Creating Museum Media for Everyone: 2012 Workshop Themes

White Paper

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August 2014
Report # 2014-8
Funded by the National Science Foundation

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NSF

Acknowledgements

Without the help of many people, this white paper would not have been possible.

Special thanks to:

- The advisors who shared their expertise at the workshop. Their presentations provided inspiration during the workshop and are the basis of this white paper for the field. This group included Mark Barlet, Dr. James Basham, Dr. Sheryl Burgstahler, Dr. Harry Lang, Jennifer Otitigbe, Dr. Christopher Power, Dr. Gabrielle Rappolt-Schlichtmann, Lisa Jo Rudy, Dr. Cary Supalo, Dr. Gregg Vanderheiden, and Dr. Bruce Walker.
- All of the Creating Museum Media for Everyone workshop attendees whose participation enriched the thinking of this project.
- Members of the Museum of Science's Research and Evaluation department who took notes on the proceedings of the workshop.

This report was based on work supported by the National Science Foundation under Grant No.1114549. Any opinions, findings, and conclusions or recommendations expressed in this report are those of the author(s) and do not necessarily reflect the views of the Foundation.

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EXECUTIVE SUMMARY

Creating Museum Media for Everyone (CMME), a National Science Foundation (NSF) Enhanced Pathways Grant, held a five-day workshop in May 2012 that brought together 55 museum professionals and accessibility experts in fields such as formal science and special education, technology product development, gaming, accessible technologies, and universal design and Universal Design for Learning. The overarching purpose was to help launch the work of the core team from the Museum of Science (MOS), the WGBH National Center for Accessible Media (NCAM), Ideum, and Audience Viewpoints in developing the next generation of universally designed computer-based museum interactives.

At the beginning of the workshop, eleven experts presented ideas from their own fields that could help museums be more inclusive informal education settings. This white paper provides an overview of the following key themes that emerged from their presentations:

- Museums can become more welcoming to all visitors by basing their work on approaches that stress inclusion.
    - These approaches include the social justice model, universal design (UD), Universal Design for Learning (UDL), and personalization; each of which provides a unique perspective for thinking about inclusion.
- Using diverse techniques will allow museums to meaningfully engage a range of individuals in science, technology, engineering, and mathematics (STEM) learning.
    - Multiple means of engagement, multi-sensory offerings, gaming approaches, and participatory experiences are all strategies that museums could use to engage visitors in STEM learning.
- Communicating STEM concepts in multi-sensory ways and providing apparent accessibility options can help museums be places where all visitors can participate.
    - Being conscious of the level of vocabulary used, the availability of cognitive supports and multi-sensory options, and the ease with which people can use assistive technology and understand what to do at an exhibit is imperative.
- Evaluation, especially involving people with disabilities, is crucial for developing inclusive museum experiences.
    - Evaluation can help identify areas that might be challenging for some visitors and where improvements can be made.

All eleven expert advisors offered advice for how museums could better incorporate inclusion approaches. In particular, when creating inclusive exhibits, speakers urged museums to:

- Employ a UD/UDL approach to enhance experiences for all
- Be consistent in design
- Make designs intuitive
- Use simple, flexible designs that allow for freedom of exploration
- Deliver information in a variety of modalities
- Provide multi-sensory offerings
- Help people be aware of available accessible options
- Consider personalization possibilities connected with technology

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I. INTRODUCTION TO THE PROJECT

Creating Museum Media for Everyone (CMME), a National Science Foundation (NSF) Enhanced Pathways Grant, held a five-day workshop in May 2012 that brought together 55 museum professionals and accessibility experts in fields such as formal science and special education, technology product development, gaming, accessible technologies, and universal design and Universal Design for Learning. The overarching purpose was to help launch the work of the core team from the Museum of Science (MOS), the WGBH National Center for Accessible Media (NCAM), Ideum, and Audience Viewpoints in developing the next generation of universally designed computer-based museum interactives. This white paper provides an overview of key themes from workshop presentations as well as recommendations for how all museums can better incorporate inclusion approaches into their work.

By devoting time during the first few days of the CMME workshop to expert presentations and group discussions, participants were able to consider how ideas from a range of fields could contribute to innovative and inclusive museum exhibits. This white paper presents the following themes that emerged from the expert presentations:

- Museums can become more welcoming to all visitors by basing their work on approaches that stress inclusion.
- Using diverse techniques will allow museums to meaningfully engage a range of individuals in science, technology, engineering, and mathematics (STEM) learning.
- Communicating STEM concepts in multi-sensory ways and providing apparent accessibility options can help museums be places where all visitors can participate.
- Evaluation, especially involving people with disabilities, can help museums be more inclusive.

Over the course of the project, the CMME core team developed two exemplar digital interactives and several resources for the museum field using ideas from the expert presentations as well as the workshop participants' prototyping work. The resources developed through CMME aim to help other institutions create their own inclusive interactives and can be found at: http://openexhibits.org/research/cmme/.

