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I, David Solko, hereby submit this original work as part of the requirements for the degree of Master of Design in Design.

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Evaluating Enhanced Reality Interfaces and the Museum Experience

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Abstract

The Cleveland Museum of Art, San Francisco MOMA, and Cooper Hewitt's new applications and interactives exemplify best-practices for museum embracement of technology. A detailed analysis of their approaches reveals how the appropriate application of technology coupled with play theory can radically change the experience and information available to the museumgoer. Providing different views, of both object and opinion, and making inaccessible archives and objects freely available can increase community outreach and visitor numbers. This thesis will look at how play, gamification, augmented reality, and social media elements can build upon these implementations and by improving the visitor experience, education and reach.

History of Interactivity in Museums

Public museums have existed since at least 1471 when Pope Sixtus IV donated sculptures to the Capitoline Museum. The first western art museum is the Kunstmuseum in Basel, founded in 1671 (Art Gallery, n.d.), and museums in America are nearly as old as the country itself. Originally, they were not much more than circus sideshow attractions with oddities like paintings of exotic places and Wooly Mammoth bones; many were owned by B.T. Barnum (Block, 2008).

The attempt to recreate reality, originally in the form of cast reproductions, date back to at least 1867 when the Victoria and Albert Museum displayed casts of sculptures and the St. Sebaldus shrine (Bearman, 2011). Interactive exhibits have their origin in children's museums during the early 20th century, where visitors were encouraged to explore by playing with the exhibits. Interactives didn't see wide adoption beyond children's and science museums until the late 20th century. Self-guided museum tours were cassette recordings and came in multiple languages. Early museum websites were up by late 1996 (MOMA, n.d.), and by late 2004, podcasts were beginning to replace audio cassettes (Art Mobs, 2004).

Currently, most museums only scratch the surface of what is possible with their implementation of technology. While finances are often an issue, a reluctance to embrace technology by directors is also a major factor, resulting in an ad hoc solutions enisled from each other. "There has been a tendency in museums to add interactivity or technology — however gratuitous — or to mask serious subjects in the guise of popular culture, in order to make their offering more 'fun" (Walker, 2011). Interactive elements are often limited to simple puzzles, and technology elements are often to audio tours or websites which make the museum's collection available anywhere. While both are positive advancements, the real value of interactive and technology implementation in museums is the ability create more engaging experience which is

more challenging, inspires thinking, and allows the visitor to experience an exhibit in ways previously not possible.

Some museum interactive elements have begun limited integration of creative technological solutions into exhibits. The British Museum had an interactive table which allowed the visitor to explore a Predynastic mummy (Figure 1). "A virtual autopsy table ... will let visitors explore this natural mummy for themselves, using the interactive touchscreen and the gesture-based interface. Information points at relevant locations guide visitors to the more significant discoveries we have made" (Virtual autopsy, 2012). Using the display, visitors can rotate and slice through the mummy courtesy of a CT scan done on him.

Figure 1. Exploring the scans of Gebelein Man on the interactive screen. (Virtual autopsy, 2012)

The Museum of Mediterranean and Near Eastern Antiquities in Stockholm also installed a virtual mummy exhibit. Their version allows for the removal of the sarcophagus, wrappings, skin and soft tissue. "Medelhavsmuseets' visitors are able to, for the first time, study a mummy

in detail, on their own and based on their own personal interest. With simple gestures they can investigate complex data, which would normally only be available to researchers. The visitor can also, themselves, choose the language, level of information and subject" (Medelhavsmuseet, 2012).

Instead of enabling the removal of layers of an object, the Royal Ontario Museum's dinosaur exhibit allowed visitors to put flesh back onto dinosaurs. "We can see what they would have looked like with skin on when they were alive and how they would have moved and behaved" (Globe and Mail, 2012). The Smithsonian National Museum of Natural History has created a similar experience in the Bone Hall with the *Skin & Bones* app, breathing new life into one of the museum's oldest exhibits (A Hall, n.d.).

With a slightly different take, in 2012, the Laguna Beach Art Museum used augmented reality to bring motion to a photo exhibit. "Dancers frozen in an image start to spin on your smartphone screen; a woman captured under water suddenly swims away. It's the first phase of images escaping their frames" (Rieland, 2012; Gourley, 2012).

