take-up. This Vademecum is meant to serve as a tool for guiding museums, cultural heritage sites, and collection owners through developing and implementing a technology strategy. **>** *Leadership*

Electronic Records Management Start-Up Project

go.nmc.org/elecrecord

(Guggenheim, accessed 18 February 2015.) The Guggenheim Museum Archives received funding for an electronic records start-up project from the National Historical Publications and Records Commission (NHPRC) with which they have created a comprehensive plan to establish and manage an electronic records repository. Their reports detailing the 18-month project are all publicly available. **>** *Leadership*

Portland Museum of Art Announces Strategic Vision and Positioning for the Future

go.nmc.org/positioning

(Kristen Levesque, Portland Museum of Art, 1 October 2014.) Portland Museum of Art has announced a strategic vision for its future that will allow digital access to the museum's entire collection for the public and scholars alike. **>** *Practice*

Real Transformation Ain't Easy

go.nmc.org/realtra

(Ed Rodley, Thinking about Museums, 18 May 2014.) This post combines key takeaways from the State of Digital Business 2014 report by Forrester and the leaked internal strategy report from the *New York Times* to create a list of questions museums can use in digital transformation initiatives. **>** *Practice*

Improving Digital Literacy of Museum Professionals
Solvable Challenge: Those that we understand and know how to solve

With the proliferation of the Internet, mobile devices, and other technologies that are now pervasive, the traditional view of the museum professional as possessing the ability to develop exhibitions and educate patrons has expanded to encompass the understanding of a variety of digital tools. This recent category of competence is affecting how quickly museums evolve and the skills they expect in new hires. Some thought leaders believe there are not enough official best practices guidelines for technology training for current and pre-service museum staff,[128] and the most progressive examples are taking place outside of their education departments. Professional development around how emerging technologies can be leveraged to further museums' interpretation goals and enhance their visitor experiences is needed at all levels of museum education. This issue is not isolated to museum education departments and is essential to improving technical infrastructure and workflows. Digital literacy needs to be achieved across the board, especially in the context of museum leadership.[129]

Overview

While digital literacy has long been acknowledged as a widespread issue in education,[130] the 2015 NMC Horizon Project Museum Expert Panel recognized it as solvable as it has already been made actionable by many museums and related organizations. The International Committees for Regional Museums and the Training of Personnel observed that tech-savvy has become a prioritized skill. In their report, "Staff and Training in Regional Museums," they noted that museums are aware that they must hire staff with ICT backgrounds in order to reach new markets and deliver new services.[131] Indeed, technology managers and directors are now commonplace positions at museums. A public listing for Senior Manager of Museum Technology at the High Museum of Art in Georgia explicitly states a requirement for "effective advocacy for museum needs in IT steering committees" and the delivery of training to the rest of the staff.[132]

As the need for digital literacy has been continuously acknowledged by museums, museum studies programs at universities are now including in their curriculum Internet copyright law, digital imaging, and scanning technologies.[133] However, current staff without sufficient technology training — and the time or funds to enroll in

formal training — face ongoing challenges. Increasingly, organizations such as the Museum Computer Network (MCN) are stepping in to fill professional development gaps. MCN Pro was designed to provide online training around pressing topics including the integration of specific technologies.[134] These virtual workshops connect experts across the MCN community to equip participants with new skills, including better techniques for storing and organizing online assets.[135] Additionally, their special interest groups convene people around technology-focused areas, such as media production and information technology, encouraging ongoing peer-to-peer learning and open dialogues.[136]

While creative training solutions are underway, the addition of visitors in the equation is further compounding the digital literacy challenge. Museum and cultural heritage institution staff need to be well-versed in emerging technology because the latest generation of patrons is already savvy. For example, a study conducted by Pew Research Center found that young adults are increasingly using their mobile devices to manage and record their daily lives — 94% use smartphones to take photos and 68% produce videos.[137] Technology is an inherent part of how they learn, as well as how they experience and create art. Several years ago, high school students who created high-tech projects at the Museum of Science and Industry Chicago's Fab Lab trained the visiting Russian Federal Youth Agency (RFYA) staff on using 3D printing software and equipment so that they could launch similar makerspaces in Russia.[138]

Implications for Policy, Leadership, or Practice

At a governmental level, no specific policies exist yet for the stewardship of technology training for museum staff. However, government organizations, such as the Institute of Museum and Library Services, are recognizing the need to fund museums to develop better digital literacy skills and technical infrastructure. "Sparks! Ignition Grants For Museums" encourage museums to prototype and bolster innovations in the way they operate and in the services they provide.[139] The IMLS Project Team and Task Force also developed 21st century skills definitions to align museums and libraries around common standards for staff skill sets. Definitions include the ability to collaborate with others by leveraging the latest media and technologies, and also understanding how to evaluate the effectiveness of

these tools.[140] The American Alliance of Museum's (AAM) Committee on Museum Professional Training has also developed standards and best practices that highlight the need for training curriculum that "reflects and responds to current and emergent needs in museums and their communities, including the challenges of new technologies."[141]

Advancing digital literacy across museum staff requires effective leadership, and often that guidance and incentive is coming from external organizations. AAM's Media & Technology Network consists of museum professionals who are using technology in their field for activities such as media production and database development. They advocate for the effective applications of emerging technologies in museums, frequently hosting events that convene community delegates to discuss ways to innovate digital implementations across various museum roles.[142] Additionally, the Media & Technology Network sponsors the annual MUSE Awards Competition, which recognizes excellence in museum media and interactive programs. President Lincoln's Cottage, for example, received a Gold MUSE Award for creatively leveraging tablets to "interpret art in terms of history, aesthetics, and culture."[143] Staff learned to develop sufficient technical infrastructure to execute this initiative. Many individual museum professionals are also building their own professional development networks. "CODE | WORDS: Technology and Theory in the Museum" is a web community where leadership staff are publicly sharing their perspectives and expertise on digital applications.[144]

In practice, digital literacy is frequently being approached in informal settings. "Drinking About Museums," for example, brings together museum professionals in various cities across the US.[145] Small groups generally convene in a bar or restaurant to share best practices and experiences, generally around the use of emerging technology. In between face-to-face gatherings, museum staff are also turning to Twitter for a steady stream of new perspectives and helpful tips. Hashtags including #musetech, #musesweb, and #artstech keep them apprised of relevant digital findings at museums in real-time. The website "Museum Geek" is home to technology stories and ideas from innovative museum professionals.[146] There is, however, still a need for museum staff to work internally with their colleagues to make sure they stay up to date with the latest digital tools. For example, the Imperial War Museum's Computer Club provides staff with regular opportunities for peer-to-peer, hands-on training.[147]

For Further Reading
The following resources are recommended for those who wish to learn more about improving digital literacy of museum professionals:

Digital Storytelling in Museums: A Tool to Engage Adults and to Evaluate the Impact
go.nmc.org/diam
(Melting Pro. Laboratorio per la Cultura, March 2014.) In the Diamond project "Dialoguing Museums for a New Cultural Democracy" European scientific museums and research centers designed and created a training program for museum professionals to teach them how to use digital storytelling to engage with disadvantaged audiences and foster social inclusion. **>** *Policy*

The Museums Computer Group
go.nmc.org/mcg
(Museums Computer Group, accessed 5 March 2015.) The Museums Computer Group (MCG) hosts an annual conference, which this year was themed "Museums Beyond the Web," inviting museum and cultural heritage professionals to consider and discuss the skills needed now in order to navigate the challenges wearable, immersive, mobile, and haptic technologies will bring. **>** *Leadership*

M-LEAD (Museum Library Education and Digitization)
go.nmc.org/mlea
(Pratt Institute, accessed 5 March 2015.) Pratt-SILS, in partnership with the Brooklyn Museum, was awarded a 3-year IMLS grant of $946,325, to support internships for 30 students for careers in Museum Libraries and Archives in the Digital Age. **>** *Leadership*

Some Must-Haves for Future Museum Professionals
go.nmc.org/innogen
(Dave Barr, *Inno/Genesis*, 24 August 2014.) A professor of Culture and Heritage Site Management (CHSM, a post-graduate certificate program) at Centennial College in Toronto, Canada describes the importance of a commitment to digital literacy underlying his teaching because cultural and heritage organizations must communicate, and need to be fluent in most effective contemporary applications to do so. **>** *Leadership*

The Real Reason Some Nonprofits Stink at Digital (And Why It Is Getting Worse)
go.nmc.org/realrea
(Colleen Dilenschneider, *Know Your Own Bone*, 2 July 2014.) This article argues that we are breeding a culture of misunderstanding around the important role of digital in the future of organizations because digital skills cannot be confined to only skill sets of specific employees. The term digital refers to the ways of our current world and the people in it, therefore it must be an aspect of every conversation in order for a museum to effectively serve museum-goers. **>** *Practice*

Balancing Our Connected and Unconnected Lives

Difficult Challenge: Those that we understand but for which solutions are elusive

With the abundance of new media content, technologies, and emerging participatory options combined with a long tradition of reflective atmosphere, museums are in a position to lead the way in forging a middle ground between connected and unconnected worlds. With technology now at the center of many daily activities, museum strategies have been adapted to meet visitors where they are — on the Internet by way of their mobile devices. Yet there is the growing concern that museums should maintain an ambiance that lends itself to deep contemplation and reflection on cultural works. Ongoing studies continue to highlight the distractive effects of technology on the human cognitive function; a recent psychological study proved the existence of the "photo-taking impairment effect" among test subjects who remembered objects in less detail because they had captured images of them.[148] As a result, museum leaders are struggling with how to thoughtfully integrate technology to enhance the visitor experience, while allocating time and space for analog activities and reflection. As museum programs continue to align with technology trends, museum educators are challenged to design interpretive experiences that encourage visitors to have profound interactions with collection objects, while making the most out of digital tools.

Overview

Museums are adapting to a sea change in digital and interpretive strategy among cultural heritage institutions. Technology is now a focal point of budgetary considerations, and museum leaders are considering long-term plans that expand technological infrastructure and digital tools to meet visitors where they are, particularly through their smartphones. Yet, amidst this institutional transformation, more museum leaders are calling attention to the importance of the thoughtful and integrated use of technology for interpretation. Today's visitor is reliant on their personal device for information and productivity. Yet, according to the 2014 IPSOS report, people across the world have reached a turning point in how they view their constantly connected lifestyle; in the past five to seven years, IPSOS researchers have revealed that an increasing number of people are concerned about the negative consequences of lives lived online.[149] While museum educators have recently become attuned to the struggle for balance

between connected and unconnected lives, the details of this challenge are newly articulated, and its solutions are still nebulous.

The crux of this challenge is that museums are pressured to embrace modern lifestyles, complete with the always-on smartphone and camera; yet there is pushback to maintain spaces and time for deep contemplation and reflection, activities that need no digital plug-in. This conflicts with the trend toward digital strategies; museums are investing in technologies and infrastructure to make galleries more inviting, as well as providing interactive content to accompany each collection. These investments may pay off in increased visitor engagement and retention, but if not adequately balanced, operational priorities, such as staff development and training, may become neglected. In the same vein, museum educators have pointed out that any technology detracts from the human-centered elements that have traditionally been the basis of museum education.[150] As discussions around this topic become more refined, the key theme has become less about favoring one side of the dichotomy over the other, and more about understanding today's audience and how their behaviors have evolved because of technology.