II. DESCRIPTION OF THE EXPERT ADVISORS WHO INFORMED THE WORKSHOP

Eleven expert advisors presented during the first two days of the CMME Workshop. Collectively, they represented a range of fields including formal science and special education, technology product development, gaming, accessible technologies, and universal design and Universal Design for Learning. Through 20-30 minute presentations and discussions, advisors shared how their areas of expertise relate to the challenge of developing an inclusive digital interactive for a museum setting. Key themes from their presentations are summarized in this white paper.

For reference, listed below is a description of all eleven advisors including information about their current and past projects.

Mark Barlet is the Co-Founder of the AbleGamers Foundation. Disabled while serving in the United States Air Force, he refused to let disabilities take away the joy of gaming. Mr. Barlet spoke on the topic of game accessibility at the 2008 and 2009 Game Developers Conference, compiled and ran Game Accessibility Day @ Games for Health in 2008, 2009, and 2010, and ran a panel at PAX 2010. He is also the CEO of AppSol Technologies, a provider of software development and IT services to companies in the Washington, D.C. area.

Dr. James Basham is an Associate Professor in the Department of Special Education at the University of Kansas. Dr. Basham's research is focused on student learning in modern learning environments chiefly related to the application of Universal Design for Learning. Some of his recent projects and collaborations include the *Interactive Field Investigation Guide (iFIG)* (PI) and the *Center on Online Learning and Students with Disabilities* (Co-PI). Dr. Basham is the co-founder of the UDL-Implementation Research Network (UDL-IRN) and serves on the executive board for the International Society for Technology in Education (ISTE) Special Education Technology Special Interest Group (SETSIG).

Dr. Sheryl Burgstahler is an Affiliate Professor in the College of Education at the University of Washington in Seattle. Her teaching and research focus on the successful transition of students with disabilities to college and careers and the application of universal design to technology, learning activities, physical spaces, and student services in educational settings. She founded and continues to direct the DO-IT (Disabilities, Opportunities, Internetworking and Technology) Center and the Access Technology Center. These Centers promote (1) the use of mainstream and assistive technology to support the success of students with disabilities in postsecondary education and careers and (2) the development of facilities and software that are welcoming and accessible to individuals with disabilities.

Dr. Harry G. Lang is Professor Emeritus at the National Technical Institute for the Deaf at Rochester Institute of Technology. Dr. Lang, deaf himself, taught physics and mathematics to deaf and hard-of-hearing students at RIT. Dr. Lang researches characteristics of effective teachers, teaching and learning styles, and factors that contribute to teacher education. He has also conducted research in technical sign language. Dr. Lang's NSF grant work includes his role as co-director for a project that established a network of science teachers interested in hands-on activities for deaf students.

Jennifer Otitigbe is the former Director of User Experience and Research at the Institute for Human-Centered Design (IHCD). In this role, Jennifer coordinated a multi-disciplinary team of people in design, technology, and social sciences that helped organizations seeking to apply principles of Human Centered Design in their services, policies & procedures, products, and Information and Communications Technologies (ICT). Much of her work is conducted through the engagement of 'user-experts' or through participatory design processes. In addition to providing consulting and training in this area, she assisted with the launch of a multifaceted event in Boston called "Products and Technologies that Change People's Lives."

Dr. Christopher Power is a Lecturer in the Human Computer Interaction Research Group in the Department of Computer Science at the University of York. A computer scientist by training, Dr. Power's research emphasizes user requirements and evaluation methodologies for the creation of compelling usable and accessible interactive technologies. He has participated in several European Union (EU) projects, including *Benchmarking Tools and Techniques for the Web* (BenToWeb), which produced testing methodologies to help meet user requirements for web accessibility. He is currently the primary investigator on the *Inclusive Future: Internet Web Services* project (I2Web).

Dr. Gabrielle Rappolt-Schlichtmann is Co-President and Chief Learning and Science Officer at the Center for Applied Special Technology (CAST). She oversees all research activities, supporting her colleagues to work as a team, and providing guidance in the areas of research methodology and data analysis. Her research focuses on the impact of emotion on learning and technology that supports the affective component of UDL. She has worked on NSF and Institute of Education Sciences (IES) projects related to universally designed curricula and science-learning. She is a co-author of the landmark book *Teaching Every Student in the Digital Age: Universal Design for Learning* published in 2002.

Lisa Jo Rudy is a museum professional with over twenty years of experience in developing print, digital, and interactive media. She has worked at The Franklin Institute and with major national clients including NSF, Space Telescope, and The Smithsonian Institution. Ms. Rudy is also the parent of a child with an autism spectrum disorder, and, since 2003, has been a leader in public education on the subject. In 2006, she became the About.com Guide for the Autism page (www.autism.about.com). Her book *Get Out, Explore, and Have Fun: How Families of Children with Autism or Asperger Syndrome Can Get the Most Out of Community Activities* was published in 2010.