Many of these were temporary installations. While they increased participation and were considered successful , the institutions failed to capitalize on the experience by including these interactives in their permanent collection. However, three institutions, the Cleveland Museum of Art, San Francisco Museum of Modern Art, and the Cooper Hewitt Smithsonian Design Museum stand out from the others and were chosen for more in-depth study due to their reputation and innovative adoption of technology as part of recent, major renovations. These museums, and others, were visited. Attempts made to follow-up with interviews or questions were unsuccessful, with only Cleveland responding.

Cleveland Museum of Art

In 2013, the Cleveland Museum of Art released a groundbreaking new gallery, Gallery One, and a companion app, *ArtLens*. This two-pronged approach to encouraging visitor interaction throughout the museum was avant-guard, and is still state-of-the-art.

Gallery One's showcase element is a 40-foot Collection Wall (Figure 2). The Collection Wall is a touch screen which allows up to six people to simultaneously explore the museum's collection. Thumbnails of the collection slowly scroll across the wall, which scale to high resolution images when touched. While looking at an image, the user can explore related objects linked by artist, time period, style, and location. This touch screen allows visitors to access and

Figure 2. Visitors using the Collection Wall

explore the more then 4000 items in the museum's collection currently on display, create a self-curated tour, and download it to the *ArtLens* app on an iPad, iPhone, or Android device (Gallery One).

In addition to the wall, Gallery One has several other interactive kiosks; the two most innovative are the face-making and pose-striking kiosks, each on 42-inch multi-touch displays (Figure 3). Utilizing Microsoft's Kinect motion sensing technology, the face-making interactive has the visitor make a funny face. Images in the museum's collection which match the visitor's are then displayed. The interaction is reversed with pose-striking kiosk. In it, the visitor selects a piece of art and attempts to strike a pose similar to the artwork's. Again leveraging Kinect's technology, a stick figure is superimposed on both the art and the image of the visitor to assist in the mimicry.

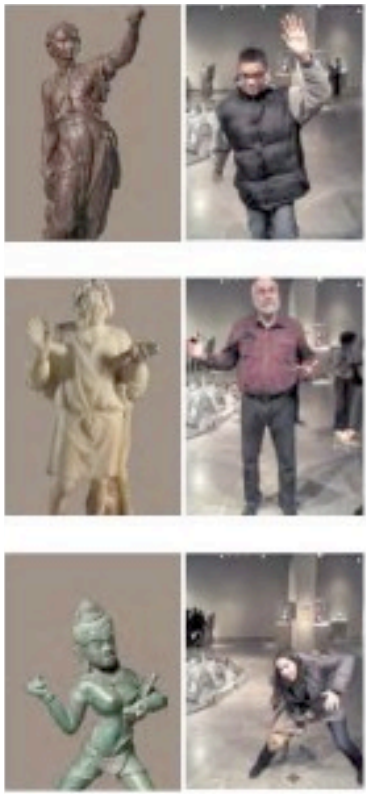

Figure 3. Visitor poses matched to artwork (Alexander, 2013)

The *ArtLens* app enables visitors to view content and tours created on the Collection Wall on their mobile device, share favourite artwork with social media, and save their self-curated tours for use by other visitors. In addition, wall labels on many of the museum's pieces have an icon indicating that the app can recognize the work simply by pointing the phone's camera at the art. Once identified, *ArtLens* brings up a high-resolution image of the artwork along with a description of the work, nearby objects, and other popular, related works. Additionally, many items have short videos which provide additional information. Inside the museum, recognized artwork brings up an augmented reality interface which displays context-sensitive labels.

If the visitor chooses to follow one of the many tours in the app, they are provided with walking directions to the next piece of art; alternatively, they can explore by suggestions of similar objects, or pursue the nearby art, "allowing visitors to scan works to find digital

interpretation for works they gravitate toward as they browse through the galleries (Alexander, 2013).” This browsing capability was integral to the design of the app as the museum’s previous research showed that visitors showed more interest in individual objects, rather than the theme of the gallery: “visitors told us that they had not really thought about overarching themes that organized the works in a gallery, but were more drawn to individual works of art” (Alexander, 2013).

