Digital Exhibits Intern Librarian Report

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Executive Summary

This report presents the findings of the Digital Exhibits Internship project, beginning May 2016. The Edmonton Public Library 2017-2018 Business Plan establishes a goal to "develop a plan for Milner's Digital Interactive Display Wall" under the broader direction to *Evolve Our Digital Environment*. The report aims to define EPL's digital exhibit services and programs, modelled after Queensland University of Technology's the Cube, through research and community consultation processes.

Based on the research conducted to date, the Cube remains the exception rather than the rule in its physical and technical set up, programming, and community outreach efforts. At the same time, the functions of the Cube as a learning space and a literacy tool clearly align with EPL's goal to deploy this type of technology as a shared community platform for all manner of digitally accessible and interactive exhibits. As a result, following the model established by the Cube and applying lessons learned from the QUT teams responsible for its operations are two strategies that are most likely to ensure the success of EPL's own vision for such a service in preparation for the renovated Milner Library in 2020. The findings from 39 in-person interviews, 58 online survey responses, 24 semi-structured discussions, 25 case studies, an in-depth review of the Cube as a service model, and an extensive literature review revealed the following key takeaways:

- Average age of digital displays is 3 years, indicating early stage of service
- Touch interactivity is present in fewer than 50% of the cases examined
- No consistent approach to scheduling, managing or automating content exists
- Average of 3 FTE at minimum is required to support the digital exhibit service
- Study participants expressed an 87% satisfaction rating with digital displays
- User-centered design principles are critical to services of this nature
- Sound is important to interactive and immersive experiences
- Exhibits need to be intuitive and require no formal instruction in order to use

Edmonton's community has a range of expertise such as subject specialization, promotion, and access to digital and analog materials that can be curated for exhibits. However, EPL is likely to act as a curation and technical lead on exhibit execution. In addition, the Edmonton community has an interest in a range of exhibit topics, ranging from Indigenous issues, local history, artistic expression, science and technology, and children's activities.

Service recommendations for Digital Exhibits at EPL have been organized around the following themes: design and planning, technology, resourcing, content partnership and programming, and funding. A complete list of service recommendations can be found on page 102. Priority recommendations for this service, each reflecting a separate theme of the service, have been identified based on the scope areas of the Digital Exhibits Intern Librarian project, such as community engagement strategies, service support models, platform solution, and content partnerships. These priority recommendations are also deemed to be key to ensuring the success of related recommendations in pursuit of the Digital Exhibits service, and include the following:

1. That by the end of 2017, the Director of Technology Services, under the direction of Executive Director, Strategy & Innovation, creates guiding documentation, which defines the vision, mission, purpose and scope of the Digital Exhibits service to help prioritize exhibit development, testing and implementation. **(Design and Planning)**

2. That between 2019 and 2020, the Digital Exhibits Librarian organizes a workshop for local community experts in design, media, game development, web development, and other related fields to generate use cases, understand functionality and explore desired user experiences for the interactive wall. Use cases created as part of this event can be incorporated into the growing body of documentation for the service. **(Design and Planning)**

3. That between 2017 and 2021, Technology Services implements the Staffing Model proposed as part of this report (p. 60). This staffing model includes Digital Exhibits Librarian, Developer, Designer, and AV Specialist roles, and parallels cross-functional Cube teams at QUT, such as the Cube Studio and Visualization and eResearch groups. **(Resourcing)**

4. That between 2017 and 2018, Technology Services establishes a research-and-development “studio” by procuring hardware and software to test functionality and application of relevant exhibit technologies in preparation for the Milner digital interactive wall installation. This studio also aims to test workflows and processes related to digital exhibits in order to ensure 2020 service launch has minimal risks and gaps in knowledge. **(Resourcing)**

5. That between 2017 and 2018, the Digital Exhibits Librarian pilots a project in collaboration with community partners who have already expressed interest and capacity to work with EPL on a digital project as part of the community consultation process. This pilot project will test exhibit development workflows and partnership models for future digital exhibit initiatives. **(Content Partnership and Programming)**

6. That in 2018, the Digital Exhibits Librarian deploys the first branch installation of an exhibit prototype to test functionality of interactive technologies with library customers in real time. User observation data on exhibit reception is collected and exhibit improvements are made as needed. Potential solutions include projection with Leap Motion sensor, standalone touch-panel or 3D camera with projection and computer powering motion-based applications. **(Content Partnership and Programming)**

7. That Technology Services staff dedicated to Digital Exhibits services prioritize Unity 3D and WebGL technologies as primary “platforms” for the development of exhibit applications. **(Technology)**

8. That between 2018 and 2019, Digital Interactive Wall team, under the direction of the Director of Technology Services, investigates opportunities to source a custom 3D database that can function as an exhibit platform and therefore be repurposed for multiple exhibits. Solutions may include an open source software package or a custom vendor product designed for EPL’s needs. **(Technology)**

9. That by the end of 2017, the Digital Exhibits Librarian, in collaboration with Fund Development, drafts a stock pitch and other appropriate supporting documentation that outlines the Digital Exhibits service including its goals, purpose, intended impacts that can aid future grant application and funding proposal processes. **(Funding)**

10. That by 2019, the Digital Exhibits Librarian, in collaboration with Fund Development, identifies an opportunity to work with a community partner with access to specialized grant and funding resources (database or subscription service) that will aid EPL in targeting funding options for the digital exhibits service. **(Funding)**

Introduction

This report presents the findings of Digital Exhibits Internship project, which was carried out between May 2016 and May 2017. The Digital Exhibits Intern Librarian conducted research and community consultations to help define EPL's digital exhibit services and programs, modelled after Queensland University of Technology's the Cube. The following questions were addressed:

1. How do organizations with digital displays support and engage their communities in content development?
2. Which Edmonton organizations and community partners have an interest in developing content for EPL's Digital Interactive Display Wall?
3. What staffing and support models are recommended for a digital exhibits service?
4. What open platform currently exists to ensure it will meet EPL's needs for ease-of-use and sharing with community partners?

Recommendations that respond to the above questions have been identified as priority and are included in the complete list of the recommendations for this project on page 102 of this report. This project focused on education, cultural, heritage and arts organizations, such as libraries, museums, schools, universities and colleges rather than retail or commercial environments with digital displays. Similarly, this project examined primarily indoor installations, therefore prioritizing public and semi-public displays rather than media facades and outdoor installations (see Definitions).

Further, this project explored digital exhibits library services from multiple perspectives, including current landscape of display technologies in the English-speaking world, local context for this emerging service, the Cube as a model for such a service, other installations around the world, and best practices gathered from literature and community experts. In addition, artist-in-residency programs and funding opportunities related to this service were also examined. These areas of study are therefore addressed as separate sections of the report.

Definitions

1. **Public displays** can refer to “small or large sized screens that are placed indoor … or outdoor for public viewing and usage”, and which may be interactive to support information browsing and searching activities” (Salim & Haque, p. 34). In public displays, a large proportion of users are passers-by and thus first-time users (Peltonen et al., p. 2). In academic environments, these technologies may be referred to as *video walls* and have been characterized as display technologies with little interactivity and input from users, often located in high-traffic, public areas with content prepared ahead of time and scheduled for display according to particular priorities (Sadler, Reaume & Nutt, 2015).

2. **Semi-public displays,** on the other hand, can be understood as systems intended to be used by “members of a small, co-located group within a confined physical space, and not general passers-by” (Peltonen et al., 2008). In academic environments, they have been referred to as *visualization spaces* or *visualization studios*, and can be defined as workspaces with real-time content displayed for analysis or interpretation, often placed in in libraries or research department units (Brosz & Sadler, 2014; Brosz, Rashleigh & Boyer, 2015; Sinclair, Sexton & Hurley, 2015).

3. **Media facades,** comparatively, are attached to or integrated with existing buildings, and become the second ‘skin’ or outer layer to the building surface, and are therefore an architectural rather than an information technology term. As a result, media facades are not necessarily flat displays, but can wrap around exterior of buildings taking on complex shapes, as they may be composed of many LED lights or screens, “and can be considerably larger in comparison to general public displays” (Salim & Haque, p. 34). They are primarily used for advertising, branding, and/or aesthetic purposes. The digital displays part of the exterior of Edmonton’s Rogers Place and the new Royal Alberta Museum are examples of media facades.

4. **Interactivity** is a term that is often overused. Most simply, it can be described as one phenomenon acting upon another to create some result, such as when a passer-by waves her arms in front of a motion sensor (input) to generate a drawing on the large screen (output). Interactive media particularly, has been defined as “when a program’s output is determined by the user’s input” (Schroeder & Kirkorian, p. 3). In terms of digital media technologies, interactivity can be understood in terms of “how people proactively use their capacities through technology, and how technology supports the use and extension of skills” (Dalsgaard, Dindler & Halskov, 2011).

5. **Pervasive games** can be described as a game experience (digital or analog) that extend beyond the in-game world to the real world, where fictional worlds created as part of the game blend with the physical world. *Pokemon Go*, *Amazing Race* and *Can You See Me Now?* are all examples of pervasive games that have seen incredible popularity recently.

6. **Honeypot effect** describes how people interacting with an information system, such as a public display, stimulate other users to observe, approach and engage in interaction with that system (Wouters et al., 2016). This phenomenon extends beyond digital displays to tourism, art, or retail environments, where a site of interest attracts attention of passers-by and draws them to participate in that particular site.

Literature review

As they differ significantly in purpose, design and functionality from personal computing devices like laptops and tablets, digital public displays have been studied extensively in the human-computer interaction field. As a result, best practices related to information architecture, usability, and user behavior with personal computing devices cannot be directly applied to public displays. Specifically, perspectives on usability, user engagement, functionality, collaboration, and best practices for design have all been explored by researchers in the field of computing science. The following section summarizes key findings in these areas.

Interactivity

The area of interactivity with public displays has been studied by many researchers, with three commonly-used modes of interaction clearly identified. These include touch, gesture, and remote modes, which are outlined in more detail below.

- **Touch (or multi-touch):** This is the most common way we interact with personal mobile devices such as smartphones and tablets. Multi-touch interaction on public displays should support many individuals interacting with the digital screen simultaneously, since many users expect immediate access and will not take turns. For example, some technologies studied in this report support up to 30 touch points at any given time, while others, like QUT's The Cube, allow for a near infinite number of touch points. Though studies show that this technique is fast and natural, it also requires additional physical effort from the user (Parra, 2014, p. 181; Kurdyukova, Obaid & Andre, 2012; Ning et al., 2011). While touch interaction using infra-red sensors has the high touch recognition rate, its shortcomings have been identified as being expensive and being influenced by light interference, such as light around the touch screen (Lee, Moon, Lee & Yoon, 2015, p. 394).

- **Gesture:** This is interaction through movement of the user's hands, arms or entire body, recognized by sensors like Kinect or Leap motion systems. Although studies show that this type of interaction is quick and intuitive, it also brings "a cognitive load to the users together with the increased concern of performing gestures in public spaces" (Parra, 2014, p.181). Specifically, body gestures were found not to be well suited to passing-by interaction, unlike hand gestures, which can be performed while walking. Hand gestures also have an acceptable mental, physical and temporal workload (Parra, 2014; Walter, Gailly & Muller, 2013). Research into gesture-based interaction shows that "more movement can negatively influence recall" and is therefore not suited for informational exhibits (Panhey, Doring, Schneegass, Wenig & Alt, 2015, p. 103). Similarly, people consider gestures to be too much work "when they require two hands and large movements" to execute (Ackad, Clayphan, Tomitsch & Kay, 2015). Not surprisingly, research suggests that gestures deemed to be socially acceptable for public spaces are small, unobtrusive and those that mimic everyday actions. They are also more likely to be adopted by real-world users.

- **Remote:** interaction using another device, such as mobile phones, tablets, virtual reality headsets, game controllers, and other special devices. Connection protocols may include Bluetooth, SMS messaging, near field recognition, radio frequency identification, wireless network connectivity, and other methods. Mobile-based interaction with public displays has received a lot of attention in research, media and commercial environments because this mode allows users to interact from any distance with minimal physical effort. However, users often find this technique "too technical and inconvenient" (Parra, 2014, p.181; Kurdyukova, Obaid & Andre, 2012) because it requires sophisticated levels of digital literacy in addition to having access to a device. Some suggest that using personal devices for input also helps "avoid occlusion and offers interaction at a distance" without requiring multi-touch or gesture-based interactions (Vepsalainen et al., p. 40). As well, subjects in studies on mobile interaction often indicate their preference for this mode because of its low mental effort and low physical demand. However, it is possible that these studies focused on users with high degrees of digital literacies rather than the general public with varying degrees of access and comfort with mobile technologies.

User Engagement

Attracting user attention is not necessarily guaranteed by virtue of having a public display. According to research, the most significant factors that influence user engagement with public digital displays are age, display content, and social context.

1. Age

Studies by Heinrichs (2008) found that children were the first to engage in interaction with public displays and would often recruit adults accompanying them toward the installation. On the other hand, the researcher found adults to be more hesitant in approaching the installation: "they would often look at it from a distance before deciding to explore it further" (n.p.). These findings suggest that designing for children first is an effective strategy for enticing interaction from users of all ages.

2. Display content

Studies on engagement in public digital display environments indicate that both passive and active types of engagement exist with digital displays. As well, the role of emotion in the content displayed cannot be overlooked. Specifically Clinch, Davies, Friday & Efstratiou (2011) state that people typically pay attention to displays "only when they expected the content to be of interest to them" and that they are "more likely to expect interesting content in a university context rather than within commercial premises" (p. 9). In other words, the context in which the display is situated affects user expectations and primes them for interaction.

The dominant communication pattern in existing display and signage systems has been *narrowcast*, a model in which displays are essentially seen as distribution points for centrally-created content without much consideration for users. This model of messaging exists in commercial spaces, such as malls, but also in public areas like transit centers, university campuses and any spaces where crowds of people may

gather. Observational studies indicate that people tend to perceive this type of content as not relevant to them and ignore it (Huang, Koster & Borchers, 2008; Muller et al., 2009). For public displays to be engaging to end users, in other words, “there needs to be some kind of reciprocal interaction” (Salim & Haque, 2015, p. 35). Müller et al. (2009) describe how public displays may be perceived as a stage in which people will only engage with a system if they feel confident about their actions and in full control over the presentation of themselves. In public spaces, Veenstra et al. support the idea that interactive displays are more successful than non-interactive displays in engaging viewers and making city centers more lively and attractive (2015, p. 15).

In terms of precise measures of attention to such displays, studies of average attention time correlate age with responsiveness to digital signage, with children (1-14 years) being most receptive than adults and with men spending more time observing digital signage than women. Studies also indicate a significantly higher average attention times for observing dynamic content as compared to static content (Ravnik & Solina, 2013). Scholars like Buerger suggest that designers of applications for public digital displays should assume that viewers are not willing “to spend more than a few seconds to determine whether a display is of interest (2011, n.p.). Instead, they recommend to present informational content in such a way that the most important information can be determined in 2-3 seconds and avoid using more than minimal text. In a museum context, the average interaction time with the digital display was between two to five minutes, which was also the average amount of time people spent exploring analogue exhibits (Screven, 2000). In other words, dynamic game-like exhibits at the Cube incorporate all of the above findings to make interaction interesting, fairly short and drawing attention of children first.

3. Social context

Social context is another aspect that has been studied extensively in the field of human-computer interaction, and it provides many valuable lessons for applying evidence-based practices to technology service planning in libraries. Many scholars have observed the *honeypot effect* as related to interaction with digital displays in public settings. This effect describes how users who are actively engaged with the display perform two important functions: to entice passers-by to become actively engaged users themselves and to demonstrate how to interact with the technology without formal instruction. In other words, users interacting with the display draw attention to the technology and teach others how to use it by actively engaging with the display.

Many argue that a conductive social context can “overcome a poor physical space, but an inappropriate social context can inhibit interaction” even in physical spaces where engagement with the technology is encouraged (Parra, 2014, p. 181). This finding also relates to use of gestures on public displays. Researchers also found that contextual social factors such as age and being around others in a public setting do, in fact, influence the choice of multi-touch gestures. They suggest enabling a variety of gestures for each action (e.g., different hand postures, number of touch points and hands) to support fluid gesture sequences and social interactions” (Hinrichs, 2011, n.p.). A major deterrent to users interacting with large public displays

has been identified as the potential for social embarrassment (Brignull & Rogers, 2003 in Tang et al., p. 4). As an implication, the authors suggest positioning the display along thoroughfares of traffic and improving the ways in which the interaction principles of the display are communicated implicitly to bystanders (Peltonen et al., 2008), thus continually instructing new users on techniques of interaction.

Participation, traffic flow and non-modality

Related to the honeypot effect, studies on location and position of public displays have demonstrated patterns of movement and various user types that emerge around public displays. For example, Muller, Alt, Michelis and Schmidt (2010) have conceptualized the flow of people toward and through display zones as the "audience funnel", which is illustrated by the diagrams below. The audience funnel is a model for how a passer-by's attention is directed toward the digital display and channels the motivation to interact with the system.

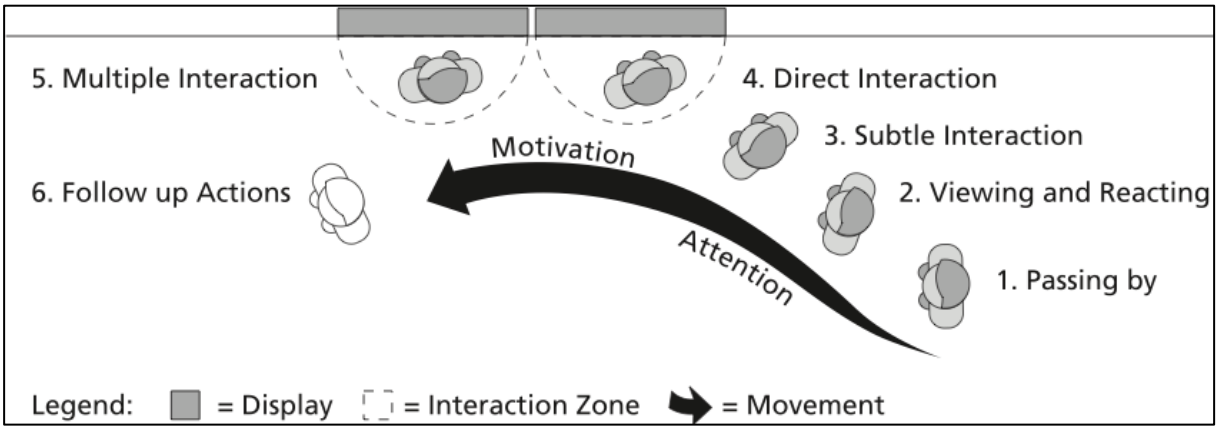


Figure 1. The Audience Funnel (Muller, Alt, Michelis and Schmidt, 2010)

Additionally, Salim & Haque (2015) have found multiple degrees of participation with public displays, all of which may be present simultaneously in different users around the displays like the Cube. Their findings can be briefly summarized in the table below.

Participation degree	User activity
Aware and consenting	Participants are fully aware of their involvement and provide their consent (e.g. for data provision) but their interaction with the system is minimal or passive.
Engaged	Users are actively engaging with the system or involved in creating their own experience through exploring the interactional opportunities with the system.
Collaborative	Individuals' active participation provokes interactions with other users, and enable collaborative participation and interactions with the systems to generate an entirely new performer/spectator experience.

Another example of collaborative degree of participation with the public display and with other users is crowdsourcing and crowd-sensing activities. In this case, users actively scavenge or hunt for more data and better data coverage in data collection activities (Reeves et al., 2005), such as in pervasive games.

It appears that the location of the display does not have a direct effect on people's collaboration. Instead, the applications running on that display, and thus, the tasks to be performed as part of the application, such as a game, actually affect the collaboration around the display (Marshall et al., 2011). Collaboration has been documented to increase people's creativity, but proper tools must be in place to support it. For example, Ardito et al. (2015), see large public displays as such a tool, though others witness less actual collaboration and more individual use segmented into personal interaction zones around public displays. While the display location may not have an impact on collaboration, it is the biggest factor for enticing individual participation. For example, Vepsalainen et al. (2016) found that placing a display in a high-traffic area had a significant impact on engaging potential players with game-based display applications. In their case study, it was "practically impossible" (n.p.) to avoid passing the screen when entering and exiting the space where the display was located. As such, the conversion rate of potential players to active players in this case was between 2.6 and 5 %, as compared to 0.10 to 6.1% rates observed in the literature on game conversion rates in Kinect-based systems. The findings in this study suggest that playing a game more than other types of content will attract interaction, which is also supported by extensive literature on gamification of everyday tasks and motivation in game playing.

Another interaction principle identified in the literature is *non-modality*. In this phenomenon, all the functionalities of the display system are available for the user all the time. This is in contrast to modal user interfaces, in which different modes of interaction are often chosen from palettes or menus. Non-modality is especially important for multi-user systems because confusions arise easily if the system needs to associate different gestures or inputs with different interaction modes. With non-modal interaction, this problem does not occur (Peltonen et al., 2008). No menu for the interaction mode is available, because all features and functions of the display are available all the time, as is the case at the Cube.

Public Display Best Practices

Arguably, best practices for designing desktop applications cannot be applied directly to public display applications. Instead, several best practices emerge in the literature on public display usability. These include:

- Public digital displays need to follow a "walk-up-and-use" model so that interaction is lightweight, intuitive, simple and immediate (Grinter et al., 2002; Hornecker & Stifter, 2006; Hinrichs, 2008)
- Do not use audio as it might be distracting to others (Nutsi & Kock, 2015)
- Consider accessibility when placing buttons and menus (Yuill & Rogers, 2012)
- Disable switching the whole view by a single user (Wigdor & Wixon, 2011)

- Non-modality: always offer all functions to the users (Peltonen et al., 2008)
- Make interactive parts distinct and differentiate them from the system's physical setup, so that they are clearly noticeable (Drossis et al., 2011)
- Allow people to interact both with the system and with each other (Drossis et al., 2011)
- Users in groups tend to focus more on the entertaining and fun aspects of the system, rather than on information provision (Drossis et al., 2011)
- People share their personal information without second thoughts (e.g. email address) when they are going to receive something that includes their own image (Drossis et al., 2011), such as the ability to email a screenshot of the exhibit.
- Keepsakes aid in creating a feeling of being personally engaged with the system (Drossis et al., 2011). For example, people will photograph themselves in front of the Cube and other public displays, such as the Cooper Hewitt wallpaper digital display (see Case Studies).

Environmental Scan

Method

The data for this section of the research project was collected between May 30 and August 20, 2016. A series of structured interviews were conducted by Skype, phone and email. The study population was driven by searching Google and Google News for keywords such as “digital interactive AND library”, “interactive display”, “public display” and “visualization wall” to identify organizations who have installed digital displays. A list of the study population was also produced by reviewing websites of creative studios specializing in interactive experiences (see Appendix H) and through the snowball effect once the interviews had begun. Participants were then recruited by email. The goal of this portion of the project was to gain a broad understanding of the emergent technology, content, and service model landscape related to public displays. As a result, structured interviews were deemed to be the most appropriate method of data collection due to the capacity to generate large amount of qualitative and quantitative data. In total, 39 interviews were conducted.

A list of interview questions prepared for the environmental scan interview process is included in the Appendix A of this report. A complete list of the study population can also be found in Appendix D of this report. The geographic distribution of the study population gathered in the environmental scan can be observed in figures 2 and 3 below. Primarily, organizations from Canada, the United States, Australia, and New Zealand are represented in this study.

Figure 2: Geographic distribution of the study population across North America

Figure 3: Geographic distribution of the study population across Australia and New Zealand

Findings

Technical and hardware landscape

The average age of public displays was found to be around 3 years, indicating a fairly early stage of development of this type of service among learning institutions. While such technologies have appeared in Europe over 10 years ago, their adoption in North American has not happened until around 2013. For example, the most widely cited early example of a public display is the CityWall in Helsinki in 2007 (Peltonen et al, 2008). On the other hand, the median year for these technologies among organizations studied in this report is 2014. Among public institutions represented in the study population, such as public libraries and museums, digital displays most frequently appeared in 2015.

While most organizations have only one display space, it not unusual to find several within a single organization. For example, for the purposes of this study, the researcher has counted The Cube as three display spaces, as documentation and promotional literature on the technology cites “3 separate display zones.” As a result, the average display spaces in the population of this study is 1.75.

The following modes of interaction with digital displays have been observed in the study population in descending order of frequency:

1. **Sound (79%)** while research on human-computer interaction is inconclusive about best practices related to incorporating sound into digital interactive displays, among the organizations interviewed in the environmental scan, it is clear that sound is a major component of digital exhibits and should not be overlooked. As one study

participant has noted, *“we learned that speakers are important to generate an audience for an opening exhibit reception."*

2. **Touch or multi-touch (46%)** - while the average age of displays is around 3 years, just under half of all organizations interviewed have touch screens capable of supporting multi-user interaction.
3. **Gesture (25%)** such as Microsoft Kinect or Leap Motion applications. Even fewer have motion-sensing capability, supporting findings from the literature review on the challenges of using this mode of interaction with public displays.
4. **Mobile (14%)** while some researchers in the human-computer interaction field suggest mobile is the most effective way to bridge the divide between large public displays, personalization of content and user engagement, mobile is not used frequently to engage with digital displays in the study population. Furthermore, no mention of designing for mobile users was mentioned in the discussions surrounding content or technical specifications. One exception is North Carolina State University Library, which takes a holistic, “massively responsive design” approach, in which responsive web design principles are applied to content that can be displayed effectively at once online, on digital display walls, and on mobile devices while optimizing institutional resources dedicated to supporting visualization services.

Further, as in the broader personal computing environment, the Windows operating system dominates the display systems, with 61% of the organizations choosing a Windows machine to power their digital display. A fifth (21%) of all organizations have some form of networked computing infrastructure, such as the Cube with its capacity to process exhibit content using 30 servers. Instead, the majority (79%) of organizations interviewed have a single computer powering the display. This finding is perhaps not surprising, given that few institutions have dedicated IT teams to support a single technology service like the Cube.

Users and use cases

Understanding the primary audiences was also important for this study, as the organizational user base defines the context for digital exhibits. The breakdown of these audiences is summarized in figure 4 below. For example, the University of Oregon’s Ford Alumni Center’s digital interactives focus primarily on showcasing the success of its alumni, thereby recruiting new students to the university. However, the interactives also serve the general public through tours and events on the University of Oregon campus. Other organizations with digital displays, like All Saints Anglican School and the Philadelphia Museum of Art target fairly specific audiences, so planning for exhibits may be easier in those contexts than in organizations like the University of Waterloo-Stratford with the display wall at its downtown campus which may receive visitor traffic from students, faculty, and the general public.

