Developing Accessible Touchscreen Interactives

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Since the advent of the Disabilities Rights Movement in the 1980s and the passage of the Americans with Disabilities Act (ADA) in 1990, museums have made great strides to increase accessibility for people with disabilities. The field has a greater focus on creating exhibitions that can be fully experienced by people with disabilities, effectively changing what is considered "normal" exhibition design.[1] Museums now routinely consider the pull-under heights of interactives, the heights of labels on the wall, and font size, all with the aim of improving the physical accessibility of exhibits. In this article, we describe what we have learned about expanding accessible design for digital interactives and share key lessons applicable to the field, including how these design considerations improve the experience for all visitors, not just for visitors with disabilities.

Today, digital technologies provide interactive learning experiences in a variety of settings, not just within exhibitions. Digital technologies have increased opportunities for Universal Design for Learning in the classroom, and smartphones have become powerful tools for people with disabilities, especially people who are blind or have low vision.[2] Digital interactives, therefore, have great potential for enhancing inclusion in museums, especially for those whom traditional text labels are inaccessible. Yet little guidance is available to help museums design inclusive digital experiences. The digital interactive interfaces most widely used by museums, such as touchscreens, trackballs, and multitouch tables do not take into consideration how people with disabilities use digital interactives. Most interfaces are inaccessible to visitors who are blind or have low vision, and many pose problems for visitors with limited upper body mobility, visitors who are D/deaf or hard of hearing, and visitors with learning or other cognitive disabilities.[3]

At the Museum of Science, Boston, we are developing new strategies for designing inclusive digital interactives. Our work has been accomplished and documented with our partners, including Ideum, WGBH National Center for Accessible Media, and Audience Viewpoints.[4] While the topics and pedagogies vary across our interactives, we seek to design engaging and meaningful learning opportunities for a broad range of audiences, including visitors with and without disabilities. We also strive to create experiences where everyone can learn alongside their friends, family, and fellow visitors.

An Accessible Touchscreen-Based Interactive

Provocative Questions (PQ) is a National Science Foundation (NSF)-funded exhibition that opened in November 2013, and was designed to engage visitors in discussions and decision-making about health issues.[5] This exhibition had both an educational goal of engaging visitors in building viewpoints about social issues connected to health, and a social goal of encouraging visitors to discuss their ideas with one another. Visitors build an argument by selecting combinations of values, personal experiences, and scientific evidence. Based on past exhibitions, we knew how to develop inclusive digital interactives that used a push-button interface, but we found through testing that many visitors expected our interactives to be touchscreens. We decided to use *PQ* as an opportunity to create our first-ever inclusive touchscreen.

When developing this exhibition, we prioritized the needs of visitors with limited mobility who have difficulty reaching all active areas of most touchscreen designs, and visitors who are blind or have low vision who are unable to detect the visual cues used to denote active areas. To search for potential solutions, we spoke with the Visually Impaired Blind User Group (VIBUG), which is a local community interest group for computer users who are also blind or have low vision.[6] We were also inspired by VoiceOver for iOS: this gesture-based screen reader for iPhones provides access to information through audio and allows people who are blind to navigate the iPhone using a series of gestures.[7]

Once we conceived the initial design concept, we engaged in an iterative development process to see if the design could support both the learning and social goals of the exhibition. Early in development, the team decided on a physical design with two computer screens facing each other, to encourage visitors to talk to each other during the activity. It was imperative, though, that the configuration was accessible and ADA-compliant (fig. 1). Evaluating the touchscreen interface with visitors with and without disabilities revealed that the physical layout worked, but that we needed to clarify our instructions and adjust the screen settings to make it less sensitive to accidental selections.

Our final touchscreen design uses an interface where visitors navigate using

Figure 1. Provocative Questions *exhibition. Photograph by Emily Marsh*

a gestural swipe in any location on the screen (fig. 2). The visitor moves between options, which are represented both visually and audibly, by swiping his or her finger across the screen, either left or right. If the visitor swipes his or her finger in a downward motion, their chosen option is selected, and both an audio