The *ArtLens* app was recently updated, correcting many of the design and usability issues with the original version. Chief among these issues was the need to pre-download all art before loading the app — more than 400MB. This could result in a 20 minute delay during the original launch. Unlike the initial version, *ArtLens2* is usable before it completes loading the images. One issue with the interface in the first version was the lack of colour coding of the galleries, changing only on each floor. The revised version differentiates each gallery, improving the usability by providing the user with stronger wayfinding capabilities.

SFMOMA

In May, 2016, the SFMOMA reopened after a significant remodel and expansion; a mobile app in June. Like *ArtLens*, the SFMOMA app has features such as image recognition, curated tours, a map of the museum, and high-resolution images of the museum’s collection with descriptions beyond that of the wall labels.

SMOMA has several innovative features in their app. In addition to traditional tours, the curated tours include creatively themed options such as play-by-play sports and comedian themes. These themes help customize the user experience and provide a more entertaining experience for the visitor.

There are several interactives which SFMOMA uses to bridge the user / artist barrier and entice exploration:

> Tools such as audio guides, computer interactives, multi-layered text labels as well as specially trained mediators are helping to make the museums experience more worthwhile for visitors by linking the visitor experience with the collection displayed and initiating a communication between the visitor and the object. (Waltl, 2006)

In the restaurant area, several interactive areas are available to use. Self Composed is a light table, camera, and display on which you place personal objects (Figure 4). Opaque objects on the table create a transparency mask on the display which reveals the user's image. Once satisfied with the work, users can create a 3" x 5" thermal printout of the display.

Figure 4. Using the light table. (Solko, 2016)

There is also the ability to pair two devices so you can listen to the audio in synch. This allows visitors to share their museum experience. Despite the ability for the app to accurately

locate a visitor in the museum, it does not share the location of the person you are partnered with. While this feature wouldn't be useful if you explore the museum together, it would be useful if your exploration isn't in synch.

When taking a guided tour, the app was quite impressive. Using iBeacons, it kept a fairly accurate track of my location and based the tour's pace on my location. However, the location awareness of the app often lagged my position by several feet when wandering randomly. This resulted in occurrences where the artwork presented was for the wrong room.

One of the most notable differences between the SFMOMA app and the CMA's *ArtLens* is the decision to not make the museum's collection available outside the museum. *ArtLens* makes the museum's entire collection on display available to anyone using the app, regardless of location. While a recent, October 2016, update added brief previews of some of the audio tours, the app is effectively useless unless you are within the museum. A virtual presence, by way of an app, can expose the museum to a larger audience: "It can reach audiences that the physical counterpart never could and through user-friendly interfaces to encourage users to visit and access the site, and ultimately become customers of the organization" (Dumitrescu, 2014). SFMOMA seems to be missing the boat by not making even a selection of its collection available to the wider public through its app.

Cooper Hewitt

Cooper Hewitt reopened with a radical new interpretation on using tech to improve the visitor's experience. One of the main interfaces they chose was a pen because they wanted a minimal intrusion into the gallery experience. "The Pen was pitched as a way to invite visitors to learn about design by designing themselves. Beyond working as a tool for drawing, it would encourage visitors to engage with the works on view in the museum, rather than looking at them

through the small screen of the more traditional approach of a 'museum App'" (Designing the Pen, 2016).

In practice, I found the pen was not as intuitive as intended. While the pen is a relatively unobtrusive device to carry, unlike a phone, it has no built-in help and the visitors need to be instructed on how to use the device. At most items, there was a plus-sign mark on the museum label (Figure 5). Aligning and pressing the pen on the icon produces a tactile feedback, activates a row of dotted lights near the bottom of the pen, and saves the item to the visitor's account. There were problems using the pen as not all marks had a functioning tag underneath. In some cases, pressing the pen around the mark eventually worked. However, in a couple of cases, I was unable to save the item. This seems to largely be an issue with implementation. In many cases, the NFC tag is placed in the label's frame with the signage slipped into the label. A sloppy installation would allow the icon to be misaligned with the tag and inhibit proper communication between the tag and pen.

Figure 5. Using the Cooper Hewitt pen. (Murphy, A)

A larger issue is that the visitor has delayed gratification when it comes to revisiting the saved items. While there was feedback, I had to have faith the items were actually being saved. The only way for me to review what I had selected is to visit the website and enter a code printed on my ticket, or on the tables described below. Because of that, I still felt the need to use my phone to document some of my items, as did several of the other pen-wielding visitors.