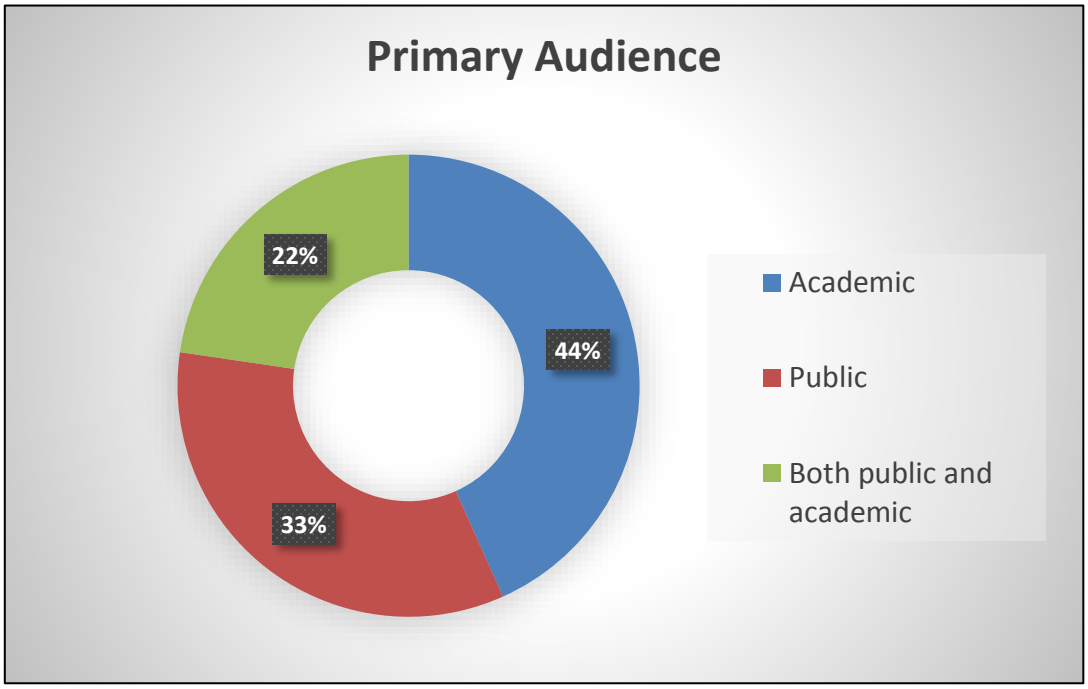


Figure 4: Audience types for digital displays in the study population

Public displays serve various purposes, which depend on the context of the organization in which they exist, their technical functionality, primary audience, service design and other factors. Interview participants were asked about the various uses for these technologies at their respective institutions. A single display could have multiple functions within a single institution. The following list summarizes these multiple uses, as is reflected in the percentages:

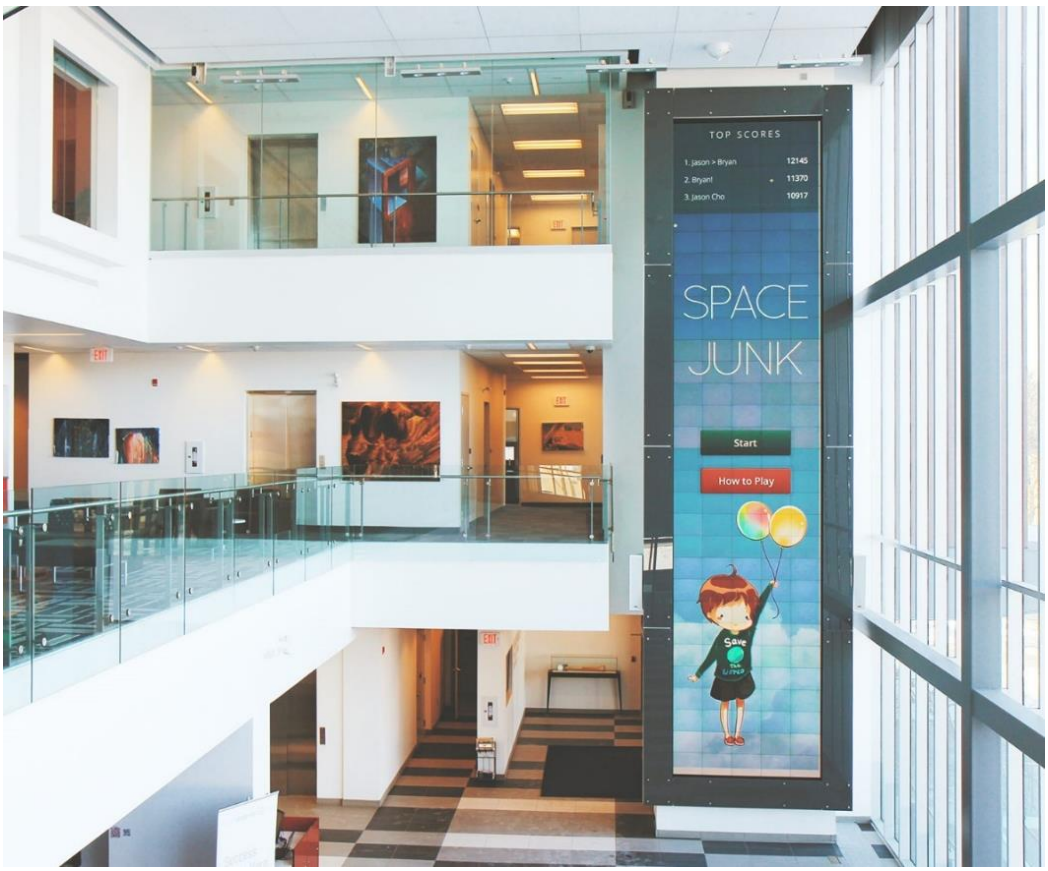
1. **Educational (67%)**, such as displaying digital collections, archives, historical maps, and other informational. These activities can be summarized in the words of one participant: “education via browse” – in other words, self-guided discovery rather than formal instruction.

Discovery and browsing at the Bradman Museum in New South Wales, Australia. Public tours, though often part of the museum experience, are identified as a separate category and discussed further below. (Source: Kidspot.com.au, 2015)

2. **Fun or entertainment (56%),** including art exhibitions, film screenings, games, playful exhibits, and other engaging content to entice users.

The Visualization Wall in the Hunt Library at North Carolina State University. (Source: NCSU Libraries)

DinoZoo at QUT's the Cube is a large-scale game for all ages. (Source: QUT Media)



The Christie MicroTile Wall at the University of Waterloo-Stratford features a game designed for the three-storey display. (Source: Lily Jiang, 2015)

3. **Communication (47%),** which can be considered a form of digital signage to promote library or institutional services, marketing content, deliver presentations and communicate scholarly work through the displays, as the photographs below show.

Griffith University's #SeeMore digital display in Gold Coast, Australia features campus news, weather, events and other relevant information about the university. (Source: Flirckr, 2015)

NCSU Libraries' non-interactive iPearl Immersion Theatre features library programs and special events information. (Source: Lydia Zvyagintseva)

NCSU Libraries' iPearl Immersion Theatre displays the #myHunt Library social media campaign drawing on user-generated image submissions through Instagram and Twitter. (Source: Library Visualization Tumblr, 2013)

4. **Teaching (42%),** including formal and semi-formal instruction, workshops, student presentations, and showcasing student course work. For example, the image below showcases the North Carolina State University Library facilitating teaching and learning in its Visualization Studio, maximizing the use of projection space. This finding is not surprising, given the prevalence of digital interactive displays in academic environments, therefore supporting the needs of students and faculty.

(Source: NCSU Libraries, Visualization Studio)

5. **Events (31%),** such as public tours, conferences, guest speakers, special events, galas, and other social activities near or using the display. For example, the image below shows India's Prime Minister Narendra Modi visiting the Cube as part of a press tour.

(Source: QUT Media, Flickr)

6. **Community engagement (28%),** including participation from community members through content contribution, showing local content, using the display technology as an outreach tool, and other strategies to build relationships with user communities. For example, the El Paso Museum of History's DIGIE Wall has been identified as serving specifically this purpose, as demonstrated in the images below.

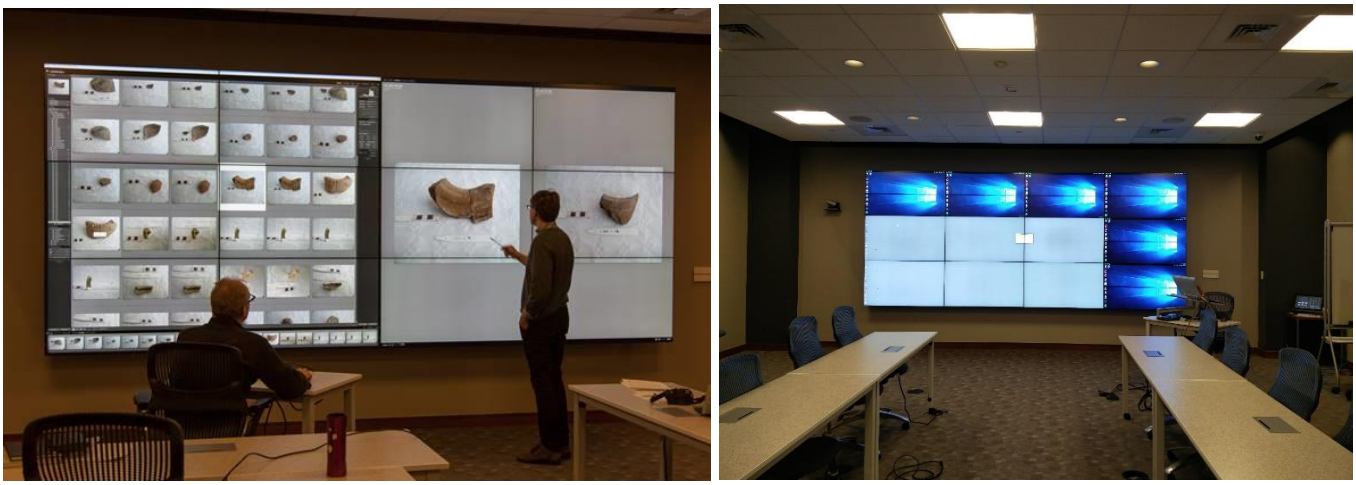
The fairly low frequency of this type of display use among the study population is, to some extent, not surprising. While the Cube prioritizes both academic and public audiences by creating content that serves both user groups, QUT is the exception rather than the rule in the sample population in this study. Most organizations do not focus on community engagement, and therefore do not use digital displays for this purpose.

Browsing local historical media collected by the museum and the citizens at the El Paso Museum of History (Source: El Paso Inc).

“The Spirit of a Place” Community History Wall at the Bellevue Branch of the Nashville Public Library highlighting history of the community. (Source: Anode.)

7. **Research (22%),** where the display functions as a tool that facilitates scholarly activities like data collection, analysis, and peer review. Many study participants acknowledged challenges in using digital displays for this purpose and have identified other services that might support this use more effectively.

For example, Brown University Library's Center for Digital Scholarship is pictured below and may be described as a digital lab rather than a public display. It supports research activities such as data visualization, use of specialized software, and team meetings using the multi-sectional display.



Patrick Ma Digital Scholarship Lab at Brown University Library. (Source: Sinclair, Sexton & Hurley, CNI, 2015)

Types of Spaces

In addition to various uses, types of functional spaces in which digital displays appear can be summarized using the following categories.

1. **Closed Studio**: This type of space is not generally open to the public, and is used for a pre-defined purpose. The data viewed in this type of space may be highly sensitive or may require special permission to access. Teaching may also take place in this type of environment.

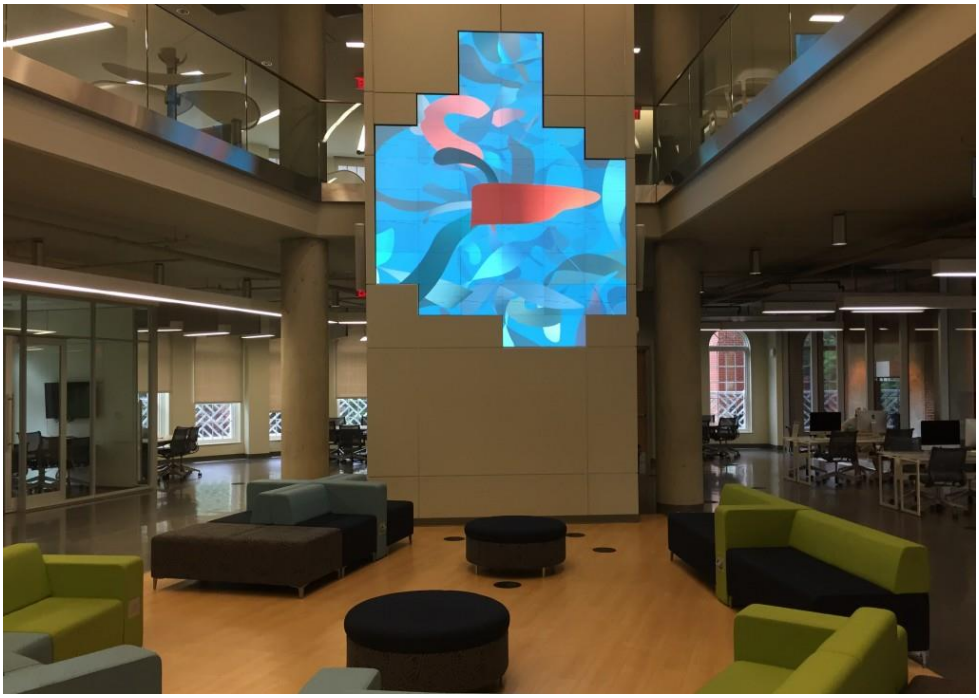
University of Calgary's Visualization Studio (Image source: Brosz & Sadler, CNI, 2014.)

2. **Open or semi-public lab**: Digital displays can be used for teaching, outreach and promotion when placed in this type of space, as it can demonstrate the functionality of the technology and various applications it can support.

CURVE at Georgia State University Library is located in the library space away from high-traffic areas. (Source: Sinclair, Sexton & Hurley, CNI, 2015)

3. **Public signage displays:** Technology in this type of space usually has minimal interactivity and functions as a stand-alone display in a high-traffic area. It may be suitable for marketing, informational and promotional content rather than immersive learning experiences. Engagement is passive as modes of interaction are limited.

Duke University Libraries' LINK Wall (Source: Duke University Libraries, 2013.)



University of Mary Washington's non-interactive Media Wall. (Source: UMW Media Wall, 2016)

4. **Public interactive displays**: Displays may still be placed in high-traffic areas, but content displayed will vary significantly from signage displays, enticing user interaction through at least one mode, such as sound, multi-touch and/or gesture. Engagement is active and may be designed for single- or multi-user interaction.

Deakin University Library's The Verge. (Source: Deakin University Library: Digital Innovations)

Historical, museum-like exhibit at the Henrico County Public Library (Source: MW2016: Museums and the Web 2016)

Content Types

In the words of Deakin University librarians, *"Content is critical, but the message is king"* (Horn, Lingham & Owen, 2014), so it was particularly important for the author to understand the current digital interactive display landscape as it relates to content. Specifically, the research project encompassed the variety of content used on digital displays, as well as how it is created, managed, shared, and received by the audiences of various organizations interviewed in this study. As can be observed in Figure 5 below, all organizations supported 2D content, such as images, video, audio, presentation slides and other visual and textual material. However, dynamic forms of content were less prevalent.

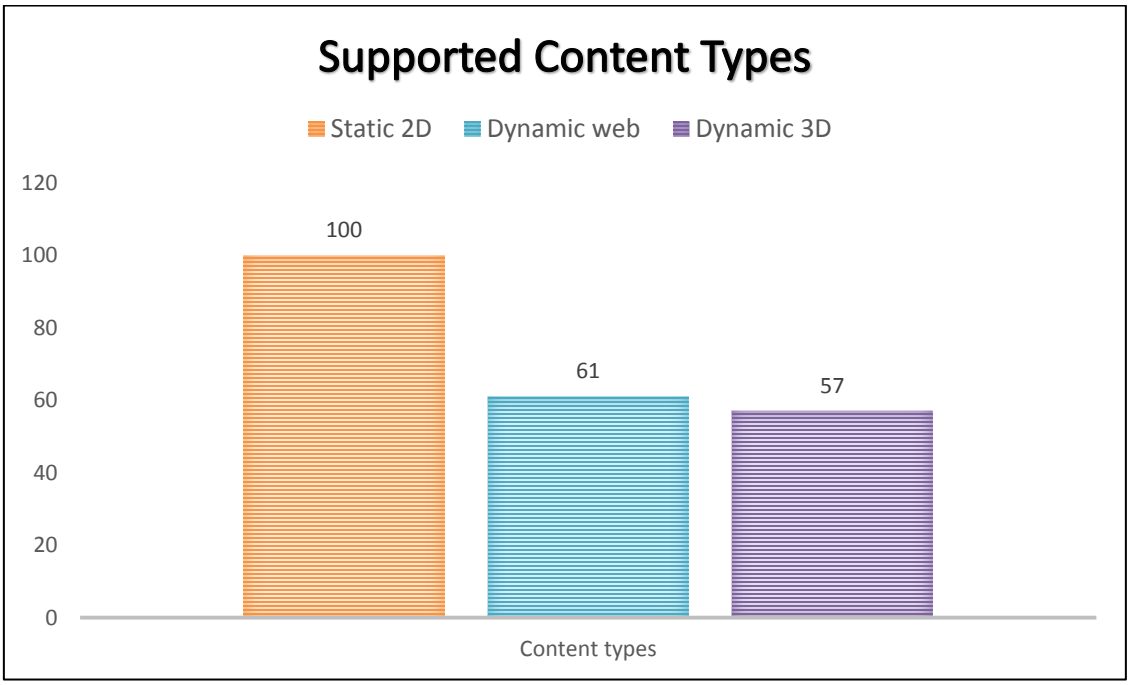


Figure 5: Types of content supported by digital displays in the study population

Dynamic content, such as social media feeds, interactive maps and web sites were also supported in 61% (n=17) of the cases. Discussions around interest in emergent, immersive, and dynamic 3D content such as games, virtual and augmented reality also came up frequently in the study interviews, and the researcher found that these types of content were supported in only 57% (n=16) of the cases. In addition, many organizations recognized that they would likely be exploring ways to present 3D games or immersive environments through their digital display in the near future. Not surprisingly, the vendor community included in this study revealed an awareness and active development of content of this nature, noting “rising demand and interest in 3D and game-like environments”. Furthermore, projects involving motion detection, the Internet of Things, and other sensor-based interactions are also seeing rise in demand, according to study participants.

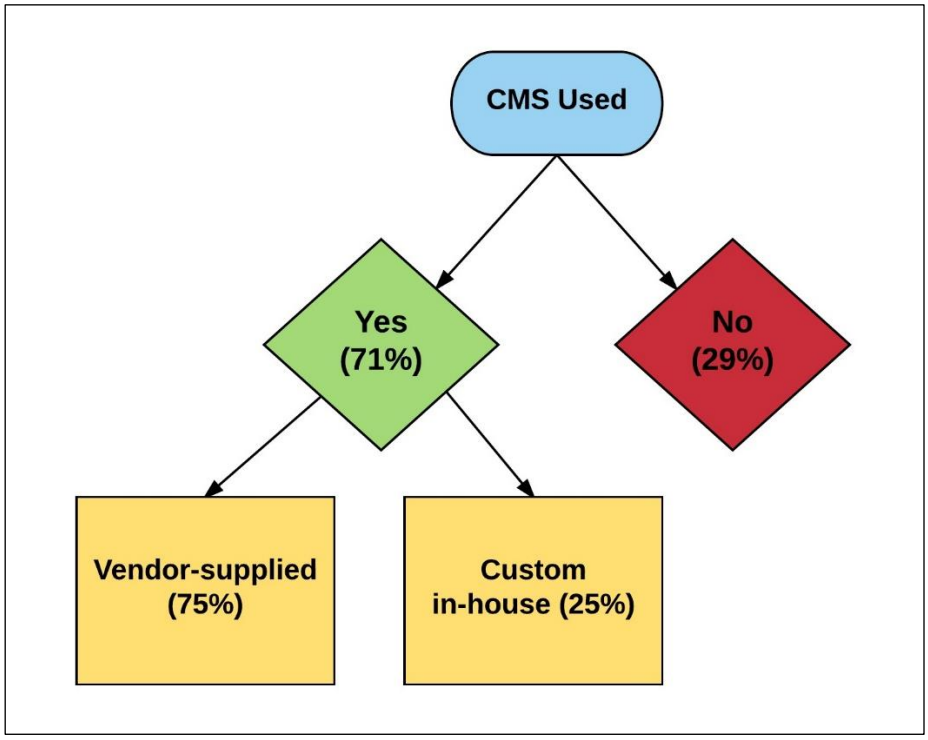


Figure 6: Content management approaches in the study population

In terms of managing various types of content, 71% (n=20) of the organizations interviewed had used some form of content management system (CMS), while the rest did not use any tool to manage or organize content. Of those organization that used a CMS, the majority (75%) relied on a vendor-supplied system, such as tools by FourWinds Interactive, Visix or NEC Live, for example. The remaining quarter of CMS users created a custom solution without going to a vendor. This finding suggests that since the majority of content supported by organizations with digital displays is 2D, current vendor solutions for managing that content are sufficient for the study population at this point. It is unclear how the rise in demand for dynamic, game-like content will be supported by vendors in the coming years.

Middleware, automation and exhibit management

Middleware can be described as the middle layer of software between the operating system and applications running on the display, especially in a networked computing environment. For example, most organizations studied in the environmental scan supported a Windows environment with a range of exhibit applications, like slideshows, web browsers, and executable files, such as games. Middleware can simplify and automate the process of starting up, switching between and shutting off display applications on a set schedule.

As figure 7 below demonstrates, the majority of the organizations in the study population (61%, n=17) did not have a middleware solution. However, this group was heterogeneous: 14 organizations (50% of total) did not require a middleware solution because they ran content semi-permanently or relied on user-supplied content, in which case the display functioned as a teaching tool. The remaining 3 organizations

(11%) manually managed scheduling and switching between exhibit content. In such cases, a middleware solution would prove to be valuable to management of content, especially as the number of applications grows, but it was not present in these organizations. Comparatively, 10 organizations (36%) used a custom solution, such as a combination of Windows or Linux scripts to manage automation and scheduling of content on the display. Finally, one organization (3%) did not specify their approach to managing content.

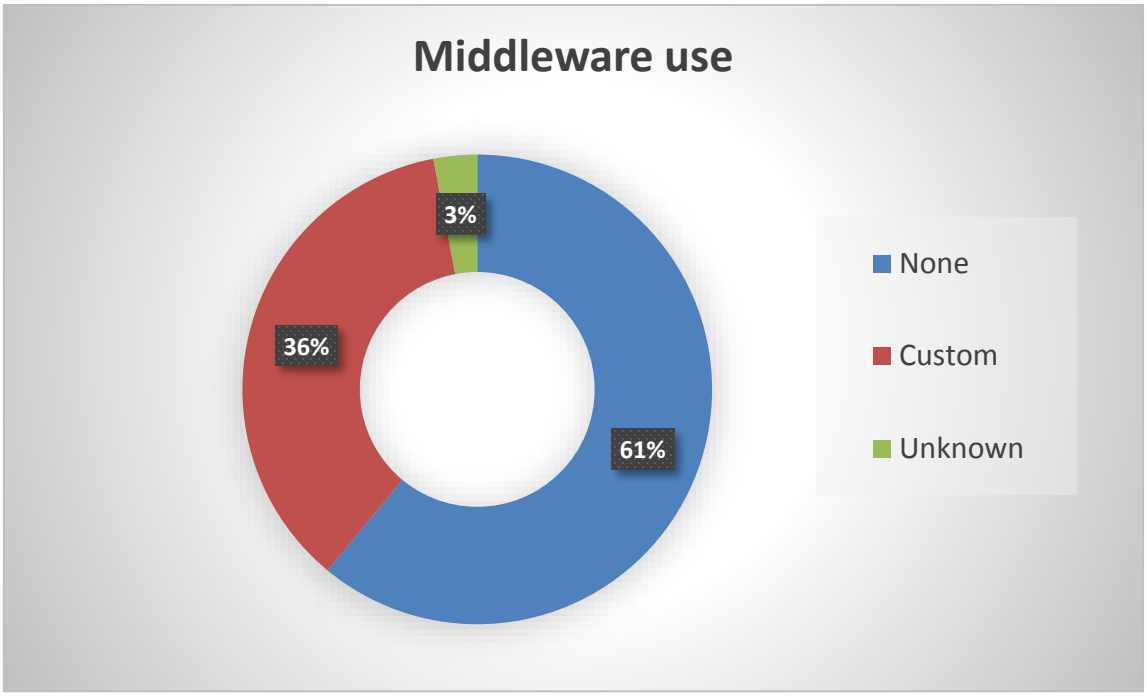


Figure 7: Middleware solutions in the study population

These findings suggest that no formalized solution to automating and managing software currently exists among the study population. In addition to organizing content, digital exhibits services involve scheduling or automating content to meet user needs according to the time of day, special events, or seasonal relevance. As a result, the middleware technology solution supports sustainable management of displays and predictable sharing of content for end-users. This environmental scan revealed that digital exhibits and interactive experiences are still in the early days of development. It is possible that new solutions for managing content both at the application and the middleware level may emerge by 2020, but they are limited to date.

Sources of content

When finding sources of content to be displayed on digital displays, organizations interviewed used multiple strategies simultaneously. The table below brings together the findings related to this theme.

Content source	Percentage
Internal or in-house	50%
User-supplied	64%
External or commissioned	64%
Partnerships	43%

For example, many organizations rely on their users to generate and submit material (n=18, 64%); others commission vendors to create exhibits for them (n=18, 64%). In 50% of all cases, organizations also produce content for exhibits in-house. In other words, most organizations used a combination of all avenues available to generate content for their digital displays. Only a select few use a single source of content, such as a semi-permanent historical exhibit at Henrico County Public Library. Others rely entirely on their users to supply content, like the Duke Media Wall, which employs a 'for students by students' model of content creation.

Additionally, only 43% (n=12) of the organizations interviewed had explored or established some form of partnership for creating exhibits. Primarily, these partnerships existed with faculties, departments, campus units and/or students in academic settings, such as the Computer Science Department, Faculty of Graduate Studies, and International Studies. Other examples of partnerships were with similar civic, educational, cultural and heritage organizations, such as municipal libraries, historical societies, art galleries, museums, and non-profits. Examples included study participants working with Ars Electronica, local symphony orchestras, Harvard Space Science, and NASA on digital exhibits. Clearly, a variety of approaches was taken in the study population to come up with digital exhibits content. Figure 8 below aims to represent the complex landscape of content sources among institutions studied in this section of the research project.