Dr. Cary A. Supalo, completely blind since the age of 17, is the Founder and President of Independence Science, LLC. Created in 2009, Independence Science offers technological consulting services and assistive hardware/software to school districts, state rehabilitation agencies, parents, students, and colleges/universities to help blind and low-vision (BLV) students have hands-on science learning experiences. In 2004, Dr. Supalo co-founded the Independent Laboratory Access for the Blind (ILAB) project at Pennsylvania State University. He served as Co-Principal Investigator regarding content evaluation and information dissemination for the

NFB Jernigan Institute's *www.BlindScience.org*, an NSF-funded project to help educators share methods for teaching BLV students.

Dr. Gregg Vanderheiden is Director of the Trace R&D Center and a Professor in both the Industrial & Systems Engineering and Biomedical Engineering Departments at University of Wisconsin-Madison. He was a pioneer in the field of Augmentative Communication (a term he coined in the 1970s) before moving to computer access in the 1980s. In the 1980s, his group created many of the accessibility features that are now built into every Macintosh, Windows, and Linux computer. He has worked with over 50 companies, served on governmental advisory and study committees, and has chaired and/or edited many of the early accessibility standards.

Dr. Bruce Walker holds appointments in Psychology and Computing at Georgia Tech. His Sonification Lab studies non-traditional interfaces for mobile devices, auditory displays, and assistive technologies. Dr. Walker's *Sonification Sandbox* software creates auditory graphs for the blind, and his *System for Wearable Audio Navigation* enables people with vision impairments to move through their environment. Dr. Walker's *Accessible Aquarium Project* is developing ways to make dynamic informal learning environments, such as zoos and aquariums, more accessible to visually impaired visitors. He has also worked for NASA, private companies, and the military.

III. THEMES FROM THE WORKSHOP

MUSEUMS CAN BECOME MORE WELCOMING TO ALL VISITORS BY BASING THEIR WORK ON APPROACHES THAT STRESS INCLUSION

During the first two days of the CMME workshop, speakers discussed different disability models and strategies that, if applied in museum settings, would help make museums more inclusive to all. In particular, the social justice model of disability, universal design, and Universal Design for Learning were all presented as frameworks for thinking about and creating inclusive experiences. Personalization was brought in as an approach that complements universal design to create inclusive museum experiences. What follows is an introduction to each of these topics and how they are relevant to the design of museum exhibits and activities.

Dr. Sheryl Burgstahler kicked off the workshop by reviewing the evolution of different disability models and proposing that museums incorporate the social justice approach into their work. As she described, this model, unlike those more prevalent in the past, approaches inclusion with the idea that everyone belongs and that all people have a range of abilities and disabilities (Loewen & Pollard, 2010). The social justice model provides a welcoming framework for thinking about the inclusion of all people in different events and activities, and provides a contrast from past models. As Burgstahler explained, some earlier approaches overlooked or marginalized people with disabilities, only considered them in terms of the abilities they lacked, and addressed many access issues only by accommodating an individual with a disability after the product or activity was already created. Sometimes including a person with a disability in an experience was viewed as a charitable act rather than considered to be a commitment to include everyone in the experience.

In reviewing models of disability, Burgstahler noted how the Medical Model of Disability distinguishes people according to “functionality and normalcy . . . infer[ing] that disability results from the individual’s physical or mental limitations” (Loewen & Pollard, 2010, p. 9). This model supports a focus on cure and rehabilitation as well as on efforts to accommodate specific people when products or environments are inaccessible to them. Burgstahler argued that while an accommodation or an “adjustment or modification to make a product or environment accessible to an individual with a disability” may enable participation for an individual, this reactive approach tends to not lead to a more inclusive product or environment for future participants (Burgstahler, 2011, UD and Instruction section, para. 1, 2). Acknowledging the need for accommodations in some situations, Burgstahler proposes the proactive application of universal design strategies to minimize the need for accommodations (Burgstahler & Crawford, 2012). Universal design (UD) is defined as “the design of products and environments to be usable by all people, to the greatest extent possible, without the need for adaptation or specialized design” (Center for Universal Design, 2008, para. 1). The inclusive philosophy behind UD is consistent with the social justice model of disability, which instead of trying to fix someone or something after-the-fact, expects and plans in the design process for people of all abilities and disabilities to take part and be included in an experience (Adams, Bell, & Griffin, 1997; Burgstahler & Cory, 2008). Burgstahler’s introduction to these different models of disability made a case that museums embrace a social justice perspective and apply universal design strategies in their work in order to create exhibits and activities that are truly welcoming to everyone.

Burgstahler was the first of many expert speakers who stressed the importance of UD. As she noted, when something is universally designed it minimizes the need for later adaptation or assistive technology and often benefits everyone (Burgstahler & Crawford, 2012). This idea, pioneered by Ron Mace and now supported by the work of the Center for Universal Design, includes seven principles. These principles underscore the idea of usability for all by stressing the need for "equitable use, flexibility in use, simple and intuitive use, perceptive information, tolerance for errors, low physical effort, and size and space for approach and use" (Connell et al., 1997). Burgstahler highlighted that applying these principles can contribute to making museums inclusive, especially because design elements are so integral to museum environments and are often within the control of exhibit developers and designers.