Cooper Hewitt also added touch-screen tables throughout the museum which can interact with the pen, showing what was saved during the visit and recommending items in the collection which are not on display.

> The best part of the interactive tables is that you can browse the collection simply by doodling a shape. Playing with a prototype of the table in Barton's office, I draw a half-hearted squiggle, and a vase that incorporates a similar shape pops up. I draw a circle, and a tapestry appears. I doodle a few curvy lines, and Peter Schlumbohm's Chemex pour-over coffee maker appears. (The 5 coolest things, 2014)

In practice, it was not obvious which items were on display and which were part of the archives. There were also several stations at the tables which were unable to show the saved items. The table interface is well designed. Sinuous paths run the the length of the table and small circular icons meander down it, inviting the user to press them. Instructions display periodically, encouraging the visitor to interact with the table. Selecting an icon reveals a larger image of the item with label information. Alternatively, scribbling a simple line will bring up an item in the collection which matches the squiggle.

The Immersion Room allows the visitor to explore the museum's collection of thousands of wallpaper samples and project them onto the room's walls. A visitor can peruse and scroll through them and also create their own pattern by drawing on a simple interface on a kiosk table.

In a different room, visitors can explore Gesture Match, where a camera analyzes movements and gestures and displays an object which is similar to the pose struck, similar to how facial expressions are matched at CMA. “Strike a pose in front of the motion sensors, and Gesture Match will cycle through its catalog of gestures to connect your posture to a piece of design. Raise up both arms, and a magazine cover from the collection featuring a doll in a similar position will appear. Pretend to drink something, and it will bring up a set of cups” (The 5 coolest things, 2014).

Emerging Technologies

Location awareness

Technology is a moving target and there is always a newer, better option around the corner. In this century, determining which object a visitor was viewing has evolved at least four times. Initially, self-selecting a tour on a mobile device was required to start the descriptions. Like audio cassettes before, if you wanted to move at a slower pace, you needed to pause the audio playback. More recently, technology has improved and allowed for the device to determine the object in front of which a visitor is standing. QR codes on an object label can be scanned to determine the object. In the past few years, location tracking has improved so the visitor’s mobile device can know its location via protocols such as Beacons, an open technology developed by Apple.

Beacons is a Bluetooth technology that broadcasts a signal. Multiple beacons are placed in a room, and in a manner similar to GPS, an app on the mobile device triangulates the position, allowing location to be determined down to a few inches. In 2014, a UN exhibit on land mines used beacons to explode virtual mines whenever a visitor walked too close to the hidden beacon (IPG, 2014).

Image recognition

Image recognition has improved in both speed and quality so that a phone can identify which artwork the museumgoer is looking at. Simply by pointing a phone at an object as if taking a picture, artwork can be identified in less than a second. While image recognition works best with flat objects due to the difficulty of identifying the varying shapes of a statue, even that limitation is quickly disappearing. Apple uses 3D mapping technology to authenticate the iPhone owner via facial recognition. This same technology could be applied to mapping and identifying sculptures on display

A recent update to Google's *Arts & Culture* app provides the ability to match a selfie with its huge artwork database. Leveraging this capability will allow visitors to find their likeness in the museum's artwork and curate a tour around them, encouraging them to explore the collection.

Using a combination of Beacons and image recognition, along with built-in compass and motion sensors, it is now possible to pinpoint not only the location, but the orientation of a visitor. This enables an audio description or tour to not only adjust to the pace of a visitor, but to guide them automatically to the next object. Once it is determined that a visitor is in front of a piece, audio descriptions and visual information such as augmented reality can dramatically increase the information available to the visitor.

Augmented reality and virtual reality

Augmented reality is the "concept of blending (augmenting) data — information, rich media, and even live action—with what we see in the real world" (Johnson, 2010). Around since the late 60s, computers, and more importantly, mobile devices are now powerful enough to make use of the technology. Google and HTC have both begun serious explorations into augmented reality with Glass and Vive respectively, Facebook recently purchased Oculus, Microsoft has

HoloLens, and Apple has released ARKit and Google ARCore, both code libraries which simplifies the development of AR applications.