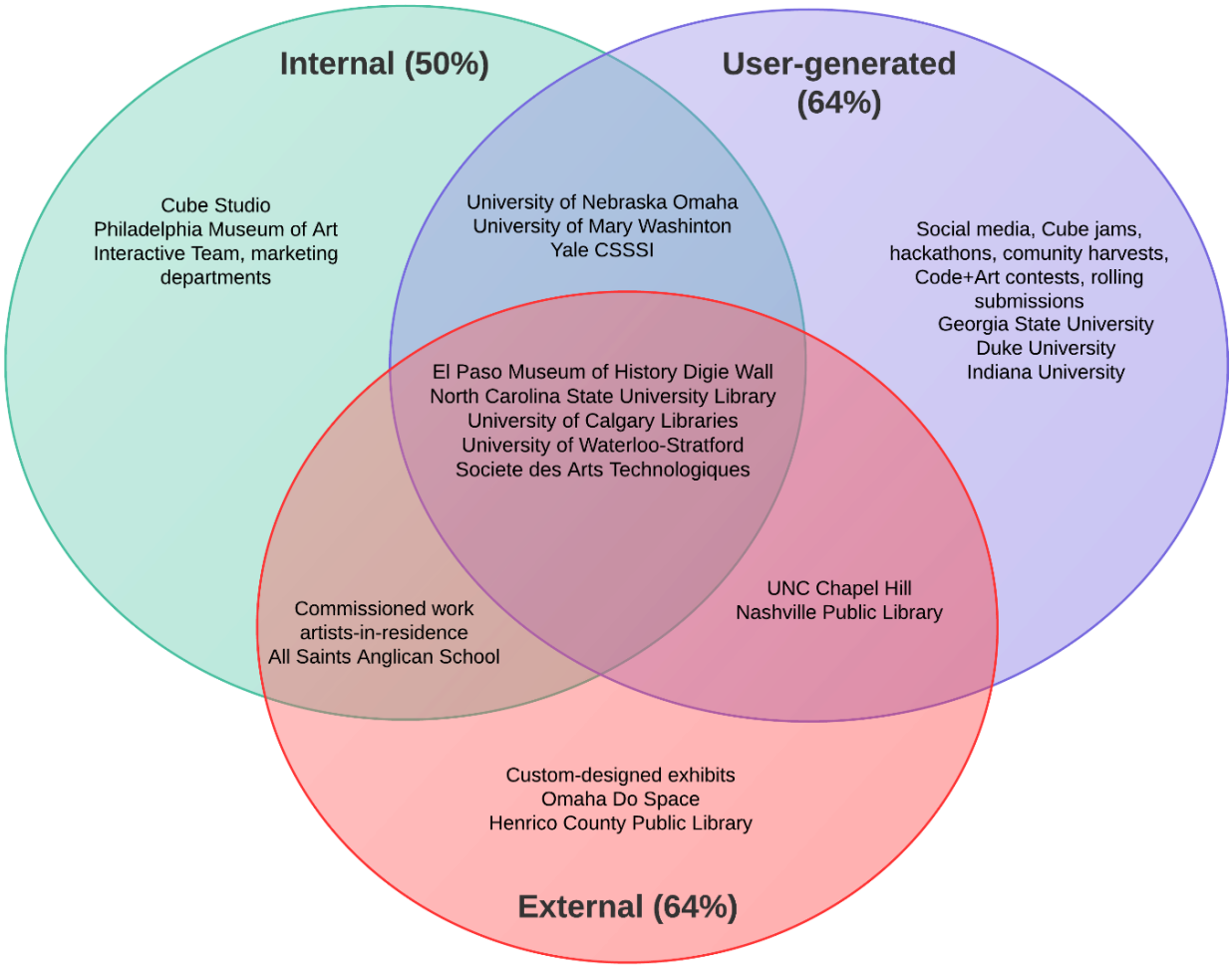


Figure 8: Content sources matrix in study population

Content Publishing Guidelines

Seven organizations (19%) in the study population actively published content guidelines aimed to simplify the process of engaging users in creating exhibits. These guidelines were analyzed based on key elements necessary for users to know in order to contribute in a meaningful way, thereby lowering the barrier to participation. These elements include resolution of the display screen(s), touch capability, ambient light around the display space, required file formats, and maximum file size. A complete list of organizations with such guidelines, along with websites where these guidelines can be found is included in the Appendix C of this report. Based on the analysis of this limited sample, the bare minimum for community participation guidelines would include clearly outlining:

- Scope, purpose, audience, and curatorial policy of the digital exhibits service;
- Technical specifications, such as the resolution, aspect ratio, and file formats supported by the display;
- Design guidelines, such as colours, templates and other visual elements;

- Contact information of the digital exhibits coordinator;
- Online or email submission form.

It should be noted, however, that such specification are primarily useful when a content management system exists and the content solicited from users is fairly standardized. For example, images, slides or webpages may be easier for community partners to contribute than video games or 3D interactive content. No examples of guidelines for the latter were observed in the study.

Content Scheduling

Whereas the middleware section of the environmental scan examined the technical approaches to content management and automation, this section explores the frequency of exhibit rotation from a service design perspective. As can be observed in Figure 9 below, no consistent or dominant model for exhibit scheduling has been identified in the environmental scan. Generally, approaches to scheduling digital exhibits reflect the organizational contexts. For example, museums typically design an exhibit and display it on a more or less permanent basis, while academic institutions display student work or scholarly communication once per semester. Overall, the following scheduling models have emerged in the descending order of frequency in the study population.

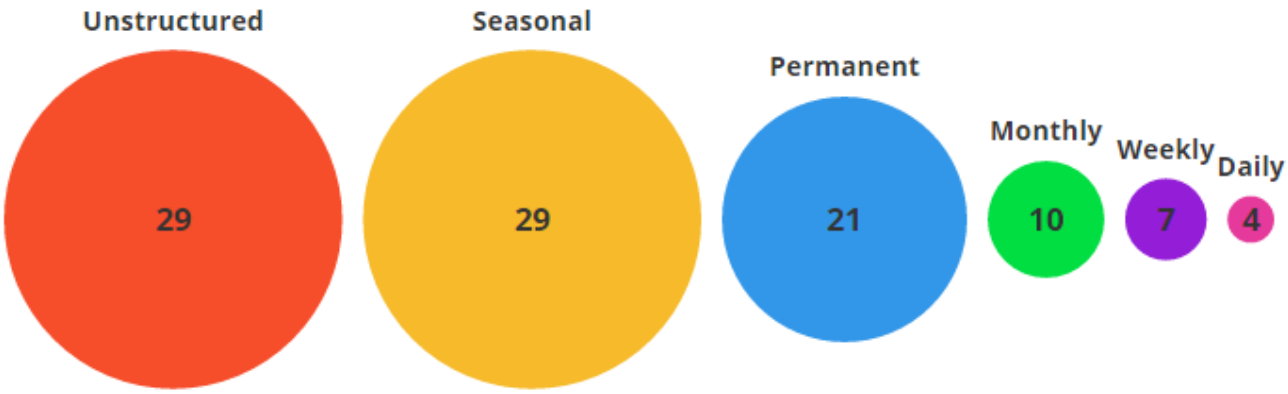


Figure 9. Content scheduling distribution (percentage) in the study population

1. **Unstructured (29%):** no formal approach, policy or expectation is identified by the organization with regard to displaying exhibits, largely related to the early stage of service development in this domain, lack of staff capacity to support the service and/or responsiveness to user needs. One study participant referred to this loose approach by noting that *"no formalized approach and no official policy exists. Framework for what kinds of general content gets displayed - no commercial images or messages, for example - but everything else is flexible."* Institutions adopting a lab space model for digital displays largely belong to this category. In other words, content is created on the fly

through workshops, data analysis and other situations as needed by users. In this case, no formal scheduling is required apart from space reservations.

2. **Seasonal (29%),** which can be defined as a period from 3 to 6 months and includes semester-based scheduling in academic institutions. Many organizations operate on a quarterly-basis, so it would seem logical that refresh of content reflects the broader workflow of the organization. Most of the content at the Cube, Duke Media Walls and Johns Hopkins University Library fits in this category.

3. **Permanent (21%):** in the cases of museums, permanent exhibits may mean displaying content indefinitely or until the next hardware refresh, which might reconfigure the entire interactive display service. For example, Sir Bradman Museum in New Zealand would adhere to this scheduling model.

4. **Monthly (10%):** this pattern was observed among academic libraries, with production of "Monthly Playlists" featuring suggested book titles, much like EPL Picks, in the case of Auraria Library at the University of Colorado-Denver.

5. **Weekly (7%):** Some academic libraries aim to have fresh content up once per week, in part by formalizing the roles needed to support their digital display and visualization services.

6. **Daily (4%):** only Griffith University ensures new content every day on the #SeeMore display, largely by relying on standardized external and internal content such as the weather updates and the university marketing department to produce communication for the service.

Staffing and Skills

One key element of the Digital Exhibits research project included investigating staffing models required to support a service of this nature at EPL. Not surprisingly, the theme around resource needs for digital interactive exhibits emerged in most interviews conducted. Several participants have noted that one *"can't just throw up content and leave it*" while others advised to *"have expertise on staff before tech is installed".* Data gathered shows that the average full-time equivalent supporting digital exhibits services in organizations interviewed was 2.97 – around 3 full time staff members, in other words. In addition, 74% of the organizations studied had maintenance or support contracts with various vendors, including AV integrators, content management system specialists, creative studios that produced original content, or hardware suppliers. Hardware and AV integrators typically provided a 12 month contract for technical troubleshooting while creative studios ensured a 3 month support contract for digital exhibits they designed. The average time to create an

exhibit was between 9 and 12 months, based on the data provided by creative agencies, The Cube teams, and learning organizations who have in-house teams creating exhibits on a regular basis. This length of time varies on the complexity of interaction designed, depth of the exhibit "narrative" and modes of input supported by the exhibit application.

Additionally, it was important to understand the curatorial labour behind digital exhibits. In 57% of the cases (n=20), the person interviewed also curated some or all of the content for the digital display in their respective institutions. In 14% of the cases (n=5), the individual interviewed was not a curator for any of the content, because there was no need for curation in the first place. For example, displays in these cases were used for analysis or teaching, and therefore did not require prepared content. In the rest of the cases (n=10, 29%), a creative agency vendor, another member of the team or a community partner was responsible for the curation of exhibit content. This finding suggests that, while a significant number of organizations outsource the design and curation of exhibits, the majority retain control over this process. Therefore, dedicating resources to curation, organization and management of exhibit content is deemed significant by the organizations represented in the study.

In terms of the capacity to carry out digital exhibit services, skills that have been identified by study participants as being important to supporting services of this nature include:

1. Technical skills, such as the ability to troubleshoot and general interest in technology, as well as flexibility and willingness to learn new things (74%)
2. Design, visual and creative sensibility (40%), as this type of work is primarily a visual experience
3. Software development or programming language knowledge (31%)
4. Communication, collaboration and relationship-building (25%)
5. Project management (20%)
6. Audio-visual and media skills (14%), as digital exhibits are *"as much an AV experience as an IT experience*" according to one study participant
7. Curatorial, organizational and content management skills (11%)

The most frequent dedicated roles mentioned in the interviews have included the following:

Position	Number of responses	Percentage
Developer/Programmer	11	31
Project Manager	8	23
Graphic Designer	6	17
User Experience or User Interface Designer	4	11
IT Systems Administrator	4	11
AV or Media Specialist	4	11

The relatively low percentages represented in this table suggest the distribution of skills mentioned above among various team members or combining multiple skills in a single role, as may be the case in small institutions or those without formalized services with dedicated roles. Nevertheless, presence of specific job titles indicates understanding of various skill sets needed to run a digital exhibits service. A more detailed analysis of staffing needs related to digital exhibits in learning organizations is explored in the Staffing Model section of this report, which can found on page 60, along with specific recommendations for staff roles needed to support the Digital Exhibits service at EPL.

Challenges and Successes

Many challenges were identified by study participants, reflecting the emergence and development of digital exhibits services. Clearly, multiple challenges could be associated with the digital display within a single organization. However, many successes and lessons learned were also shared by interviewees, often overlapping with identified challenges. This pattern suggests that some organization are able to pursue strategies that address challenges faced by their library or museum colleagues while perhaps lacking resources of capacity in other areas related to this type of service. For example, some organizations have observed a lack of user engagement due to limited interactivity of the technology solution. Still others have identified user engagement as a success largely by investing in technology solutions that provide a range of modes of interaction. Consequently, it is important to learn from both these areas in order to anticipate possible pain-points and to be able to capitalize on successes that lead to industry recognition and engagement from library customers. The following table summarized the range of challenges identified.

Challenge identified	Number of responses	Percentage
Technical	14	41
Content	11	33
Costs	11	33
User expectations	11	33
Workflow	10	29
Service design	9	26
Time	8	24
Organizational culture	8	24
User engagement	7	20

As reflected in the chart above, several key challenges have been discussed:

1. **Technical**, such as troubleshooting the technology, keeping up with new technologies or upgrades, and making exhibits work on the hardware and the software solution.
2. **Content**, such as coming up with original content or curating existing sources. In the words of one participant, *"Quality and refresh of content is key - it has to be meaningful, interesting and new."* This clearly presents a resource requirement.

3. **Costs**, such as the overall financial commitment to the service, the unseen costs in putting exhibits together, software licensing, and hardware upgrades.
4. **User expectations**, such as keeping the service at its full potential, using maximum functionality of the hardware and software solutions. After all, according to study participants, users *"may not want what they think or they say they want"* and to some extent, *"such technologies are almost an expectations now, and not as exciting for users".*
5. **Workflow or project management strategies**, specifically related to emergent multi-media experiences that require new cycles of development and testing.
6. **Time** to plan, source, create, troubleshoot, launch and improve exhibits.
7. **Service design**, such as thinking holistically about the functions of the technology within larger organizational structure. As one study participant stated, organizations *"cannot disregard the reality of the service being tied to a physical space"* in that these types of technologies are both a virtual and physical customer experience.
8. **Organizational culture and policy**, in terms of adapting project-based approaches to planning and resourcing services, getting institutional support, and educating all staff about the purpose, function, and benefits of the service.
9. **User engagement,** particularly keeping users interested in the exhibits and continually finding new and exciting content. Various participants have found that *"linger time is between 30 seconds to few minutes"* and content being displayed needs to be *"something interesting, unique and succinct, but not a destination in itself."*

Despite the clear challenges with delivering digital exhibits services, organizations that participated in this study have identified the following approaches as keys to success:

Successful approach or lesson identified	Number of responses	Percentage
User engagement and interactivity	16	47
Service design	14	41
"Wow" factor	12	35
Organizational leadership	12	35
Technology solution	10	29
Flexibility	10	29
Communication and collaboration	10	29
Project management	9	26
Team and skill sets	9	26

1. **User engagement and interactivity**, particularly for those institutions that invested in highly interactive and immersive experiences, the rewards are seen in interest and enthusiasm of their user groups.
2. **Service design**, for those organizations who have carefully planned the service, they found that this particular technology was successfully serving the needs of their user communities.

3. **Promotion and "wow factor**" that has brought attention to the organization and the service. It is not surprising that digital displays are central points on tours of dignitaries, political figures, and external guests. Further, many have commented that they *"did not imagine a Library could be involved in such an innovative experiment*" and others have added that their digital displays have *"created new conversations that did not exist before".*
4. **Leadership and vision** at the organizational level, which secures support and resources as well as defines the scope of the service to ensure its sustainability and success: *"Money is not necessarily the only barrier to doing this service, but risk taking, culture."*
5. **Technology solution**, where "everything works" and both the organization and users of the service are happy with the functionality, features, and performance of the chosen solution.
6. **Flexibility and willingness to learn new things**, including being open to agile project management methods, taking risks, and continually learning new tools, technologies, and processes as the service matures.
7. **Communication and collaboration**, both internally among stakeholders and externally by building community partnerships, new audiences, and user participation in content creation. For example, one study participant noted that the technology *"has contributed to giving the museum a new audience of primarily young people and families – a key objective held in 2010 at the commencement of the gallery refurbishments."*
8. **Workflow and project management**, for those embracing new approaches required to bring multiple skill sets together to create engaging new exhibits. As one participant has put it, *"These types of approaches require testing, improvement, a new workflow and lifecycle for the projects."*
9. **Having the right team with appropriate skills to support the service,** though this theme was rated as being less significant than designing services effectively and securing institutional support for the technology service. In other words, study participants noted that having programming or design skills in-house is not enough without proper definition of success for digital exhibits services.

Perceptions

Overall, institutional and user reception of digital displays has been identified as overwhelmingly positive, with 87% of the organizations noting positive feedback. Some have gone as far as to say that the reception among users has been *"through the roof*" and they have *"never had a negative feedback comment"* about the digital exhibits service. This finding indicates a high degree of satisfaction with such technologies by organizations who pursued a digital display. The following table further explores the range of perceptions observed in the study.

Perception	Number of responses	Percentage
Positive	20	87
Negative	3	13
Hesitation or uncertainty	7	30
Concerns about costs	3	13
Concerns about purpose	4	17
Concerns about user engagement	4	17

While a minority of cases (13%) have noted some negative perceptions, largely related to concerns about costs or functionality of the technology, in another 30% of the time, study participants have observed uncertainty and hesitation on behalf of the staff and users in terms of engagement and general questioning of its purpose in the organization. For example, one study participant has summarizes this mixed sentiment by saying, *"The perception is that it's really neat and worthwhile for exploring new ways of teaching, but that the same features and functions could be achieved with less (which we think is a good thing!)."* It is helpful to note this trend in perception, as any new service will likely bring a mixture of excitement, hesitation, and occasional opposition. Interestingly, these reactions have originated both from the staff of organizations interviewed and their communities of users.

Naming and Promotion

The following table summarizes these findings and lists specific names for each distinct display present in the study population organizations.

Organization	Display name	Website
Griffith University	#SeeMore	web page
Johns Hopkins University Library	Balaur	dedicated site
University of Waterloo Stratford	Christie® MicroTiles® Wall	dedicated site
Queensland University of Technology	Cube	dedicated site
Georgia State University Library	CURVE	dedicated site
El Paso Museum of History	DIGIE	dedicated site
University of Colorado Denver	Discovery Wall	web page
North Carolina State University Libraries	iPearl Immsersion Theatre	web page
North Carolina State University Libraries	Visualization Wall	web page
North Carolina State University Libraries	Commons Wall	web page
North Carolina State University Libraries	Art Wall	web page
Indiana University-Bloomington Libraries	IQ-Wall	web page
Duke University Library	LINK Media Wall	web page
UNC Chapel Hill	Liquid Galaxy	web page
University of Mary Washington	Media Wall	dedicated site
Société des Arts Technologiques	SATosphere	web page

Organization	Display name	Website
Deakin University Library	Verge	web page
Henrico County Public Library	Heritage Wall	none
Nashville Public Library	Community History Wall	none
Yale Center for Science and Social Science Information	Media Wall	none
University of Oregon Alumni Center	Oregon Alumni Table	none
University of Oregon Alumni Center	Oregon Cascades	none
University of Oregon Alumni Center	Oregon Entry Wall	none
Philadelphia Museum of Art	Rice Room Interactives	none
All Saints Anglican School	Sophie	none
Omaha Do Space	Video Wall	none
Brown University Library	none	none
Saint Louis University Reinert Center	none	none
Stanford David Rumsey Map Center	none	none
University of Calgary	none	none
University of Illinois Chicago	none	none
University of Nebraska Omaha	none	none
Sir Donald Bradman Museum	none	none

As can be observed in the data collected, no consistent naming convention exists in the study population, with the majority of public displays (40%) containing the word “wall” in the name, such as Media Wall, History Wall, or Commons Wall. A fifth (21%) of the displays have no special name. For the remainder of the study population reviewed, 18% adopt a one- or two-word original names, such as Sophie, Verge or #SeeMore, 10% use acronyms like DIGIE (Digital Information Gateway in El Paso) or CURVE (Collaborative University Research & Visualization Environment) for the technology name, and the last 10% use vendor or descriptive names for their displays, such as Liquid Galaxy or Oregon Cascades. In addition, only 52% of digital displays studied have a dedicated website or at minimum a web-page on the organizational website. The remaining 48% have no web presence for their display on the library or institutional site.

Discussion

The findings from this study indicate that the functions of the digital displays are highly dependent on the organizational context in which displays exist. This context, in turn, defines the nature of the services delivered through the digital display. For example, the following diagram can be useful in classifying the various ways in which digital displays appear in the study population, from research and teaching-oriented lab spaces to public spaces with passive messaging or active immersive game-like digital experiences.

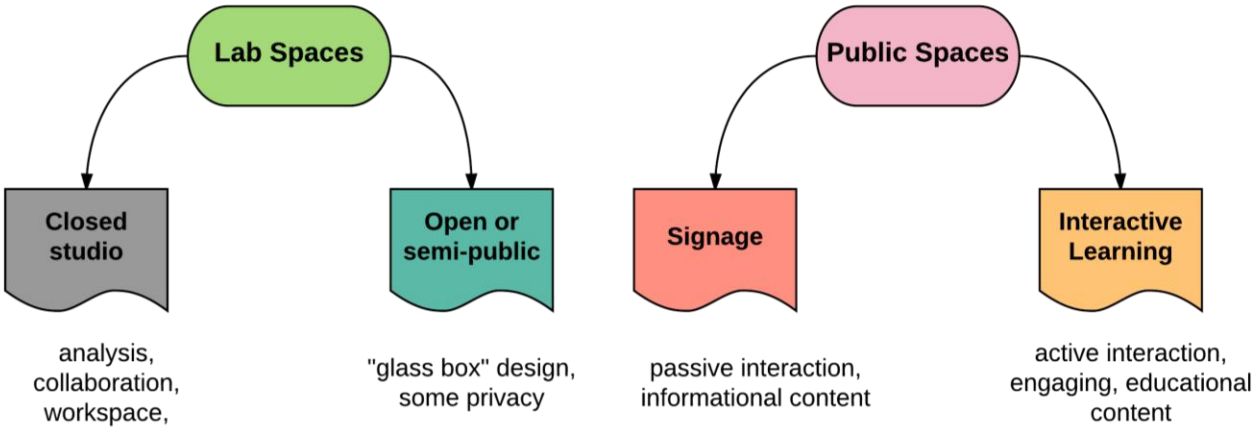


Figure 10: Types of digital displays in the study population

As such, interactive visualization walls, might belong in the “lab spaces” category that typically appear in academic libraries or research units and do not require content planning and scheduling. What we might call “digital interactive exhibits” tend to appear in museums and galleries with a primarily public audience, and may range from permanent, seasonal to monthly exhibit rotation schedule. However, despite a range of approaches taken to provide content and in terms of use of these technologies, many organizations share resourcing needs and challenges, such as troubleshooting the technology solution, creating engaging content, and managing costs of interactive projects. Despite these common concerns, the digital exhibits services were perceived as being overwhelmingly satisfactory in all types of organizations included in this study, as they brought new audiences to the organization and were often seen as “showpieces” in the broader community.

Overall, the data gathered in the environmental scan demonstrates that there is currently little consistency among public and semi-public displays in learning environments. This lack of consistency is seen in content development methods among study participants, their programming, content management, technology solutions, and even naming of the display (and, by extension, the display service). For example, this study revealed that no evidently “open platform” for managing content at the application or the middleware level, currently exists. A small number of software tools are used by organizations engaged supporting digital displays, but their use is in no way standardized, as compared to nearly every other area of library services. There is some indication that digital exhibits services may become more standardized by 2020, and more tools, solutions, vendors, and communities of practice will be available. For example, many signage content management systems are currently on the market, and the number of game-like immersive experience companies is growing, suggesting extension of these services to libraries in the coming years. Only a few software tools exist for creating exhibits to date, such as IntuiFace and TouchDesigner, though no free, open-source versions of exhibit software are currently available.

In contrast, some consistency exists in staffing needs and skills required to support the digital exhibits service. A majority of organizations interviewed agreed that design, software development, systems administration, and project management

skills are needed to ensure digital exhibits services run in a sustainable manner in a learning organization. In addition, lack of public library representation in this study makes it challenging to draw parallels to the EPL context. Adapting museum practices is also not necessarily reliable, as there is rarely a mandate to engage communities and partner on content creation, as there is in libraries. For example, only the El Paso Museum of History engages the local community to source and organize content, as seen in Figure 8 (p.33).

These findings suggest that digital displays are a growing domain, and more solutions are likely to emerge by 2020. The Cube, compared to the rest of the study population, is a unique service model because it successfully brings together most elements examined in the environmental scan. For example, to ensure continual engagement with the digital display, the Cube schedules exhibits on a regular basis and employs user interface designers, systems administrators, software engineers and project managers. It also extends the content through community engagement, public tours, and STEM programming. It has created an in-house middleware solution to simplify exhibit delivery, and has chosen Unity3D as its “platform” of choice for exhibit development. As well, investing resources in interaction generates payoff in terms of customer engagement, perception and attention beyond library customers to local communities, industry, media, government, and tourism.

Limitations

Organizations only from English-speaking countries were interviewed as part of the environmental scan. It is therefore unclear if access to organizations from non-English speaking countries would have produced new themes and significantly different results. In addition, as with all environmental scans, the data is limited by the degree of understanding, knowledge, and willingness to share information of the individual being interviewed. Particularly, individuals with whom the author spoke may or may not have been technology or service leads for the digital display at their respective institutions. Thus, the study participants had a range of understanding of hardware specifications, functionality, and service design components associated with digital displays. For example, having access to technology leads would have likely provided more nuanced responses around the middleware solutions and the underlying technical infrastructure required to support this service.

A small number of vendors were also interviewed as part of the environmental scan even though vendors did not necessarily have digital displays or service models parallel to libraries or museums. Nevertheless, gathering data from this group was deemed relevant to the study, as creative agencies have formalized staffing models and clearly identified skill sets necessary to support services of this nature. In addition, this group possesses knowledge of best practices, workflows, and project management processes related to exhibit development.

Finally, this environmental scan also did not capture any interaction with direct users of digital displays, whose experiences and perceptions of these technologies may or may not support the findings gathered from the organizations interviewed. These limitations were addressed by increasing the sample size of the study within the time and resource constraints of the research project.

Community Consultation

Method

This stage of the Digital Exhibits Research Project sought to investigate the capacity for content creation and partnership among Edmonton community organizations aligned with EPL's mission. Due to the exploratory nature of this project, a qualitative approach was adopted to gather necessary data. As a result, a survey was created to collect data that would help define needs and interests in our communities for new technology services specifically related to using the digital interactive display wall. A list of organizations was collected by the Digital Exhibits Intern Librarian in collaboration with EPL's community librarians, the manager of Digital Literacy and Web Services, and by asking survey participants to suggest contacts at other community organizations. The survey was administered digitally using FluidSurveys. Data was collected between September 12 and November 7, 2016. A copy of the survey is included in Appendix B of this report.

Overall, the survey received 58 responses and the total number of unique organizations represented was 42, with several organizations offering responses from multiple internal units. For example, the University of Alberta represented a single organization with responses from the Departments of Computing Science, Humanities Computing, and Urban Planning. Similarly, the City of Edmonton was counted as one organization while members of the Analytics Center of Excellence, Community Recreation, and Citizen Services responded to the survey. MacEwan University and MacEwan University Library were counted as two separate organizations, however, because the mission and priorities of various academic departments at MacEwan was deemed to be significantly different from those of the Library. The same approach was applied to Concordia University of Edmonton and Concordia University of Edmonton Library. The complete list of participating organizations, along with their contacts, is listed in the Appendix F of this report.

Findings

Types of audiences

Survey participants were primarily local organizations from arts, educational, community services and/or cultural heritage backgrounds. The audiences that these organizations serve consist of various groups of Edmontonians, including school-age children, Indigenous youth, low-income families, post-secondary students, genealogists, artists, teachers, and the public at large. The following categories can be applied to the audiences served by the organizations represented in the community consultation study population:

Audience type	Number of Reponses	Percentage
Arts	7	12
Education	22	38
Families	3	5
General Public	9	16
Specialized	14	24
Varied	3	5

Though the purpose of the community consultation was to understand the local context for a digital exhibits service at EPL, a small number of provincial and national organizations were included in the data collection. Inclusion of non-local organizations was done for several reasons: they were deemed to have content or skills that would be relevant to EPL customers, they were located in Edmonton, and/or they were referred to in the survey responses by another organization.

While each organization has unique mandates, audiences, and goals, for the purposes of the community consultation, the following broad categories of organizational types can be observed in the population surveyed in this portion of the research project:

Organization type	Definition	Number of responses	Percentage
Domain experts	These organizations possess either subject knowledge or content or both	18	31
Catalysts	These organizations are able to build projects or finance them through grants or both	9	16
Promoters	These organizations cannot necessarily offer specific content or capacity to build but can bring in new audiences for digital exhibits	5	9
Multi-talented	These organizations have various combinations of the above expertise, sometimes all at once	25	43

Organizational expertise

The first multiple choice section of the survey aimed to gather information on the range of knowledge, skills, access to content, access to funding, and other resources that participating organizations might have in a potential collaboration to create digital exhibits. The following table summarizes the responses received.