Indeed, throughout the workshop, staff from the MOS echoed Burgstahler's sentiments about UD and described to workshop participants how the museum has integrated this philosophy into its exhibit design process for over two decades. To showcase examples of how MOS has incorporated universal design elements into its exhibits, staff gave tours of four exhibits, one of which was *New England Habitats.* This was the first MOS exhibit designed with universal design in mind and incorporates tactile models, audio labels, and sensory components into a series of dioramas (Davidson, Heald, & Hein, 1991). Staff explained that a strong cross-departmental commitment to UD has evolved at MOS, in particular, by drawing on visitor feedback that has underscored how not only visitors with disabilities, but all visitors benefit when exhibits are universally designed.

Another strategy that was referenced throughout the CMME workshop by MOS staff and expert presenters alike was Universal Design for Learning (UDL). In particular, Dr. Gabrielle Rappolt-Schlichtmann and Dr. James Basham pointed out that while universal design provides guidelines for the accessible design of all products and environments, Universal Design for Learning more specifically focuses on making learning experiences accessible to all—a notion which ties directly to the informal learning experiences museums offer (Rose & Meyer, 2002). UDL, which was developed in the formal education context, is defined as "a set of principles for curriculum development that give all individuals equal opportunities to learn," and takes into account the need for multiple means of representation, action and expression, and engagement (CAST, 2013, para. 1). With a focus on ways to support "the 'what' of learning, the 'how' of learning, and the 'why' of learning," the principles of UDL are clearly relevant for museums as informal learning settings (CAST, 2011, p.5). Indeed, Rappolt-Schlichtmann stressed how critical it is for museums to incorporate different means of representation within their interactives. As she said, all visitors should be able to take-away the main concepts and messages of an experience even though they may grasp information in different ways. Basham, too, emphasized how basing experiences on UDL principles would help ensure that museums create experiences appropriate for a range of people and different types of learners.

The fourth and final strategy that was introduced at the workshop was personalization. Like universal design, the goal of this approach is to have the same content delivered to all visitors—yet through personalized options. Thus, this approach aims to provide individuals with a range of choices that can support their particular needs. This approach implements design-for-all through a one-size-fits-one approach, providing a variety of personalized alternatives that can create more inclusive experiences. An exhibit, for instance, designed from a personalization standpoint would allow visitors to tailor the experience according to their needs. Options may include the ability to turn on/off/adjust particular design elements such as font size, image descriptions, or captioning (Rothberg, Botkin, & Reich, 2014). Personalization features might even permit visitors to use one of their own electronic devices to facilitate the experience. Dr. Gregg Vanderheiden, in particular, talked about how personalization efforts would allow museums to react to the needs and wants of individual visitors, therefore, transforming experiences that are currently inaccessible into ones that are more inclusive.

When introducing the possibilities connected with auto-personalization to museums, Vanderheiden highlighted the work of an international effort he is actively involved in called the Global Public Inclusive Infrastructures (GPII). This project is devoted to insuring "that everyone who faces accessibility barriers due to disability, literacy, digital literacy, or aging, regardless of economic resources, can access and use the Internet and all its information, communities, and services for education, employment, daily living, civic participation, health, and safety" (Raising the Floor, 2011, para. 1). To do so, GPII is working to "create the infrastructure for making [access technology] development, identification, delivery, and use easier, less expensive, and more effective" (Raising the Floor, 2011, para. 3). In his presentation, he described how having digital interfaces that could automatically change to meet the needs of whoever was using them, such as the ones envisioned in the GPII project, would be an immense step forward (Vanderheiden & Treviranus, 2011; Vanderheiden et al., 2012; Vanderheiden et al.,2013). Vanderheiden stressed the advantages of presenting information in a simple, straightforward, and familiar way and described the far-reaching applications if users' preferences could be stored and transmitted to any device (Wassermann & Zimmermann, 2011; Zimmerman, Jordan, Thakur, & Gohil, 2013). As Vanderheiden mentioned, the work of the GPII project connects not only with UD but directly with the UDL framework for learning, since it aims to provide people with options depending on their needs. Vanderheiden felt, for museums, advances in personalization technology could help exhibits become flexible enough to react to visitors' individual requests.

When taken together, these four approaches underscore the importance of creating accessible physical environments and learning experiences that are inclusive of all visitors. Each of the overlapping ideas offers a perspective for thinking about inclusion—the social justice model provides an overarching context for understanding why museums need to take into consideration all visitors when creating experiences; UD provides guidelines for designing and building those experiences; UDL adds detail for supporting learning for a broad range of visitors who engage with museums; and personalization considers specific options to aid individuals. Since museum work incorporates aspects from all of these areas, speakers repeatedly stressed that there is a need for museum professionals to familiarize themselves with these approaches and apply the underlying principles.

USING DIVERSE TECHNIQUES WILL ALLOW MUSEUMS TO MEANINGFULLY ENGAGE A RANGE OF INDIVIDUALS IN STEM LEARNING

Besides introducing several frameworks that museums could rely on to develop welcoming experiences for all, multiple speakers discussed specific techniques that could help museums engage a broad range of visitors in STEM learning experiences. Drawing upon their work in other fields and their own experiences in museums, speakers talked about the exciting possibilities of offering game-like experiences along with multi-sensory and participatory options in informal science education settings. By using techniques such as these, the experts felt museums could provide powerful, engaging, and inclusive STEM learning experiences.