AR is an emerging technology, and is one of the most important directions technology will take, not only within museums, but in everyday life. Some solutions, like Oculus and Vive require the user to don an opaque headset which looks like oversized ski goggles, while ARKit and ARCore enable AR implementations on mobile devices. HoloLens splits the difference, projecting objects on a clear headset. Apple and Google's solutions are likely to be the winners for three reasons: headsets are bulky, headsets often run hundreds of dollars, the code libraries add features to millions of existing smartphones.

Museums are full of a rich variety of objects which have a wealth of information available about them and a limited space and time to provide that information. Of necessity, wall labels need to be small and only have room for limited information. Audio recordings go a long way towards providing additional background information, but are limited in their ability to customize the experience, and fail to fully leverage the capabilities of the available technology.

The possibilities to enhance a visitor's experience are nearly unlimited, and simple implementations are already being explored. When pointed at a piece of artwork, the *ArtLens* app allows the visitor to view additional information about the work such as popups and videos.. More ambitious possibilities could recreate St. Sebaldus shrine, allow a visitor to flip through the Book of Kells, or provide a full translation of cuneiform appearing as an overlay on the clay tablet.

> We can, of course, already envision the potential of such technologies for museums: a small shard of pottery will be augmented by a complete and beautiful vase, while the skeleton of a dinosaur will be layered with muscle, tissue and skin. We can indeed

> imagine seeing the audience sitting on the benches in the Colosseum, even hear the lions roar. (Schavemaker, 2011)

Virtual reality is a maturing technology similar to AR, and differs in that AR enhances what is seen whereas VR replaces what is seen. This imposes safety limitations on VR implementations as the user cannot see the environment around them. Also, immersion requires significant processing power, and current technology cannot create environments indistinguishable from reality. Like other computing limitations, those of VR will likely be resolved in the next decade as computing power increases and components decrease in size, but until VR can exist in an eyeglass size, it will be a limited to niche museum exhibits.

Artists are already using AR and VR in their artwork (Farago, 2017; Perez, 2017), and they will undoubtedly push the new technology in unexpected ways. Museums may find clues from artists as to how these technologies can be applied. Matt Collishaw has recreated an early photo exhibit from 1839, including the gallery, as a virtual exhibit (Thresholds, n.d.). While impressive, his exhibit exemplifies the problems with virtual reality. The bulky headset requires a backpack to power the system; once it's on, a guide is needed to help the museumgoer into the exhibit; and due to the technical limitations of the equipment, the graphics look clunky.

Felice Grodin's exhibit in The Perez Art Museum Miami uses augmented reality to place virtual sculptures in the museum (Figure 6). Built on ARKit, the exhibit is experienced through iPhones. The same concept can be applied to creating VR representations of museum objects, making it possible for a visitor to manipulate objects too fragile to touch in reality. A Chinese vase can be scanned and recreated digitally, allowing the visitor to inspect the potter's mark. An object on loan can still be appreciated in its original location, or the back of a painting examined.

Figure 6. Invasive Species AR exhibtion at the The Perez Art Museum (Perez Art Museum, 2017)

Implementation costs of AR and VR have dramatically reduced with the new solutions which have rolled out in the past year by technology juggernauts. Museums are competing with the enticing visuals of video games. AR and to a more limited extent VR are a pair of technologies which can revolutionize the museum experience.

Gamification

Museums often struggle to encourage better visitor engagement. One possible tool to encourage better engagement is gamification, the process of taking game-like concepts and techniques, such as rewards and puzzles, and applying them to non-game situations for training and motivational purposes (Robson, 2014). Huotari defines gamification as “a process of enhancing a service with affordances for gameful experiences in order to support user's overall value creation” (Huotari, 2014). In the last few years, gamification has become a staple with

businesses. The Khan academy successfully uses gamification techniques to increase user investment in learning, "one of the first things we did was bring in the concept of badges and other game mechanics" (Sinha, 2012). When marketing a new car in China, Volkswagen used gamification techniques: "VW's recognition that participation in a popular business initiative needs to be not only enticing and rewarding but also engaging and fun—more than a bit, in fact, like playing a game" (Ryan, 2013).