Expertise	Number of responses	Percentage
Subject specialization	40	69
Promotion and partnership with other organizations to further digital exhibits	34	59
Access to digital content that can be organized, modified or curated	30	52
Access to print or physical materials that can be digitized	29	50
Access to other resources, such as media, software, etc.	24	41
Partnership on grants to support digital exhibits	23	40
Web development skills	20	34
Game development skills	20	34
Ability to provide metadata to contextualize exhibits	20	34
Software development skills	15	26
Financial capacity to support digital exhibits	4	7

Other expertise mentioned:

- Best practices when working with multimedia
- Project management in multimedia contexts
- Peer-evaluated submission process for artistic projects
- Animation and graphic design
- Media educational content production with a focus on customized, in-house support

EPL's roles in Digital Exhibits Service

The following section asked the survey participants to rank, on a scale from 1 to 8, the various roles they might see the Edmonton Public Library playing in terms of a future digital exhibits service, with 1 being the highest priority and 8 being the lowest priority. The following tables break down the responses to this question based on those rankings.

Role rated as high priority (rating 1-3 out of 8)	Number of responses	Percentage
Provide space and time to showcase work created by the partner organization	40	69
Host workshops or programs using the video wall as a teaching tool	27	47
Provide technical expertise to create projects or adapt existing projects for the wall	24	41

Less important roles for the Library to play:

Role rated as medium priority (rating 4-6 out of 8)	Number of responses	Percentage
Organize and make accessible content on behalf of the partner organization	26	45
Host special events	25	43
Provide a venue to prototype projects and gather feedback	24	41
Partner on grants to create exhibits	24	41
Digitize physical materials or other media	24	41

There were no responses that received majority rating as “low priority”. In other words, all options provided in this section were rated by survey participants as being either high or medium priorities for the organizations they represented.

Other identified roles for EPL to play in terms of a digital exhibit service:

- “Cultural and pedagogical venue”
- “Champion the use of technology in the community”
- “Connecting on public programming”
- “Continuing to grow the maker space”
- “Exhibition space that works directly with artists”
- “Host artwork from the provincial art collections in the digital interactive exhibit”
- “Fun for children and somewhere for adults to have a chance to discover and explore”
- “Provide a venue for a digital festival”
- “Providing exhibit access to organizations for training purposes”
- “Provide new opportunities to engage the public in history and heritage issues”
- “Being hub for showcasing creative projects throughout the city”
- “Provide learning opportunities for our artists about how best to engage with this new interactive technology to expand their art practice into new forms”

Modalities of interaction

The middle section of the survey aimed to gauge the interest in various modalities of interaction with the digital display wall. Specifically, the Digital Exhibits Intern Librarian asked about what types of experiences the audiences of the participating organizations would want to have with the digital display wall in the new Milner Library. Survey respondents could choose multiple answers, which are summarized in the table below.

Modality	Number of responses	Percentage
Touch	50	86
Gesture or motion	45	76
Mobile	42	72
Video content	42	72
Audio content	36	62
Gaming and 3D environments	33	57
Web content	32	55
Special device interactions (ie. stylus, wearables, etc)	29	50
Ability to plug in own device	28	48

Other experiences and interactions mentioned included:

- "Ability to run in-house made programs or experiences on the screen".
- "Group-based interaction (co-operative interactions) and omni-disciplinary showcases (multiple media forms that coalesce into one experience)"

Digital Exhibit Project Themes

The last section of the survey was designed to gather qualitative data in the form of long-form responses to questions about potential projects of interest as well as any other feedback. In total, 116 exhibit ideas were suggested, which can be organized into the following themes:

First Nations/Indigenous content (n=10, p=9%)

Ideas in this category were not specifically defined by survey participants, but can be interpreted to mean storytelling both in content and in First Nations tradition delivery. The following specific exhibit ideas were suggested: Indigenous artwork and music, stories and storytelling, sharing circles, interactive educational exhibits for children and adults of all ages.

Youth and children (n=10, p=9%)

This category includes K-12 Alberta Curriculum content, school-age student project showcase, school-age STEM-oriented programming and content. For example, projects related to the school curriculum or school-age interests were repeated in the suggestions, such as discovering shapes, colours, animals, lifecycles, and weather. As well, family events, children's gallery space, and learning opportunities for school field trips were recurrent suggestions.

Heritage (n=18, p=16%)

This category of exhibits reflects interest in local history. For example, digital tours or 360 degree views of local places were mentioned, such as the River Valley, Alberta

railways, aviation history, and historic buildings. Other suggestions included "interacting with layered maps of historical and environmental data about the City", oral histories from all communities, and "vignettes on famous Edmontonians and their contributions" including a "feature on the Famous Five and their contribution, all of whom resided in Edmonton."

Art (n=28, p=24%)

This category is not surprising for a highly audio-visual nature of a digital interactive display, therefore brings together ideas for exhibits related to visual art, performance, design, architecture, and music. For example, interactive art projects, "making space" initiatives, work by local designers and performance artists, space for film screenings and filmmakers to experiment and showcase their work, as well as photography and projects that facilitate creativity were recurring ideas in this category. Projects with cultural components, such as "drumming, storytelling, interactive songs/games from other cultures" and a "creativity wall where students can design research approaches to their questions" were mentioned. Other suggestions included "an active drawing tool for students and faculty to visualize concepts when brainstorming group ideas" and related "active multimedia for idea generation", "opportunities for our local filmmakers to learn how to make media art using the new technology" as well as "large multi-player games, artists showcase, and live art/technology performances."

Civic (n=16, p=14%)

This category aims to reflect the interest in visualization of open city data, community engagement, and Edmonton-specific issues, as expressed by survey participants. For example, a space for newcomer stories, 3D exhibition of Edmonton's evolution as a city, community-created maps of downtown, digital human library that allows participants to learn about their fellow Edmontonians, interactive statistics about key topics related to city life such as literacy, movies, music, homelessness as well as interactive polls were all ideas that fit in this category of potential projects. As well, opportunities for civic engagement around issues within the city were mentioned, such as "ask questions, allow answers" polls, digital mapping of the city, and "programming that highlights Edmonton's connections globally". Seattle Public Library's library usage visualization project was also mentioned. (See Case Studies)

Digital Storytelling (n=8, p=7%)

This category can also be considered as storytelling more broadly using the digital wall in some way. Projects in this category were not specifically defined, and the term is used very frequently though it could mean a range of immersive or passive experiences.

Science and Technology (n=12, p=10%)

This category brings together exhibit suggestions concerning learning about and using skills related coding, programming, Virtual Reality, augmented reality, citizen science and crowdsourcing data, space exploration, robotics, etc.

Ecology (n=6, p=5%)

This category reflects interest in topics such as conservation, environmental assessment, interactive maps of the trail system and points of interest, animals and nature programs, sustainability. As well, “live camps of species at the Zoo”, “maps highlighting connectivity of the river valley” and geocaching programs were specifically mentioned.

Other (n=7, p=6%)

- Physical activity programs and “community involvement in sports”
- Public Health training and environmental assessment
- Digital festival
- Film screenings

It is clear from observing these categories that many exhibits may contain several themes. For example, an Indigenous storytelling display about the history of the River Valley and in-person program may be about art, local history, First Nations topics and ecology. The number and range of exhibit ideas indicated the rich potential in this type of service and the interest in EPL’s customer base for unique and meaningful experiences with a particular emphasis on the local.

Other comments and feedback

- *Connecting the inner city to the natural world even if it is through this digital media has great value to share knowledge on what is happening on our planet and allows us to engage demographics that do not normally interact with us. Looking forward to the outcome.*
- *Thank you for consulting the community for what we want to see on the board!*
- *Amazing opportunity to provide interactive programming for children of all ages and their families.*
- *I think this project has huge potential - it needs to be owned by the people of Edmonton - I think EPL is the perfect organization to achieve this.*
- *I think that this would be a very interesting tool and some great collaboration could come out of it!*
- *Sounds like a great project to partner on. Would be most interested in working with the EPL to reach out to a greater audience in Edmonton that we might not otherwise reach. Excited to work with professionals to develop curriculum resources which could utilize the wall.*

Discussion

Based on the findings in this portion of the research project, EPL is in a realistic position to rely on external sources of content to curate unique, locally-

themed exhibits. However, management of both content and relationships with those external sources is to be expected in the pursuit of a digital exhibits service.

In this emergent service, EPL is likely to continue to serve as a community and learning facilitator. However, it is clear from this study that community partners look to EPL to act as a technical lead on digital exhibits. EPL can rely on its community partners for content, promotion, and some degree of financial support, though the extent of funding reliance is to be determined through project prototyping and further collaboration. Staff dedicated to this service should also continue to offer digital literacy programming, as data gathered indicates a need for workshops and programming in the community. It is evident also that a wide interest in exhibit subject matter exists in the Edmonton community, and designing for children first are best practices in line with literature. In other words, EPL has no shortage of exhibit ideas, and many topics will likely appeal to EPL's customers, as suggested by the survey results. EPL is well positioned to follow the Cube model in incorporating STEM programming into the Digital Exhibits service as well as extending that content through makerspace, youth, and adult programming. These strategies are supported by data gathered in this project, and are therefore guiding practices to pursue. There is general excitement around the digital interactive wall among community partners, and several organizations are ready to collaborate before the wall is installed. Piloting a small number of projects before the final hardware installation is a good practice to follow, as it minimizes the risks and formalizes workflows required to develop more complex interactive exhibits.

Further, the community consultation findings indicate that the Digital Exhibits service should focus on touch and motion interaction, as this is what the community prioritizes to date. Staff dedicated to the service should then apply lessons learned from touch and motion-based exhibits to mobile interactivity as the service matures, likely around 2019-2020. There is interest in mobile interactivity, but it is not the highest priority at this time.

A small but vocal number of education institutions also sees the digital display as a tool for formal instruction, having expressed a desire to have access to this technology once it is implemented. This suggests that competition for use of the wall may emerge among community partners, as awareness of the service spreads across Edmonton. Clearly defining and communicating the purpose of the technology will address misunderstanding or conflict surrounding this service among community organizations. In addition, discovery and less formal learning opportunities should be prioritized for the digital interactive wall, as they support EPL's mission.

Limitations

There was some variation in the backgrounds of individuals who answered the survey in terms of their understanding of the technology, its potential and extrapolation of user needs. It is possible, therefore, that there was a gap between what survey respondent reported as having (in terms of content, skills, or funding opportunities) and what their organizations actually had available. Given the nature of

survey as a research tool and lack of opportunity to clarify responses, this limitation became apparent in certain responses received.

While the types of organizations contacted to participate in the community consultation were well aligned with EPL's mission, it is possible that some organizations in the areas of sport, recreation, design, or community services were not targeted. Consequently, it is uncertain if there are gaps in content, capacity for exhibit development, or project support that exist in the wider Edmonton area.

Finally, the list of exhibit themes should not be seen as exhaustive or representative of all Edmontonians, as some suggestions were counted in multiple categories. These limitations were address by increasing the sample size and allowing multiple individuals within a single organization to answer the survey. In addition, a recommendation for conducting further research into community groups not represented in this study has also been proposed.

Exhibit Planning and Prototyping

Method

In addition to the community consultation survey, the Digital Exhibits Intern Librarian also conducted a series semi-structured interviews with community groups to build a deeper understanding of issues emerging in the survey data. In total, 24 discussions were held. Some of the participants in this stage of the research were organizational representatives who expressed interest in working on a project with EPL in the near future or wished to share comments further to the survey. Others did not complete the survey but were judged to have relevant information, contacts or resources that would contribute to the Digital Exhibits Research Project. A list of participants from this stage of the project is included in Appendix F of this report along with the rest of community consultation survey respondents. Participants were contacted by email and interviewed in person or over the phone. Data for this this portion of the project was collected between November 1, 2016 and February 10, 2017.

As the community consultation process was a significant focus of the Digital Exhibits Internship, collecting qualitative data through in-person interviews was deemed to be an effective method for this portion of the research project. In general, participants were asked questions that sought advice on best practices in terms of exhibit planning, design, and execution, including the following:

- "What steps might we consider when creating an exhibit?"
- "Can you recommend a resource or an expert to help us understand the interactive exhibit design process?"
- "Is there a particular domain to gather best practices related to exhibit design?"
- "What grants currently exist to support this type of service?"

Since the interview process grew using the snowball effect, the questions posed became less structured and varied depending on the community organization. Nevertheless, the overall goals of this portion of the research were as follows

1. Investigate grant and other funding opportunities for digital exhibits;
2. Assess the number of interactive media companies working in the Edmonton region;
3. Seek further recommendations or considerations for the Digital Exhibits service.

Findings

As individuals interviewed at this stage of the project represented organizations with different types of expertise, they did not comment on all questions with equal detail. Additionally, every organization provided recommendations within the context of their domain. Nevertheless, a large number of suggestions was collected during these interviews and several trends emerged, which serve to guide EPL in planning for a digital exhibit service. They are organized thematically below.

Project Design

Suggestions gathered in this section relate to exhibit planning and service design.

- Integrate user experience and design thinking approach at the core of the Digital Exhibits service
- With the help of designers, developers, and architects, write clear use cases for the digital interactive wall, which can then drive exhibit specifications
- Consider hosting a charrette with designers, makers, and developers to explore options for content extension and to think holistically about the technology service
- Similarly, hosting a half-day workshop that brings together experts in video game, design, animation and other skills allows the Library to recognize the limitations in house and guide drafting future project specifications
- To ensure success when seeking submissions, be as specific as possible in content requirements by including technical specifications, file formats, sizes, colours, etc.
- Motivate Edmonton creators with money, promotion, or portfolio-building opportunities
- Investigate options for tactile inputs for children in interactive exhibits
- Exhibit curation can focus on a theme, specific audience (ie. youth), emerging need in the community, or an identified issue relevant to the community (ie. poverty reduction)
- Artist-in-residence programs are a great way to generate content in a short amount of time with limited risk
- When designing for interaction, identify pain points (make a user's life easier) or empower users (allow them to do something they can't do anywhere else), as these are primary motivators for user participation
- For complex projects, such as Indigenous history or Science and Technology, organize an advisory group to guide exhibit planning

Exhibit Prototyping and Testing

Suggestions gathered here address specific processes related to developing, testing, and improving digital exhibits.

- Collect real-world user data based on library customer interactions in real space and in real time. For example, use a wall in front of Highlands branch for projection and see how people approach the exhibit prototype, how they act, what they say and do
- Abstract the situation: recreate the potential functionality of the larger digital exhibit and outline clearly what is to be accomplished through this experience. What problem is the exhibit aiming to solve?
- Break down complex interactive systems into individual variables: What element is being tested at every instance of the prototype?
- Apply design thinking to the process: the digital display is a starting point for ideas, learning, literacy, conversation, cultural reflection. What kinds of experiences would EPL like to facilitate through this tool?
- Start with a small exhibit on a clearly defined topic and source media related to it
- For the final, large-scale exhibit, less than real-time and real-space would be an unreliable test environment. For example, leave the exhibit up on the screen for 3 weeks, test different content, different features. Do users engage with multi-touch

features as planned? Are motion-based interactive features used by real people? Do users miss the point completely?

Collaboration, Outreach and Promotion

The following suggestions relate to opportunities to share information with community partners and promote the Digital Exhibits service more broadly.

- Exhibit projects can be advertised as small requests for proposals with detailed instructions and clear expectations
- Preserve exhibits in digital public space to allow creators to demonstrate their contribution to the Library as well as entice new creators to contribute in the future

Technical Considerations

These recommendations focus primarily on technology needed to execute the exhibits. For more tools and platforms related to digital exhibits, please see Appendix I of this report.

- Test at all points of the exhibit to understand the technical performance of the hardware and software involved in exhibits
- Prioritize performance over quality in exhibits: content needs to load quickly
- Design for accessibility by all users, such as those visually and hearing impaired, wheelchair access, and other needs
- Unity3D is a better platform to pursue for exhibit development than Unreal, Torque or other game engines, because it is relatively easy to learn and has a large community of practice where to seek help, support, and share knowledge
- Investigate opportunities to integrate Near Field Communication technologies (part of many mobile devices) that can enrich the digital exhibits and Library experience
- Consider if one side of the wall has an option to interact with the other? Smart cameras on both sides may allow a “virtual mirror” to the other side. Additionally, one side may be able to control, influence or have input into what happens and is available to the other side of the wall through sensors, mobile, touch, etc. This will facilitate EPL customers to interact with the technology and each other to foster a social space.
- Gamifying the public display through mobile devices creates opportunities for personalization and engagement with the Library
- Investigate feasibility of exhibits that use “persona-based” or conversational user interface, such as an artificial intelligence-driven character to help guide the interaction
- Retain some degree of control over sound, such as the ability to turn it on during specific times and adjust volume, as sound is an important element of digital experiences
- Investigate solutions for sound control such as Bluetooth or wireless connectivity and/or parabolic speakers that create an “audio spotlight” effect

Exhibit Content Opportunities: Community Members and EPL Customers

In addition to recommendations for planning the Digital Exhibits service, a number of content development opportunities were discussed with study participants, which include:

- Makerspace jams and semi-formal mentorship programs that bring together communities like Game Discovery Exhibition, Global Game Jam, and organizations like the Edmonton Digital Arts College
- Competitions and contests, following the "Code+Art" contest model at North Carolina State University Libraries (https://www.lib.ncsu.edu/codeart)
- Artist-in-Residence programs (3-6 months)
- Livestreaming events, such as art performances or music shows by artists from Capital City Records, Capital City Press author readings, partner organization content, live coding events, or digital media productions

Discussion

The Edmonton community has a range of expertise, including user experience, graphic design, architecture, visual arts, multimedia, game development, web development, research, and community services, among others. The Digital Exhibits service will remain most effective by applying user-centered design principles, as indicated in the findings of this study. Relationships established over the course of this project will also continue to provide guidance and formalize practices related to digital exhibits development. In contrast to expertise available, grant opportunities are not extensive locally, and civic and provincial funding models are likely to change between 2017 and 2020. Community organizations, including arts funding bodies, can facilitate workflows, promotion, and community engagement processes. However, few formal granting channels exist for digital exhibit development to date.

The following diagram represents the emergent landscape of various sources of content for digital interactive exhibits, drawing on the findings from previous chapters (environmental scan and community consultation). Especially in the early stages of the Digital Exhibits service, the sources of content included in the diagram below should be considered for prototyping and extending exhibit experiences to branches or in Milner in preparation for the 2020 launch.

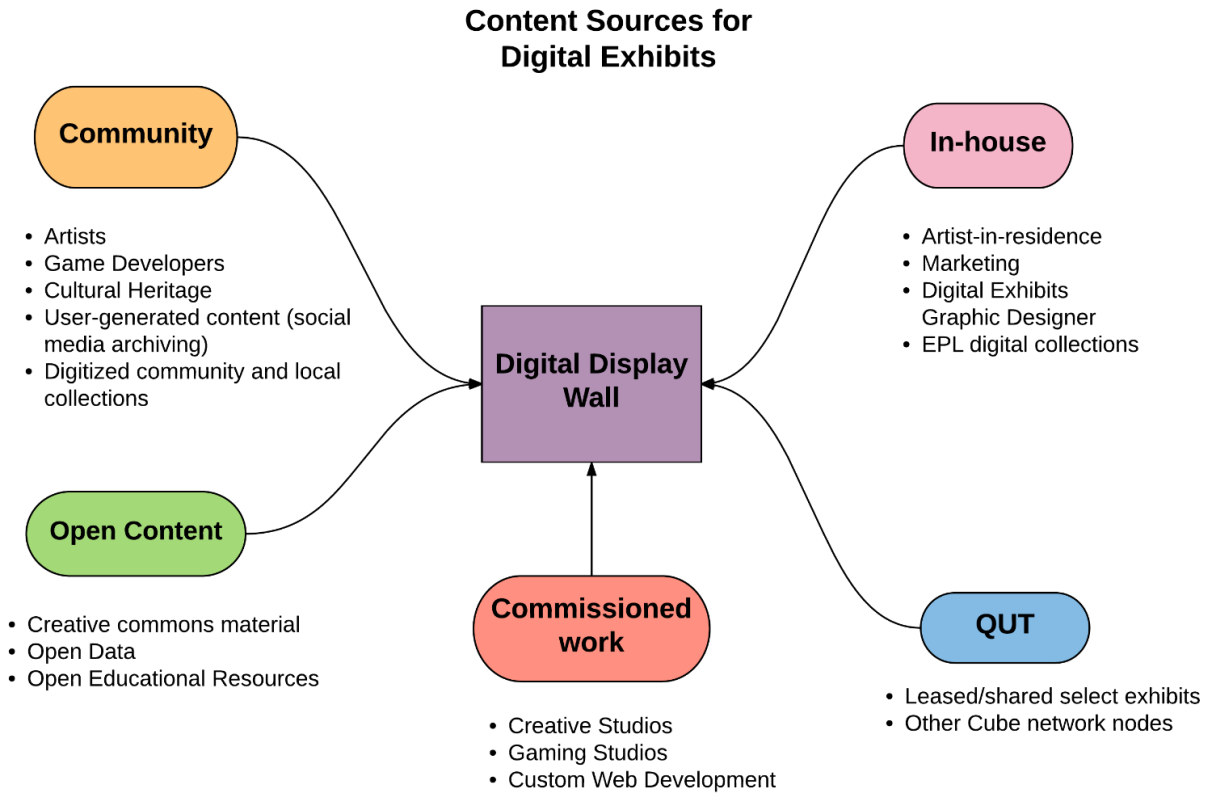


Figure 11: Digital exhibits content sources

Clearly, a variety of exhibit content sourcing options are available. However, each source of content depends on a unique project workflow. For example, commissioning a digital exhibit platform by working with a creative studio like Second Story would likely take less time that collaborating with several community organizations, but would cost significantly more. Alternatively, leasing an exhibit from QUT would be the simplest and fastest option, requiring very little staff involvement, but would not necessarily be reflective of the local context. Pursuing opportunities to source as many Cube exhibits for as lowest cost (ideally free of charge) as possible will be a goal of the consultancy process with QUT. There is indication from discussions with QUT teams that sharing exhibits is within the scope of Cube mission and is feasible. The only limitation to sharing specific exhibits may be confirming that QUT owns all the digital assets involved in exhibit applications, such as Unity3D components, select graphics or proprietary code involved in execution of the exhibit. Continuing to work with QUT in clarifying which exhibits may be eligible for sharing with EPL will be a priority for the Digital Exhibits service.

Finally, there are plenty of open access digital content available online, but curating it into a meaningful interactive experience would require institutional resources. The following diagram outlines specific steps involved in creating an exhibit in collaboration with a community organization. Broadly, it reflects common steps which need to be in place in order to complete the exhibit development process. These steps include:

1. Identify a theme or a topic – ie. history of the river valley
2. Find a domain expert organization with content and subject expertise on the topic
3. Perform an audit: what types of content is available? How much of this content is available immediately? In what formats does the content currently exist? What needs to be digitized? What needs to be described, edited, or reviewed?
4. Create an agreement and project plan that governs the project
5. Identify tools and platforms necessary to support the exhibit
6. Obtain access to content
7. Organize the content
8. Build an application or extend current platform solution. This stage may require involving a Catalyst organization at this stage.
9. Test, review, and revise the exhibit, including user test observations.
10. Allow both organizations to edit and revise the exhibit as relevant
11. Display the exhibit
12. Collect user observations on the final exhibit
13. Document and extend content using these observations, including recommendations for future exhibits

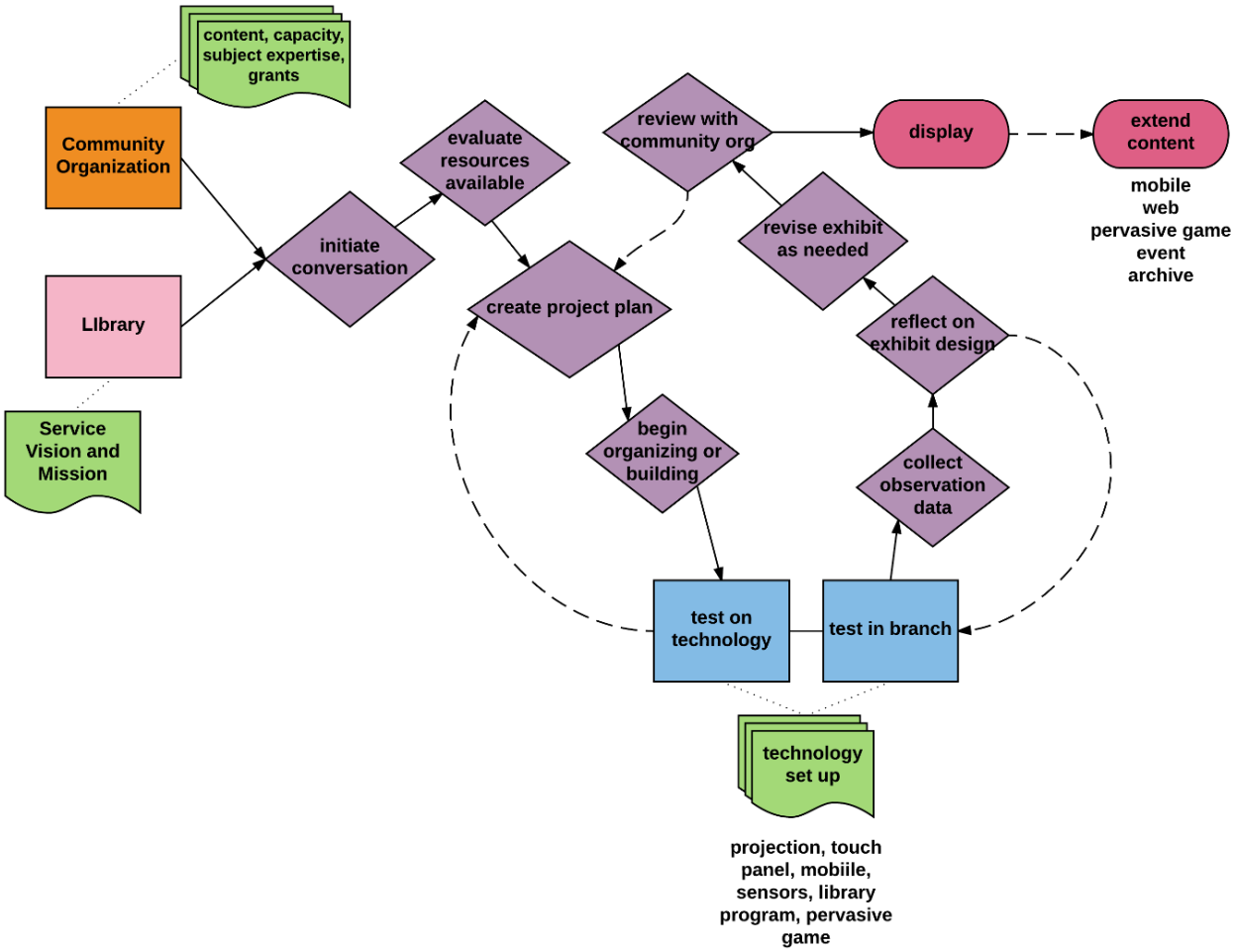


Figure 12: Community collaboration project workflow

Limitations

Though the suggestions and recommendations gathered in this section of the project were part of a broader community consultation process, only select organizations were contacted for further discussion. The main method of recruitment for participation in the semi-structured interviews was referral or recommendation from other community organizations. Due to the diversity of organizational backgrounds covered in this section of the project, no standardized questions were posed in every case, and therefore no consistent domain of expertise emerged. This limitation was addressed by growing the sample size and aiming to address the overall goals of the semi-structured interviews, as outlined on page 53, until recurrent themes emerged.