Gaming approaches and multi-sensory offerings will help museums provide engaging learning experiences

Mark Barlet pointed out that design components of games are very relevant for museums thinking about creating enjoyable, learning experiences that engage all visitors. With the average American household owning "at least one dedicated game console, PC or smartphone," Barlet underscored how companies that create games have clearly honed in on engagement techniques that have mass-appeal (Entertainment Software Association, 2012, p.2). Barlet mentioned how, in order to create an engaging experience, games often include several common features such as the ability to undertake specific tasks or challenges, work through different stages or levels of a game, compare one person's progress and results with another's, have the option to continue the experience at a later point in time, and incorporate sound-effects and other sensory reactions. Since both museums and games aim to involve participants in compelling, interactive, and often social experiences, he noted that museums could draw on these common gaming techniques to create more engaging experiences.

Like Barlet, Dr. Bruce Walker also presented strategies museums could use to create more engaging and inclusive exhibits. Walker, whose research focuses on sonification or "the use of sound to display and analyze scientific data," (Georgia Institute of Technology Sonification Lab, 2014, para. 5) stressed that by incorporating more multi-sensory experiences, especially using sound, museums could convey information in unique and accessible ways. Referring to Georgia Tech's Sonification Lab projects, Walker explained the broader possibilities available through sound. In work connected with their System for Wearing Audio Navigation project, for instance, his lab has created wearable software that can pinpoint a person's location and provide audio information about what is in the surrounding area and where he/she is headed (Georgia Institute of Technology Sonification Lab, 2013b). Walker also described how the Sonification Lab's Accessible Aquarium project is exploring how to convey experiences that "constantly change and require sensory access for visitors to understand what is happening in real-time" (Bruce & Walker, 2009, p. 1). For this project, Walker's lab is testing how to track fish movements in order to translate them into soundtracks and narrations that visitors might hear when walking into an aquarium space (Georgia Institute of Technology Sonification Lab, 2013a). Walker believes that assistive technologies could move beyond providing what Maslow (1943) describes as basic and essential needs and towards conveying aesthetic and cognitive information as exemplified in these two projects.

While Walker and Barlet felt museums could incorporate these techniques to further engage museum visitors, they both noted considerations to keep in mind. Walker, in his presentation, pointed out specific factors that need to be addressed when sonifying graphs to ensure that they can be usable by all. For example, his Sonification Lab has studied design issues related to auditory factors such as pitch, tempo, and stereo audio when presenting graphical information and how various audiences might interpret these differently. Walker encouraged museums to have their audiences in mind and to do user testing to make sure choices such as these are universally designed. Barlet, when talking about gaming strategies, mentioned how inclusive options need to be built into the physical navigation of the exhibit and preferences. Barlet, for instance, explained how gamers or visitors should have the option of turning on or off the time component of exhibits since time pressures might make participation impossible for some. Emphasizing how crucial it is for museums and the gaming world alike to consider accessibility features such as this, Barlet noted that gaming is growing in popularity with older Americans and that people within this demographic often have a disability (Robinson & Walker, 2010). Barlet stressed how building inclusive options into exhibits will help all visitors engage with and learn more STEM content.

Balancing multiple means of engagement will allow museums to be welcoming to all visitors, especially those affected by overstimulation

Like Barlet and Walker, Rappolt-Schlichtmann praised museums for being unique environments capable of engaging people in multi-sensory, memorable experiences. However, Rappolt-Schlichtmann suggested that museums must offer visitors the appropriate balance of emotional stimulation. In her presentation, she described research being done on people's emotional and cognitive responses in order to understand their reactions to certain experiences and how this impacts their learning (Immordino-Yang & Damasio, 2007; Bargh & Chartrand, 1999; Rappolt-Schlichtmann, Tenenbaum, Keopke, & Fischer, 2007). Rappolt-Schlichtmann stressed that museums need to think about how their spaces can encourage active, prolonged learning while taking into account that eliciting too many emotions can actually be overwhelming and detrimental to a visitor's experience (Rappolt-Schlichtmann & Daley, 2013).

To illuminate why museums should consider the emotional stimulation of their experiences, Rappolt-Schlichtmann told two personal stories. In one she described how her daughter was enthralled in a museum theater experience in part because of the show's low-intensity images and noise levels. In contrast, Rappolt-Schlichtmann recalled a different theater visit when the emotional stimulation produced a negative emotional response in her daughter due to the high-intensity graphics and music. Pointing to UDL guidelines and the need to have multiple means of engagement, Rappolt-Schlichtmann used these examples to encourage participants to think about ways to balance emotional arousal states for different visitors. Rappolt-Schlichtmann's presentation provided a reminder that museums need to consider the emotional demands of exhibits that use engagement strategies such as sensory options or gaming features.