This issue has gained attention since The National Gallery enabled Wi-Fi for its patrons with the intention of engaging them through social media and the web. *The Independent* recounted the debate among leaders in the field about the new development. On the one hand, art historians argued that museums are responsible for making themselves accessible and accepting to all; on the other hand, there is fear that being able to photograph an artwork diminishes the experience of looking at a collection object uninterrupted. The overarching sentiment, however, was that embracing smart devices in The National Gallery has made it possible for the museum to expand its reach through openly shared images, which stimulates cultural interest and encourages people to visit in order to see the objects in-person; that is, technology has not undermined, but changed the way people engage with cultural works, and it is the museum's task to hone their strategies for education accordingly.[151]

Implications for Policy, Leadership, or Practice

A number of museums have addressed this challenge

through institutional policies that enforce photography bans — an increasingly less common practice, especially among world-renowned institutions such as the Louvre and the Metropolitan Museum of Art, which permit smartphone photography.[152] Instead, the museum community is channeling their efforts in the preliminary stages of policy-making, which require extensive research of the use of digital tools to justify their use in museums for operation and interpretation. A 2014 study in the *Journal of Audience and Reception Studies* investigated how mobile sensing, BYOD, and big data analytics are being applied in various museums to create an integrated approach to understanding visitor behaviors and needs.[153] Similarly, leading museum strategists have proposed mindful approaches to using technology in museums; among their key considerations is the need to integrate technology, create a real social space, support social behavior, and personalize the experience.[154]

Examining the impact of digital tools is critical to establishing the balance between connected and unconnected experiences. This is the goal of a long-term research collaboration, Culture24, an organization that is actively helping museums evaluate their digital strategies. Launched in 2010, the initial phase of Culture24 focused on designing standards of measurement and evaluation to determine the success of online programs, with an emphasis on social media analytics.[155] Phase 2 of the project engaged 22 cultural organizations including the Tate, the British Museum, and the National Museums of Scotland in an effort to uncover what digital engagement means and looks like.[156] The third phase of the project was aimed toward helping collaborators understand how to design content purposefully, for presentation and promotion.[157] Currently, the Culture24 action research project is in Phase 4, which is focused on examining the audience, their needs, and behaviors in order to shift the model away from a broadcast model of content delivery, to help visitors engage more holistically with cultural content.[158]

In practice, striking a balance between a connected and unconnected museum experience is happening through projects that educate visitors about mindful observation and other analog methods of viewing art. At the El Segundo Museum of Art in California, a meditation educator collaborated with the museum to organize a workshop called "Art in the Heart: The Heart-Mind Connection in Viewing Art." The participants — museum educators, docents, and artists — were instructed in walking meditation and other holistic practices for viewing cultural objects.[159] Currently, the Frye Art Museum in Washington works with a partner organization, the Swedish Medical Center Rehab Services, to offer weekly classes in Mindfulness Meditation. Led by physical therapists, the free program is intended to help visitors apply present-moment awareness and hone a calm focus as they explore the gallery and take in the artworks.[160]

For Further Reading

The following resources are recommended for those who wish to learn more about balancing our connected and unconnected lives:

U.S. Holocaust Memorial Museum Adopts New Rules to Attract Digital Generation

go.nmc.org/holo

(Menachem Wecker, *The Washington Post*, 3 October 2014.) The U.S. Holocaust Memorial Museum is seeking to find a balance of visitor engagement while still preserving the meditative aura in their galleries, and has launched a mobile app designed to complement the museum visit, effectively reversing a ban on smartphone use in its permanent collection. But their concern is that in memorials, it is of paramount importance for visitors to be respectful with how and what they share, and the museum understands this will be difficult to monitor.
> *Policy*

Can the Arts Get Smart About the Smartphone?

go.nmc.org/artsmarts

(Steve Johnson, *Chicago Tribune*, 28 March 2014.) This article gives examples of how museums, theaters, and even zoos are embracing a culture of ubiquitous smartphones while still seeking to preserve face-to-face engagement with the arts. Chicago's Spektral Quartet recently led a project inviting composers to craft original ringtones, text alerts, or alarms for a string chamber group that are available to the public. **>** *Leadership*

Designing For the Space Between Devices

go.nmc.org/desfor

(Josh Clark, *Invision App Blog*, accessed 23 February 2015.) This blog argues that by creating more natural user interfaces including using the aid of sensors, our digital interactions will move off screens and into the natural environment. We will be equally aware of our physical and digital connections, and our devices will not lead to the same isolation as the current scenario in which we each navigate the physical environment heads-down when using our personal devices. **>** *Leadership*

Pick Up Your Smartphone Less Often. You Might Think Better.

go.nmc.org/might

(Serri Graslie, *WNYC*, 9 February 2015.) Research suggests that our brains need downtime and reflexively checking our phones takes away from that. Letting the mind wander stimulates creativity which is also an important aspect of a museum visit. Museums should be careful that the mobile apps and methods of encouraging device use in their institutions do not take away from serendipitous discovery and creative thought processes.
> *Practice*

Measuring the Impact of New Technologies
Difficult Challenge: Those that we understand but for which solutions are elusive

Museums are increasingly leveraging emerging technologies such as mobile apps, social media, natural user interfaces, and augmented reality to add interactive elements to their exhibits and collections.[161] With the growing emphasis on the digital realm, some thought leaders fear that use of these tools is superseding the development of sufficient technology evaluation frameworks.[162] While many museums are astute at assessing their traditional programs,[163] they have yet to cultivate standard protocol for measuring the success of the technologies they deploy. Exacerbating this challenge is the notion that evaluation should occur both before and after technologies are implemented; staff must have a thorough understanding of how the tools correspond with the museum's mission and goals prior to being embraced at scale. Unfortunately, there are not always concrete precedents for the use of new technologies in the cultural heritage sector, and museums that are early adopters often gamble when trying them. The hope is that as museums become more adept at measuring the impact of these technologies and share the results with other institutions, the risk factor will be significantly mitigated.

Overview

The use of emerging technology has pervaded nearly every facet of people's lives, making it difficult to pinpoint the precise impact of each device and tool.[164] In a recent Debate.org poll, 60% of respondents believed that the devices they own were improving their lives, while 40% asserted that they were hindering them. The difference between positive and negative associations hinged on how technologies were being used, not the devices themselves.[165] The "how" has become one of the most important considerations for institutions adopting 21st century tools. Learning-focused organizations such as museums are in a unique position because some of the technologies they deploy typically must correlate to an educational outcome; the goal is ultimately for technology to enhance how patrons learn about artworks, objects, history, or culture. The impact of a museum's mobile app, for example, may not be solely reflected in the sheer number of people using it, but also in the quality of their interactions with it. Quality is inherently more difficult — and subjective — to measure than quantity.

Many museums have already turned to social media to bolster interactions with followers and track their engagement. A museum professional and researcher in Denmark presented at the 2014 Museums and the Web conference and reported that incorporating social media activities allows staff to categorize levels of interaction from their followers as either Enthusiast, Connected, Contributor, Interested, or Informational.[166] Additionally, one of the most tangible ways to measure impact is through monetary gains. In the case of the small museum Palazzo Madama in Italy, their digital strategy recently included a crowdfunding endeavor to purchase and house a renowned collection of porcelain. In addition to surpassing their goal and securing 100,000 euros from art and history enthusiasts from all corners of the world, Palazzo Madama used the campaign as a promotional vehicle. Contributors to the campaign are now bonded to the collection, which can deepen the relationship between the institution and their audiences.[167] While the example serves as anecdotal inspiration for other museums, evaluating the success of an isolated project is a short-term effort; stories are important, but so is concrete data. There is still a need for assessment frameworks that address long-term programs and technology use.

According to *The Museum of the Future*, many museums have a narrow concept of value as it relates to profit. They point to the "social, political, emotional, educational, and creative," in addition to how deeply people are participating in a museum's programs and objects, as elements for measuring the value of applied technologies.[168] However, for small museums that do not have the budget or time to design and manage sophisticated tracking systems, monitoring impact may pose an even greater challenge. Especially in the mobile realm, large technology providers are increasingly weaving analytics into their platforms. In late 2014, Google announced that it was making app development software available to museums via Google Cultural Institute to take advantage of mobile features such as 3D maps and video as a way to make virtual visitors feel like they are actually inside a museum.[169] The aim is to enable all museums to foster highly participatory experiences for people that cannot access the physical spaces. Through the Google Developer Console, museums will be able to track the behaviors and engagement details of their virtual patrons from the app, though measuring the emotional experience is still elusive.

Implications for Policy, Leadership, or Practice

This challenge is notably difficult for museums due to a lack of formal policies available to govern the evaluation of technology impact. Museums can, however, look to standards and protocol from relevant fields and adapt them to their environments. IMLS is dedicated to providing cultural heritage institutions with evidence-based knowledge that demonstrates the value of technology innovation. They have curated a list of recommended general guides for program evaluations, templates for building scalable models, project planning tools, and evaluation methods.[170] Ultimately developing effective standards for technology measurement is only taking place at small scale, though individuals are sharing best practices. Researchers at three universities in Greece recently published the paper "Usability Evaluation of Virtual Museum's Interfaces Virtualization Technologies" to analyze the offerings of museums' online features as they relate to user experience and recommend ways to humanize digital interactions.[171]

It is vital for museums to develop evaluation benchmarks before deploying new technologies so they are not trying to retrofit a solution to standards created post-implementation. In the Minneapolis Institute of Arts' "Dynamic New Approach" strategy brief, they outlined their major goals, which included increasing audience engagement and globalizing their efforts. Every technology they adopt must be in service of those objectives and evaluated for their role in achieving them.[172] Leaders in the field are also recognizing that understanding how to use digital tools to measure the broader impact of museum programs is an equally important activity. The University of Pennsylvania's Social Impact of the Arts Project (SIAP) was founded on the mission that cultural, art, and heritage institutions are critical to urban vitality and social wellbeing. SIAP emphasizes the use of linked open data to reveal patterns in positive community responses to museums.[173] In August 2014, they leveraged this data to showcase how the arts influenced the economy, health, and social connections in four U.S. cities.[174]

Some museums see fostering innovation and improved workflows as key indicators of successful practices. In 2014, the Smithsonian's Digitization Program Office leveraged their National Numismatic Collection, housed at their National Museum of American History, to digitize proofs that were used to create paper money in the 19th and early 20th centuries.[175] Virtually capturing the 250,000 proofs — hand-engraved, metal plates — would have normally taken 15 minutes per sheet at a cost of $10 each; the process projected to take several years to complete. In well under a year, a team of 20 Smithsonian staff developed a more cost-effective, rapid capture workflow using a conveyor belt and a custom-designed 80 megapixel imaging system. This technology made available to the public details of the proofs that would have otherwise never been exposed. The Smithsonian considers providing unprecedented access to historic objects a genuine measure of the effectiveness of their new digitization process.

For Further Reading

The following resources are recommended for those who wish to learn more about measuring the impact of new technologies:

Museums See Different Virtues in Virtual Worlds
go.nmc.org/virtues
(Anand Giridharadas, *The New York Times*, 7 August 2014.) This article describes the importance of a plan beforehand that includes benchmarking and measuring progress against articulated goals, before museums experiment in the digital arena with new platforms and apps. **>** *Policy*

Measuring the Value Created by Auckland Museum's Moana - My Ocean Exhibition: A Social Return on Investment (SROI) Analysis
go.nmc.org/auck
(Allpress, JA, Rohani, M, and Meares, C, Auckland Council, 2014.) New Zealand's first museum, Auckland War Memorial Museum, featured an exhibit called "Moana - My Ocean" that explored New Zealand's unique marine environment. This report describes how they used an evaluation methodology of Social Return on Investment (SROI) to understand the benefit-cost ratio of their investment in the exhibit. **>** *Leadership*

What Can We Learn From Watching Groups of Visitors Using Digital Museum Exhibits?
go.nmc.org/canwe
(Andrew Lewis, *V&A Museum*, 25 September 2014.) This post looks at three digitally-mediated museum experiences and how a recent study combined the observation and video-recording of user behavior to provide a detailed look at people's 'natural' behavior. The authors leveraged this study to generate empirically based insights for informing museum exhibition design, visitor research, and evaluation. **>** *Leadership*

Interweaving Social: An Interview With The Cleveland Museum Of Art's Reena Goodwin, Part 1
go.nmc.org/weav
(Kristen Sorek West, AMT Lab, Carnegie Mellon University, 5 November 2014.) Social media allows museums to measure engagement using both qualitative and quantitative metrics for a fuller picture of audience participation. Museums can glean valuable insight from these platforms that allow visitors to freely express their opinions and share which content and experiences they personally relate to within the museum. **>** *Practice*

Maintaining Progress in Technology, Workflows, and Infrastructure

Wicked Challenge: Those that are complex to even define, much less address

Many museums are not yet equipped with the technical infrastructure to realize their vision for digital learning, digitization of assets, and content production. While the value of digital tools for accessibility and interpretation are becoming better understood in the museum world, the vast majority of institutions are not prepared technologically or structurally to pursue these contemporary objectives. Lack of specialized personnel and funding leave little time for articulating, much less realizing a vision that requires long-term planning and a complete reinvention of operational practices. Continual progress for museums hinges on whether institutions can properly address different areas for development including comprehensive digital strategies, standards for content management, digital interpretation and preservation, and staffing. Altogether, the requirements for museums that aim to use effective practices are complex in their diversity and type, and not yet completely grasped by the museum community.