Mobile interactivity and extending content through mobile experiences was not explored in depth due to the time and resource constraints of this project. As a result, recommendations related to this area of digital exhibits are proposed in order to build on knowledge gathered over the course of the research project. Recommendations to continue to expand digital exhibits interactivity with relation to mobile are proposed as a response to emergent limitations.

The diagrams featured in this section emerged from synthesizing interview data, semi-structured discussions and understanding of project management processes rather than borrowing from external models or resources specific to museums or digital media design. This limitation is not significant as the general principles of project management are reflected in the workflows proposed.

Staffing Model

Method

The Digital Exhibits Intern Librarian has conducted an analysis of job descriptions to analyze the skills sets sought after in positions with titles such as “User Experience Designer”, “”Digital Engagement Librarian” and “Director of Digital Experience” from learning organizations across North America, Australia and New Zealand. In total, 71 job descriptions were gathered primarily by searching and browsing several websites for keywords like “digital”, “curator”, “user experience”, “interactive”, “designer”, and/or “digital media”. In this sample, 28 job descriptions were for positions related to a curator-type role, 24 job descriptions were for a designer (user experience, graphic, interface, interactive) role and 19 job descriptions were for the role of a developer. The data was gathered in two segments, between August 5 and 19, 2016 and December 16 and 29, 2016. A complete list of job titles, organizations and locations used for this analysis can be found in Appendix G of this report. The following job lists were consulted in order to gather the sample of this portion of the research:

- Code4Lib Jobs - http://jobs.code4lib.org/
- LITA Job Postings - http://www.ala.org/lita/professional/jobs/looking
- Museums and the Web job archive - http://www.museumsandtheweb.com/jobs.html
- American Museum Association Jobs - http://aam-us-jobs.careerwebsite.com/
- Australian Library Association Jobs - https://www.alia.org.au/jobs
- Australian Museum Association Jobs - http://www.museumsaustralia.org.au/site/jobs_vacancies.php
- Graphic Designers of Canada Association Jobs - https://www.rgd.ca/talent/jobs.php
- Advertisers Club of Edmonton - http://adclubedm.com/jobs/
- RGD: Association of Registered Graphic Designers - https://www.rgd.ca/talent/jobs.php
- Behance - https://www.behance.net/joblist
- Smashing Magazine Jobs - http://jobs.smashingmagazine.com/
- Moment Factory Careers - https://momentfactory.com/careers
- Local Projects Jobs - https://local-projects-llc-1.workable.com/
- Second Story Jobs - http://secondstory.com/studio/join-us
- BioWare Careers - http://www.bioware.com/en/careers/

Findings

There was no indication that organizations represented in this sample had digital interactive display technologies such as display walls. However, based on the job titles, job descriptions and regular duties listed in the postings, it is likely that work

described in this sample would parallel digital exhibit design in its overall workflow and process.

The majority (50%, n=35) of the job descriptions in this sample advertised positions in the corporate sector, while 25% (n=18) of the postings were advertised for roles in academic environments, such as university libraries and research centers, with the remaining quarter (25%, n=18) being positions in public environments, such as libraries, museums and non-profit organizations.

The following staffing model is based on the analysis of several data sources: the job descriptions listed in Appendix G, the interviews conducted as part of the Environmental Scan, and the consultation with the Cube Project Manager. As a result, the following staffing model is proposed for EPL to pursue in order to prepare for the 2020 Milner Library reopening and launch of the Digital Exhibits Service.

1. Digital Exhibits Librarian

In interviews with QUT's Cube teams and in the job description analysis, it became clear that a coordinator of digital experience would be required to support exhibit design, curation, testing, deployment and promotion. Based on the analysis of recurrent skills in this sample, supporting work of this nature, would require a non-management, but rather a project management and a community liaison role. More specifically, skill sets that have been identified in the job description analysis and environmental scan interviews include the following, with percentages in brackets reflecting the prevalence of specific skills in the job description sample:

- Technical skills and interest in technology (63%), including keeping up with technology trends, learning about technology platforms, functionality of tools, software and programming languages
- Communication skills (69%), including ability to coordinate between technical and non-technical communities of stakeholders
- Project management skills (50%)
- Collaboration (39%) and interpersonal skills (57%), including relationship building and relationship management
- Ability to work independently and as part of a team (72%)
- Flexibility, open-mindedness and willingness to learn new things (14%)
- Service ethic, leadership, experimentation and self-motivation

Educational requirements

In 75% of the job descriptions (n=21), a role of this nature sought a Master's degree, including an MLIS in libraries and learning environments and other types of Master's in academic or non-profit environments. As the Digital Exhibits service at EPL will take place in a public library setting and the duties of this role will be in a leadership, project coordination, and community engagement capacity, an MLIS degree as a minimum requirement for this role would be in line with the growing community of practice identified as part of this research project.

2. Developer

A developer role was also frequently cited in interviews and represented nearly a third (27%) of the job description sample, as technical capacity to design, configure, test, deploy, and maintain digital exhibits is critical to the success of the Digital Exhibits technology service. As such, skill sets that have been identified in the job description analysis include:

- Software development principles and practices
- Thinking skills like problem-solving and an analytical approach (47%)
- Organization and attention to detail (32%)
- Flexibility and willingness to learn new things (58%)
- Ability to communicate effectively (74%)
- Ability to work independently and as part of a team (68%)
- Sharing code, documentation and collaboration
- Markup and scripting languages like HTML5, Python and JavaScript (with associated libraries and APIs, such as node.js, D3.js, three.js, WebGL)
- Compiled languages like C++, C#, Java
- Familiarity with Unity, Torque, Unreal game engines
- Familiarity with Processing and OpenFrameworks
- Familiarity with 3D modelling tools like Blender, Sketchup, Maya, 3DS Max

Educational requirements

In 68% of the job descriptions (n=13), a role of this nature sought a Bachelor's degree, including a specialization in Computer Science, Information Science or similar disciplines. As the Digital Exhibits service at EPL will take place in a public library setting and the duties of this role will be in a specialist, technical capacity, a Bachelor's degree as a minimum requirement for this role would be in line with the growing community of practice identified as part of this research project.

3. Designer

Finally, both environmental scan interviews and job descriptions analyzed in this section of the research project (34% of the sample) have demonstrated the need for a dedicated role responsible for the design, user experience and graphics of the digital exhibits. Specifically, the skill sets that have been identified as being significant for this role include:

- Media and interactivity design (48%)
- Ability to think creatively, visually, and analytically, including problem-solving (42%)
- Storytelling and communication skills, including wire-framing and prototyping (67%)
- Focus on user experience, knowledge of user-centered design principles and user interface design (25%)
- Collaborative (38%) approach and interpersonal skills (42%)

- Ability to work independently and as part of a team (71%)
- Adobe Creative Suite (50%), InDesign, AfterEffects, Premier, FinalCutPro
- Familiarity with Processing and OpenFrameworks
- Familiarity with 3D modelling tools like Blender, Sketchup, Maya, 3DS Max

Educational requirements

In 58% of the job descriptions (n=14), a role of this nature sought a Bachelor's degree, including a specialization in Art & Design, Computer Graphics, Interactive and Digital Media or User Experience. This role can be supported by a wide variety of skill sets, but a focus on design, user experience and "eye for aesthetics" was a recurring theme in interviews and in the job description analysis. As the Digital Exhibits service at EPL will take place in a public library setting and the duties of this role will be in a specialist, technical capacity, a Bachelor's degree as a minimum requirement for this role would be in line with the growing community of practice identified as part of this research project.

4. AV Specialist

In addition to the roles outlined above, following the Cube service model and applying lessons learned from QUT, an AV Specialist role is an important part of the team required to support the Digital Exhibits service. Specifically, the AV Specialist would be responsible for audio-visual integration, such as troubleshooting sound, projection, video inputs/outputs of the digital display wall and/or other audio-visual needs of EPL. A more detailed portrait of this role is likely to emerge around 2018, once the core mission of the Digital Exhibits service is defined and the technical needs and requirements of the service are specified with hardware and software purchases. A recommendation to further define this role before recruiting is put forward in the next sub-section.

Discussion

It is likely that specific job duties and skills required for all roles proposed here will continue to evolve. EPL will be able to define the requirements and duties of the AV Specialist through consultancy with QUT's Cube team. The AV Specialist role is also left undefined at this point in time, as EPL has not yet chosen the hardware solution for the digital interactive wall. Nevertheless, research conducted to date indicates that some degree of support for the display, sound, video, and other media management of the interactive wall is to be expected at part of the service of this nature.

As digital exhibit projects are researched, tested and piloted, a more detailed image of skills required of the Designer role will also likely emerge. At this point, the staffing model brings together skill sets in graphic design along with user experience, user interface and digital media design. However, these are broad areas of design and it may be challenging to find a single individual with skill sets in such diverse areas of expertise. As a result, the QUT consultancy will also aid in defining this role

further. For example, EPL may prioritize recruiting a User Interface Designer with a user experience foundation, while growing the in-house graphic design capacity for digital exhibits.

While the proposed Digital Exhibits timeline establishes dates for staffing the service, the following recommendations address Digital Exhibits Service staff roles and functions.

Limitations

Job descriptions are a useful lens through which to analyze emerging skills, but they are an incomplete picture of the digital interactive market. As no standardized skill sets exist in libraries related to this domain, the author of this report relied on a large sample size and a variety of organizations to observe common themes. No interviews were held with organizations in the sample of this section of the study. Tools, programming languages and platforms change rapidly, so specifics are not necessarily a reliable indicator of what technologies are required knowledge. Broader focus should be on knowledge of design principles, interest in emerging technologies, willingness to learn and ability to work collaboratively. Digital exhibits development takes place in teams, relies on managing diverse stakeholders and working within shifting priorities. Reliance on related themes gathered through the environmental scan with actual libraries and museums provide cross-reference to ensure validity of the data gathered in this portion of the research.

Artist-in-Residence Models

Method

The data in this portion of the project was gathered from semi-structured interviews carried out as part of the community consultation. In particular, recommendations related to artist-in-residence initiatives from community experts working in the arts or digital media were collected. In addition, internet searching for "artist residencies" as well as recommendations related to arts residencies that emerged during the environmental scan interviews were also synthesized. The scope of residencies was primarily North American organizations in arts, culture, heritage and non-profit sectors. Data was collected in two segments: between May 30 – August 20, 2016, and between January 3 – February 3, 2017.

Findings

While a large number of artist residency models are currently in place in North American fine arts, cultural, heritage, and learning organizations, the following four models were recommended by community partners as a brief overview of variation in fee structure, length of placement and degree of support provided to the resident. It should be noted that in most residencies, an expectation exists for the artist/developer/creator to engage with the public and to communicate the process in addition to sharing the results of their work.

Residency: Banff Center for the Arts
URL: https://www.banffcentre.ca/programs/performing-arts-residency/20170901
Location: Banff, Alberta.
Length: 6-7 months
Fee: None; room and board are covered, access to studios and other work spaces, but no artist fee is included.
Details: Aims to support projects in the creation phase (such as those requiring studios) and production phase (such as those requiring a theater or concert hall). All types of artists, including visual and performing are eligible.
Open to individuals, collectives and companies.

Residency: EMPAC
URL: http://empac.rpi.edu/residencies/artist
Location: Troy, New York.
Length: 9-12 months.
Fee: None; travel or material costs are also not covered under this program. Instead, on-campus accommodations and staff expertise are offered to the resident.
Details: Open to individuals and teams working in experimental media and performing arts. EMPAC offers extensive work and performance spaces, including a concert hall, theatre, studios, media production facilities, wood and welding shops, equipment, instruments and other technology integrated into the physical facilities.

Residency: Nova Scotia Joggins Fossil Cliffs Museum
URL: http://jogginsfossilcliffs.net/artscape/
Location: Joggins, Nova Scotia.
Length: 6 weeks.
Fee: $3262 artist fee, $500 living cost fee and up to $1500 in travel costs are covered by the residency.
Details: Individual visual, literary and performing artists are eligible. Accommodation costs, studio and office space is provided. In addition to the artistic production, the resident is expected to hold limited public office hours, deliver two public presentations and seek other public outreach opportunities.

Residency: Times Square Arts Residency
URL: http://www.timessquarenyc.org/times-square-arts/projects/hidden-assets/residency-at-the-crossroads-2015-16/index.aspx
Location: New York City, New York.
Length: 3 months with four placements per year.
Fee: $5000 artist fee and $1500 material costs are covered by the residency
Details: Open to individuals and small groups of all types of arts, including visual, literary, architecture, choreography, design, music, film and others. Office space is provided by the program but no accommodation or living costs are covered. Residents are expected to produce a public output, such as an intervention, performance, convening or published findings. Their work is also expected to be shared online or in print.

In addition to the brief overview of placement models, the following recommendations were gathered over the course of the environmental scan and semi-structured interviews as they pertain specifically to the residency initiative.

Edmonton Community Artist-in-Residence Recommendations

- Ensure opportunities for artists to immerse themselves in the environment and the technology; without hardware in place, this may be challenging before 2020.
- Advertise a call for proposals, much like art galleries do, in order to understand local talent and capacity to fulfill both the creative and technical elements of digital exhibits.
- Involve artists in the call-for-proposals and administrative processes: an advisory committee can assist EPL and building awareness and skills in the artist community as well. To drive a call for proposals process, the Library can connect with art galleries and other cultural organizations such as dance, performance, or design groups.

Cube Artist-in-Residence Recommendations

The following suggestions are compiled from interviews with and documentation provided by two Cube residents from 2014 and 2015. While their experiences are unique as external, temporary staff of QUT, they are nevertheless useful perspectives on exhibit development, testing, and deployment from a practical point-of-view. Their recommendations include technical considerations, user experience observations, as well as workflows related to hosting a resident in a learning organization.

- Carefully evaluate the decision to network computers to drive the touch screens: “There is greater complexity and longer projection and testing when actions cross nodes” in a computing network (Dena, 2014, p. 6)
- Keep the test wall for high level functionality tests but be aware that “the real wall” resolution, performance, size and features are likely to be significantly different from the test hardware
- While much of the resident’s development work can be virtualized, it is unrealistic to expect to develop exhibits without access to screen space
- Provide support, training and documentation for artists-in-residence. If running an artist-in-residence program, despite best intentions and even with best documentation, each artistic placement experiences institutional memory loss
- Plan for exhibit development to take between 6 to 9 months
- Consider having an “about the exhibit” pane as part of the larger display to provide context for the users
- Log all (user/touch events/interaction) transaction data for later analysis even if exhibit performs well. Logs are rich sources of data for improvement and documentation of application development.
- Conduct user behaviour observations as part of exhibit development process as a way to test both exhibit functionality and reception from customers
- Ensure artists-in-residence have channels for regular communication with their team and the host institution
- Sound: what appears very obvious on a small screen may not be noticed on the big screen. For example, some images, gestures, and sounds may need to be exaggerated in order to be perceived by the users.
- Proximity to windows and natural light will affect display appearance, so treat it as an outdoor screen
- Keep the user experience, narrative, and storytelling at the center of the service rather than strictly focus on technology processes, workflows, or procedures

Discussion

Based on the findings gathered in this portion of the research, it is evident that not all models of residency programming are applicable to EPL. Despite variation in models of residency programs, an artist fee is a reasonable expectation across cultural communities. The length of the residency varies also, though 3-6 months is in line with several organizations examined as well as being an appropriate length of time for a technology project. In addition, EPL can rely on arts organizations locally and provincially to facilitate the recruitment and promotion process, though managing the program would be the Library's responsibility. Continuing to be in touch with Cube residents is likely to provide more recent and reliable data in relation to this program. Therefore, EPL can continue to work with QUT consultant(s) to learn from Cube resident experiences in the coming years. Recommendations from Cube residents are in line with those from the Edmonton community experts, which suggests common best practices to follow when planning a residency program and broader exhibit development and project management.

Due to reliance on having hardware and documentation in place before recruiting a resident, EPL would be best positioned to pursue this type of program after 2020 opening of Milner Library. As well, the design and promotion of the program will affect the type of creator EPL attracts. Specifically, artists with technical skills bring a different perspective from developers with artistic sensibilities. As a result, there is value in evaluating the scope, expectations, and the audience for the residency program, and involving Marketing in promotion of the initiative.

Limitations

The method of data collection and the small sample size in this portion of the study is a clear limitation. In particular, the environmental scan did not specifically ask about artist-in-residence opportunities, though relevant information about funding, administration and perception of such programs would have added a deeper level of understanding of digital exhibits. Only one former Cube resident was specifically interviewed about the residency experience. This section was not meant to be exhaustive and definitive for formalizing an Artist-in-Residence program at EPL, but rather an introduction and an overview of various models that exist in performing arts and cultural-heritage sector in North America. As a result, a recommendation to conduct further research to expand on knowledge gained from Cube residencies is put forward. In addition, the scope of the study focused primarily on established residency opportunities in North America arts and cultural organizations. Broadening the scope of the research may have increased the number of findings, but the time spent analyzing a significantly larger dataset in this case would limit the completion of the research project.

Case Studies: The Cube

Method

The data for this portion of the research project was gathered between May 24 and August 19, 2016. Its sources include structured interviews with Cube staff and residents, website review (such as the official Cube site, the CubeJam tumblr (http://cubejam.tumblr.com), individual exhibit sites, and residents' personal websites), review of supporting documentation (such as Cube tours and promotional information) and literature review of publications specifically on the Cube by QUT researchers. This mixed-method approach to building a profile of the Cube as a public display case study was judged as an effective way to understand the functionality of the Cube in its context rather than relying on a single source of information, such as interviews with Cube staff or Cube promotional materials alone.

Findings

The Cube is an impressive installation from a technical perspective. Launched in 2012, the specifications for its various components include:

- 6 separate education display "zones" where users can discover content
- 190 square meters (approximately 145 megapixels) of display surface
- 14 high definition projectors
- 48 multi-touch screens
- Infinite number of touch points (using infrared technology)
- 55 custom-made surround sound speakers
- High performance computing with a dedicated enterprise-class data center
- 4 dedicated gigabit Ethernet networks
- Physical and virtual machines to serve content
- Windows 2008 and RedHat Linux enterprise environments
- RFID sensor system

Cube Exhibits

A large number of major exhibits has been developed in the last 5 years uniquely for the Cube, which primarily consist of large-scale video games capable of supporting multiple players simultaneously. In addition, web-based interactive content has also been developed. The following table captures most of these exibits, and demonstrates that the majority of them have been developed on the Unity 3D game platform. Where they exist, the author hyperlinks exhibits to their websites for more information. Most of the exhibits have been develped by the Cube Studio team, some by the Visualization and eResearch group, and a handful of others by visiting artists-in-residence hosted by QUT.

Exhibit Name	Description	Exhibit platform
Arcade	The Arcade is a trip down memory lane into 80s style games, revitalized in full 3D. Built into each game are behind-the-scenes mathematical insights, capable of showing off the algorithms that go into achieving simple arcade fun.	Unity3D
Chem World	Chem World is an inspiring and hands-on experience of chemistry and its fundamentals. This project allows students to conduct virtual chemistry experiments too dangerous or difficult to run in a classroom.	Unity3D
Cryptext	Australia Council for the Arts Digital Writing Resident, Jason Nelson, and programmer Matthew Horton, extend SciFi genre to the dynamic, interactive, two-storey space of The Cube, creating one of the world's first speculative fiction games for large touchscreen displays.	Unity3D
CubeGlobe	The user interface displays HD video, interactive 3D models and dynamic charts, as well as traditional multimedia of the globe and geospatial data.	WebGL THML5 D3.js Cesium
CubeIT	CubIT is a multi-user, large-scale presentation and collaboration framework developed in collaboration with QUT faculty. The CubIT system allows users to upload, interact with and share their own content on the Cube's display surfaces.	Ruby on Rails, Python, Kivy
Data Wall	Data Wall is an interactive project that displays various layers of local data to the community. Cycling through statistical and socially generated data, the Data Wall allows visitors to search through layers of Brisbane city, from local public transport routes to public art. The project allows the community to view their city in a different light, peel back the layers of Brisbane and contribute their own.	Google Maps API JavaScript Node.js TUIO client ASP.net web app
DinoZoo	The Cube team has partnered with Queensland Museum's renowned paleontologist Dr Scott Hocknull to recreate these hyper-realistic, prehistoric reptiles and their environment, all backed by the latest research. Dino Zoo includes digital activities, an archaeological dig simulator, an interactive Earth timeline and more. A series of related STEM workshops will also be offered for visiting high school students.	Unity3D
ECOS	ECOS uses interactive data and illustrations to help people understand how everyday energy use impacts people in a "green" building. Inviting play and reflection on the role of green buildings, ECOS presents data on The Cube using a simple and interactive game-like application.	Unknown
iCO2	iCO2 teaches eco-driving practices in a game-like environment to help drivers maximize the energy efficiency of everyday vehicles. Compete with your friends in a networked and multi-user 3D simulation to drive virtual vehicles using eco-driving methods. In iCO2, the winner is not the first over the line, but the person who travels the furthest on a tank of fuel.	Unity3D
Nomencluster	Designed by The Cube's Digital Writing Resident, Jason Nelson, with the help of programmer Matthew Horton,	Unity3D

	Nomencluster is a highly interactive digital artwork and poem that explores the space as a drawing and creative play environment. Instead of drawing with lines, Nomencluster allows you to create your own designs with insects, 19th century engineering engravings, food chemistry, and a continual stream of poetic texts and interactive writing.	
Physics Observatory	Physics Observatory is a game-like environment where people of all ages can engage in learning about physics. Tapping into our desire to construct and to deconstruct, the playroom is a space where people can come together to build (and destroy) each other's creations in fun and engaging physics simulations.	Extempore (custom programming language); rewritten in Unity3D
Plasma Wall	Plasma Wall uses motion capture technology for a fun and colourful interactive experience of The Cube. Let your body talk with Plasma Wall's collection of abstract light and movement games.	Microsoft Kinect web application
Robot University	Cube's first Production Residency, partnered with the Australia Council for the Arts Literature Board, Robot University allows people of all ages to engage with robots. People can command robot weapons, send messages to a robot on Mars, and choose domestic items for a household robot.	Unity3D Blender
Soul of the Cube	The Soul looks like a large active intelligence, full of evolving computations of live data feeds from the Science and Engineering Centre, and other areas of QUT. Some of the live data utilized for the Soul includes solar energy creation, building power consumption, and data from research papers at the QUT Library.	Unity3D
Virtual Reef	Virtual Reef is a life-sized marine ecosystem which provides an immersive, simulated underwater experience that invites users to learn about the Great Barrier Reef's unique ecosystem.	Torque 3D Torque C++ Awesomium; rewritten in Unity3D

In addition to the range of exhibits outlined above, over the past five years, Cube staff have collectively contributed to two guiding documents: Cube Software Development Manual and the Cube Operational Manual. These documents cover processes and standards as well as prototypes and demos for computing (such as applications), network (such as data exchange) and control (such as scheduling) technologies used in operating the Cube on a regular basis. This documentation-building process reveals the growing knowledge base for the display as well as emerging best practices related to technology development, training, and support.

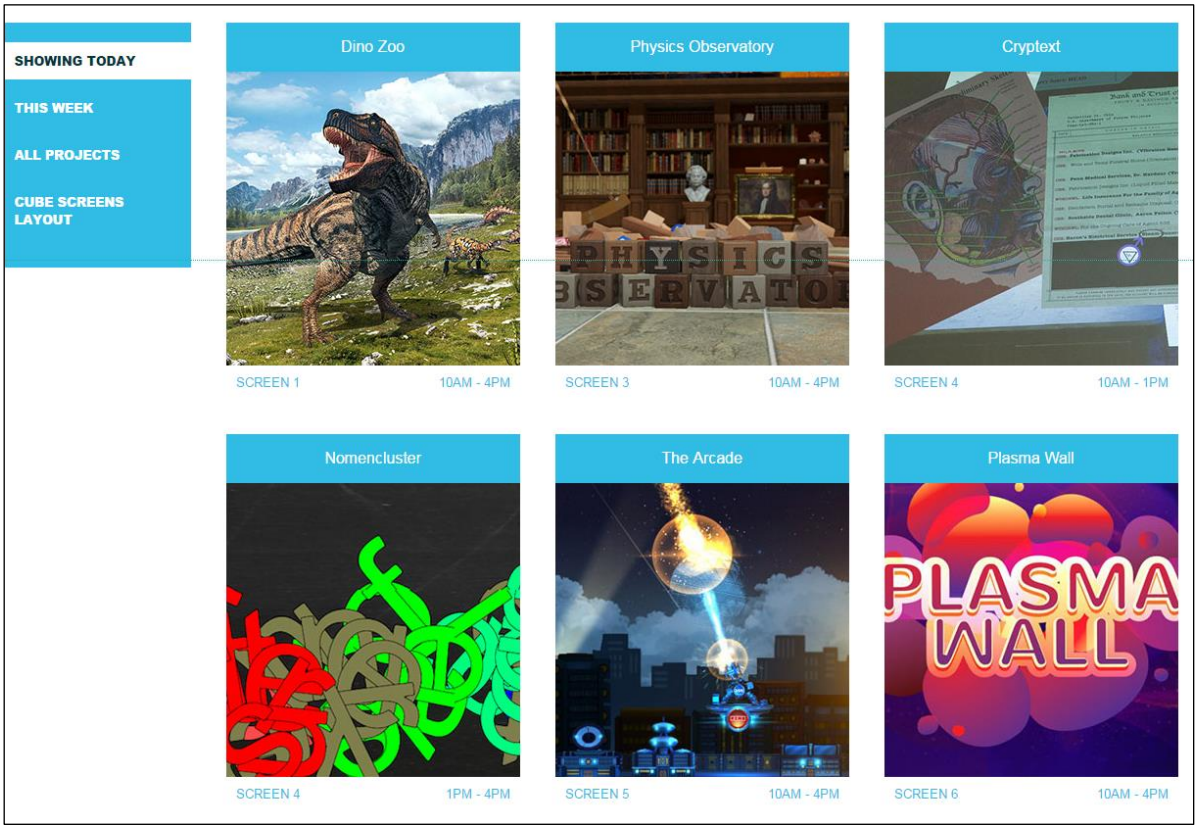


Figure 13: Screenshot of daily schedule of exhibits on display at the Cube (Image source: QUT)

Figures 13 and 14 demonstrate the scheduling of Cube exhibits on the Cube site, much like a library "program guide", that describe what is available on at the screens at any given time. Interested visitors can explore all exhibits or see what will be displayed on a particular day to plan their visit accordingly.