Lisa Jo Rudy also encouraged museums to consider the balance of sensory experiences they offer because some people with autism can be deeply affected by overstimulation. Much like Rappolt-Schlichtmann, Rudy's presentation underscored the need to design experiences for people who might have a wide range of sensory and cognitive differences. In speaking about people who have autism, Rudy described the continuum of behavioral and communication challenges that are included in the definition of autism spectrum disorder (American Psychiatric Association, 2013). During her presentation, Rudy urged workshop participants to recognize that people with autism often can be overwhelmed by certain social or sensory experiences such as noisy museum interactives, stage/theater presentations, or crowded lobbies and to consider these factors when deciding on the most inclusive design options.

While recognizing that people with autism may have specific challenges pertaining to noise and crowds, Rudy emphasized how important it is for museums to provide a variety of ways for visitors to connect with the content presented. She stressed how museums have the ability to offer people with autism successful engagement in STEM—which is not always the case in formal education settings—because of the sheer range of free-choice learning options. Rudy, for instance, shared personal examples of how museums and aquariums allow her son, who has autism, to immerse himself in science. Whether it is exploring every detail of a diorama or a fish tank, these settings have provided a venue where he has become engrossed in science. She also felt museums, by showcasing information on a range of topics and using diverse formats, can be comfortable, appealing settings to explore science and even build social skills for people with autism (Rudy, 2010). As Rudy explained, the opportunities to interact with other visitors at exhibits or to take part in programs offers people with autism, especially children, the chance to work on the often challenging skill of social communication in a STEM setting. By highlighting experiences such as these, Rudy underscored the ability of museums to be engaging and welcoming learning environments to a large variety of visitors including people with autism.

Participatory experiences and multiple supports will help museums be more inclusive

At the CMME workshop, Dr. Harry Lang described research pointing to participatory learning experiences as especially effective ways to engage people who are deaf or hard of hearing in STEM education. Citing work he has done on science instruction and educational research, Lang explained the importance of participatory experiences for students who are deaf or hard of hearing as compared to independent or competitive experiences (Lang, Stinson, Kavanagh, Liu, & Basile,1999; Dowaliby & Lang, 1999; Lang & Steely, 2003). According to Lang and his colleagues, a participatory experience in which students can directly engage in questioning, analysis, and discovery of answers is the best approach for enhancing science learning and potentially impacting the “achievement” and “motivation” of students who are deaf or hard of hearing (Lang, Stinson, Kavanagh, Liu, & Basile, 1999, p.24).

Similar to Lang, in Basham’s presentation on Digital Backpacks, he stressed how important it is to create participatory experiences that will support the needs of a range of individuals. Recalling the benefits of personalization that Vanderheiden had mentioned, Basham described how Digital Backpacks provide an example of individually tailored learning experiences within an informal education setting. These backpacks, which apply UDL principles, have three core components. He explained how the digital backpack must have 1) a foundational technology that uses “hardware and software systems…as the general building block for a lesson or project,” 2) modular technology that helps “achieve specific curricular, instructional, and/or student learning needs and outcomes,” 3) instructional support material “that provides structure and/or support for the learning experience” (Basham, Meyer, & Perry, 2010, p. 342-343). In particular, Basham described how he and his colleagues have used Digital Backpacks with elementary students at a zoo to see how the backpacks facilitate “problem-based learning experiences” (Basham, Perry, & Meyer, 2011, p. 24). For this particular project, kids were asked to use their digital backpack to gather data such as images or audio/video clips in order to describe a "kid-friendly zoo" (Basham et al., 2011, p. 26).

Drawing from this work at the zoo, Basham shared applicable lessons for museums hoping to engage visitors in STEM learning through digital technology. He stressed how both museums and digital backpacks should incorporate scaffolds and flexible, easy-to-use technologies that support participatory learning experiences. These technologies should be based in UDL and offer multiple modalities for relaying instructions and encouraging active use. Advocating for a "backwards design process . . . [that] starts with the desired learning outcomes and then moves through designing specific tasks and determining the resources you need to facilitate these outcomes" he explained how important it can be to build hooks that encourage engagement (Basham et al., 2011, p.27). Hooks could include specific roles or responsibilities students might take on during the project or different scenarios they might have to solve. Basham noted how through their research, his team also learned the importance of allowing students to make open-ended decisions. Nonetheless, Basham described how scaffolding an experience can also be useful for participants. In particular, an activity can be structured by providing information about the content of the activity, how to use the technologies at hand, and the expected process and timeline. As he stressed, the goal "is to develop . . . [a] digital backpack that provides for targeted learning but maintains sufficient flexibility and scalability to be useful for multiple teachers and students" (Basham et al., 2011, p. 27). By incorporating a UDL approach and providing various ways for people to participate and express their ideas, Basham explained that Digital Backpacks engage a range of learners and he urged museums to consider similar techniques.

While acknowledging that some museums are already using strategies such as participatory experiences, audio soundtracks, or game-like features, all of these experts encouraged museums to do more in these areas. By using a range of dynamic approaches, the speakers felt museums would be better able to create engaging and meaningful STEM learning experiences for all visitors. However, the experts cautioned museums to be particularly aware of the high emotional stimulation levels that interactive exhibits and multi-sensory experiences can generate because of their potential detrimental effects on some visitors. Nonetheless, they envisioned these techniques as vital components of inclusive museums.