Overview

Today's museums are increasingly concerned with using up-to-date digital systems to manage their assets in ways that guarantee collections and their metadata will be accessible to museum stakeholders, and perhaps more importantly, to future generations. Yet digital asset management (DAM) is a constantly moving target, and it requires a dedicated, skilled professional to maintain. The DAM Learning Center has covered the detriment that underdeveloped data asset management systems cause for museums. In the case of the National Trust for Scotland, a decentralized, fragmented system meant that personnel were spending hours trying to fulfill image requests for clients and colleagues. These inefficiencies made it difficult to focus on projects, collection work, and other advances in infrastructure. The need to employ effective digital collection management is a growing concern for museums seeking sustainable expansion in the modern, technological landscape.[176]

This wicked challenge applies to nearly every department of cultural heritage institutions, and it is complicated by the lack of resources to develop and execute plans that lead to progress. While these difficulties have yet to be explored in comprehensive detail for museums, the library community, a sector with similar priorities and processes, has covered this topic

to some extent. In a recent study published by Illinois State University, researchers from the Milner Library explored the difficulty of implementing a modern digital preservation program at an under-resourced institution, ultimately relating how they managed to take action and advance their mission. The discussion highlighted a long list of challenges, including minimal funds, lack of training, lack of engagement, change fatigue, and getting buy-in from administrators. Among the approaches to resolve these issues, the researchers cite the importance of developing a common language to discuss digital preservation, regional or multi-institutional collaboration, and additional training for department heads that helps them allocate resources effectively.[177]

Crucial to understanding the complexity of this challenge is acknowledging that the ever-changing technological landscape favors long-term strategies, which incorporate flexible approaches to technology integration and a broader perspective about what types of skilled professionals are needed in museums. Yet institutions are often faced with budgetary limitations that hinder their ability to hire and train staff that can lead or contribute to digital initiatives including programmers, designers, and gallery technicians. As a result, more museum experts are emphasizing the importance of diversifying staff and ensuring various disciplines, both digital and curatorial, are represented to establish a strong foundation of in-house knowledge. Formulating budgets to promote progress, however, requires a comprehensive understanding of how these decisions affect museums on an operational level, leading to a change in practice that forgoes short-term, project-based paths in favor of visions that promote sustainable and persistent growth.

Implications for Policy, Leadership, or Practice

Maintaining standards for infrastructure can be bolstered at the national level. The Canadian Heritage Information Network (CHIN) is a government agency that provides a network for museums and other cultural heritage institutions in Canada to connect through digital technologies.[178] The online resource is aimed toward museum professionals and offers collection management resources and expertise for the cultural heritage sector. As part of their assets, CHIN has comprehensive documentation on metadata standards

for art collections of every discipline and type as well as standards for intellectual property rights, education, and digital preservation.[179] The United States Library of Congress is also actively supporting progress in developing standards for contemporary workflows and infrastructure with the *2015 National Agenda for Digital Stewardship*, which was published with the help of experts in the field. Intended to provide insights about technological trends, gaps in capacity, and crucial areas of funding, the annual report covers emerging concerns about infrastructure and makes recommendations for practitioners in digital stewardship.[180]

A number of museums are already making strides toward continual progress through innovative approaches to leadership and professional development. At the Metropolitan Museum of Art, the Chief Digital Officer (CDO) works closely with the CTO and CIO to build strategies around content that is shared with the public. In a recent interview, the CDO at the Met described how technology should establish a cycle in which a memorable experience online compels visitors to see the art in-person, and then the memorable experience onsite compels the visitor to stay in touch.[181] The Digital Library Federation (DLF) provides professional development opportunities for museum professionals focused on the digital humanities through the DLF Cross-Pollinator Fellowship, a stipend that covers travel for museum practitioners who wish to attend the DLF Forum. Devised with the goal of breaking down organizational silos and inviting fresh viewpoints, the fellowship actively seeks museum professionals involved with digital collections and services to bring greater understanding of how cultural heritage institutions operate and accomplish their missions in a networked environment.[182]

Progress is a goal shared by a community of forward-thinking practitioners, and many organizations as well as individuals are leading the way by making their knowledge and experience accessible to all. Started in 2012, the Museum Digital Publishing Bliki has provided a platform for museum experts to discuss topics such as digital strategy, digitization, and workflow, in an open, collaborative blogging space.[183] The online publication has engaged many leaders in the museum community and experts in digital services to relate their experiences implementing contemporary strategies that leverage emerging technologies. At the Guggenheim, museum leaders are making progress in their digital practices through the establishment of a public-facing three-tiered plan for managing electronic records.[184] Funded by the National Historic Publications and Records Commission, the 18-month project is working toward preserving the history of the Guggenheim for future generations and making sure that future archive submissions will be exclusively electronic.[185]

For Further Reading

The following resources are recommended for those who wish to learn more about maintaining progress in technology, workflows, and infrastructure:

Convincing Employees to Use New Technology
go.nmc.org/conv
(Didier Bonnet, *Harvard Business Review*, 9 September 2014.) Organizations tend to focus on deployment of new platforms and technologies rather than adoption, which can lead to the spreading of cynicism if any employees are unable to voice their qualms or do not feel on-board with new plans. Doing fewer things better, planning and budgeting for adoption from the start, leading by example, engaging true believers, and aligning rewards and recognition can help organizations embed adaptivity into their processes, workflows, and culture. **>** *Policy*

Creating A Digital Infrastructure for Science
go.nmc.org/datainfra
(Natural History Museum, accessed 18 February 2015.) The Natural History Museum is working with Museum colleagues, other academics, and industrial partners to build a data infrastructure so it can share its vast collection and research data freely online. Informatics is key to providing the framework to store, manage and share their data, which can in turn have great cultural impact by providing support for government objectives in developing successful habitat protection policies. **>** *Policy*

Digital Myth
go.nmc.org/digmyth
(Mia Ridge, Museums Association, 17 January 2014.) A recent report by independent research agency MTM for the the Arts Council England, the Arts and Humanities Research Council, and Nesta held that museums are less likely than the rest of the sector to report positive impacts from digital technologies, particularly in terms of revenue generation and audience development. With that finding in mind, this article stresses how senior management in museums must better understand the impact of digital technologies to build in space for experimentation within the museum's infrastructure. **>** *Leadership*

National Museum of Wales Tackles Digital Technology
http://go.nmc.org/wales
(Caroline Baldwin, *Computer Weekly*, 17 October 2014.) This article describes the challenges the National Museum of Wales faces mid-way through a three-year strategy of digitizing and embedding digital thinking across its seven campuses. So far, 1.4 million of 4 million objects have been electronically documented and efforts to tidy up legacy data systems, install Wi-Fi and test beacon technology are in progress. **>** *Practice*

Privacy Concerns

Wicked Challenge: Those that are complex to even define, much less address

As individuals allow companies and museums to track their transactions and visitor behavior in exchange for convenience and discount or free services, the security of data privacy is an increasing concern. A recent Accenture survey revealed that although 80% of consumers aged 20-40 in the United States and United Kingdom believe total privacy in the digital world is no longer possible, 87% believe that adequate safeguards are not in place to protect their privacy. The survey also highlighted consumer concern about the transparency around how their information is being stored and used.[186] Recent security breaches at Home Depot[187] and Sony Pictures Entertainment[188] help to underscore the vulnerability of personal information. Privacy policies in the museum sector are continually being refined, but they are hardly keeping pace with the rapid acceleration of new data-centered technologies, creativity of cybercriminals, and changing expectations of privacy.

Overview

As the collection of data for consumer insights increases, so does the risk for data breaches. Forty-three percent of a Ponemon Institute survey's respondents state their companies had a data breach involving the loss or theft of over 1,000 records in 2014 — an increase of 10% from the previous year. Alarmingly, 60% of respondents said they experienced more than one breach. Even though 26% of respondents said their company had a data breach or cyber insurance policy, this is woefully inadequate.[189] A Trustwave Global Security report found the US was especially attractive to cyber criminals because of the country's consumer-driven economy. While 59% of global security breaches occurred in the United States, they are not alone.[190] Findings from a Central European University's Center for Media, Data, and Society report show that the personal data of millions of Europeans have been compromised, and that 89% of the data breaches were the fault of corporations.[191]

Museums are struggling to develop plans to guarantee the privacy of newly acquired data. They emphasize opting-in for museum programs that accumulate their data, encrypt credit card numbers, and unlink payment details from their guest profiles in their databases.[192] Despite these assurances, museums are just as vulnerable as other companies. Cyber criminals attacked the Ashmolean Museum, a university museum on the Oxford campus, in the summer of 2014. An unidentified hacker

broke into their website and stole the names, addresses, email addresses, telephone numbers, and time and date of visits of nearly 8,000 guests. While the museum apologized, they downplayed the attack by reporting that no financial details were taken and explained that the largest risk came in the form of unsolicited marketing communication through various channels.[193]

Compounding this wicked challenge are the continuously shifting expectations of privacy in light of technological advancements. Citizenship and social life are rapidly blurring the lines between public and private life. In order to exist online, individuals post status updates and share photos in open, public spaces to enrich friendships and find and grow communities. Personal data is also the currency of the knowledge economy – it is the key focus of many business models.[194] Furthermore, there are also contradictory messages coming from individuals; when being surveyed, museum visitors say they want more privacy, yet when they are asked to opt-in, they are willing.[195] Solutions may come from the way teenagers and millennials, who have spent all or most of their lives online, increasingly adopt tools that help protect their privacy and personal information. New methods of communication such as Snapchat and Cyber Dust highlight a new wave of communication that blends the best of public and private communication while leaving a light digital footprint.[196] The Los Angeles County Museum of Art, Blanton Museum of Art, Georgia Museum of Art, and San Francisco Museum of Modern Art are just a few of the museums experimenting in the Snapchat space.[197]

Implications for Policy, Leadership, or Practice

Federal policy regarding privacy is continuously evolving and is often needed to respond to new types of threats and attacks. In light of the security breaches that plagued the US in 2014, President Obama unveiled legislation that will help protect consumers and students against cyber attacks. His plan would require companies to notify customers within 30 days after personal information is compromised and provide federal enforcement of cybercrimes.[198] The United Nations is also developing a draft resolution for privacy protection led by Brazil and Germany, titled "Right to Privacy in the Digital Age."[199] At the institutional level, privacy policies are ubiquitous. A quick scan of any museum's website will show their policy statements,

which typically include language about opting in to communications, information that is tracked, use of web beacons, and cookies — as is seen on the Heard Museum's website, for example.[200]