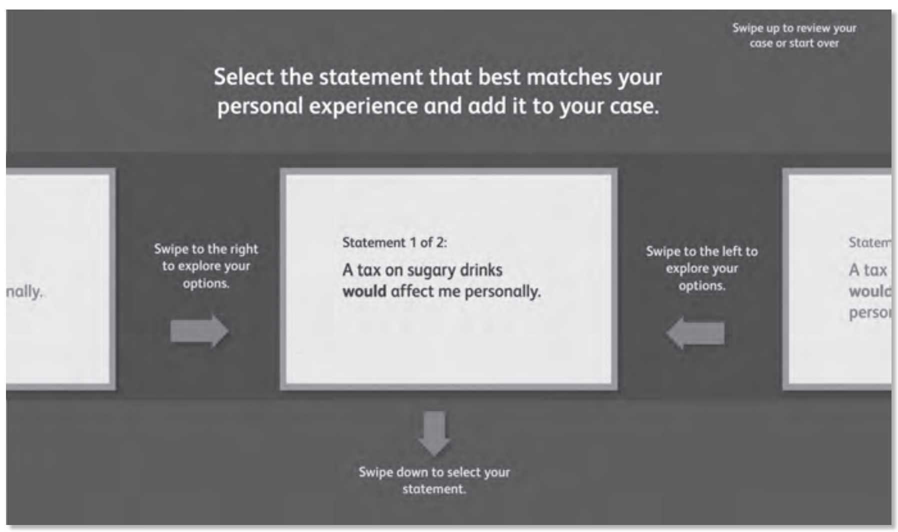

Figure 2. Screen design with gestural swipe instructions. Courtesy of the Museum of Science

and visual cue confirms the selection. We were pleased to find that when using the swipe interface, visitors engaged more thoroughly with the content than in previous versions that employed a traditional touchscreen design.

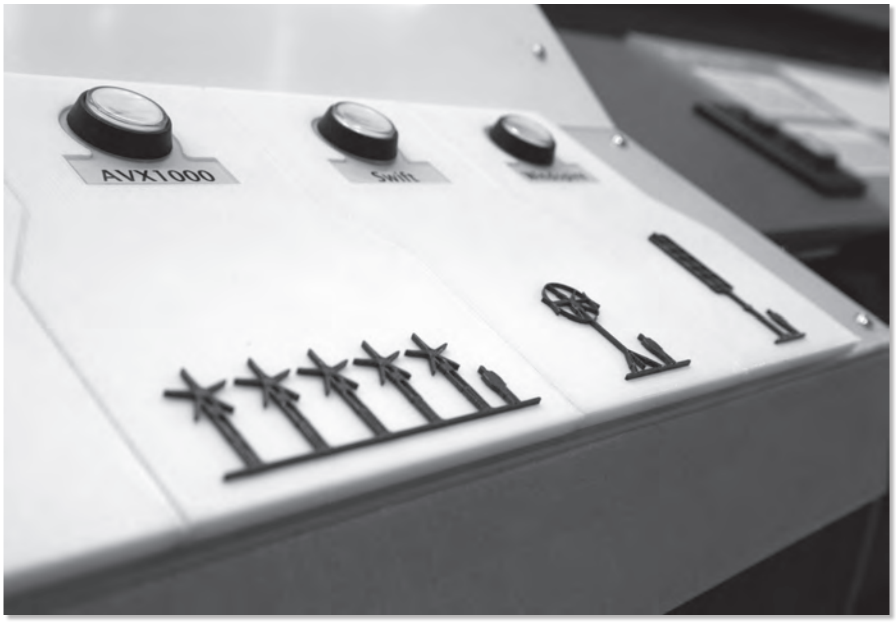

Figure 3. Three-dimensional prints of high-contrast, tactile wind turbine models. Courtesy of the Museum of Science

A Multimodal Way to Engage with Data

As part of our work on the Creating Museum Media for Everyone (CMME) project, through support from NSF, we aimed to find accessible ways to use digital technology to let visitors explore and understand graphed data.[8] We reworked an existing interactive in the Museum's *Catching the Wind* exhibition, which displays graphs showing the power production of wind turbines mounted on the museum's roof.[9]

As with the *Provocative Questions* exhibition, we sought to create an interactive that would work well for visitors with widely different abilities and disabilities. The team focused on a particular aspect of the existing design that hindered access for much of our audience: an over-reliance on visual data presentations, especially when working with dynamic data sets that change over time. The goal, therefore, was to expand the nonvisual representations of the graph content.

This project began with a planning workshop, including experts from the fields of assistive technology, gaming, educational media, Universal Design, and data sonification, many of whom had disabilities. During the workshop we learned about each other's expertise, brainstormed ideas, and then executed some of those ideas into conceptual prototypes. We used data-based descriptions of prototypical individuals with disabilities, also known as personas, to guide this process.[10]

Following the workshop, the CMME team developed some of the conceptual ideas into full exhibit prototypes. One of those exhibit ideas, which ultimately led to the final exhibit design, sought to make data accessible in a multimodal way, specifically by including broadcast audio sonification of both the trend line and individual data points.[11] For the sonified data, the pitch corresponds to the value on the y-axis of the graph, with a higher pitch representing a higher value.