COMMUNICATING STEM CONCEPTS IN MULTI-SENSORY WAYS AND PROVIDING APPARENT ACCESSIBILITY OPTIONS CAN HELP MUSEUMS BE PLACES WHERE ALL VISITORS CAN PARTICIPATE

At the workshop, all of the speakers emphasized how museums are unique places that can engage a range of visitors in a variety of ways. However, several speakers emphasized the challenge of communicating STEM concepts in an inclusive manner. Their presentations highlighted, in particular, factors that museums need to be aware of when designing STEM experiences that are inclusive of visitors who are deaf or hard of hearing or who are blind or have low vision. At the workshop, speakers also stressed the need to clearly communicate details and instructions related to available accessibility features.

In his presentation, Lang focused on several challenges related to communicating scientific concepts to people who are deaf or hard of hearing. Lang described how one major challenge for this group is the fact that American Sign Language (ASL) lacks terms and consistency for communicating scientific concepts (Lang et al., 2007). Because of this lack of standardization, students may be introduced to different signs for the same STEM concept throughout their schooling. Museums' ASL sign-based media or interpretation, therefore, could pose problems for visitors who are deaf or hard of hearing because they may be unfamiliar with the signs chosen to communicate the scientific concepts presented in the exhibits or programs. Lang has been working to create an Online Technical Science Signs Lexicon that aims to provide a way for people to quickly reference or learn new science terms (Rochester Institute of Technology National Technical Institute for the Deaf, 2013). Lang stressed that museums could address this issue of scientific terminology they are employing by providing simultaneous text (e.g. captions) along with media using ASL.

Lang also pointed out that, although much work needs to be done to introduce STEM concepts into ASL, not all people who are deaf use sign language to communicate. In addition, people who are deaf or hard of hearing frequently have low comprehension of English (Marschark & Wauters, 2008; Nover, Andrews, Baker, Everhart, & Bradford, 2002). Thus, reading in-depth labels or explanations may be difficult for them. Building off of his own research, Lang urged museums to incorporate a range of supports such as visuals, text/captions with appropriate reading levels, and ASL when designing exhibits because research has shown that a combination of instructional conditions benefits learners who are deaf or hard of hearing. Lang has found that relying solely on text to communicate educational messages during a computer science lesson has been shown to be less effective than including opportunities to answer questions while reading text and/or viewing media (Dowaliby & Lang, 1999). Including questions that the deaf or hard of hearing museum visitor may answer in an exhibit increases their cognitive engagement. Overall, Lang's presentation underscored the need for museums to design experiences with these various communication options and considerations in mind in order to be inclusive of visitors who are deaf or hard of hearing.

Dr. Cary Supalo spoke about the communication challenges that can arise for people who are blind or have low vision trying to independently take part in STEM. As Supalo explained, there are often very few opportunities in formal or informal educational spheres for people who are blind or have low vision to guide their own STEM experiences. This can occur because the lab equipment does not communicate information in an inclusive manner, and people who are blind or have low vision may need to rely on sighted lab assistants. At the workshop, Supalo shared his own experiences of being blind and being relegated to the role of the note taker or prohibited from conducting certain experiments himself when growing up.

Driven by his own frustration, Supalo decided to create tools that would facilitate entry into STEM careers for people who are blind or have low vision. During his presentation, Supalo demonstrated how his company provides probes and software that allow in-depth lab exploration for people who are blind or have low vision through products that communicate auditory readings in real-time (Independence Science, LLC, 2013). By incorporating auditory capabilities into products such as thermometers, drop counters, temperature sensors, and a periodic table that reads out facts about each element, people who are blind or have low vision can fully participate in lab experiences. This software allows for text-to-speech capabilities during both the data collection and data analysis phases. Stressing the need to provide multi-sensory modes of communication, Supalo's presentation was a reminder for museums to consider how STEM concepts can be communicated in a variety of ways and how assistive technologies for people who are blind or have low vision can provide significant access to information.

Beyond focusing on how to communicate STEM content in an inclusive fashion, speakers at CMME emphasized the need to create apparent accessibility features. Both Walker and Vanderheiden reiterated that sonification and personalization options need to be so obvious that no explanations are required for visitors. Vanderheiden cited a study commissioned by Microsoft Corporation in which Forrester Research, Inc. found that US "working-age computer users" are largely unfamiliar with built-in accessibility features (Forrester Research, Inc. 2004, p. 55). According to this study, "only 44% (57 million) of computer users make use of accessible technology even though a wider audience of computer users can benefit" from using these options (Forrester Research, Inc. 2004, p. 43). Vanderheiden described how this study underscored the need for museums to utilize intuitive design in order to make sure visitors are aware of any accessibility features. In contrast, Vanderheiden highlighted the EZ® Access Keypads designed by Trace R&D Center that allow for accessible navigation of electronic devices (The Board of Regents of the University of Wisconsin System, 2014). Vanderheiden showed how these keypads provide intuitive navigation options. Indeed, both Walker and Vanderheiden stressed that accessibility options need to be readily apparent no matter what type of technologies museums end up employing on their floors.