While formal privacy policies take shape across governments, leaders in the field are developing best practices that can protect privacy at the institutional level. Mozilla recently reviewed and updated their data privacy principles, which guides how they build their products and services, manage user data, and select and interact with partners, providing a valuable baseline for museums. Their five Data Privacy Principles are "no surprises, user control, limited data, sensible settings, and defense in depth."[201] Conferences and presentations are also ways for museums to further data privacy conversations. The Exploratorium is facilitating a conversation at the Museums and the Web 2015 conference about how museums can learn about current online privacy issues. Topics will include privacy within museum web and app publishing; US federal, US state, and EU privacy regulations; and, ways to evaluate a vendor's tracking and reporting technologies.[202]

Exhibitions and interpretation tools that use digital footprints as their source are adding increasing complexity to the privacy debate in museums. At the Jewish Museum, an artist mined information from a variety of online sources including dating sites for an exhibition titled "Composed: Identity, Politics, and Sex" which caused some backlash from visitors because of privacy concerns. The museum received complaints from patrons claiming the artist had taken their photographs from a dating site and exhibited their portraits publicly as part of the exhibition.[203] The recent emergence of visitor tracking technologies is causing museums to be more transparent about their surveillance. Currently in use in several museums, location-based services such as iBeacons are the most recent source of concern. Museums and vendors are being more upfront about how this technology is and is not being used. They need to make it explicit that it is not about tracking a user's location and activity, but providing a better overall experience.[204]

For Further Reading
The following resources are recommended for those who wish to learn more about privacy concerns:

Big Data: Seizing Opportunities, Preserving Values
go.nmc.org/values
(Whitehouse, February 2015.) The big data and privacy working group has created a report identifying specific policy recommendations as deserving prompt action in a world where data collecting is nearly ubiquitous. These include advancing the Consumer Privacy Bill of Rights and passing national data breach legislation.
> *Policy*

If There's Privacy In The Digital Age, It Has A New Definition
go.nmc.org/iftheres
(Steve Henn *NPR*, 3 March 2014.) This article explains how expectations for privacy must be redefined because we will never be able to totally disappear, but putting the right rules and technologies in place can help keep personal data under control. **>** *Policy*

Making Your Privacy Policy Public
go.nmc.org/privpub
(Kamala D. Harris, Attorney General, California Department of Justice, May 2014.) This document created by the California Department of Justice offers recommendations for making a general privacy policy statement more effective and meaningful than a policy that simply meets minimum legal requirements. Privacy policies are an opportunity for organizations to build their brands and to develop goodwill and trust through transparency. **>** *Policy*

Obama Proposes Legislation on Data Breaches, Student Privacy
go.nmc.org/breach
(Katie Zezima, *The Washington Post*, 12 January 2015.) In a speech at the Federal Trade Commission President Obama unveiled legislation that would require companies to notify customers within 30 days after the theft of personal information is discovered. **>** *Leadership*

How Safe is Your Quantified Self?
go.nmc.org/howsafe
(Mario Ballano Barcena, Candid Wueest, Hon Lau, Symantic, 11 August 2014.) As wearable devices and the quantified-self movement takes off, companies like Symantec warn that it found security risks in a large number of self-tracking devices and applications. One of the most significant findings was that all of the wearable activity-tracking devices examined, including those from leading brands, are vulnerable to location tracking. **>** *Practice*

What One Man's Cat-Tracking Map Can Tell Us About Privacy Settings
go.nmc.org/cat
(Audra Schroeder, *The Daily Dot*, 21 July 2014.) An associate professor of art at Florida State University created a data visualization project called "I Know Where Your Cat Lives" that maps a sample of 1 million public cat photos from sites like Flickr and Instagram. He wrote the software to access public APIs data and hopes the project will contribute to dialogue on data use, sharing, and privacy. **>** *Practice*

Important Developments in Technology for Museum Education and Interpretation

Each of the six developments in technology detailed in this section were selected by the project's expert panel using the NMC Horizon Project's Delphi-based process of iterative rounds of study, discussion, and voting. In the NMC Horizon Project, educational technology is defined in a broad sense as tools and resources that are used to improve teaching, learning, and creative inquiry. While many of the technologies considered were not developed for the sole purpose of education and interpretation, they have clear applications in the field.

The technologies, which the members of the expert panel agreed are very likely to drive technology planning and decision-making over the next five years, are sorted into three time-related categories — near-term technologies that are expected to achieve widespread adoption in one year or less; mid-term technologies that will take two to three years; and far-term technologies, which are forecasted to enter the mainstream of museum education and interpretation within four to five years. Each technology topic opens with an overview of the topic.

The initial list of topics considered by the expert panel was arranged into categories that were based on the primary origin and use of the technology. The potential applications of the technologies featured, specifically in the context of global museums, were considered in a series of online discussions that can be viewed at museum.wiki.nmc.org/Horizon+Topics.

The expert panel was provided with an extensive set of background materials when the project began that identified and documented a range of existing technologies used in both education and beyond. The panel was also encouraged to consider important developments in technology whose applications for museums may still be distant. A key criterion for the inclusion of a new technology in this edition was its potential relevance to education and interpretation in museums.

In the first round of voting, the expert group reduced the master set, shown above, to 12 developments in technology that were then researched in much greater depth by the NMC staff. Technologies that do not make the final report are often thoroughly discussed on the project wiki at museum.wiki.nmc.org. Sometimes a candidate technology does not get voted in because the expert panel believes it is already in widespread use in museums, or, in other cases, they believe the technology is more than five years away from widespread adoption. Some technologies, while intriguing, do not have enough credible project examples to substantiate them.

There are currently seven categories of technologies, tools, and strategies for their use that the NMC monitors continuously. These are not a closed set, but rather are intended to provide a way to illustrate and organize emerging technologies into pathways of development that are or may be relevant to education and interpretation. The list of seven categories has proven fairly consistent, but new technologies are added within these categories in almost every research cycle; others are merged or updated. Collectively, the categories serve as lenses for thinking about innovation; each is defined below.

> **Consumer technologies** are tools created for recreational and professional purposes and were not designed, at least initially, for educational use — though they may serve well as learning aids and be quite adaptable for use in museums. These technologies find their ways into institutions because people are using them at home or in other settings.

> **Digital strategies** are not so much technologies as they are ways of using devices and software to enrich education and interpretation, whether inside or outside of the museum. Effective digital strategies can be used in both formal and informal learning; what makes them interesting is that they transcend conventional ideas to create something that feels new, meaningful, and 21st century.

> **Enabling technologies** are those technologies that have the potential to transform what we expect of our devices and tools. The link to learning in this category is less easy to make, but this group of technologies is where substantive technological innovation begins to be visible. Enabling technologies expand the reach of our tools, make them more capable and useful, and often easier to use as well.

> **Internet technologies** include techniques and essential infrastructure that help to make the

technologies underlying how we interact with the network more transparent, less obtrusive, and easier to use.

> **Learning technologies** include both tools and resources developed expressly for the education sector, as well as pathways of development that may include tools adapted from other purposes that are matched with strategies to make them useful for learning. These include technologies that are changing the landscape of education and interpretation, whether formal or informal, by making it more accessible and personalized.

> **Social media technologies** could have been subsumed under the consumer technology category, but they have become so ever-present and so widely used in every part of society that they have been elevated to their own category. As well established as social media is, it continues to evolve at a rapid pace, with new ideas, tools, and developments coming online constantly.

> **Visualization technologies** run the gamut from simple infographics to complex forms of visual data analysis. What they have in common is that they tap the brain's inherent ability to rapidly process visual information, identify patterns, and sense order in complex situations. These technologies are a growing cluster of tools and processes for mining large data sets, exploring dynamic processes, and generally making the complex simple.

The following pages provide a discussion of the six technologies highlighted by the 2015 Museum Expert Panel, who agree that they have the potential to foster real changes in museums, particularly in the development of education and interpretation. As such, each section includes an overview of the technology; a discussion of its relevance to education and interpretation; and curated project examples and recommendations for further reading.

Consumer Technologies
3D Video
Drones
Electronic Publishing
Mobile Apps
Quantified Self
Robotics
Tablet Computing
Telepresence
Wearable Technology

Digital Strategies
Bring Your Own Device
   (BYOD)
Flipped Classroom
Games and Gamification
Location Intelligence
Makerspaces
Preservation/Conservation
   Technologies

Enabling Technologies
Affective Computing
Cellular Networks
Electrovibration
Flexible Displays
Geolocation
Location-Based Services
Machine Learning
Mesh Networks
Mobile Broadband
Natural User Interfaces
Near Field Communication
Next-Generation Batteries
Open Hardware
Speech-to-Speech
   Translation
Statistical Machine
   Translation
Virtual Assistants
Wireless Power

Internet Technologies
Cloud Computing
The Internet of Things
Real-Time Translation
Semantic Applications
Single Sign-On
Syndication Tools

Learning Technologies
Badges/Microcredit
Learning Analytics
Massive Open Online Courses
Mobile Learning
Online Learning
Open Content
Open Licensing
Virtual and Remote
   Laboratories

Social Media Technologies
Collaborative Environments
Collective Intelligence
Crowdfunding
Crowdsourcing
Digital Identity
Social Networks
Tacit Intelligence

Visualization Technologies
3D Printing/Rapid
   Prototyping
Augmented Reality
Computer Vision
Information Visualization
Visual Data Analysis
Volumetric and Holographic
   Displays

Bring Your Own Device (BYOD)
Time-to-Adoption Horizon: One Year or Less

BYOD, also referred to as BYOT (Bring Your Own Technology), refers to the practice of people bringing their own laptops, tablets, smartphones, or other mobile devices with them to be productive in learning institutions or at work. Intel coined the term in 2010, when the company observed that an increasing number of its employees were using their own devices and connecting them to the corporate network. Since implementing a BYOD policy, the company has reported up to 5 million hours of annual productivity gains, a compelling statistic for other organizations weighing the benefits of BYOD.[205] In museums, the trend toward BYOD is happening two-fold: on one hand, museums are adapting to a patronage that carry mobile networked devices everywhere, and, on the other hand, museum employees are using their personal laptops and smartphones to conduct business and complete tasks at their institution. In essence, museums are leveraging BYOD policies to meet visitors where they are most comfortable; personal smartphones have become the entry point for delivering museum-based services and interactive, educational programs of all kinds.

Overview
Mobile devices have become the gateways to personal working and learning environments because they afford a level of ease that allows for exploration and productivity to happen anywhere, at anytime. In a BYOD work environment, staff are no longer tethered to a desk nor confined to a physical space in order to carry out their tasks. Gartner predicts that by 2018, there will be twice as many employee-owned devices used for work than company-owned devices. Their findings suggest a global shift in the way IT infrastructure is being developed in every industry, citing BYOD as the best alternative to limit costs and expand access.[206] Cultural heritage institutions that are aligning themselves with this shift are investing in next generation wireless networks to accommodate increased online activity and address the emerging connection between mobility and enhanced visitor experience. In the museum workplace, as in other sectors, the transition to BYOD continues to gain traction because it reflects a contemporary lifestyle and way of working.