Gamification can be used to increase visitor enjoyment,learning, and retention of new facts. In his comparison with The Laws of Learning, first postulated by Edward Thorndike, Murphy discovers that "Games work because of the laws of learning. In other words, the things that are known to improve learning are almost exactly the reasons why games work" (Murphy, 2011). A central concept to successful games is Csikszentmihalyi's flow: "We become so totally engaged in what we're doing that time becomes distorted, somehow it seems to both slow down and to fly by unnoticed. In such a state, we perform better, forget ourselves, and become one with what we're doing" (Hussain. 2013).

Gamification is more than simply taking gaming elements and applying them to a non-game environment. Some elements, such as time pressure, boss battles, and consequences, are not generally conducive to the learning environment. Accenture identifies seven significant gaming mechanics which can be leveraged: personalization, milestones, social connectedness, rankings, status, immersion reality, and competition (Ryan, 2013). Applying these elements to museums can increase visitor engagement and learning. Discrete interactives such as Cleveland's face-making and pose-striking kiosks can be tied to the museum's collection to create a personalized tour. Social connectedness can be encouraged by creating a museum microsite for visitors to share their experiences online and encourag sharing on existing social media sites.

Flow

In the 70s, Mihaly Csikszentmihalyi defined flow as "the state in which people are so involved in an activity that nothing else seems to matter; the experience itself is so enjoyable that people will do it even at great cost, for the sheer sake of doing it" (Csikszentmihalyi, 2009) This subjective state is reached when the difficulty of the task at hand matches the skill of the user; the more skillful the user the more difficult the task needs to be, and when achieved, activities become more engaging. There are seven elements intrinsic to the creation of flow: balancing the challenge with player skill and time, an intense concentration, the use of clear tasks with immediate feedback, a minimization of distractions, an impression of control, a diminished awareness of self, and an altered sense of time (Murphy, 2014). When the tasks are too difficult, users become anxious and lose interest; when they are too simple, users become bored. Both result in a frustrating experience (Figure 7). However, when balance is achieved, it is possible to create a self-rewarding system which entices additional play. "When an activity is able to limit the stimulus field so that one can act in it with total concentration, responding to greater challenges with increasing skills, and when it provides clear and unambiguous feedback, then the person will tend to enjoy the activity for its own sake" (Csikszentmihalyi, 2009).

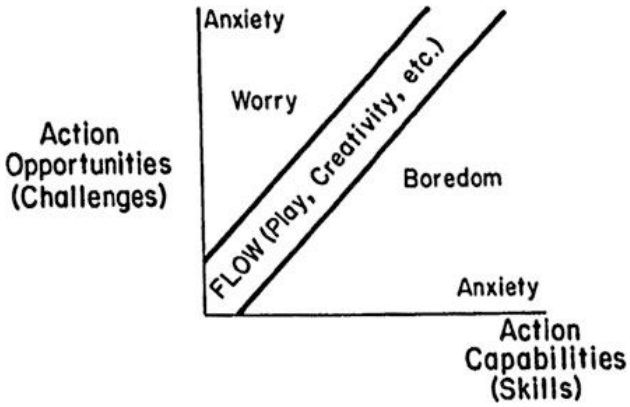

Figure 7. Illustration of Flow. (Csikszentmihalyi, 2014)

Learning opportunities are increased by flow because the elements of flow closely parallel the laws of learning first described by Edward Thorndike in the early twentieth century.

These laws, based on observation of animals and since tested on people, describe what enables more effective learning. His principles are readiness, someone learns best when they are prepared to learn; exercise, practice and repetition increases learning; effect, positive feedback increases learning; intensity, strong experiences lead to a heightened focus and better learning; primacy, first impressions are the most influential; and recency, we retain recent knowledge better (Murphy, 2014).

Looking at flow and the laws of learning, it becomes obvious why interactive exhibits like the CMA's expression and Cooper's pose are successful. Both involve exercise by allowing the user to repeatedly perform a simple task. Both incorporate intensity and concentration to create the facial expressions or poses. Both provide effect and instantaneous feedback in the form of an image which matches the player's. In addition, both leverage the principle of flow. They require relatively simple tasks which, while initially entertaining, quickly become repetitive and drop the experience opportunity below the flow area. Because neither allows leveling up — they don't provide an increasing level of difficulty over time — they rapidly move out of flow. The end result is a fun, but short period where the activity fits within a typical museum visitors interest and encourages short episodes of use by individual visitors. This is most likely intentional; because flow is not maintained, demand is artificially limited to help balance the limited supply of kiosks.