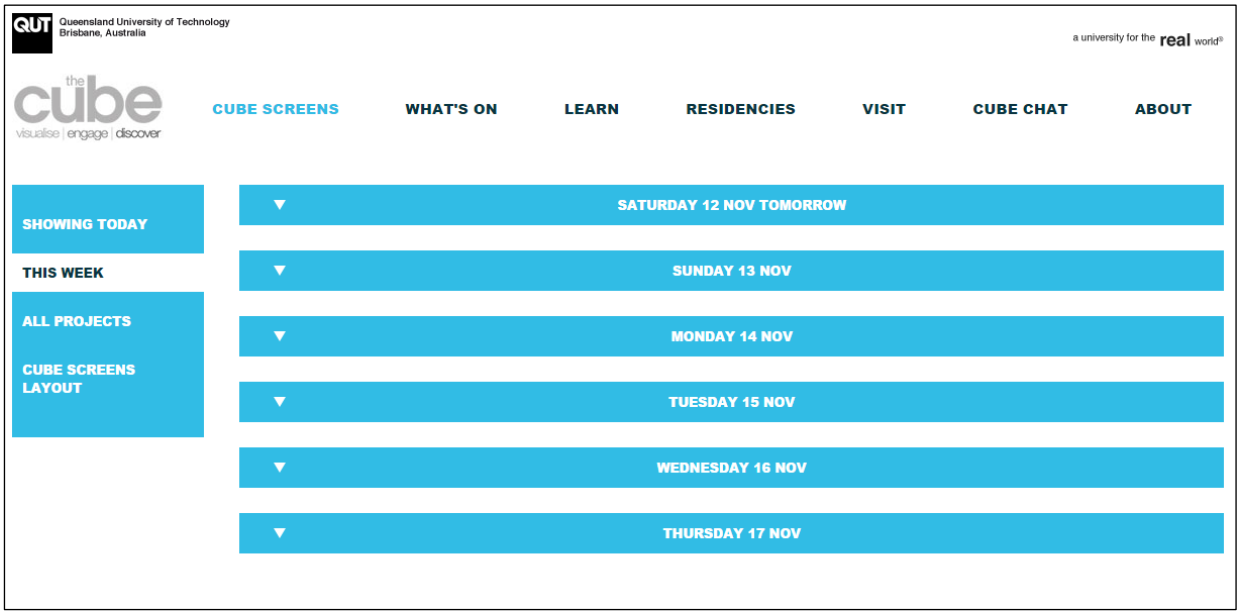


Figure 14: Scheenshot of Cube exhibit browsing menu by week (Image source: QUT)

Cube Staffing

The staffing data was gathered from interviews with the Project Manager of Visualization and eResearch group, housed under QUT's Institute for Future Environments, as well as Manager of Stakeholder Relations, housed under QUT Precincts division. Findings of the environmental scan reveal that the Visualization and eResearch team typically spends 20% of their time on Cube projects while the Cube Studio spends 100% of their time on Cube projects. The former acts to some degree as a research-and-development unit, while the latter acts as a full-time production studio for the Cube. Additionally, an artist-in-residence, (not represented below) who may rely on a team of QUT designers, developers, and technologists, also spends 3-9 months out of the year creating content for the Cube can therefore also be considered as an additional team supporting the service. It is estimated that around 17 FTE are dedicated to supporting the Cube in terms of research, development, planning, content creation, operations, outreach, and programming.

Promotion

Cube has a range of social media channels actively promoting events and activities taking place on site, which include:

- Main site: http://www.thecube.qut.edu.au/
- Blog: https://qutthecube.wordpress.com/
- Twitter: https://twitter.com/QUTTheCube
- Facebook: https://www.facebook.com/QUTtheCube/
- Instagram: https://www.instagram.com/qutthecube/
- Vimeo channel: https://vimeo.com/qutthecube

Associated with the Cube are also a team of STEAM Education Officers, who promote science education and integrate science and technology programming into curriculum planning. Extending programming and outreach efforts at QUT, several Cube Jams have also been held over the past five years to brainstorm ideas, generate content and engage the local community, which are captured on a dedicated blog (http://cubejam.tumblr.com/).

Cube Studio's Pillars of Interaction

The following guiding principles for Cube operations, programming and outreach have been identified in the interview with the Manager of Stakeholder Relations at QUT Precincts and the supervisor of the Cube Studio team responsible for 80% of all Cube exhibits. These "pillars" are specific to QUT's context and each organization deploying a digital exhibits service will have a unique approach based on institutional mission, priorities, and resources.

1. **Community engagement** – this includes schools, families, seniors, and anyone visiting the Science and Engineering Center on campus. Exhibits developed for the Cube are popular with all types of visitors. For example, the

Cube received 25,000 visitors in 3 weeks during winter break, at a time when most campuses are empty. With the theatre next door, Botanical Gardens, museum district, and other cultural attractions, the QUT campus has become a destination both for the city and tourists. It also helps potential undergraduate students see themselves in the university, so community engagement is a core component of the Cube as a service.

2. **Conferences, programs and events** – the Cube has served this type of activity so well that the Cube team has to manage expectations from various organizations interested in booking the space and holding events.
3. **Undergraduate learning** – while it is, at times, difficult to support formal instruction in such a unique space, the Cube team hopes to have students produce games and other learning objects for the display as part of experiential learning initiatives and university programs.
4. **Visualization and research** – building on its potential for learning, the Cube team finds it challenging to employ the Cube as a tool for research. Like many academic institutions seeking ways to integrate technology into scholarly practices, QUT is exploring strategies for integrating the Cube's interactive potential into research contexts.

Discussion

In the context of the environmental scan and the community consultation findings, the Cube remains an exception rather than the rule in terms of the broader landscape of digital displays in learning environments. It is by far the biggest, most technologically robust, and highly engaging display examined to date. As well, the Cube is used in the widest variety of ways by the widest range of user groups. For example, the Cube routinely sees around 70,000 visitors per week. In 2015, it has logged 314 "engagements", consisting of tours, workshops, hackathons, programs, and special events apart from regular programming and usage open to the public.

However, it is also evident that significant resources have been dedicated to developing content. Management of priorities regarding Cube's purpose and function, the high cost associated with resourcing the content and programming, and continuous research into extending functionality of the Cube with emerging technologies such as the Internet of Things, sensors, augmented and virtual reality all require staff time and internal capacity to support the service. Challenges with mission and the role of the Cube along the research-public education spectrum have been discussed with QUT staff. Similarly, the community consultation has suggested that similar challenges will likely arise with managing expectations from EPL's community partners who may have varying interests in using the digital interactive wall. Seeing such issues arise reduces the risk associated with the service and prepares EPL for its launch in the coming years.

Drawing on the lessons learned from the literature review, the success of the Cube in terms of high engagement, use, and perception, can be attributed to such factors as:

- Honeypot effect – visitors observing others using the technology to learn how the Cube "works" and becoming active participants as well
- Walk-up-and-use system – no specific instructions on how best to interact, intuitive design, and original content
- Immediate availability of content – large screen real estate accommodates many users simultaneous, including those observing from a distance
- All functionality available at all times (non-modality) where users don't need to select the mode of interaction from a menu. Rather, both touch and gesture interactivity is always enabled and available for interaction with the exhibit.
- Social experiences – the Cube is a shared space, conducive to play and learning
- Parallel interaction – many people can engage with the display at once without disrupting the system or taking turns, which supports immediacy of interaction
- Technology solution - the hardware architecture was well-planned, and as a result, the Cube has stood the test of time in functionality, performance, and attractiveness to thousands of users

In addition, the following diagrams describe the processes taking place at the Cube to render game applications. They were produced after analyzing data gathered during interviews with Cube staff, documentation, and website review. Figure 16 demonstrates the input flow through the display and its subsequent communication with the exhibit application, which, in this case, is hosted on the web. The Cube has used both executable content, such as Unity3D game files, and web-based applications, like the Data Wall, to visualize content. Both game-based and web-based exhibits deployed on the Cube demonstrate the capacity to respond to multi-user inputs. This suggests that the technical architecture is similar in both web-based and game-based exhibits, and supports the recommendation by QUT teams to adopt both the "platform" of choice for developing exhibits for EPL's interactive wall. Modeling these technical processes and expanding upon them with appropriate contemporary solutions, such as 3D cameras, augmented reality applications, and new types of sensors will allow EPL to lead the development of digital interactive services in public libraries across North America.

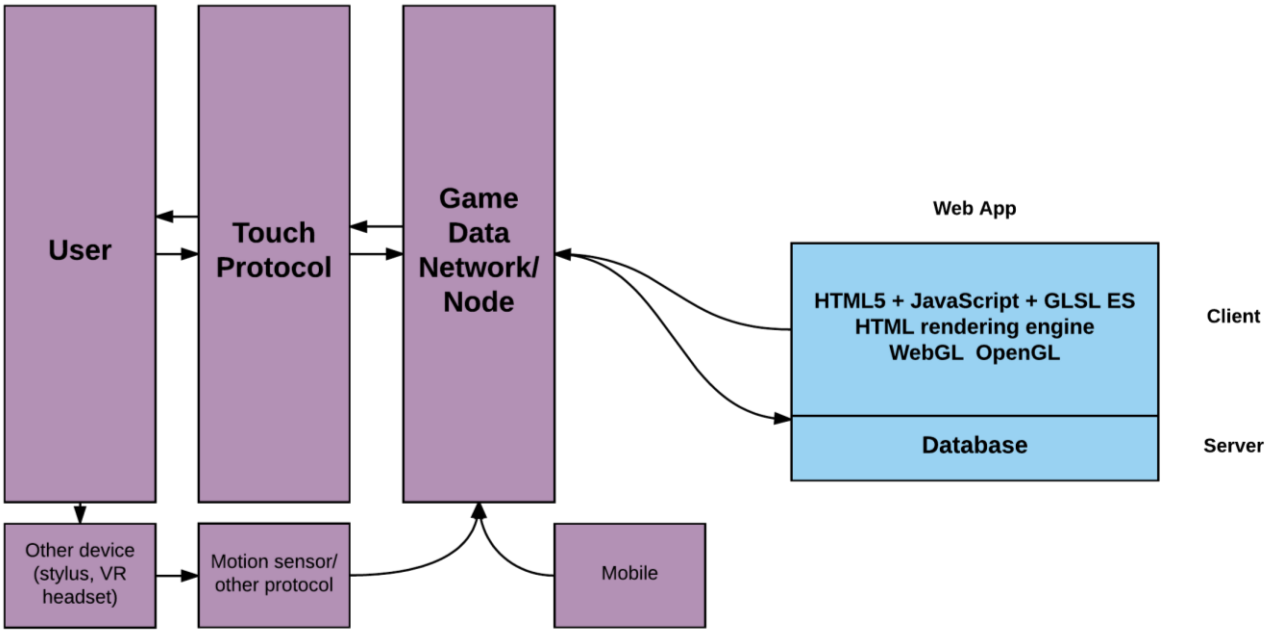


Figure 16. Touch panel interaction process with relation to exhibit application

Clearly, following the Cube model is unprecedented in public libraries, but its focus on community engagement, STEAM education, and ensuring the wow factor remains strong in the face of changing user expectations make it worthwhile for EPL to adopt its best practices. STEM Engagement Team ensures education and outreach services by translating the potential of the Cube into accessible and meaningful experiences for non-QUT audiences, such as youth and their families. Such programming is already taking place in all library locations. Therefore, STEM programming is another way to integrate the digital interactive wall into makerspace and school-aged services.

Finally, defining EPL's own "pillars of interaction" will help guide the service and drive priorities for digital exhibit development. To date, the following goals have been identified for the Digital Exhibits service in the preliminary documentation by EPL and Cube staff:

1. Deliver the 'wow' moment and a lasting impact by making the digital interactive wall a location of distinction and attraction;
2. Activate spaces connected to the main installation;
3. Create new ways for visitors to connect, create, learn, and collaborate;
4. Leverage personal devices and personalization of user experience;
5. Connect with local and regional content providers and showcase talent and establish a sustained supply of content and innovation long term.

Formalizing EPL's approach will help guide content partnership and programming, as well as prioritize resources for the Digital Exhibits service in the coming years.

Limitations

Case study limitations concern the generalizability of findings, since each case study is ultimately unique and even commonalities within categories created as part of this research project are tenuous. In addition, being a qualitative method of research, case studies are therefore limited by the sensitivity and integrity of the investigator. These limitations were address, however, through examining a variety of sources including interviews, website review, literature and documentation review. On the other hand, the benefits of the case study are its flexibility of approach and capturing reality of the phenomenon, as was a priority for this project with respect to Cube operations.

Furthermore, the goal of this section of the research project was not evaluation or comparison of the Cube to other display models, but gathering recommendations and best practices that can be applied to the Edmonton Public Library context. After all, QUT is the model which EPL plans to pursue in installation of its own digital display wall. Therefore, the limitations of the case study as a method are outweighed by best practices gathered from staff involved in Cube operations. Additional data gathered from users of the Cube would enrich the case study, but costs associated with gathering observational or interview data are significant barriers in the context of the Digital Exhibits Internship.

Case Studies: Other Organizations

Method

The data for this section of the project was gathered between November 1, 2016 and February 1, 2017. The following 25 real-world examples have been identified in the literature, internet searching for “interactive installations”, and referral from semi-structured interview participants. Overall, the author sought examples that demonstrated applications of various aspects of digital exhibits over the last 10 years around the world. These case studies serve as useful lessons learned from the museum, civic technology, art gallery, library and information, and other non-profit domains upon which to draw approaches to digital exhibit design. In line with the rest of the research project scope, applications primarily in educational and entertainment domains were examined, rather than those in commercial or retail environments. In addition, in order to be included in this section of the report, projects needed to demonstrate some degree of interactivity, with digital or tangible interfaces being equally considered, as well as representing the widest range of subject matter and geographic location. After gathering the data from the sources listed above, the author then applied 3 keywords to describe the topics addressed by each case study. The keywords were ranked, analyzed and organized to find common themes. The following thematic categories emerged in the analysis: artistic expression, data visualization, social interaction, information architecture, children’s activities, games and experimental applications.

Findings

Artistic Expression

The following projects use digital displays and other interactive technologies primarily for artistic purpose rather than for informational use. They also rely on input from participants in real-time and are therefore always original.

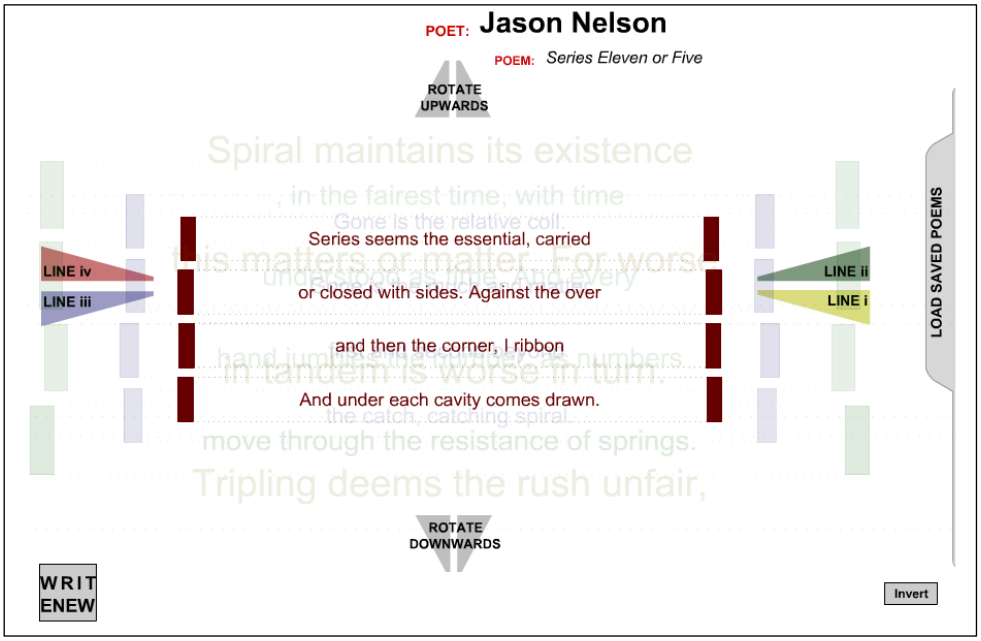
1. Magic Cube

(Image source: Derivative)

URL: https://www.derivative.ca/events/2013/Pixelux/
When: 2012-2013
Where: Lyon, France
What: The Magic Cube combines principles of physical computing, a large public LED display, interactive art and public performance into “a graphic monolith made from a mysterious scattering and glowing matter” (Derivative, 2013) surrounded by 28 bicycles connected to a computer. Magic Cube was installed on a city street to capitalize on the impressive size of the display and to allow anyone to participate in the exhibit. The speed and the stamina of the bicycle riders produce a data stream with a unique pattern that generate the graphics, animation and sound effects in real time. Everything in the exhibit was created using the TouchDesigner software, a professional tool for producing interactive media experiences.

2. Digital Writing and Digital Poetry

URL: http://www.secrettechnology.com/poem_cube/poem_cube.html
When: 2016
Where: Brisbane, Australia



(Image source: Secret Technology)

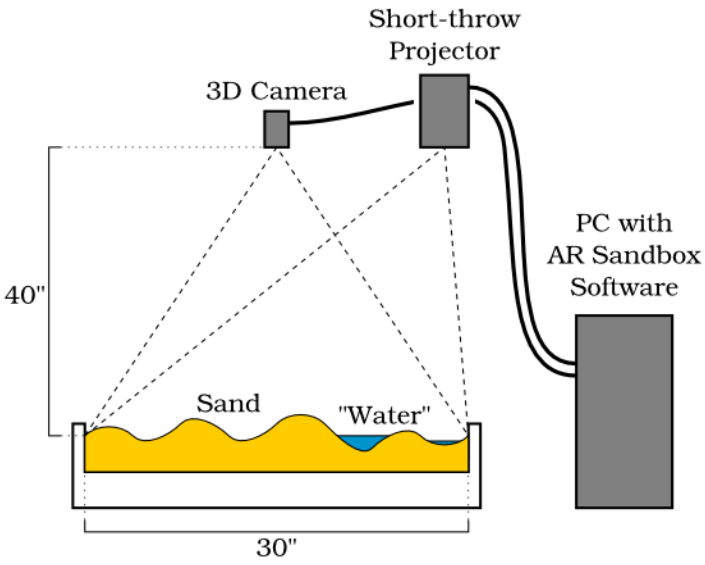
What: Jason Nelson is an artist, writer, professor at Griffith University in Australia and a former Artist-in-Residence at the Cube. He creates interactive poems, digital fictions and generative web experiments. The poem cube pictured above allows the site visitor to create a poem computationally by clicking buttons all sides of the poem space. The poem is therefore always original and unpredictable. Digital writing interfaces like Jason Nelson's work demonstrate the potential for interactivity in digital exhibits applied to textual content. For example, projects like these can connect Digital Exhibits services with Capital City Press initiatives by highlighting the work of local writers and developers making unique experiences both for the web and the digital display wall.

3. Sandbox

URL: http://www.lozano-hemmer.com/sandbox.php
When: 2010
Where: Santa Monica, CA
What: Sandbox is a large-scale interactive installation created originally for the Glow Santa Monica art festival by artist Rafael Lozano-Hemmer. The installation consists of two small sandboxes where images of people on the beach are projected at small scale in real time. As participants reach out to touch these projections, a camera detects their hands and relays them live to two of the world's brightest projectors, which hang over 8,000 square feet of beach surface. In this exhibit, people in the same space share three scales: the tiny sandbox images, the real human scale and the monstrous scale of large projection. This project is an example of interaction that does not rely on touch or gesture recognition but nevertheless employs digital projection in a public setting to facilitate people to interact with the technology and with each other.

Children's Activities

1. Augmented Reality Sandbox



(Image source: UC Davis)

(Image source: UC Davis)

URL: https://arsandbox.ucdavis.edu/; http://tangible-landscape.github.io/
When: 2014
Where: Davis, California
What: Augmented reality sandboxes are an emerging community of practice, which are appearing in makerspaces, libraries and museums across North America. For example, University of California Davis was one of the first to create and share the

code base for its interactive projection, while Ryerson University's Digital Media Experience Lab has installed one in 2015. As well, North Carolina State University has developed Tangible Landscape, an open source, collaborative environment for analyzing terrain. The Tangible Landscape project aims to make Geographic Information Systems accessible to all by designing engaging and intuitive interfaces. A typical augmented reality sandbox set-up consists of an application that scans the sand surface using a Kinect 3D camera and projects a real-time updated map of a particular landscape. Topographic contour lines and bodies of water are simulated back onto the surface of the sand using a calibrated projector. In public library contexts, these types of technologies are a concrete and playful introduction to the idea of augmented reality to people of all ages. They are also an example of physical-virtual interactivity that do not rely on digital screens.

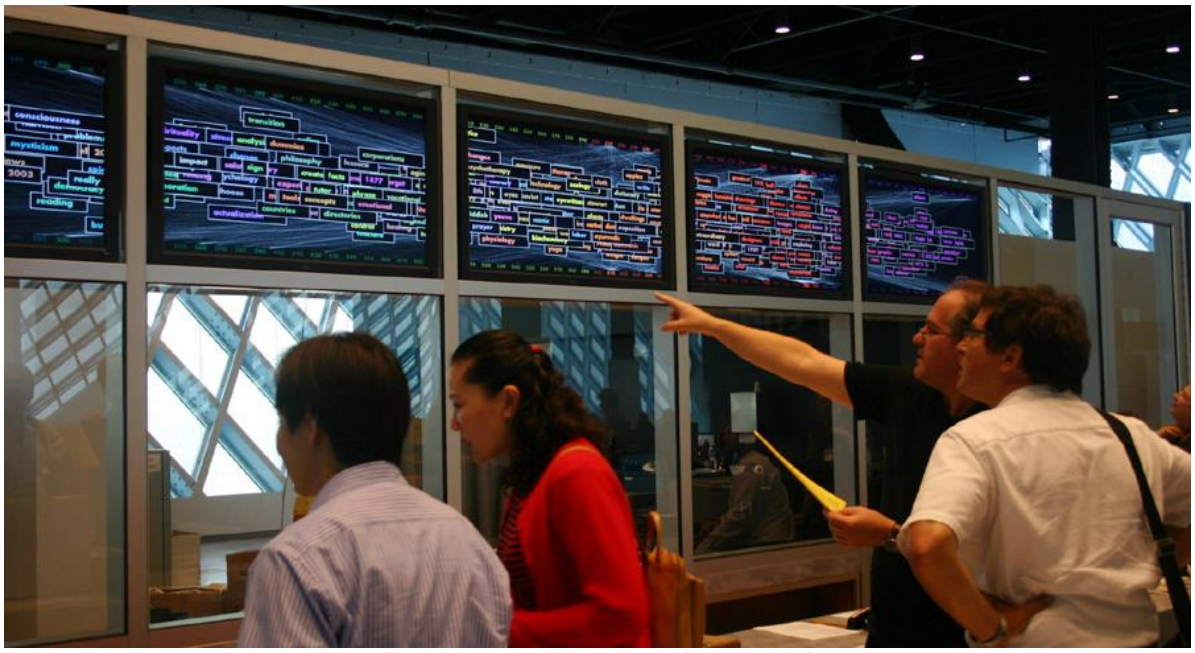
2. Google Expeditions

(Image sources: Daily Mail ; TechCrunch)

URL: https://www.google.com/edu/expeditions/
When: 2016
Where: online
What: Google Exhibitions is a teaching tool made up of over 200 different 3D virtual tours of places around the world like Machu Picchu, International Space Station, and the Great Barrier Reef designed specifically to be paired with Google Cardboard (or other virtual reality viewers). Expeditions are also designed for school-age students to explore the environment simultaneously by connecting multiple VR viewers to a router that brings them all into one virtual space. In essence, teachers can bring their classes on virtual fieldtrips. The content is free but requires equipment, such as cardboard viewers and mobile phones, to benefit from the immersive 3D perspective. While Expeditions may not lend themselves well to projection on a large display, they may be incorporated into other digital literacy programming involving Makerspace and youth services.

Data Visualization

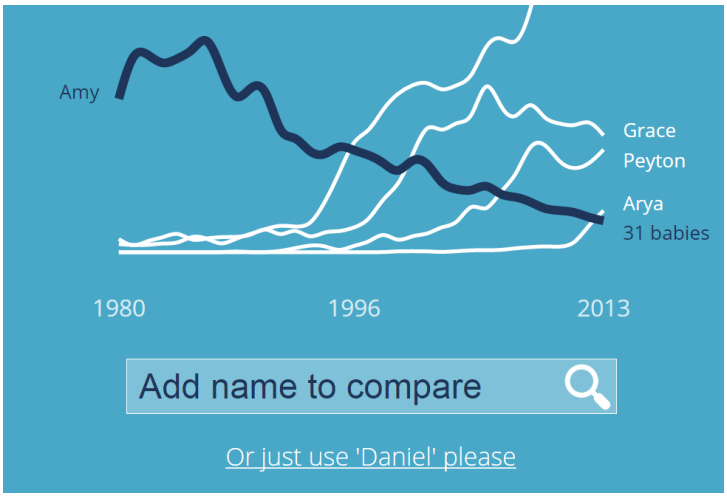
1. Making Visible the Invisible



(image source: Rama Karl Hoetzlein)

URL: http://www.mat.ucsb.edu/g.legrady/glWeb/Projects/spl/spl.html
When: 2005 - present
Where: Seattle, Washington
What: "Making Visible the Invisible" is a project commissioned by the Seattle Arts Council for the Seattle Central Library, and is located in a large open 19,500 sq ft "Mixing Chamber" of the library. The installation consists of 6 large LCD screens located on a glass wall horizontally behind the main information desk. The screens feature real-time visualizations generated by custom software using library data received hourly. The project has been up since 2005 and is considered to be the longest running media arts project that has been continuously collecting data. The system has now collected over 50 GB of raw circulation data spanning nearly a decade (Legrady & Forbes 2016, p. 2). Projects like "Making Visible the Invisible" demonstrate the interest in library data and data visualization as a public information service.

2. Open Data Visualization



Data visualization of most popular baby names in the last 30 years

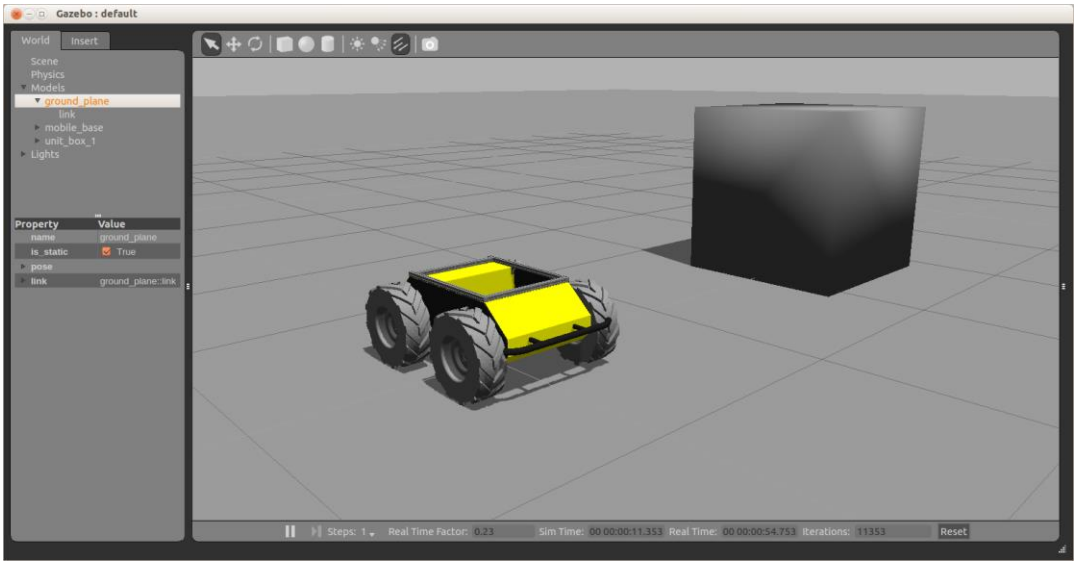
URL: http://www.darkhorseanalytics.com/portfolio-all/
When: 2016
Where: Edmonton, AB
What: Darkhorse Analytics is an award-winning Edmonton-based company specializing in data analysis and data visualization for business intelligence and communication with clients like Enbridge, Government of Alberta and Strathcona County. Using a provincial open data set of every baby name registered in Alberta for the last 30 years, the company created a web-based exhibit to visualize and compare trends in names over time. Combining Darkhorse Analytics' expertise in data analysis and visualization with interactivity functions, a digital exhibit project using library data could be easily designed for multi-touch panels and the web.