The convenience of BYOD for museum staff has also prompted a shift in how the visitor experience is conceived. While traditionally, museums have provided patrons with devices to accompany audio tours, they are now encouraging visitors to use their personal smartphones and tablets on site. Many museum administrators are seeing the potential of BYOD to save money purchasing, insuring, and maintaining devices for loaning to visitors, thus allowing the redirection of resources to support IT infrastructure that will foster long-term growth.[207] Moreover, BYOD has users navigating the museum's digital resources on a device they are comfortable with, saving time and efforts once reserved for device orientation. Museum educators, however, are noticing that there are still many patrons that lack devices, especially children. As a result, a hybrid approach to BYOD, termed CYOD (Choose Your Own Device), has been recognized as a way to design technology-based programs that are inclusive and prevent alienation among visitors.[208]

One element embedded into BYOD policies for museums is that visitors are permitted to carry in their cameras, a now ubiquitous feature in smartphones. This has been a point of contention for many cultural heritage institutions that are managing the delicate balance between leveraging the freedoms BYOD policies offer while protecting museum ambiance. The Van Gogh Museum, for example, reinstated its ban on personal photography in January 2014 after eight months of it being permitted. The museum changed its policy due to the stress that it caused between patrons wishing to see the artworks and those struggling to get a clear shot of the artworks in a space that is constantly crowded.[209] On the other hand, there are a fair amount of famous institutions including the Louvre, the Tate, New York's Metropolitan Museum of Art, and the Vatican museums that allow the use of smartphones for personal photography.[210]

Relevance for Museum Education and Interpretation
The proliferation of mobile devices, coupled with the growing focus on mobility, has had a tremendous effect on museums' technology strategies, which are driving investments in large scale, high-capacity networks. The Fernbank Museum of Natural History in Atlanta, Georgia, recently partnered with AT&T and Cisco Networks to build out a next generation network that supports their native mobile app, which incorporates location-based services, browser-based services, and real-time location analytics. Essentially, the app offers visitors a

chance to interact with museum-focused content on their personal devices, and the increase in access points ensures that they will always be connected.[211] A similar strategy has been implemented at the Rijksmuseum, the national museum of the Netherlands. Closed for ten years for renovation, the museum opened up in 2013 with state-of-the-art wireless and wired networks that support more than the 10,000 to 15,000 visitors it receives each day. The improved network has also streamlined IT activities, making it easier for staff to on-board guests through profile-based policies.[212]

More museums are seeing the value of enabling visitors to capture and share their experience of art with their personal devices for educational purposes, and for promoting the institution to a broader audience through social media. The Crystal Bridges Museum of American Art in Arkansas spearheads a comprehensive BYOD policy that encourages users to take pictures in designated areas and share via their unique hash tag on social media, among other directives.[213] As part of Seattle Museum Month, 56 cultural institutions participated in a digital campaign based on STQRY, a mobile storytelling app that allows users to explore, favorite, and share exhibitions with other users, in one place that every institution shares.[214] Some museums have begun to engage users through their personal devices beyond institutional walls. "#captureParklandia" was a recent large-scale social media initiative from the Portland Art Museum that used Instagram, a geolocated map on the museum's website, and a web-based photo stream to organize people in conversations around Portland's parks.[215]

Permitting personal smart devices in the museum space has unleashed vast opportunity when it comes to collecting data that institutions use to integrate personalized learning experiences. Emerging way-finding technologies are allowing institutions such as the Los Angeles County Museum of Art and the Guggenheim to track footfalls and to get a more precise sense of which pieces garner the most attention.[216] The Estimote Beacon, for example, is a wireless, energy efficient Bluetooth transmitter that connects to users via their smartphones within the museum.[217] App developers for museums are synching apps with these new technologies in order to push targeted information to visitors according to their location and to leverage big data about visitor behavior that can aid with exhibition planning or the development of mobile-based reward programs.[218] As a result, the BYOD-enabled experience has become a seamless extension of a user's cultural journey that they engage with on their own terms, on their own device. This personalization of content and services made possible by emerging technologies empowers museums to meet visitors where they are, and make their trip to the museum more memorable.

Bring Your Own Device in Practice
The following links provide examples of BYOD in use that have direct implications for museums:

Special Exhibit in Wilmington Offers Italian Art as Seen Through Apps
go.nmc.org/ital
Melissa DiPento, *Technical.ly*, 9 October 2014.) Paolo Russo has created an exhibit titled "Treasures and Tales of Italy's Art Recovery Team: Antiquities from the Guardia di Finanza," that showcases priceless stolen Etruscan and Greco-Roman art, artifacts, and antiques from Italy. He has set up the exhibit at the University Museums of the University of Delaware using a 'bring your own story' concept that leverages the Aurasma app, inviting visitors to add their own stories to the collection of ideas associated with ancient artifacts using their personal phones and devices. **>** *Leadership*

Science Museum Launches App for Visitors with Disabilities
go.nmc.org/ncm
The N.C. Museum of Natural Sciences in Raleigh has launched an app that offers multiple benefits to visitors. An important feature is that it provides visitors with visual impairments a way to mentally map the museum and exhibits so they can decide what they want to spend their time doing. **>** *Practice*

For Further Reading
The following articles and resources are recommended for those who wish to learn more about Bring Your Own Device:

What's It Like for Museum Visitors to Connect to Wi-Fi on a Mobile Phone?
go.nmc.org/splash
(Andrew Lewis, Victoria and Albert Museum, 6 May 2014.) The Victoria and Albert Museum is looking into how to improve the user experience for visitors who connect to museum Wi-Fi with their personal devices. The museum recently pulled together a review on Wi-Fi splash screens through a Twitter call that received over thirty responses from museum professionals around the world who submitted examples from their own institutions. **>** *Policy*

Bring it on: Ensuring the Success of BYOD Programming in the Museum Environment
go.nmc.org/bringit
(Scott Sayre, Museums and the Web 2015, 31 January 2015.) This paper provides an overview of preliminary research findings and practices being developed around visitor-focused BYOD at the Corning Museum of Glass (CMoG). Based on Stanford University's design thinking, used to envision and hone the BYOD visitor experience, the museum has found and describes eight related variables that could significantly impact overall success of a BYOD program. **>** *Leadership*

Games and Gamification
Time-to-Adoption Horizon: One Year or Less

he culture around digital games is growing to encompass a substantial proportion of the world's population, with the age of the average gamer increasing every year. The gaming industry is producing a steady stream of games that continue to expand in their nature and impact — they can be artistic, social, and collaborative, with online gaming allowing for massive numbers of people from all over the world to participate simultaneously. The American Psychological Association has highlighted the cognitive, motivational, emotional, and social impact video games have on human behavior, and a significant body of research underlies the overwhelming potential of games to teach new forms of thought and behavior.[219] Gamification — the integration of gaming elements, mechanics, and frameworks into non-game situations and scenarios for training and motivational purposes — has added another facet to discussions surrounding the potential of games to transform teaching and learning. The gamification of learning environments is also helping museum exhibitions and programs resonate with the next generation of museum-goers.[220]

Overview

Games are the most popular category of mobile apps on the market[221] and museums across the world have created interactive mobile apps that appeal to this rising interest in gameplay.[222] Gamification is a related approach that is also gaining momentum as institutions integrate game-like elements and mechanics, including quests, experience points, leader boards, milestones, and badging into non-game environments. The Accenture report, "Why Gamification is Serious Business" highlighted the impact gamification will inevitably have as Generation Y, a demographic that is enthusiastic about online and social gaming, comes of age to become the museum patron of the future. Southeast Asia, in particular, has been identified as a region of the world that is especially promising for the impact of gamification because of online gaming trends and high rates of smartphone penetration.[223] Indeed, research on mobile gaming in museums has revealed that museum visitors feel that mobile games would enhance their learning experiences without being a distraction.[224]

Gamification has been an integral part of the consumer experience for some time now; companies have incentivized their loyal customer base for decades with

frequent flyer-style programs and other cumulative reward systems. For years the mobile app Foursquare has brought gamification into the realm of social media, rewarding users with points, titles, and even tangible bonuses including coupons and discounts.[225] Indeed, as previously mentioned in this report, the Dallas Museum of Art has set the precedent by leveraging similar gamification techniques to distribute museum rewards as incentives for participation in programming and exhibitions.[226] As the correlation between gamification and increased engagement with museum programming grows stronger, more museums are seizing the potential for game mechanics to transform cultural interactions into a rewarding, fun, and memorable experience.

Museum leaders are articulating the most effective ways to create and integrate games and game-based learning. The nuances between extrinsic and intrinsic gameplay was the focus of a recent presentation at the Museums and the Web conference. Extrinsic gameplay establishes game rules that operate independently from the museum's content, and intrinsic gameplay requires players to understand both content and gameplay in order to succeed. The session's presenter focused on several gaming examples and argued that museums need to learn the benefits and risks of each approach depending on the learning outcomes they hope to achieve.[227] Likewise, a preliminary study of the Australia National Maritime Museum's game, "The Voyage," based on the nineteenth century convict experience, revealed promising results for increased engagement and has stimulated a two-year Australian Research Council Linkage project for effective integration of gaming into museums.[228]

Relevance for Museum Education and Interpretation

Games that have gained mainstream popularity outside of museums are often viewed in a new light when they are placed in an educational context. The best selling Massively Multiplayer Online (MMO) game, "Minecraft," is a good example; it is an all-ages game in which there are no prescribed goals, and players are free to explore a seemingly infinite virtual space and construct or deconstruct their surroundings with blocks of various materials.[229] With thousands of gamers playing in their free time, and learning math and design skills along the way, leadership at the British Museum has taken note of "Minecraft's" potential for museum education. In late

2014 the museum posted a call for volunteers to build the museum virtually using "Minecraft" and received 1,000 applications in one day.[230]

Museums are increasingly working with consultants and companies from the gaming industry to develop custom interpretive materials that leverage the power and flexibility of mobile gaming. "Murder at the Met," a collaboration between the Metropolitan Museum of Art's multimedia team, Green Door Labs, and Toursphere, was one of the first museum mobile gaming projects to gain widespread attention.[231] The mobile app encourages visitors to explore galleries and search for clues in the fictional death of Madame X. Museums are also using tools such as the web-based game development software Edventure Builder to create their own customized mobile games, such as scavenger hunts at the Smithsonian American Museum of Art.[232]

Museum games can create digital experiences that focus on objects without the fear of damage from handling. With this in mind, in-house programs for families, adults, and teens that focus on game creation based on objects from museums' collections are flourishing. At the Brooklyn Museum of Art, teens utilized the TaleBlazer game-design app to collaborate on a mobile game that invites visitors to explore their Luce Visible Storage Center, home to 2,000 objects.[233] Game jams that challenge patrons to create digital games are also growing in popularity in museums around the world.[234] The Victoria and Albert Museum recently undertook a Games Designer in Residence program to carry out the museum's gaming initiatives, such as game jams.[235] Likewise, at the Getty Center, 24 students from the University of Southern California recently participated in the GettyJam to create games that encourage closer looking at the collection objects in their galleries. The teams created 12 museum games ranging from narrative story form to those that were more experiential.[236]

Games and Gamification in Practice
The following links provide examples of games and gamification in use that have direct implications for museums:

An In-gallery Adventure Game of Resemblance
go.nmc.org/ingall
(National Museum Australia, accessed 9 March 2015.) The Museum Game app at National Museum Australia challenges players to work as a team while they photograph, think critically about, and make connections between museum objects as they explore and later reflect on their experiences. **> *Leadership***

Mike Horn Designs Frog Pond Exhibit for Computer History Museum
go.nmc.org/frogpond
(Marilyn Sherman, Northwestern University, 13

November 2014.) An exhibit at the Computer History Museum in Mountain View, California, called "Frog Pond" is a multi-touch tabletop game that invites museum visitors to play while simultaneously introducing them to computer programming. Visitors program the actions of frogs using a graphical language. **> *Leadership***

Project Syria: An Immersive Journalism Experience
go.nmc.org/projsyr
(Nonny de la Peña, YouTube, 28 January 2014.) An immersive journalism experience created by the University of Southern California School of Cinematic Arts called "Project Syria" uses virtual reality video games to immerse players in a war zone in Syria, created using real footage and voices. These experiences help players empathize with citizens in areas they may never be able to physically visit. **> *Leadership***

For Further Reading
The following articles and resources are recommended for those who wish to learn more about games and gamification:

Serious Games Go Informal: A Museum-Centric Perspective on Intelligent Game-Based Learning
go.nmc.org/intelli
(Jonathan P. Rowe, Eleni V. Lobene, Bradford W. Mott, and James C. Lester, The Intellimedia Group, 2014.) This paper proposes a prototype game-based learning exhibit for sustainability education in science museums called "Future Worlds" that can foster significant gains in sustainability understanding and high levels of engagement based on findings from a museum-based study. **> *Leadership***

Using Biofeedback Technology for a Game That Knows Your Fear
go.nmc.org/biofeed
(Allison Meier, *Hyperallergic*, 19 February 2014.) Erin Reynolds' master's thesis project at USC's Interactive Media Program has resulted in the development of a game that gets increasingly horrifying based on the user's anxiety by incorporating a heart rate monitor to calculate players' heart rate variability. Her findings open doors for how developers can leverage biofeedback to create games that better interact with players. **> *Practice***

Evaluating the Effects of Orchestrated, Game-Based Learning in Virtual Environments for Informal Education
go.nmc.org/evaluating
(Panagiotis Apostolellis, Doug A. Bowman, ACM, 2014.) This research explores the opportunities afforded by social experiences in museum spaces combined with serious games and collaborative virtual environments. The study found that a multiplayer design with social interactions improved engagement in the game experience. **> *Practice***

Location-Based Services
Time-to-Adoption Horizon: Two to Three Years

L ocation-based services (LBS) provide content that is dynamically customized according to the user's location.[237] These services are commonly delivered to mobile devices; cellular tower coordinates are often refined with GPS data to ensure a high level of accuracy in locating mobile devices. New location intelligence technologies are extending that capability into buildings and interior spaces with remarkable accuracy. Current common applications for LBS include advertising, news, social networking, and tours. In the commercial realm, location-based services have become an almost transparent way to generate actions triggered by a user's interest data and matched to their location. A recent compelling development for location-based services is the advent of indoor geolocation,[238] which is providing museum visitors with very specific information tailored to their exact location within a building, allowing fine-tuned information or services to be accessed that are very specific to where they are, not only relative to the planet's surface, but in 3D space, so that even different floors of a building can be identified.

Overview
Location-based services digitally pinpoint the physical position of an object or individual through Wi-Fi cellular networks, and most recently, Bluetooth Beacons and ByteLight technologies. The popularity of this topic in the consumer sector can be attributed to how LBS helps strengthen two-way communication between people and business. For users, location-based services conveniently provide information or recommendations pertaining to their surroundings, such as shortcuts and nearby cultural sites. LBS enables businesses to target customers with promotions that are relevant to their geographic area.[239] The proliferation of smartphones and tablets, equipped with built-in GPS and an array of sensors, has accelerated the use of location-based services. According to Pew Research Center, 74% of adult smartphone owners leverage LBS to obtain directions and other information. Additionally, many of the leading social media apps, including Facebook and Instagram, constantly prompt users to include their location. Pew reports that 30% of adult social media users opt to automatically indicate their locations when posting to these networks.[240]

In addition to mapping efficient routes for travel and enhancing social media interactions, location-based services are ripe for innovation in the museum sector. With an increasing number of people bringing their own devices with them,[241] LBS-enabled mobile apps can enrich patrons' experience by providing recommendations on specific objects, collections, or exhibits that may be of interest to them, based on their previous museum visits. When coupled with analytics about patrons' habits and movements, location-based services foster methods for tailoring the content that is dispensed. The future of the technology lies not just in discerning an individual's location, but also in delivering to them helpful information before they even ask for it.

In 2013, Apple purchased two location intelligence companies that specialize in indoor GPS, formerly Locationary[242] and WiFiSLAM,[243] signaling a new direction for location-based services. Some experts predict that powerful indoor GPS technology will soon be integrated into a microchip, making it easy to incorporate in everyday objects, including keys.[244] The US military is currently developing "Micro-PNT," which requires very little power to sense location. Additionally, Google has gathered indoor maps for places such as Wembley Stadium in London for the Google Map program.[245] These kinds of technologies have major implications for large museums, and are ushering in what *Newsweek* called "the final frontier of personalized navigation."[246] Location-based services are positioned to help people better understand their environments and even contribute their own measurements in an effort to map the entire world, inside and out. Museum docents have long been using handheld devices and kiosks to augment tours, and LBS can further enhance how patrons are guided through exhibits.

Relevance for Museum Education and Interpretation
Many museums have responded to patrons bringing their own mobile devices by offering free access to Wi-Fi throughout their public spaces and leveraging Wi-Fi triangulation to provide personalized location-based services. The Smithsonian Institution's "Tours" app, for example, provides patrons with turn-by-turn navigation to five museums, and includes a free, special tour that showcases all components of collections that include presidential artifacts.[247] Similarly, the "Montréal Museums" iPhone app uses LBS to tailor content and recommendations to patrons, identifying nearby exhibits, related activities, and more.[248] Smartphones,

however, are not the only mechanisms museums are using to better connect patrons to exhibits. In earlier deployments of LBS, the Jewish Museum Berlin incorporated RFID tags on spoons that were provided to people as entry tickets as part of a personalized information system. These spoons helped lead patrons to different media stations throughout the museum, equipped with RFID readers so that they could access hidden information online and learn more about culturally significant objects.[249]

The next wave of LBS technology for museums is expanding the possibilities for indoor navigation. The Royal BC Museum in Victoria, Canada was among the first to adopt sophisticated indoor GPS, initially using Wifarer's mobile app platform to enhance exhibits with location-aware guides. Objects appear as icons on a virtual map, and physically moving towards those objects triggers additional contextual information for each object.[250] In 2015, Wifarer launched "Blue Dot" navigation; multiple Bluetooth LE beacons and RF fingerprinting were deployed at the Royal BC Museum to allow for more precise and private indoor positioning of smartphones and tablets.[251] Facebook is also testing the use of Bluetooth beacons for location-based recommendations at the Metropolitan Museum of Art in New York.[252] In the Netherlands, LabWerk's new mApp platform was designed expressly for engaging visitors with personalized museum tours.[253]

While many location-based services projects and pilots are currently underway, this topic falls on the mid-term horizon mainly because of the undertaking of retrofitting old buildings with the appropriate technologies. Successful implementation requires museums to update their physical and technical infrastructures. Researchers in Athens, Greece published a paper outlining the architectural and technology design considerations of deploying indoor GPS for museums.[254] The application of their architecture framework was prototyped through the "e-Museum Guide System." Among their recommendations for museums is the need to anticipate the various paths a patron can take from one object to another, so that every potential route can be mapped electronically.

Location-Based Services in Practice
The following links provide examples of location-based services in use that have direct implications for museums:

PanGo's Proximity Platform Powers Location-Based Guided Tour Over Tate Modern Museum's Wireless Network
go.nmc.org/pango
Tate Modern has worked with PanGo Networks and Antenna Audio to create a wireless museum docent application that uses short-range wireless networks to

deliver interactive audio-visual content, based on the visitor's location in the gallery and interests. The data also allows Tate to improve its exhibits and policies by learning which areas attract the most visitors and where visitors are requesting additional information about exhibits as they tour the museum. **>** *Policy*

MIT's 'Local Warming' Exhibit Previews the Energy-Saving Future of Personalized Climate Control
go.nmc.org/localwarm
An art installation dubbed "Local Warming" was displayed at Vienna Architecture Biennale, developed by MIT's Center for Wireless Networks and Mobile Computing. The technology uses Wi-Fi-based motion tracking to track the movement of people in an indoor space, sending the person's coordinates to an array of IR lamps and attendant optical elements mounted on the ceiling that respond by beaming localized heat to the person. **>** *Leadership*

For Further Reading
The following articles and resources are recommended for those who wish to learn more about location-based services:

How to Increase Visitation Value for Museums Using Technology
go.nmc.org/increase
(David Morales, XStudios, 29 September 2014.) RFID and iBeacon are two location-based technologies that can personalize the visitor's unique experience within the museum while also allowing museums to see what their visitors are interacting with and for how long. Similarly to the way many websites already track their users, gathering this data can be done anonymously and without recording any personal information. **>** *Policy*

Bluetooth for the Blue Period: Art and Tech Unite in MONA's Gallery App
go.nmc.org/fuse
(Claire Reilly, *CNet*, 22 December 2014.) Australia's Museum of Old and New Art's app has allowed the museum to forgo gallery wall labels which disturbed the space and could only give a limited description of each object. Museum-provided iPod touches loaded with their app, the "O," give each visitor a proximity-ordered list of collection objects that changes as they move around the museum. **>** *Leadership*

iBeacons and the Personalized Museum
go.nmc.org/ibeac
(Jenny Ford, *Musings*, 27 January 2015.) iBeacons work with the Spotzer app to give museum-goers associated audio, pictures, text, and more as they approach specific collection objects and exhibits. The app can also chart a personalized route based on the user's interests and history and allows visitors to save and share their favorite works. **>** *Practice*

Makerspaces
Time-to-Adoption Horizon: Two to Three Years

The turn of the 21st century has signaled a shift in the types of skillsets that have real, applicable value in a rapidly advancing world. In this landscape, creativity, design, and engineering are making their way to the forefront of educational considerations, as tools such as robotics, 3D printers, and web-based 3D modeling applications become accessible to more people. Makerspaces are increasingly being looked to as a method for engaging learners in creative, higher-order problem solving through hands-on design, construction, and iteration.[255] The driving force behind makerspaces is rooted in the Maker movement, a following comprised of artists, tech enthusiasts, engineers, builders, tinkerers, and anyone else with a passion for making things.[256] The foundation of the Maker movement was built on the success of the Maker Faire, a gathering that launched in 2006 and has since propagated itself into numerous community-driven events all over the world.[257] Museum leaders are considering the addition of makerspaces into museum floor plans to create designated areas where visitors can act on their ideas and engage more deeply with artistic concepts and media.

Overview

Makerspaces, also referred to as hackerspaces, hack labs, or fab labs, are community-oriented workshops where tech enthusiasts meet regularly to share and explore electronic hardware, manufacturing tools, and programming techniques and tricks.[258] Much of the hype around this cultural trend burgeoned around 3D MakerBot printers, a rapid-prototyping technology that requires a DIY mentality to assemble, operate, and replicate it.[259] Tools that are commonly found in makerspaces include laser cutters, soldering irons, Arduinos and Raspberry Pi computers, and circuitry gadgets as well as analog tools such as Legos and sewing devices. Makerspaces appeal to dual-use groups, such as at the Impression 5 Science Center where adult community members as well as young visitors can engage in age-appropriate, independent making.[260] Like formal education institutions, museums are aligning with the trend toward hands-on, authentic learning experiences, and more museums are starting to adapt the makerspace for cultural heritage programming.