In addition to audio sonification, we also experimented with haptic, or touch-based feedback, such as vibrations or air streams that corresponded to changes in the data. We found, however, that visitors became confused by what parts of the experience they controlled to make selections (input mechanisms) and which parts the computer programming controlled to provide feedback.[12]

During prototyping, it also became clear that visitors needed a clear, concrete connection to the source of the data. We added high-contrast, tactile, to-scale representations of each wind turbine, with audio descriptions, to help visitors connect with the actual turbines on our roof (fig. 3). We also paired the graphs with an animation of the spinning turbine represented in the data.

Finally, prototyping revealed that visitors needed to be oriented to the graph in order to understand it. We again employed multimodal techniques through

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the digital interface, including animated instructions with visual and audio cues to orient visitors to the graph. We found that almost all visitors, regardless of ability, benefitted from this orientation.

For touchscreen orientation, we included tactile and audio cues to help visitors understand what portion of the graph they were touching. For example, if a visitor holds their finger in one place on the graph, a text box appears, and audio verbalizes details about that specific spot (fig. 4). When testing this version with visitors who are blind or have low vision, we found that tactile graph axes with supplemental audio were enough to orient visitors. Because we did not need to include a full tactile grid over the screen, we were able to maintain the digital interface's flexibility to display a variety of graphs, without the full tactile grid conflicting with the data representations, for example, as it would with a bar graph.

Figure 4. Touchscreen text and audio pop-up graph information. Courtesy of the Museum of Science

Lessons Learned, and Recommendations for the Field

The above exhibits are two of the many digital interactive experiences we have designed to be inclusive of visitors with a broad range of abilities and disabilities. Through our exhibition development process, we have learned a number of lessons about the design of inclusive digital interactives that we continue to refine and strengthen moving forward.

Specifically, our process for developing digital interactives involves three core elements:

1. We build upon existing designs from within the museum field, and learn from work in other fields, such as the design of accessible ATMs, smartphones, and classroom software.

2. We focus on the user by hiring advisors with disabilities, working with community groups, and/or using personas. Advisors provide our exhibition development teams with continued feedback and help personalize the effort. Data-based personas inform our initial brainstorming process, and then serve as a tool to refocus our designs and ensure that we have kept in mind a broad range of visitor needs.[13]

3. We prioritize time and funding for iteration and testing with a broad range of users. While we feel it is important to test interactives with all of our visitors, it is critical to include visitors with disabilities whose lived experiences might differ from our own.

This process always begins with an initial set of design considerations, which we recommend as essential for developing digital interactives:[14]

- ***Ensure that there are multisensory ways to input choices and receive feedback.*** For example, button and

Endnotes:

[1]*Everyone's Welcome,* John Salmen, ed. (Washington D.C.: American Association of Museums, 1998); Jeff Kennedy, *User friendly: Hands-on Exhibits That Work* (Washington D.C.: Association of Science-Technology Centers, 1997); Smithsonian Accessibility Program, *Smithsonian Guide for Accessible Exhibition Design* (Washington, D.C.: Smithsonian Institution Press, 1996); Association of Science-Technology Centers, *Accessible Practices*, last modified 2000, http://www.astc.org/resource/access/index.htm.

[2]James D. Basham, Helen Meyer, and Earnest Perry, "The Design and Application of the Digital Backpack," *Journal of Research on Technology in Education* 42, no. 4 (2010): 339-59; David H. Rose, Anne Meyer, Nichole Strangman, and Gabrielle Rappolt, *Teaching Every Student in the Digital Age: Universal Design for Learning* (Alexandria, VA: Association for Supervision and Curriculum Development, 2002); Liat Kornowski, "How the Blind are Reinventing the iPhone," *The Atlantic*, May 2, 2012, http://www.theatlantic.com/technology/archive/2012/05/how-the-blind-are-reinventing-the-iphone/256589/.

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gestural interfaces provide both tactile and visual cues for making selections; audio and visual cues tell the visitor that the computer has detected their input.

- ***Present goals, directions, and interpretive information in multimodal formats.*** We have found it to be most effective when text, audio, and images combine to communicate to visitors all of the information they need—not just what to do but the goals of the activity and the content to be learned as well.