Recommendations

While gamification is a trendy theory to apply to museum needs, it is not the best solution as it create an environment where the museum experience is the means, and not the end. Rather, we should look at the slightly different theory of play for a better solution. "In play, people engage in an activity for its own intrinsic value or pleasure. In play, attention is focused on the

means more than the ends, and players do not necessarily look for the easiest routes to achieving the ends (Gray, 2015).

However, flow and elements of gamification are important components of play. The characteristics of play are: self-chosen and self-directed, intrinsically motivated, guided by rules, imaginative, and conducted in an active and nonstressed frame of mind (Gray, 2015). A distinction between gamification and play is that gamification is used to "motivate people to engage in particular targeted behavior" (Landers, 2014), whereas play is a pleasure for its own sake (Sutton-Smith, 2008). While education is expressed as an important purpose of a museum, it is not the only purpose. "Museums are seen as a fun and educational day out, either as a supplement to the more rigid education of schools or as a way for families to spend time together" (Museums Association, 2013). When interactions are entertaining, users, especially children, tend to spend more time exploring the exhibit. "Results indicate that the exhibit elicits more extended durations of engagement among boys and young children than girls and older children" (Rowe, 2014). This is important because there is a strong correlation between time spent in a learning activity and the amount of retention (Apostolellis, .2014).

Play can also be used to introduce the visitor to new experiences and help guide them through their visit as they usually come without a specific experience or learning outcome in mind (Walker, 2013). Encouraging play doesn't require a large investment. Because of this, it can be applied nearly universally to the benefit of both the museum and the museumgoer: "it is not the quality of the collection which is the main factor for potential visitors when deciding to visit a museum or gallery, it is much more the environment as a whole and the interaction with the collection that proves to be the key factor" (Waltl, 2006). It is this unifying the disparate

interactive elements in the museum which is the most effective way to improve the overall engagement.

Looking at the museums previously discussed, designing for play can improve their visitor experience. The introduction of play elements can improve the integration between Cleveland's GalleryOne and ArtLens app. Creative narratives can turn the self-curated tour created at the Wall into a fun activity, encouraging further exploration of the museum's collection. The face-making and pose-striking kiosks are the fun elements whose intrinsically playful experience can be better connected to the museum's collection by using the corresponding artwork as the basis for a tour.

Despite having an avant-garde collection, SFMOMA has the most traditional approach towards their digital strategy. There is some personalization with the choice of audio tour, other play elements are lacking. While some gamification elements such as socialization are found in SFMOMA's solution through the sharing of a tour with one other. The excellent location awareness of the app could allow for further self-directed play by providing more celebrity voices and give the museumgoer branching options in their tour. Imagination and exploration can be encouraged by creating a virtual object treasure hunt built around recent objects viewed.

Cooper Hewitt may have the largest barrier to keeping its visitor experience up-to-date. Their choice of a pen leaves few options to engage visitors better with play principles. Due to the lack of display and feedback with the pen, additional kiosks are one way to provide greater opportunity for feedback. This lack of a portable display means there is no way to provide continuity among the various kiosks and interactive areas.

One of the design goals of the pen was to encourage the visitor to pay greater attention to the objects on display than to the mobile device, "it would encourage visitors to engage with the

works on view in the museum, rather than looking at them through the small screen of the more traditional approach of a 'museum App'" (Designing The Pen, 2016). The risk that visitors will fixate on the interactive, experiencing the museum and its objects through the lens of their mobile device instead of looking at the objects in front of them is not a completely unfounded problem, and is an opportunity for future research. However, the benefit of improved visitor engagement and learning along with the desires and expectations of visitors will outweigh the concern until the issue can be quantified.

Conclusion

New technologies are having an overwhelming influence on the zeitgeist . These technologies are weaving themselves into the most fundamental aspects of society and becoming the norm that interactions are measured against at such a rapid pace that museums who eschew them risk the danger of becoming obsolete. However, with careful consideration, museums can dramatically improve visitor engagement by making appropriate use of technology to encourage exploration. One of the simplest ways this can be accomplished is by embracing play to create a unifying experience where technology is not seen as discrete interactions within the museum, but as coalescing force which guides the museumgoer through a deeper interaction, appreciation, and retention of their visit.

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