Widespread enthusiasm behind makerspaces has helped the concept gain mainstream traction. Dale Dougherty,

the CEO of Maker Media, Editor of *Make Magazine*, and creator of Maker Faire, is a major advocate of installing makerspaces into learning environments and has helped make it a part of national discussions about innovative approaches to education. Recently, the White House hosted its first ever Maker Faire, leading President Obama to publicly highlight the power of DIY to revolutionize American manufacturing and stoke innovation and job growth.[261] The Obama administration's commitment to providing students more access to tools, mentors, and spaces has led to the strategic investment of one million dollars to support makerspaces and maker-related programming in libraries and museums. Further, the Institute of Museum and Library Services will create a Maker@Your Museum and Library toolkit based on the expertise of over 50 innovative museum and library makerspaces.[262]

Makerspaces have been a part of science museums for years because of their ability to facilitate experiential learning; the Exploratorium's Tinkering Studio is a notable example of a creative space where museum patrons can deeply engage in an investigation of science phenomena through hands-on making activities.[263] Digital making, however, is still largely unexplored territory for art museums.[264] Although art-making activities have long been a part of art museum education programs, it is the introduction of digital tools such as 3D scanning and rapid prototyping that has stimulated interest in technology-based maker programs. At the Museum Victoria in Australia, museum educators experimented with a temporary makerspace called a SmartBar where individuals could scan specimens from their marine invertebrates collection and 3D print them onsite.[265] Research on the types of competencies needed to facilitate museum makerspaces are beginning to emerge and will likely drive more widespread adoption over the coming years.[266]

Relevance for Museum Education and Interpretation

Museums are taking advantage of makerspaces to provide visitors and artists with a place for experimenting and tinkering that is integrated into their community. The Metropolitan Museum of Art's Media Lab is one of the more established museum makerspace communities that were formed to explore the ways that emerging technology can affect the museum experience. There are two major trends that are accelerating makerspace

adoption: the low barrier of access to digital production tools such as Garage Band, iMovie, and 123D Catch and the rise of a do-it-yourself ethos found in hacker and maker communities.[267] Recently, the Met has been hosting 3D "Funday Meetups" to teach patrons about 3D scanning, modeling, and printing technology. A recent workshop held by sculptor Jeff Hesser involved scanning sculptures from the museum's collection, which had the valuable outcome of participants examining objects more closely than they have before.[268]

The products of maker activities have enriched online communities as well, extending the geographic reach of a museum's collection. Sketchfab, a platform for publishing and sharing 3D content online, has allowed users to make their files downloadable under Creative Commons licensing. The British Museum was the first museum to use the platform to open a collection of 14 downloadable 3D models of various statues including a bust of Julius Caesar and a red granite sarcophagus.[269] MakerBot Thingiverse is another online community for discovering, making, and sharing 3D printable objects that is being leveraged by the museum community.[270] A recent search showed 2,152 results for the term "museum" with 3D models from museums around the world including the Asian Art Museum, Royal Ontario Museum, and Museum Victoria among many others.[271]

Studies around the importance of "grit," or perseverance in the face of challenges, are also helping to justify the integration of makerspaces into museums. They are seen as dedicated spaces where young people can work on projects, solve problems, and iterate their products until they are satisfied. At the Children's Museum of Pittsburgh's MAKESHOP, young people are able to try new things without the pressure of receiving a bad grade; it is an environment where everyone is failing and focusing on how to learn from mistakes. Experimentation and grit are also the focus of the New York Hall of Science's 10 learning labs. In these makerspaces, teens use 3D printers to create solutions for community problems, including 3D printed wheels that make shopping carts more functional for the elderly.[272] While rapid prototyping has emerged as a key element in a makerspace, it is just one of many types of experiments unfolding. At the Peabody-Essex Museum's Maker Lounge, they have transformed their makerspace into a design process laboratory where visitors and staff can investigate the potential uses of wearable technologies.[273]

Makerspaces in Practice
The following links provide examples of makerspaces in use that have direct implications for museums:

Maker Corps 2015 at Children's Creativity Museum
go.nmc.org/ccm
Programming, facilitation, and exhibit spaces at the Children's Creativity Museum (CCM) focus on guiding

children away from passive media consumption and instead empower children to explore, create, and produce for themselves. CCM is hosting Maker Corps Members this year to train the CCM team on how to combine educational technologies such as the MaKey MaKey, Wonder Workshop's Dash & Dot robotics, and Scratch/Tynker with other artistic practices such as painting and sculpting. > *Policy*

WebWise to Feature Makerspaces in Libraries and Museums
go.nmc.org/webwise
Webwise addressed policy issues around makerspaces at its conference last year with a panel of experts moderated by IMLS senior program officer Tim Carrigan. The panel covered issues of professional development, evaluation, sustainability, and institutional philosophies of making. > *Policy*

Re:Make
go.nmc.org/remake
The Re:Make project encourages visitors and volunteers to become citizen curators, designers, and makers, learning new skills or applying skills they already have to support the redevelopment of Derby's Silk Mill (site of the world's first factory). The museum staff members have included community members as partners in redeveloping an important cultural space through design, prototyping, artifact interpretation, collections preparation, and audience development. > *Leadership*

For Further Reading
The following articles and resources are recommended for those who wish to learn more about makerspaces:

Learning Through Making
go.nmc.org/nsf2
(Maria C. Zacharia, National Science Foundation, 17 June 2014.) This article describes an NSF-supported study and projects that seek to broaden the participation of community members in makerspaces. Making is a critical aspect of learning and bringing in diverse makers will in turn contribute to a more diverse workforce. > *Policy*

MAD Museum NYC Makers Biennial
go.nmc.org/madhouse
(Araz Hachadourian, *WNYC News*, 29 June 2014.) To celebrate and showcase the diversity and talent of the maker scene across New York City for their inaugural biennial exhibition, the Museum of Arts and Design brings together around 100 artists and craftsmen from the five boroughs to exhibit their work. The exhibition encompasses all kinds of local makers and tells captivating stories of the city. > *Leadership*

Natural User Interfaces
Time-to-Adoption Horizon: Four to Five Years

A growing list of devices built with natural user interfaces (NUIs) accept input in the form of taps, swipes, and other ways of touching; hand and arm motions; body movement; and increasingly, natural language. Tablets and smartphones were among the first in an array of devices that allow computers to recognize and interpret natural physical gestures as a means of control.[274] These NUIs enable users to engage in virtual activities with movements similar to what they would use in the real world, manipulating content intuitively. Natural interaction with computers is not new, but neither has its full potential been realized. There is a rising level of fidelity in systems that understand gestures, facial expressions, and their nuances, as well as the convergence of gesture-sensing technology with voice recognition. Users' interactions with their devices are becoming more natural with gesture, expression, and voice communicating their intentions. The next wave of NUIs is electrovibration, which involves the use of an electrostatic force to produce detailed tactile sensations that users can feel.[275] Electrovibration allows users to not only provide touch-based input, but also tactile output via a wide variety of textures, topography, and other features as they interact with the screen.

Overview

Although natural user interfaces were largely popularized with the launch of the iPhone and its touchscreen in 2007, the concept of an NUI was not new at the time. Discussions around the development of interfaces beyond command line interface (CLI) and graphical user interface (GUI) started in the 1970s and 80s when Steve Mann, widely regarded as the father of wearable computing, began experimenting with human-machine interactions.[276] From his work, the idea of natural user interfaces was born, along with the potential for scientists and designers to adapt this innovation to new technologies. Museum spaces are naturally conducive to incorporating large-scale NUIs into exhibits and collections, making the topic a staple in previous editions of the museum-focused *NMC Horizon Report* series.

The potential role of natural user interfaces in sophisticated simulations and demonstrations makes the latest incarnations particularly exciting for museums, where showing a patron how an object was created is a typical activity. Elon Musk, Tesla CEO, recently developed a 3D holographic interface that resembled the science fiction-like computer in the *Iron Man* movies. Using only hand gestures, he demonstrated rocket part models before printing them.[277] Musk also spearheaded the launch of TeslaTouch (now known as Electrostatic Vibration) at Disney Research,[278] a technology that enhances flat surfaces with tactile sensations, enabling users to feel bumps, curves, and other textures. Recently, Disney researchers invented a process to stimulate tactical feedback on smooth glass displays.[279] This technology offers many possibilities for more profound interactions with museum content, and with it, greater accessibility for disabled patrons. Applied to mobile devices, the phenomenon of electrically induced tactile sensation creates the potential for them to feel museum works.

Speech-to-speech translation is another compelling facet of NUIs. It is already common to see people interacting with voice-activated virtual assistants on their mobile devices via Apple's Siri or Google's Cortana. The next steps include new technologies like automatic translation engines; Microsoft has already released a preview of "Skype Translator," which will translate voice input in real-time and offers instant message translating in over 40 languages.[280] The potential of this technology for museums is vast, as they are common attractions for people visiting from other countries. Cultural heritage sites can especially benefit from automated foreign language translation in helping to disseminate historic information and helping visitors connect with each other around art in a common language.

Relevance for Museum Education and Interpretation

Natural user interfaces render technology transparent; transforming the way museums can present their collections and exhibitions, as well as how visitors interact with them. Gesture-based technologies have the potential to unhinge velvet ropes and allow patrons to experience collection objects by playing with them through simulated touch and other movements. As a result, more museums are integrating NUIs to engage their patrons on a deeper level. In an effort to provide patrons with a more hands-on experience with technology, Deutsches Museum München in Germany is using Intel RealSense camera technology to develop an exhibition project that will allow patrons to control a

Thymio II robot with gestures.[281] Additionally, when the Cooper Hewitt, Smithsonian Design Museum reopened in December 2014, they provided each visitor, upon entry, with touch-sensitive stylus pens to draw on large, interactive tables and surfaces throughout the building.[282]

Multi-touch kiosks and walls are becoming increasingly popular for exhibits and permanent collections. At the Museum of Science + Industry Chicago, the 2014 *THINK* exhibit featured a 40-foot gesture wall that visualizes how a wide variety of data flows in patrons' daily lives in the form of solar energy and air quality. When visitors interact with the wall simply by moving their bodies in different ways they generate unique shapes, images, and colors.[283] Moreover, the American Alliance of Museums announced their 2014 MUSE Award winners and runner-ups, including National Palace Museum in Taiwan for their "New Media Art Exhibition," which made use of gesture recognition, facial mapping, augmented reality, and image recognition.[284]

These types of NUIs can have profound effects on learners.[285] Children using multi-touch displays adapt to the mechanism naturally, which has increased support for using mobiles and Microsoft Kinect. NUIs are already being used to help children with mental and physical disabilities learn new concepts and skills, making it easier for them to communicate and learn through touch, voice, and other gestures.[286] This facet of NUIs makes them particularly conducive for museum patrons with disabilities. For example, the Louvre in Paris deployed Kinect technology to enable gesture scanning of ancient objects. Visitors can manipulate a veil dating from the 4th century AD, allowing them to explore different narratives that are painted on the fabric.[287] The Tech Museum of Innovation in California is home to several exhibitions that incorporate motion-sensing innovation. In "Space Palette," visitors can play virtual instruments and create colorful visuals.[288]

Natural User Interfaces in Practice
The following links provide examples of natural user interfaces in use that have direct implications for museums:

Augmenting Masterpieces
go.nmc.org/augma
This research project addresses the design challenges of developing prototypes of new interfaces for virtual and physical interaction in the museum context and aims at creating a theoretical framework, formulating existing and desired features, testing user experience, and creating a final product to be used for augmented museum tours at the Rijksmuseum. **> Policy**

Maps That You Can Hear and Touch
go.nmc.org/betmaps
A group of scientists, architects, and advocates are working toward new methods of wayfinding for blind people by making maps that convey information through touch and sound. By using a Livescribe smart-pen, users can tap on icons and listen to more detailed information, such as the price for an entrance fare or what intersection the stairs lead to. **> Leadership**

'Mind Art' Project Allows Individuals Living With Disabilities To Create Art With Their Brains
go.nmc.org/mindart
Chinese artist Jody Xiong teamed up with paint vendor Winsor & Newton to launch a project called "Mind Art," in which 16 volunteers living with disabilities wore a Neurosky headset connected to a processing unit that allowed electronic brain signals to set off tiny detonators attached to paint-filled balloons. The artists were able to trigger the individually chosen pigments to splatter across blank canvases through their deep concentration. **> Leadership**

For Further Reading
The following articles and resources are recommended for those who wish to learn more about natural user interfaces:

Atheer Wants to be the HoloLens of the Workplace, Releases New SDK
go.nmc.org/ath
(Mark Sullivan, *VentureBeat*, 5 February 2015.) Atheer makes a virtual reality user interface called AiR, or Augmented Interactive Reality, that uses a pair of smart glasses to detect the movements of the user's hands. The Atheer technology runs on a small Wi-Fi device that connects to the smart glasses. **> Practice**