These experts reminded participants at the CMME workshop of the importance of communicating both the content and instructions in an inclusive manner. As emphasized by the speakers, several factors need to be taken into account in order to overcome the challenges of trying to clearly communicate STEM concepts to all visitors. These factors include being conscious of the level of vocabulary used, the availability of cognitive supports and multi-sensory options, and the ease with which people can use assistive technology and understand what to do at an exhibit. Attention to these aspects can enable museums to better communicate STEM concepts to all visitors including those who are deaf or hard of hearing or those who are blind or have low vision.

EVALUATION, ESPECIALLY INVOLVING PEOPLE WITH DISABILITIES, IS CRUCIAL FOR DEVELOPING INCLUSIVE MUSEUM EXPERIENCES

At the CMME workshop, evaluation was highlighted as an important step in the design process that can help museums identify areas that might be challenging for some visitors and where improvements can be made. Both Dr. Christopher Power and Jennifer Otitigbe provided important reasons as to why gathering feedback, especially from people with disabilities, is crucial for the development process of inclusive museum experiences.

In giving an introduction to evaluation, Power described how evaluation allows researchers and designers to better understand participants' reaction to an experience, any problems that may arise due to its design, and the overall needs and preferences of users. Otitigbe, too, underscored how gathering feedback from people with disabilities is important since they can provide "user/expert" perspectives and give a sense of what is or isn't working (Ostroff, 1997). She gave workshop participants an overview of how various data collection methods such as ethnographic studies, contextual inquiry, diary studies, focus groups, card sorting, interviews, participatory design experiences, and expert reviews can provide information that will help improve museum experiences. Power also shared details about several evaluation methods including how to run a concurrent verbal protocol (think-aloud testing session) or a retroactive protocol in which participants review a recording of their actions. When considering the effectiveness of museum exhibits, Power suggested asking participants to rate the severity of any problems they encountered. Problems could range from cosmetic issues to ones that produce a "usability catastrophe" that would entirely derail the experience such as the inability to navigate to the next step of an interactive (Nielsen, 1995, para. 5).

In his presentation, Power dispelled the myth that evaluation is difficult, expensive, and time-consuming by emphasizing that even gathering feedback from 7-20 participants can provide indications of how and why visitors are interacting with exhibits in certain ways. When recruiting for evaluations, Power advised workshop participants to make sure they don't always call on the same users but vary testers in order to capture a range of opinions and not burden the same people. He also felt it was important to consider the participants' age, gender, and experience level with different types of relevant technology in order to make sure to get a range of feedback. For recruiting, Otitigbe also stressed the need to build relationships with participants and to work with local disability groups when marketing testing opportunities.

Before concluding her presentation, Otitigbe reminded museums to be on the lookout for exhibits that have accessibility features which could still be improved. As she described, user testing could help determine whether or not museum experiences that are thought to be inclusive actually are. Videos, for instance, may have captions, but if the captions are too small or scroll too quickly they will not be useful. Power also urged museums to think about evaluating their overall visitor experience. Specifically, he mentioned research from the University of York which asked visitors about their level of engagement and learning along with their rating of the meaningfulness and emotional connection to an entire museum visit. Power believes these are key areas to consider when measuring a visitor's overall museum experience (Othman et al, 2011).

The examples presented by both Power and Otitigbe illustrate how evaluation could help museums learn more about and address issues that prevent inclusion.

IV. RECOMMENDATIONS FOR MUSEUMS

Even though speakers presented information from a range of fields during the CMME workshop, all made points that related to informal education settings and provided lessons that can be applied to museums. While recognizing several considerations that affect museum work, such as finances, aging exhibits, and the sheer number and range of visitors they serve, speakers highlighted specific steps museums can take to be more inclusive institutions. In particular, they emphasized key takeaways related to the exhibit development process and the design of museum exhibits.

For the exhibit development process, speakers repeatedly stressed how museums should take the following steps to imbed inclusion into their work. In particular museums should:

- Incorporate the goal of inclusion into projects from the very beginning
- Consider ways to involve people with disabilities in the design process
- Perform user testing and evaluation with people with disabilities

By carrying out these actions, speakers felt museums would be more likely to keep inclusion issues at the forefront of a project and not lose sight of their audiences' diverse needs and preferences.

Speakers also offered several suggestions related to the design of inclusive museum exhibits. When creating exhibits, speakers urged museums to:

- Employ a UD/UDL approach to enhance experiences for all
- Be consistent in design
- Make designs intuitive
- Use simple, flexible designs that allow for freedom of exploration
- Deliver information in a variety of modalities
- Provide multi-sensory offerings
- Help people be aware of available accessible options
- Consider personalization possibilities connected with technology

By applying these ideas to exhibits, speakers felt that museums could provide welcoming and enriching learning experiences that communicate STEM concepts to all visitors, including those with disabilities.

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