Experimental

1. Virtualization

URL: http://gazebosim.org/
When: 2016
Where: online
What: Simulation software like Gazebo allow programmers and enthusiasts alike to design, test and train robots virtually while following the laws of physics. Gazebo provides a "robust physics engine, high-quality graphics" (gazebo.org, 2017) and a user-friendly graphic interface for working on projects in a virtual environment. Tools like these can be integrated into existing Makerspace programing and extend Digital Exhibits services. For example, Gazebo can be combined with Lego Robotics and Augmented Reality Sandboxes to test the movement of a robot army on the surface of Mars and then physically implement it in the Makerspace using a sandbox with digital projection. A suite of virtualization software like Gazebo extends the digital

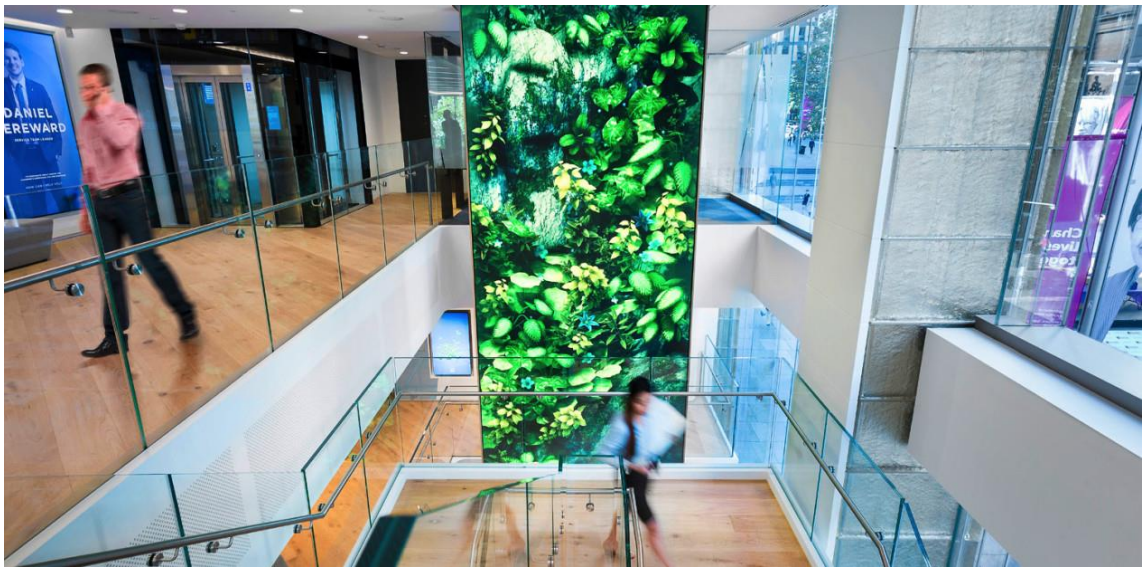
literacy and making services to a wide range of library customers by supporting the physical-virtual understanding of technologies and their applications.



(Image source: Robohub)

2. ANZ Virtual Garden

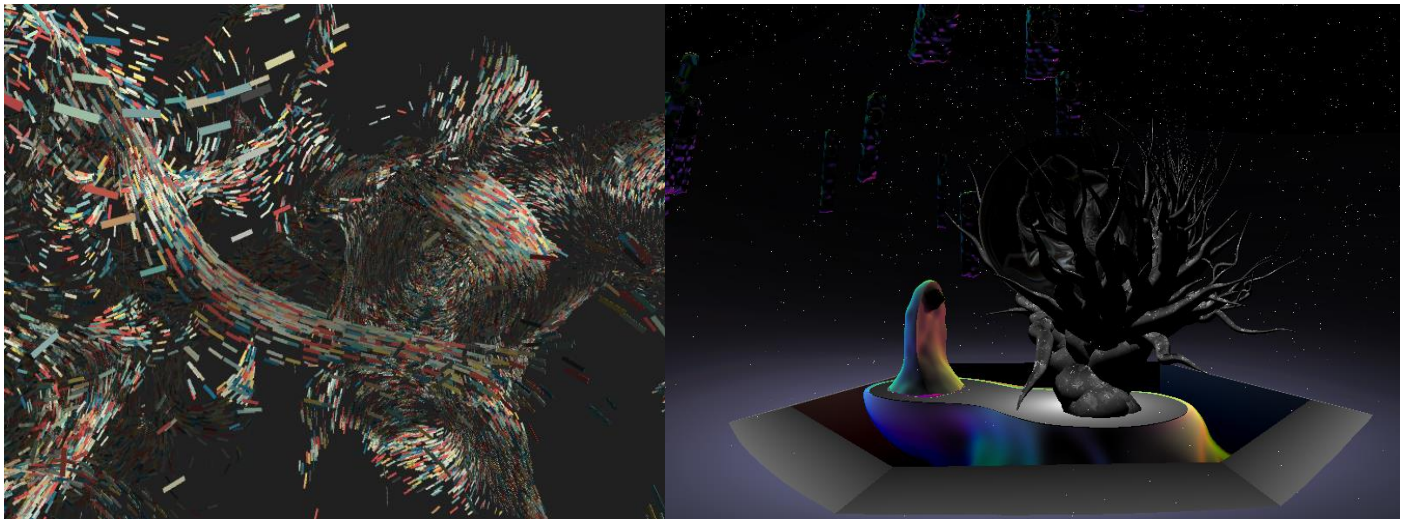
When: 2016
Where: Sydney, Australia
What: The Virtual Garden is an interactive wall 11m in height, spanning three floors of the ANZ Bank Martin Place Branch. The content of the wall responds to changes in the environment, such as weather, time of day and tweets sent to “the garden”. Visitors can tweet to the digital display using the hashtag #ANZVirtualGarden to request butterflies, birds, insects, flowers, mushrooms and a waterfall to change their colour and to increase or decrease in number. The exhibit was developed by Deloitte Digital’s creative team, and is an example of mobile interactivity that supports multiple users concurrently. Unlike many examples of interactivity with digital displays, users do not need to be physically present in the bank branch to provide input to the interactive wall. Unlike many examples of interactivity with digital displays, users do not need to be physically present in the bank branch to provide input to the interactive wall.



(Image source: Bandt.com)

3. Code/Art

URL: https://processing.org ; https://www.clicktorelease.com ; http://cabbi.bo
When: 2014 - present
Where: online
What: A robust and diverse community of individuals working at the intersection of code and art is emerging online, employing the latest web technologies to create interactive, responsive and engaging experiences. Also called generative art or creative coding, these works are rendered in the browser and support touch interactivity through click and scroll functions. Some experiments also incorporate sound and video into original, multi-media experiences. Code/art developers typically work in Processing, HTML5, JavaScript, and WebGL. By enabling touch protocols like TUIO, these web experiments can lend themselves to being displayed on multi-touch public displays as a source of ready-made digital exhibits that introduce the concepts of art and digital literacy in a visually-engaging, immersive experience.



Games

1. Manhattan Story Mashup

(image source: MobiLenin)

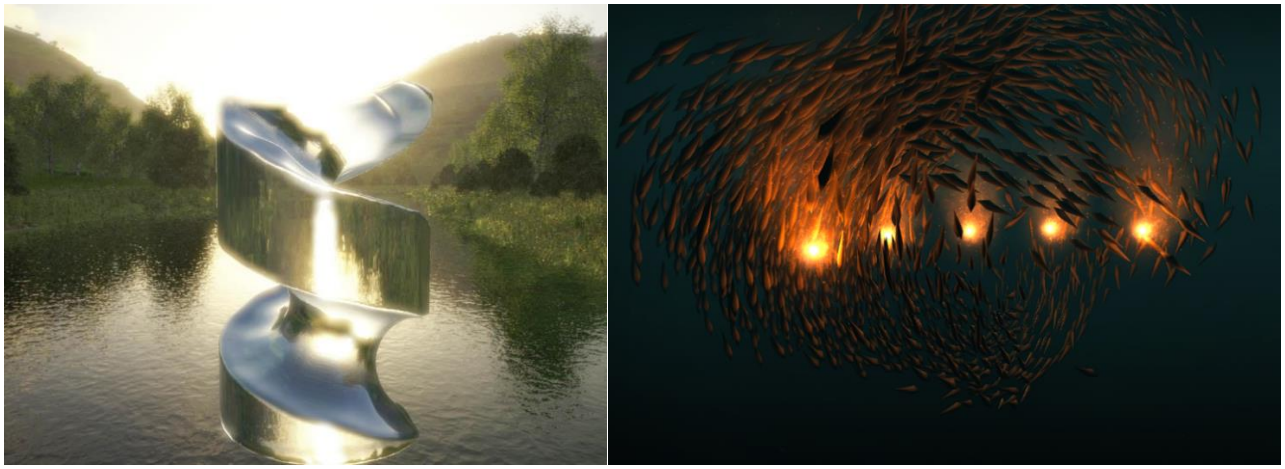
When: 2007
Where: New York City, NY
What: Manhattan Story Mashup was a large-scale pervasive game designed for Nokia Research Center to be played using a website, mobile phones and a large public display in Times Square. The game was actively played by over 150 people on the web and by 184 street players in downtown Manhattan. The game asked street players to take photos of the city around them, posting those photos onto the dedicated game website. Web players could put together original sentences using submitted pictures and words. Best sentences would then be featured on the public display. The game engaged players in a collaborative and competitive effort of storytelling. It also enticed them to share their experiences publically through the digital display. In fact, according to Tuulos, Scheile and Nyholm (2007), the Times Square display added a "unique twist and a big wow-effect" to the game by providing a feedback channel to street players who were able to follow in real-time how their photos were being used in stories online. The authors believe that having a shared view to the game was a key important feature of the display. In addition, the opportunity to leave a personal, though ephemeral, impression on Times Square motivated both the web and the street players to produce imaginative content. Projects like these demonstrate the continued popularity of pervasive games in the digital age, as well as the willingness of adults to participate in a multi-modal experiences given right motivation.

2. Edmonton Trolley Car

URL: http://fiala3d.com/gametrip/
When: 2016
Where: Edmonton, AB
What: Edmonton Trolley Car is a mobile app and a first-person 3D game in which players experience Edmonton's history by taking a virtual ride in a trolley across the High Level Bridge and through the city. It can be controlled using a mobile device, a game controller or a virtual reality device like Google Cardboard. Players earn points for interacting with historical characters and viewing Edmonton landmarks. While this game was designed for personal devices, it may be adapted for large public displays. It is an example of digital exhibits with heritage themes that emerged in the community consultation.

(Image sources: Gametrip)

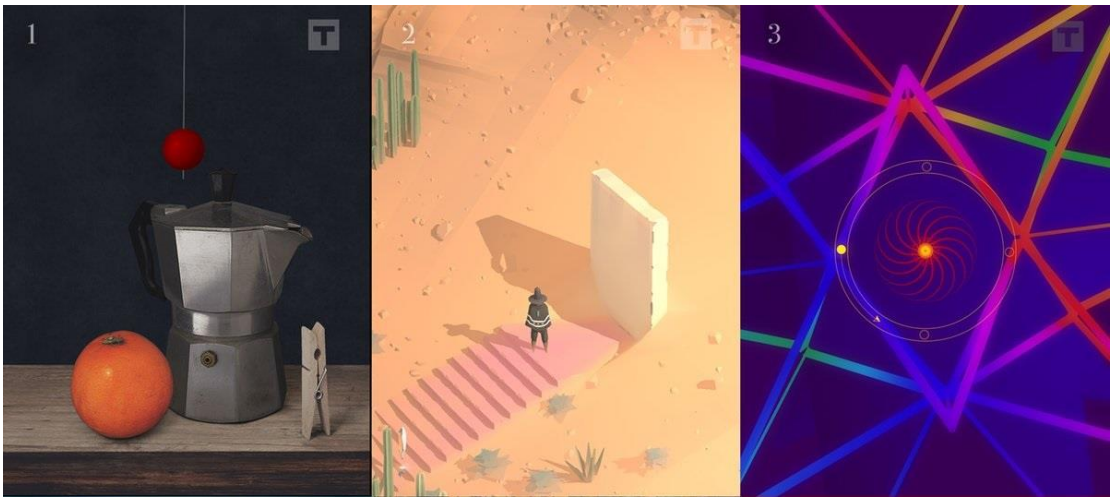
3. Leap Motion Applications



URL: https://apps.leapmotion.com/
When: 2016
Where: online
What: Leap Motion is a manufacturer of hardware and software for motion-based interactive games suitable for players ages 3 and up. Many game applications

available through its app store are free and can also be paired with virtual reality headsets like Occulus. The apps fall under such categories as “creative tools”, “educational”, “experimental” and “science”. Due to its small size, user-friendly set-up and reliance on hand gesture motion rather than full-body motion, Leap Motion is arguably a more accessible, intuitive and portable alternative to Microsoft Kinect system. Specifically, the controller plugs directly into a computer using a USB cable. As well, the various games developed for Leap to date appeal to people of all ages and backgrounds. For example, Sculpting, pictured above on the left, allows the player to model 3D objects virtually using different materials and sculpting tools. Flocking, pictured above on the right, relies on gesture interaction to simulate naturalistic migration of fish based on player’s hand and finger movements. Though multi-user interaction is not as widely supported as single-user, Leap is an affordable and accessible introduction to gesture for a public library environment.

4. Triennale Game Collection



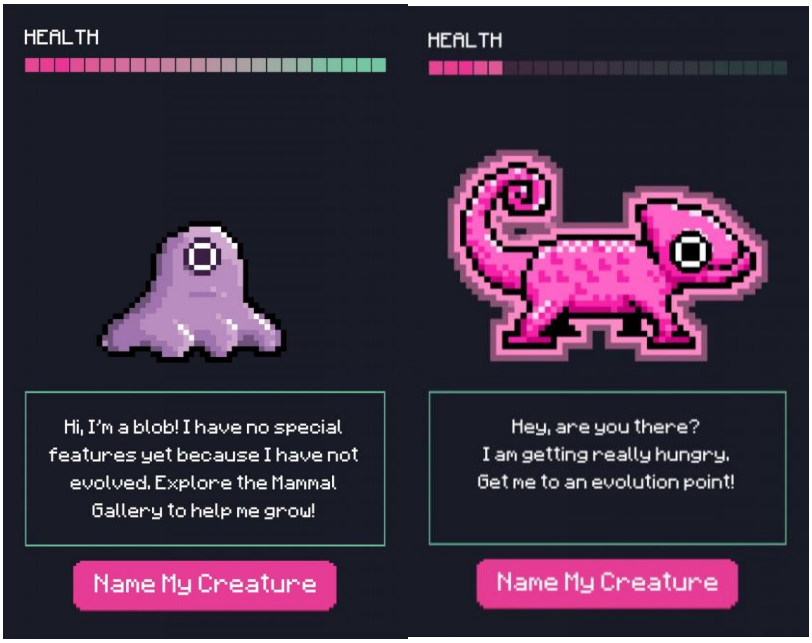
(Image source: WarpDoor)

URL: http://www.milanogamefestival.com/collection/
When: 2016
Where: Milan, Italy and online
What: A downloadable virtual exhibition of video games created for the XXI Triennale International Exhibition in Milan, Italy, this collection demonstrates the experimental approaches to interactivity taken by several artists. Available as a mobile app for Android/iOS as well as a release on Steam, the short playful exhibits blend artistic expression, game logic and touch interactivity. Further research into adapting these games to large public displays will demonstrate their feasibility and applicability to engage multi-user interaction in a public space.

5. Estimote Beacons at the Canadian Museum of Nature

When: 2015
Where: Ottawa, ON

What: Partnering with bv02, a digital creative agency, the Canadian Museum of Nature created an interactive project that allowed museum visitors to explore the principles of evolution using mobile devices and proximity beacons. Each participating visitor downloaded an app or used a museum mobile device with a random creature on it, which started off as a generic blob (pictured below on the left). With each stop near a beacon placed throughout the museum, the creature on the app would develop new, randomly-chosen features, such as change in colour, size, behaviour, or diet. A complete creature formed after five stages, corresponding to stops near five separate beacons. The final creature could then be shared on social media. After testing the app with 150 users, the Museum of Nature logged 1,500 interactions and grew 330 creatures. Beacons and other sensors are a functional extension of digital exhibits and immersive experiences. The Canadian Museum of Nature project is an example of a fun learning initiative with clear scope and simple implementation.



(Image source: bv02)

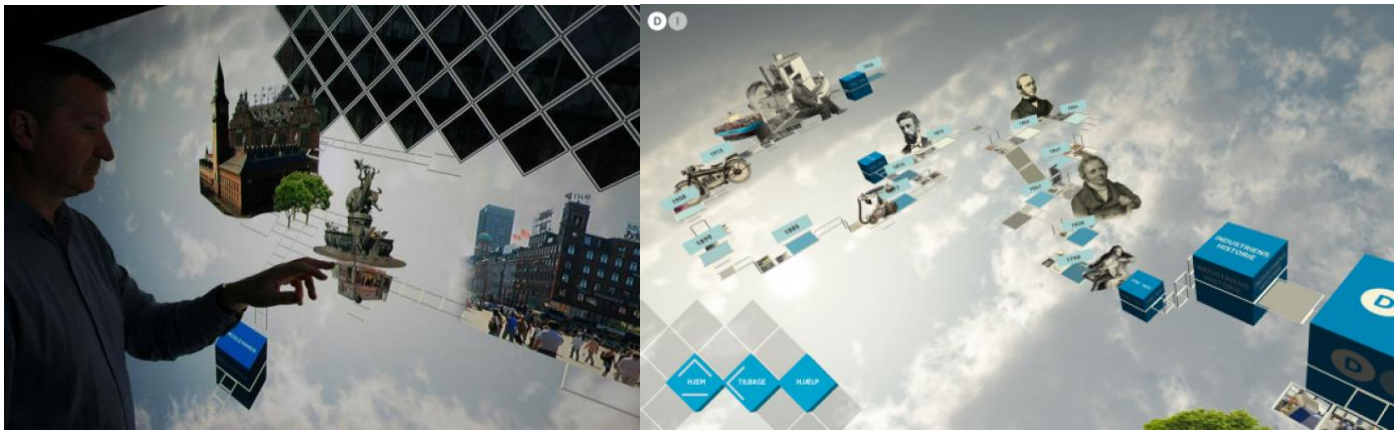
Information Architecture

1. Connection Engine

URL: http://www.gibson.co.nz/visitor-experiences/connection-engine
When: 2016
Where: Wellington, New Zealand
What: Connection Engine is a dynamic 3D database created by the Gibson Group, a creative agency that produced exhibits for digital displays in museums in Copenhagen, El Paso and Cairo. The application allows users an original way to browse digital collections: by providing a bird's-eye overview of all of the content available in the exhibit. Users can then focus on a specific section, and unfold more content associated with a particular "node" in the network. The display automatically

re-centers itself. Users explore the complex interconnected themes by progressively unfolding pathways and viewing images, text and videos related to those themes. Connection Engine represents an innovative approach to visualizing digital collections and allowing multi-user, multi-touch interaction with digital exhibits in a public setting.

It is unclear whether Connection Engine is the underlying driver behind CityScape, an application described below. Based on the Digital Exhibits Intern Librarian's interview with Allan Smith, Gibson Group's Director of Visitor Experiences, it is likely that CityScape relies on the information architecture of Connection Engines to power various collections of content as part of El Paso Museum of History's DIGIE wall application.



(Image source: Gibson Group)

2. CityScape

URL: https://youtu.be/iZ9SF7EkzG4
When: 2015
Where: El Paso, Texas
What: CityScape is the application created by Gibson Group for DIGIE Wall at the El Paso Museum of History. It is a 2D representation of the 3D city experience, which allows visitors to explore the content of the exhibit in several ways, including:

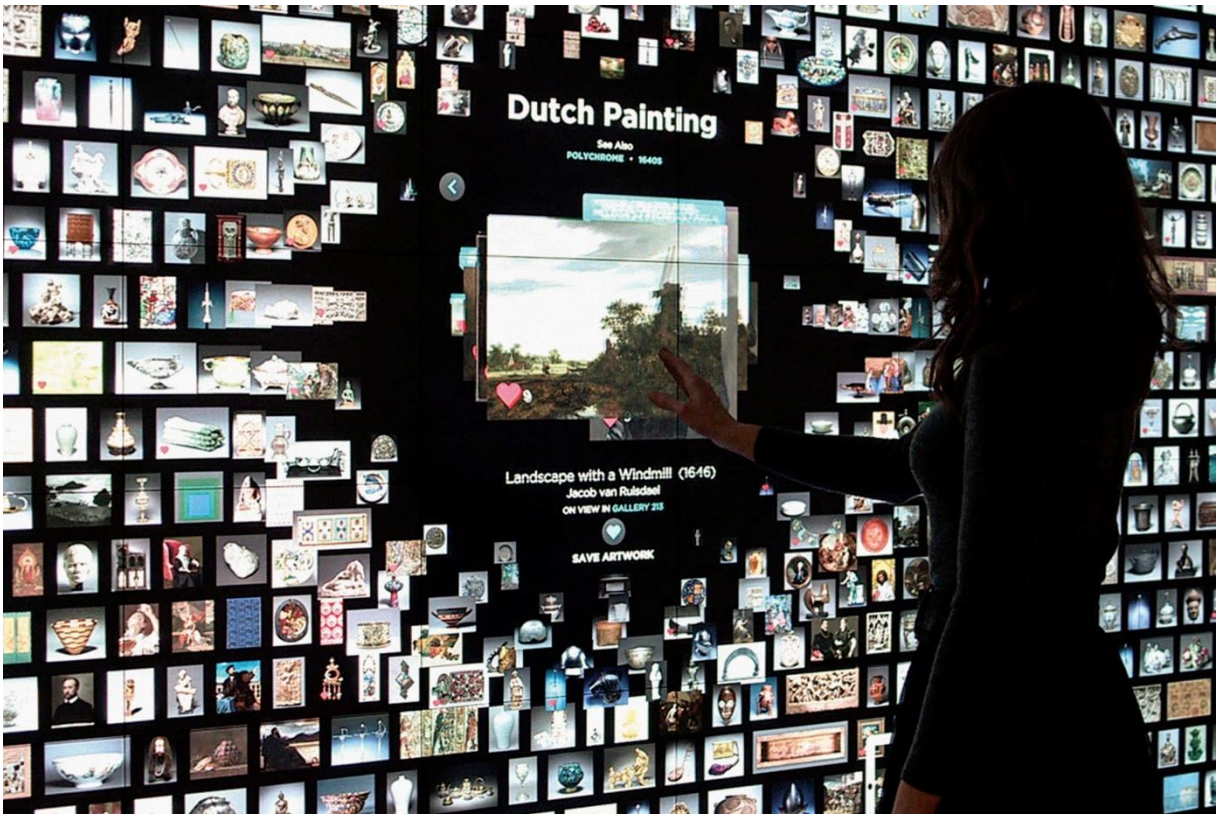
- Timeline – browse by date (time period) at the bottom of the display
- Map – browse by place
- Tags associated with a particular theme, such as "Celebration" or "Downtown"
- Touch – browse by virtually moving through the city
- Search for a particular person, place or keyword

(Image source: Gibson Group)

In addition, the CityScape provides instructions in English and Spanish on how to navigate the display, as well as metadata about the media (photographs and video). Visitors can submit their own photographs and email a digital postcard from the digital display.

3. Gallery ONE Collection Wall

URL: https://vimeo.com/album/2243637
When: 2013
Where: Cleveland, OH
What: The Collection Wall is part of Gallery One in Cleveland Museum of Art, an interactive space offering engaging experiences to museum visitors. The Collection Wall is a dynamic digital display of the entire gallery collection that can be viewed according to categories such as theme, type of art, time period, materials used, technique employed, and others. According to the Museum, the display is the largest multi-touch screen in the United States at 40 feet in length. Created by Local Projects, the exhibit software allows visitors to browse the works of art by theme or to create their own collections. Additionally, visitors can use mobile devices to download prepared tours or to generate a custom tour of the museum based on their personal interests. The Collection Wall acts as a public catalogue of the possibilities open to discovery and a tool to create an individualized experience for every museum visitor.



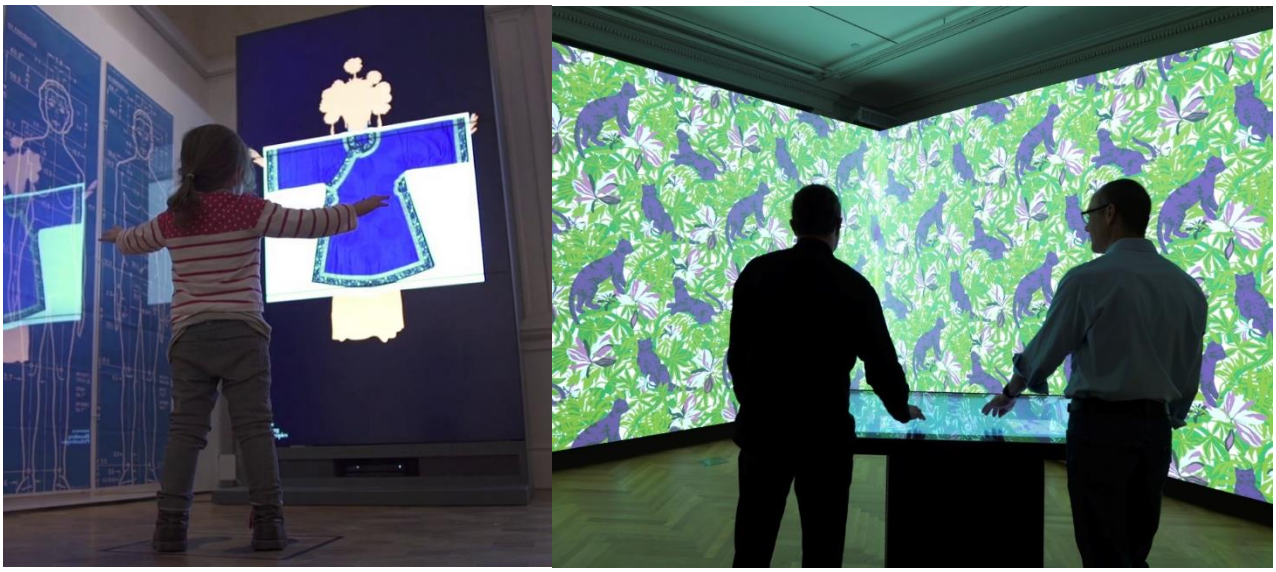
(Image source: Art Museum Teaching)

4. Digifieds

When: 2011
Where: Oulu, Finland
What: Digifieds (derived from digital classifieds) is a digital public notice area developed as part of the UbiChallenge 2011 Computing Competition held in Oulu, Finland. Research focused on users' expectations "with regard to content, suitable interaction techniques, and potential privacy concerns" (Alt et al., 2011) arising from providing relatively private information into information systems in a public setting. The researchers deployed several large touch-screen kiosks on streets and public spaces around Oulu. They then evaluated their design, use and perception. Study authors found that preferred content types for public displays included events, sales, and community-based information. With the move of classifieds and other community information to online spaces, it is unclear whether public displays are best suited for sharing this type of information in 2017.