Feel Invisible 3D Shapes With Blasts of Ultrasound
go.nmc.org/invis
(Evan Ackerman, *IEEE Spectrum*, 4 December 2014.) Using an array of focused ultrasound that can create patterns of turbulence in the air, computer scientists from the University of Bristol have been able to generate 3D shapes in midair that you cannot see, but that you can touch. If paired with virtual or augmented reality technologies, this could allow visitors to feel objects normally behind museum cases or freely explore a virtual world while receiving haptic feedback. **> Practice**

Museums of the Future Will Let You 'Touch' Treasures Behind Glass
go.nmc.org/treas
(Sarah Griffiths, *Mail Online*, 7 October 2014.) Scientists have developed interactive semi-transparent mirrors that allow people to 'touch' exhibits in museums that are behind glass, using the reflection of their fingers, to reveal information and manipulate inaccessible objects. **> Practice**

The Internet of Things
Time-to-Adoption Horizon: Four to Five Years

he Internet of Things (IoT) is a network of connected objects that link the physical world with the world of information through the web. When TCP/IPv6 launched in 2006, it expanded the capabilities of the Internet and enabled objects, sensors, and devices to be addressable and communicate across the web.[289] This augmented address space became particularly useful for automation: in industrial and manufacturing processes, tracking technologies that monitor sensitive equipment or materials, point-of-sale purchases, passport tracking, inventory management, and identification.[290] Embedded chips, sensors, or tiny processors attached to an object can transmit information about the object such as cost, age, temperature, color, pressure, or humidity to another smart device or piece of machinery. This networked connection allows remote management, status monitoring, tracking, and alerts if the objects are in danger of being damaged or spoiled. For cultural heritage institutions, networked technologies have vast potential for improving conservation efforts, increasing access to contextual knowledge, and reinventing interaction with cultural works. Museum leaders envision collections of networked objects that tell their own stories; with IoT, histories and metadata can be potentially downloaded from the objects themselves, forever changing the paradigm of interpretation and public engagement.

Overview

It is no longer far-fetched to envision a world where all people, objects, and devices are connected to act in concert, regardless of brand or vendor. This idea is also known as The Internet of Everything (IoE), which is comprised of machine-to-machine (M2M), machine-to-person, and person-to-person networked technologies. In this environment, sensors embedded on machines, people, and objects can capture events, which are sent through the IPv6 network to applications that create actionable information. Many consumers are already familiar with IoT through their experience with Nest, a next-generation thermostat that programs itself based on its surroundings and can be controlled via a smartphone.[291] On the industry side, M2M IoT technologies are being used to modernize railways, agricultural equipment, and construction machinery with real-time monitoring capabilities.[292] In the world

where the Internet of Everything is realized, many choices and decisions will be automated, making life, and potentially learning, an efficient, streamlined experience.

A long-time innovator in entertainment technology, Walt Disney World, has used IoT to develop the MagicBand, an all-in-one wristband that streamlines the vacation experience by allowing visitors to unlock their hotel rooms and buy food and merchandise with a swipe of their wrist.[293] Using IoT for enhancing visitor experience can go much further than that, however; wearable technology can monitor vital signs, which could automatically trigger messages and notifications intended specifically for the wearer. For instance, the heart rate of a roller coaster rider who was less than impressed would be sent a targeted message about a more thrilling attraction via their mobile smartphone.[294] In the museum sphere, this model can be easily adapted to increase engagement through personalization; the vital signs of a tired patron, for example, could trigger a message to their smartphone, which offers directions to a nearby courtyard where they can rest and enjoy their surroundings.

Currently, the enabling technologies for IoT such as smart sensors and chips are already well understood, easily mass-produced, and inexpensive, and a number of museums are incorporating IoT technologies in their exhibits.[295] The iBeacon, an Apple technology that works with Bluetooth transmitters and mobile apps, has become a mainstay in cultural heritage institutions that are using networked sensors to send personalized content to visitors via their smart devices.[296] In 2014, the National Museum Wales was the first national museum in the world to embark on a full-fledged IoT pilot in which 25 iBeacons were placed around their National Slate Museum to aid in visitor engagement.[297] The embedded technology allows visitors to access digital content and watch demonstrations at any time, or visit the "learning zone" in the museum and participate in online activities and quizzes on their device.[298]

Relevance for Museum Education and Interpretation

IoT carries the potential to create a museum without walls; that is, networked technology can give rise to an environment where cultural knowledge is embedded into everyday activities, and it can be accessed anytime,

anyplace, and anywhere. Museum leaders see the trajectory as being aligned very closely with wearable technology, which will diminish the use of apps in favor of experiences where humans interact directly with objects in their surroundings.[299] In December 2014, the San Francisco de Young Museum began offering the first ever in-gallery tour using Google Glass enabled by a mobile storytelling platform called GuidiGO, which leverages Bluetooth LE and augmented reality technologies to create an enhanced experience. Arranged around the Keith Haring exhibit, visitors with Google Glass are automatically presented contextual audio and visual content as they approach certain pieces. Augmented reality gives them a deeper look at the collection objects and the opportunity to detect unnoticeable details.[300]

Increasing accessibility of Bluetooth and network technology is also creating conditions for memorable exhibits that engage with the visitor in unique ways. For the International Day for Mine Awareness and Assistance, the UN organized an installation in New Museum in New York City that incorporated iBeacon technology and a mobile app called "Sweeper," which detects hidden transmitters throughout the exhibit. Designed to convey the fear of living with land mines, visitors that stumbled upon a transmitter receive a jarring explosion through their headphones followed by the personal testimony of a survivor.[301] The Cooper Hewitt Smithsonian Design Museum has embarked on an innovative use of Near Field Communication (NFC) technology in an exhibit which allows visitors to carry networked styluses and capture designs using NFC labels around the museum or to create their own. Once satisfied with their creation, the visitors can send their designs to an interactive screen to keep working, or share with friends via social media.[302]

IoT is also being used to monitor the conditions of paintings and ancient artifacts in real-time through sensors. These devices can alert humans to changes in the condition of the piece, or better yet, trigger a mechanism that will improve environmental conditions to ensure preservation. In fact, environmental monitoring technology has become a crucial part of the conservation process, not just for individual objects, but also for architectural structures. The Los Angeles County Museum of Art (LACMA) is undergoing an intensive conservation project of the Watts Towers, a mid-20th century historical landmark that was constructed by hand with steel rods wrapped in wire mesh and coated with cement. To guarantee every action goes smoothly, the LACMA Conservation Department has installed a comprehensive smart system within the structure, which uses sensors located in the foundation and throughout to monitor the movement of cracks in the cement.[303]

The Internet of Things in Practice

The following links provide examples of the Internet of Things in use that have direct implications for museums:

Europeana Meets the Internet of Things in MeSch – Material EncounterS with digital Cultural Heritage
go.nmc.org/mesch
The goal of the meSch project, Material EncounterS with digital Cultural Heritage, is to provide a platform for the creation of tangible smart exhibits so that museum professionals will be able to create interactive smart objects and compose the narratives to be embedded within them without the need for specialized technical knowledge. **>** *Leadership*

The MEMORI Technology Innovation for Conservation
go.nmc.org/memori
MEMORI is an early warning system sensitive to the main degradation factors of indoor environments including climate, light, and air pollution. A dosimeter alerts users on their handheld devices if an environment may be hazardous for storing museum artifacts. The tool allows environmental data to be collected, analyzed, and visualized on-site. **>** *Leadership*

Decision Support System for Museum Management through Distributed Wireless Sensing
go.nmc.org/wsn
The ELEDIA Research Center of the University Trento is testing a wireless sensor network (WSN) with an open platform called E-MUSEUM that can leverage WSN nodes to collect and transmit information wirelessly, providing evaluation and forecasting information concerning museum pieces and visitor activity. **>** *Practice*

For Further Reading

The following articles and resources are recommended for those who wish to learn more about the Internet of Things:

FTC Report on Internet of Things Urges Companies to Adopt Best Practices to Address Consumer Privacy and Security Risks
go.nmc.org/ftc
(Federal Trade Commission, 27 January 2015.) In this report the staff of the Federal Trade Commission recommend a series of concrete steps that businesses and organizations can take to enhance and protect consumers' privacy and security, as Americans start to reap the benefits from a growing world of Internet-connected devices. **>** *Policy*

Managing Privacy in the Internet of Things
go.nmc.org/iotprivacy
(Usman Haque, *Harvard Business Review*, 5 February 2015.) The Internet of Things will bring about a number of questions and concerns around privacy, interoperability, and data-access privileges, including how people will control what can access the data generated by their devices. **>** *Policy*

The 2015 Museum Edition Expert Panel

Larry Johnson
Co-Principal Investigator
New Media Consortium
United States

Nik Honeysett
Co-Principal Investigator
Balboa Park Online Collaborative
United States

Alexander Freeman
Report Editor
New Media Consortium
United States

Samantha Adams Becker
Horizon Project Director
New Media Consortium
United States

Michele Cummins
Research Manager
New Media Consortium
United States
_____

Kaja Antlejr
University of Ljubljana
Slovenia

Jeffrey Aronowitz
Historic Jamestown-Jamestown Rediscovery Project
United States

David Asheim
Guide by Cell
United States

Jane Burton
Tate
United Kingdom

Lori Byrd Phillips
The Children's Museum of Indianapolis
United States

Suse Cairns
Baltimore Museum of Art
United States

Sebastian Chan
Cooper Hewitt, Smithsonian Design Museum
United States

Marc Check
Museum of Science, Boston
United States

Jim Devine
Interpretive Media Limited
United Kingdom

Ryan Dodge
Royal Ontario Museum
Canada

Robin Dowden
Walker Art Center
United States

Jennifer Foley
Cleveland Museum of Art
United States

Ben Garcia
San Diego Museum of Man
United States

David Greenfield
Independent
United States

Beth Harris
Khan Academy
United States

Susan Hazan
The Israel Museum
Israel

Douglas Hegley
Minneapolis Institute of Arts
United States

Amy Heibel
LACMA
United States

Anne Helmreich
Getty Foundation
United States

Luanne Kanzawa
Japanese Friendship Garden Society of San Diego
United States

Lynda Kelly
Australian National Maritime Museum
Australia

Jack Ludden
J. Paul Getty Trust
United States

Alex Morrison
Cogapp, UK
United Kingdom

Liz Neely
Independent
United States

Jen Oleniczak
The Engaging Educator
United States

Joaquin Ortiz
Museum of Photographic Arts
United States

Elizabeth Merritt
AAM
United States

Bill Meyer
Exploratorium
United States

Christopher Reich
IMLS
United States

Carolyn Royston
IIndependent consultant
United Kingdom

Adrianne Russell
Independent
United States

Merete Sanderhoff
Statens Museum for Kunst
Denmark

Scott Sayre
Corning Museum of Glass
United States

Marsha Semmel
Knight Foundation
United States

Charlotte Sexton
MCN
United States

Silvia Singer
MIDE Interactive Museum of Economics
Mexico

Marilyn Sklar
DAR Museum
United States

Koven Smith
Blanton Museum of Art
United States

Paul Sparrow
The Newseum
United States

Margaret Collerd Sternbergh
The Phillips Collection
United States

Sarah Stierch
Berkeley Center for New Media
United States

Neal Stimler
The Metropolitan Museum of Art
United States

Robert Trio
Hong Kong Maritime Museum
Hong Kong

Jasper Visser
Independent
Netherlands

Michael Wall
San Diego Museum of Natural History
United States

Elycia Wallis
Museum Victoria
Australia

John Weber
Institute of the Arts and Sciences, University of California, Santa Cruz
United States

Chad Weinard
Balboa Park Online Collaborative
United States

Heather Marie Wells
Crystal Bridges Museum of American Art
United States

Endnotes

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For the *NMC Horizon Report: 2015 Museum Edition*, an expert panel identified 18 topics very likely to impact technology planning and decision-making: six key trends, six significant challenges, and six important developments in technology.