- ***Use clear, simple text that is free of jargon.*** As with written text labels, this is especially important for visitors who experience difficulty reading or listening to the language.

- ***Ensure that input devices are within easy reach, require minimal dexterity, and provide tolerance for error.*** If we use a button interface, we make sure that the controls are at the edge of the table, easy to press, and placed close enough together to be operated with one hand. If we use a touchscreen, we place all active areas at the bottom of the screen and make sure there is enough space between areas so that visitors do not make unintentional selections.

- ***Provide user control over the pace of interaction and feedback***. Some visitors need more time to process information or respond to feedback; other visitors may need information repeated.

- ***Limit the amount of content and/or activity that is available through any one interactive.*** With digital interactives, it is tempting to overload content; after all, there are no physical limits to the amount of information that can be provided. Our evaluations, however, show that most visitors do not purposefully select content in the kiosk and very few dive deeply into the content provided. We have also found that having a large number of choices present at any one time can overwhelm visitors, especially those with cognitive disabilities and those who rely on auditory feedback.

- ***Pay attention to the physical design of the digital interactive.*** As with any hands-on interactive it is important to consider the physical design. This includes providing stools, having adequate room for wheelchairs to pull underneath a kiosk, reducing background noise, and providing adequate lighting while also minimizing glare.

We have found that these design considerations improve the experience for all visitors, not just for visitors with disabilities. We do not view these design considerations as extras, or something we only do when time and budget allows. Rather, they have become our hallmark of a strong digital interactive design. This is not to say, however, that these design considerations are fixed. Through each new interactive

Endnotes continued:

[3]Deaf with a capital "D" is used to identify individuals who view being Deaf as a cultural and not a disability group. Culturally Deaf individuals tend to speak Sign Language as their primary language. Lower case "d" deaf refers to individuals who have hearing loss, but do not necessarily identify with Deaf culture and may not speak Sign Language. Carol Padden and Tom Humphries, *Deaf in America: Voices from a Culture* (Cambridge, MA: Harvard University Press, 1988).

[4]"Making Exhibits Accessible," *Open Exhibits*, 2015, http://openexhibits.org/research/cmme/; "Creating Museum Media for Everyone Project Details," *Informal Science*, 2012, http://informalscience.org/projects/ic-000-000-001-031/Creating_Museum_Media_for_Everyone.

[5] *Provocative Questions: Supporting Effective Dialogue about Societal Issues Informed by Human Biology in a Changing World* (Division of Research on Learning grant: National Science Foundation, 2010). Award number DRL-1010830.

[6]*Visually Impaired and Blind User Group*, (VIBUG), http://www.vibug.org.

[7]"VoiceOver for iOS," *Apple, Inc.*, 2015, http://www.apple.com/accessibility/ios/voiceover/.

[8]*Creating Museum Media for Everyone* (Division of Research on Learning grant: National Science Foundation, 2011). Award number DRL-1114549.

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we develop, we try something new as we test our ideas with visitors and advisors with disabilities. This process causes us to refine our design criteria over time. As technology advances, and visitors use technology differently in their day-to-day lives, we, as a museum field, need to strategically adopt and adapt these advances, in order to take advantage of accessibility opportunities and make exhibitions useable by visitors with and without disabilities.

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[9]"Catching the Wind," *Museum of Science,* 2015, http://mos.org/exhibits/catching-the-wind.

[10]Stephanie Iacovelli, "Using Personas to Create Inclusive Digital Exhibit Interactives," *Open Exhibits* (blog), July 15, 2014, http://openexhibits.org/accessibility/using-personas-to-create-inclusive-digital-exhibit-interactives/8777/. CMME: *Using Personas In Exhibit Development*.

[11]Emily O'Hara, "CMME Final Exhibit Component," *Open Exhibits* (blog), September 30, 2014, http://openexhibits.org/museumofscienceexhibit.

[12]Marta Beyer, Peter Moriarty, Emily O'Hara, and Robert Rayle, "CMME: Haptic Paths Not Taken," *Open Exhibits* (blog), November 14, 2014, http://openexhibits.org/accessibility/cmme-haptic-paths-not-taken/8972/.

[13] Emily O'Hara, "CMME: Using Personas in Exhibit Development," *Open Exhibits* (blog), December 30, 2014, http://openexhibits.org/CMMEPersonaUse.

[14] Emily O'Hara, "Universal Design Guidelines for Computer Interactives," *Open Exhibits* (blog), June 16, 2015, http://openexhibits.org/accessibility/UDguidelines.