(image source: Florian Alt)

5. Cooper Hewitt Museum

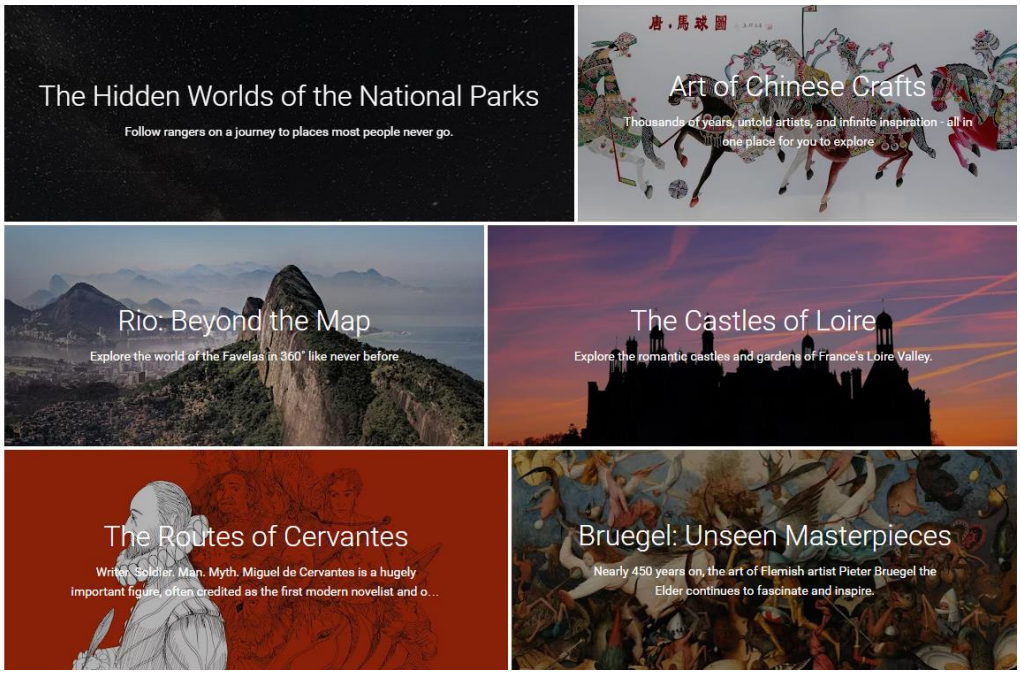

(Image sources: DesignBest and New Yorker)

When: 2015
Where: New York City, NY
What: In 2013, the Cooper Hewitt, Smithsonian Design Museum began to reimagine the overall museum experience. Its goals were to extend the amount of time visitors

spent on site and to engage museum-goers by incorporating digital experiences into every aspect of the museum visit. As a result, when the museum reopened in 2015, each visitor to the Cooper Hewitt received an interactive pen, as part of regular admission. The penacted as “an all-access pass to the world of design” (Local Projects, 2016), andvisitors could use it to save any object in the museum to their personal collection, which was automatically associated with their admission ticket barcode. They could then extend the physical visit by logging in to their personalized space to see objects they collected and created during the physical visit to the space. After the initial testing period, the average uptake of the Pen was 94%, indicating active participation in the redesign process.

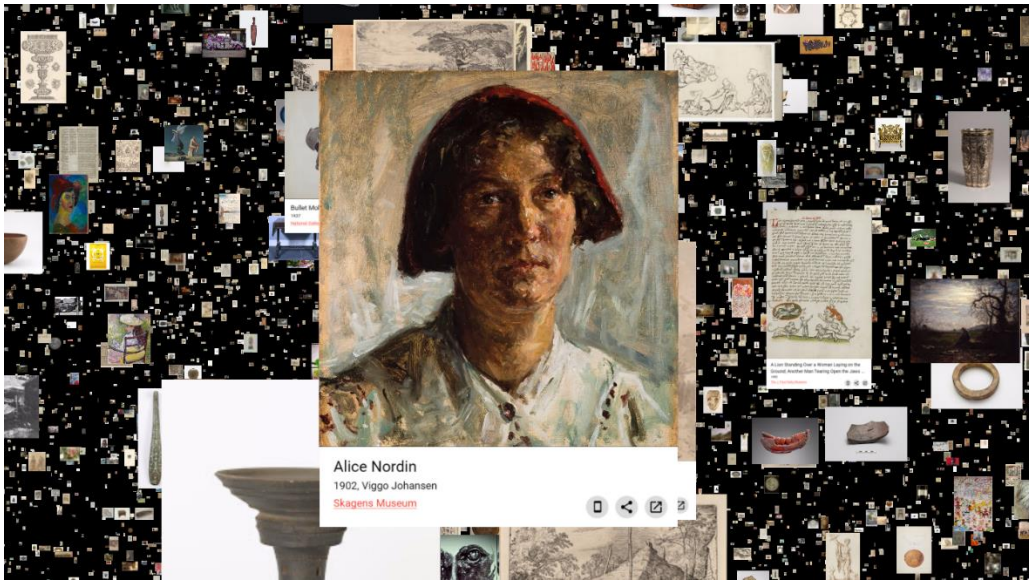
In the Process Lab, a hands-on section of the museum, visitors can design and submit improvements to everyday objects, and browse ideas created by previous users. The museum team sought a variety of ways to explore the museum’s digital archive, and to avoid the traditional methods of tap and swipe. For example, visitors can search artworks by drawing lines and patterns, or by posing in front of a motion detector, as pictured above on the left, in order to search the collection. Similarly, The Immersion Room, brings the museum’s large collection of wallpaper samples to life using a seamless array across two projection walls, as pictured above on the right. As visitors create their own designs, the system analyzes them, and provides feedback from renowned designers based on shape, colour, and other design elements. By turning visitors “from observers to designers”, the Cooper Hewitt seeks to transform the way museum goers relate to the collection, and therefore have an enriched, multi-dimensional, memorable experience. In many ways, this project parallels the principles behind the maker movement that allows people of all ages to be active participants in learning rather than passive consumers of information.

6. Google Cultural Institute



(Image source: Google Cultural Institute)

URL: https://www.google.com/culturalinstitute/beta/u/0/
When: 2016
Where: online
What: Described by Google as a space for the "culturally curious" (Google, 2016), the series of web exhibits that make up the Cultural Institute allow site visitors to explore artworks, collections and stories from around the world. Some of the features include a close zoom function for viewing images of art at high resolution and guided "tours" that cover topics such as space exploration, street art and cultural figures. Google also offers a mobile app with the same content. Additionally, 3D Virtual Tours of places like the Taj Mahal, Kyoto temples, Grand Canyon and other iconic locations around the world, which are available for use with the Google Cardboard virtual reality viewer. Finally, the Experiments section displays work "at the crossroads of art and technology" created by artists and creative coders on Google's Arts and Culture team, such as the infinite artwork browsing interface (pictured below). Sourcing content from numerous cultural organizations from around the world, Google Arts and Culture can be considered a free source of web-based digital exhibits.



(Image source: Google Cultural Institute, 2017)

Social Interaction

1. CityWall

When: 2007
Where: Helsinki, Finland
What: CityWall was a large multi-touch display installed in a central Helsinki as part of an applied study in human-computer interaction. Over eight days of its installation, over 1100 people interacted with the technology in a variety of social configurations: whether approaching the display alone, in pairs or in groups of 3 or more. Findings by Peltonen et al. (2008) reveal that most users of CityWall worked in parallel to each other rather than coordinating their actions. Occasionally, conflict arose due to lack of

awareness of others' activity on the digital display. While the authors of the study describe the wall as being large at 2.5 meters in width and being able to accommodate several users at the same time, this project represents the first generation of public displays and is relatively small compared to the surface area of more contemporary displays. The image below demonstrates the actual size and the popularity of the technology. As can be seen in the reflection, crowds of people gathered around the display waiting their turn or observing others.

(Image source: Flickr)

Findings from the Peltonen et al. study (2008) also revealed that 18% of users of CityWall were individuals while pairs were present in 72% of the cases of using the display. Additionally, the authors of the study found that groups larger than three very rarely stopped at the display at any time. The honeypot effect was observed in the CityWall study, with presence of other users being a motivator for passers-by to become active users themselves, and indicating that people appear to pay more attention to other people's behavior at the display rather than formal instructions part of the display itself. While multi-user interaction was the dominant type of interaction with the display observed by the authors (primarily in pairs), parallel and teamwork patterns of use were observed. In parallel use "people can occupy an area of the screen and focus on their own task irrespective of the activities on their left or right" whereas teamwork can be described as "grouping with other users and focusing on the same object or set of objects" (n.p.)

The CityWall project demonstrates that interactive displays are social spaces as much as information technologies, and this study suggests there are ways to support social learning in relation to communication of information. Technology can

therefore enable social interaction, but people using the actual technology create the social space around it, by taking on various roles, resolving conflict and assigning meaning to their experience of using that technology.

2. DOK Agora

When: 2010
Where: Delft, Netherlands
What: DOK Agora is a library multimedia center that provides opportunities for library visitors to share stories using a video recording station, a storytelling station and a large (33’ x 10’) digital display. Visitors can browse shared stories, create their own, and leave them for future library customers to discover. The Agora exhibits are organized around a particular theme and change every three months. Library staff provide help recording the stories at the multimedia desk. It is an example of community engagement using several technologies and an early adoption of a public display in a library setting.

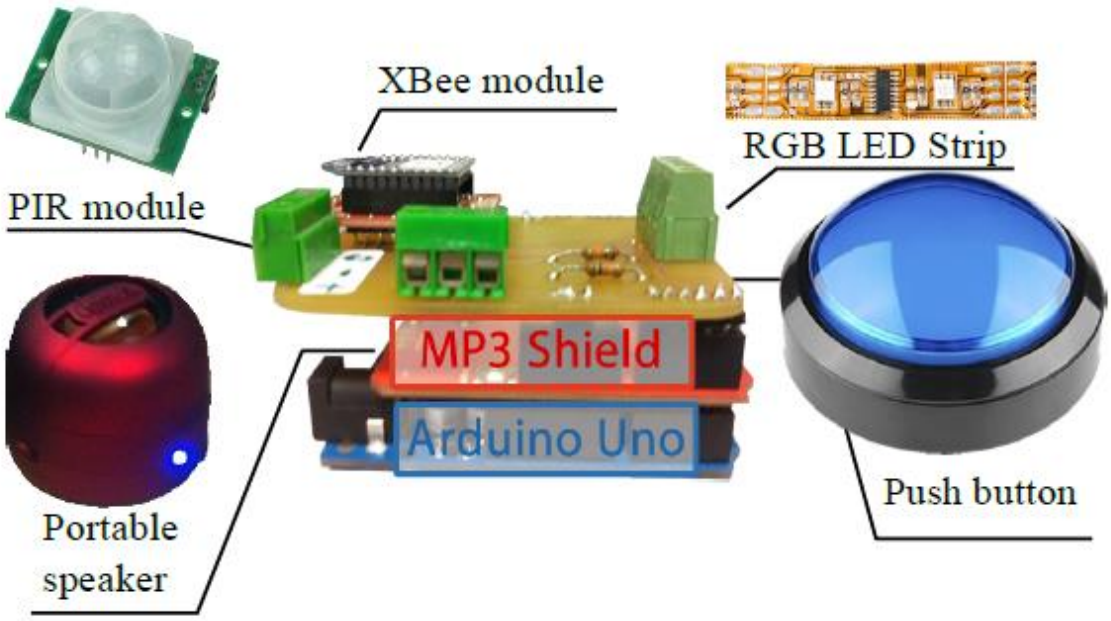
(Image source: Hoog + Diep)

3. JokeBox

When: 2015
Where: London, UK; Ensanada, Mexico

(Image sources: Balestrini et al., 2016; PC Authority)

What: Jokebox is a technology prototype designed to attract passers-by in a public space and to provide them with an opportunity to engage both with the installation and with each other. The installation comprises two wooden boxes, each one meter in height that feature arcade buttons at the top as well as embedded speakers. Both boxes can be paired within a distance of 2 to 5 meters. The installation requires two people to coordinate a sequence of actions in order to hear a joke. Designed to be non-intrusive and to protect personal space, Jokebox is a physical computing example that does not rely on a digital screen to facilitate social interaction in public spaces. Instead, it uses audio (recorded jokes) and social coordination as the primary mode of interaction in a public setting (Balestrini et al., 2016).



Jokebox installation components (Image source: Balestrini et al., 2016).

4. Cellular

(Image source: New American Public Art)

URL: http://www.newamericanpublicart.com/cellular
When: 2014
Where: Minneapolis, MN
What: Cellular is an interactive projection that allows users to control glowing orbs on a large public display from the web. Participants can use their mobile devices to log on to a dedicated site for the project. When a participant's device connects to the Cellular site, their assigned orb glows bright on the display. Players can control the movement of the glowing orbs by physically moving their mobile devices. In this project, multi-user interaction is enabled as everyone can see the glowing orbs of other participants on the projected screens in real time. When orbs connect, they briefly form a larger one. Cellular players can form orbs of different sizes together, or zip through rapidly, forming and destroying them. Another example of a pervasive game, this project seeks to create digital space connecting people at home and at the art piece itself, forming "a membrane to highlight collaboration and interactivity".

Discussion

Themes identified in this section parallel to some extent those emerging out of the community consultation survey, indicating that some projects are better suited for interactive interfaces, such as digital displays, than others. While case studies examined here are not limited to digital displays, they also provide further evidence to user-centered design principles identified by community partners. In addition, these case studies demonstrate real-world application of digital exhibits themes with concrete definition of purpose, scope, users, timelines, and context for the project. For example, children's activities are projects that focus on kids as primary users. Some projects are clearly designed to be experienced outdoors, while others facilitate social interaction through the technology, but are not about the technology itself.

Games identified here can be played using mobile devices, but can also be adapted for large displays. As a result, while most will not be generalizable to EPL context, they model design and development approaches that can guide the Digital Exhibits service. They may also serve as ready-made test content in the pursuit of a research-and-development "studio" as recommended in the "Exhibit Planning and Prototyping" section (p. 53). Getting access to select applications' codebase(s) or case study project leads can provide further information on interactive exhibit design, development, deployment, and reception by users.

Limitations

This section examined projects not strictly related to digital displays, and as such, not all lessons gathered here may be applicable to a public displays in a library environment. Data collection relied primarily on the snowball effect and recommendation from community consultation participants rather than systematic searching. In addition, due to the website analysis method employed in this section, there was no opportunity to learn in depth from project leads or clarify arising questions related to the technology or service design of the case studies. Given a wide range of contexts and purposes for these case studies, not all are generalizable to Edmonton Public Library. Any bias or omission was mitigated through increasing the sample size and categorizing case studies to seek emergent themes that can be applied to programming and outreach initiatives in the broader scope of the Edmonton Public Library digital literacy programming.

Service Recommendations

The following section brings together all recommendations proposed throughout the report and organizes them thematically. The themes represented here reflect the broad areas of the digital exhibits service, which need to be considered for launch of this initiative at EPL. Priority recommendations chosen based on scope areas of the Digital Exhibits Intern Librarian research project, as outlined in the Introduction of this report (p.7), are also indicated in this list.

Design and Planning

1. **Priority recommendation:** That by the end of 2017, the Director of Technology Services, under the direction of Executive Director, Strategy & Innovation, creates guiding documentation, which defines the vision, mission, purpose and scope of the Digital Exhibits service to help prioritize exhibit development, testing and implementation.

2. That by 2018, the Director of Technology Services, under the direction of Executive Director, Strategy & Innovation, selects a standardized name for the digital interactive wall and its corresponding service to ensure EPL maintains consistent communication and promotion, both internally and externally.

3. **Priority recommendation:** That between 2019 and 2020, the Digital Exhibits Librarian organizes a workshop for local community experts in design, media, game development, web development, and other related fields to generate use cases, understand functionality and explore desired user experiences for the interactive wall. Use cases created as part of this event can be incorporated into growing documentation for the service.

4. That between 2018 and 2020, the Director of Technology Services works with QUT consultant(s) to draft EPL's Digital Exhibits documentation after QUT's "Software Development Kit" and "Digital Wall Operations Manual", as well as other relevant technical documentation.

5. That between 2019 and 2020, the Technology Services team dedicated to supporting the digital exhibits service clearly outlines and documents the hardware and software architecture of the digital interactive wall. This document is meant to address the infrastructure and technical overview, modelled after QUT's Cube Specifications, in addition to addressing the principles and workflows in exhibit development and deployment.

6. That between 2017 and 2019, the Digital Exhibits Librarian conducts research (through surveys, consultations, and other methods) targeting groups not represented in the community consultation survey at this stage of the project. Potential targets include community organizations in the sports, recreation, design and community services domains.

Technology

1. **Priority recommendation:** That Technology Services staff dedicated to Digital Exhibits services prioritize Unity 3D and WebGL technologies as primary "platforms" for the development of exhibit applications.

2. That by 2020, the Director of Technology Services, in collaboration with QUT consultant(s) implements a middleware solution that parallels QUT's The Cube to manage scheduling and automation of exhibits for display. It may include a collection of Windows utilities or a vendor product, such as a content management system that acts as a middle layer between the wall's operating system and the exhibit applications.

3. **Priority recommendation:** That between 2018 and 2019, Digital Interactive Wall team, under the direction of the Director of Technology Services, investigates opportunities to source a custom 3D database that can function as an exhibit platform and therefore be repurposed for multiple exhibits. Solutions may include an open source software package or a custom vendor product designed for EPL's needs.

4. That between 2018 and 2020, the Digital Exhibits Librarian, working with the Digital Public Spaces Librarian and Digital Literacy Initiatives, investigates solutions to source toolkits to allow community partners to contribute to digital exhibits, by leveraging the existing digital public space platform, mobile applications, digital storytelling kits or custom 3D database that can be reused for several exhibits.

5. That between 2017 and 2019, the Director of Technology Services, in collaboration with the QUT consultant(s), investigate options for sound management solutions in line with EPL community needs and interests.

6. That by the end of 2019, the Director of Technology Services reviews a list of tools and software identified in Appendix I of this report, working with Digital Literacy Initiatives and Technology Services teams to select, procure and install appropriate software on the prototyping equipment and/or makerspace workstations.

7. That between 2019 and 2020, the Digital Exhibits Librarian, working with QUT consultant(s) and Technology Services staff dedicated to the service, explores solutions for multi-user mobile interactivity with public displays through research, community expert consultation and technology testing.

8. That between 2020 and 2021, the Digital Exhibits Librarian identifies a prototype project to implement mobile interactivity with the Milner digital interactive wall. Findings and observations from the mobile prototype project will inform best practices and contribute to the growing body of documentation related to digital exhibits.

9. That between 2017 and 2018, the Digital Exhibits Librarian designs and tests a pilot exhibit using tools like IntuiFace, GameMaker, TouchDesigner and other web-based content management systems to evaluate feasibility of using these tools as part of the digital exhibits "platform" (at the application level).

Resourcing

1. **Priority recommendation:** That between 2017 and 2021, Technology Services implements the Staffing Model proposed as part of this report (p. 60). This staffing model includes Digital Exhibits Librarian, Developer, Designer and AV Specialist roles, and parallels cross-functional Cube teams at QUT, such as the Cube Studio and Visualization and eResearch groups.

2. **Priority recommendation:** That between 2017 and 2018, Technology Services establishes a research-and-development "studio" by procuring hardware and software to test functionality and application of relevant exhibit technologies in preparation for the Milner digital interactive wall installation. This studio also aims to test workflows and processes related to digital exhibits in order to ensure 2020 service launch has minimal risks and gaps in knowledge.

3. That between 2017 and 2018 the Digital Exhibits Librarian identifies and recommends training opportunities in design thinking and user experience methods to support the planning and implementation of digital exhibit projects.

4. That the Digital Exhibits Librarian acts as a champion of the emerging service, and continues to engage the Edmonton community to identify and develop opportunities for exhibit creation and programming.

5. That between 2018 and 2019, the Director of Technology Services defines the role for AV Specialist and recruits for the role in preparation for the digital interactive wall installation. The Digital Exhibits Librarian, along with QUT consultant(s), can assist in the definition of this role through research and community consultation procedures.

Content Partnership and Programming

1. **Priority recommendation:** That between 2017 and 2018, Digital Exhibits Librarian pilots a project in collaboration with community partners who have already expressed interest and capacity to work with EPL on a digital project as part of the community consultation process. This pilot project will test exhibit development workflows and partnership models for future digital exhibit initiatives. Potential partners include Royal Alberta Museum, NAIT, and Edmonton Digital Arts College.

2. That, between 2019 and 2021, Digital Literacy Initiatives evaluates feasibility of offering programming, such as workshops and lectures, on data literacy, visualization, digital storytelling and other digital literacy skills that begin to build capacity for community participation in the Digital Exhibits service.

3. That, between 2018 and 2020, the Digital Exhibits Librarian, working with the Adult Services Team, identifies and proposes opportunities to invite data journalists, data scientists and civic technology leaders to offer programs that promote issues relating to digital literacies and the Edmonton community.

4. That between 2019 and 2021, the Digital Exhibits Librarian works with community partners to source, curate and test content for a hyperlocal project, bridging interest in Edmonton history, natural landscape, and civic issues.

5. That between 2019 and 2020, Digital Literacy Initiatives, in collaboration with the Digital Exhibits Librarian, conduct a review of makerspace and digital literacy programming that can be adapted to the digital interactive wall.

6. That by the end of 2020, the Digital Interactive Wall team, working with Marketing, identifies and proposes opportunities for contests or other strategies to seek submissions of generative graphics, browser-based experiments and web artwork that can be used as digital exhibits from community partners and expert community members.

7. That in 2021, the Digital Interactive Wall team pilots an Artist-in-Residence program as a way to extend the Digital Exhibits service to the community and to continue to generate content displayed. Potential partners include the Alberta Foundation for the Arts.

8. That in 2021, the Digital Interactive Wall team, in collaboration with Marketing and Communications, implements a marketing strategy for the artist-in-residence program to ensure EPL targets appropriate community of creators for the digital wall in outreach and promotion.

9. That in 2020, the Digital Exhibits Librarian interviews all Cube Residents since 2012 to compare their experiences, find common themes and to propose best practices to the Digital Interactive Wall team in preparation of the Residency pilot at EPL.

10. That between 2019 and 2020, the Digital Exhibits Librarian works with Digital Public Spaces Librarian to identify and test content from EPL's digital public space(s) to the digital display wall.

11. That between 2019 and 2020, the Digital Exhibits Librarian works with the Capital City Press lead to identify, curate, test and deploy content from EPL's digital public space(s) to the digital display wall, including written works and/or author readings.

12. That between 2019 and 2020, the Digital Exhibits Librarian works with Digital Public Spaces Librarian to identify, test and deploy livestream content from events, such as Capital City Records Concerts.

13. That between 2020 and 2021, the Digital Exhibits Librarian works with Valley Zoo, Art Gallery of Alberta and Royal Alberta Museum staff to identify, curate and test content that may be displayed on EPL's digital wall. Potential project include evaluating feasibility of a zoo livecam, artist performance or interactive exhibit software.

14. That between 2017 and 2018, the Digital Exhibits Librarian, working with the Makerspace staff, explores the feasibility of using Google Expeditions as ready-made content for digital literacy programs and display wall.

15. That by the end of 2017, the Digital Exhibits Librarian creates an 'opportunities' database or calendar to track a growing body of knowledge related to communities in gaming, design, multimedia and other domains in Edmonton. This tool will help the Digital Wall staff to scope out new partners for content creation and capture implicit knowledge gathered about community partners that is not reflected in the Community Librarians Database or the yearly Community Profile. It will extend the work initiated by the Digital Exhibits Intern Librarian with community consultation by identifying criteria such as "likelihood of collaboration" on digital exhibits projects.

16. That between 2017 and 2018, Digital Exhibits Librarian researches, plans and prepares for the installation of the first test digital exhibit in an EPL branch. The test exhibit aims to evaluate customer interest in the Digital Exhibits service, build awareness of interactive technologies among customers and staff and to identify critical elements necessary to support a digital exhibit in a library branch.

17. **Priority recommendation:** That in 2018, the Digital Exhibits Librarian deploys the first branch installation of an exhibit prototype to test functionality of interactive technologies with library customers in real time. User observation data on exhibit reception is collected and exhibit improvements are made as needed. Potential solutions include projection with Leap Motion sensor, standalone touch-panel or 3D camera with projection and computer powering motion-based applications.

18. That in 2019, the Digital Exhibits Librarian deploys a second test exhibit in a different EPL branch. User observations on exhibit interaction are conducted and recommendations are made to improve future exhibits.

19. That between 2019 and 2021, the Digital Exhibits Librarian, in collaboration with the team dedicated to supporting the service continues to deploy third and fourth digital exhibits in EPL branches. This recommendation is dependent on budget to source additional hardware, customer reception, and availability of engaging content.

20. That in 2021, the Digital Exhibits Librarian conducts an evaluation of the model of content extensions in branches and proposes recommendations for improving the service in the future. New branch projects are planned and installed based on recommendations proposed and the maturation of the Digital Exhibits team.

21. That by 2019, the Director of Technology Services, as part of the QUT consultancy process, seeks to establish access to Cube exhibits in order for EPL to use, display, test, modify and expand upon exhibit applications, as appropriate within the consultancy agreement.

Funding

1. That from 2017 onward, the Digital Exhibits Librarian, in collaboration with Fund Development, continues to monitor opportunities for grants and other funding sources.

2. That from 2017 onward, the Director of Technology Services works with Fund Development to identify local business leaders' roles in content creation and seek out opportunities to support, generate or contribute to exhibits. Potential partners include BioWare, Edmonton Economic Development Council, TEC Edmonton, and gaming studios listed in Appendix G of this report.

3. **Priority recommendation:** That by the end of 2017, the Digital Exhibits Librarian, in collaboration with Fund Development, drafts a stock pitch and other appropriate supporting documentation that outlines the Digital Exhibits service including its goals, purpose, intended impacts that can aid future grant application and funding proposal processes.

4. **Priority recommendation:** That by 2019, the Digital Exhibits Librarian, in collaboration with Fund Development, identifies an opportunity to work with a community partner with access to specialized grant and funding resources (database or subscription service) that will aid EPL in targeting funding options for the digital exhibits service.

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Appendix A. Environmental Scan Interview Questions: Museums, Libraries, Public Organizations

1. What are the technical specifications of the digital interactive technology at your institution?
2. Who are the primary users of this technology (those interacting with the platform)? Is there anyone you thought would use it and isn't?
3. What are primary uses for the technology (events, presentations, analysis, workshops)?
4. What types content is supported by the technology (video, images, audio, maps, text, games, 3D, all of the above?)
5. Where is content created and how is this content managed?
6. What is the schedule for the content and how is it prioritized?
7. Can you estimate the FTE (full time equivalent) of staff members involved in supporting this technology/service, both directly and indirectly? What does indirect support for this technology entail?
8. In your experience, what kinds of skills are necessary in order to support this service?
9. Have partnerships with other organizations producing content to be exhibited been established or explored?
10. What challenges have you encountered in providing this service?
11. What have been some keys to the successes in supporting this service?
12. What has been the biggest success of this service and what has been the biggest disappointment?
13. What is the perception of this technology in institution more broadly?
14. Are there any other institutions you suggest we contact to learn more about similar technologies?

Digital Exhibits Environmental Scan Interview Questions: QUT Team(s)

1. Can you please describe the platform(s) on which the Cube runs? Can the Cube support other platforms?
2. Who are the primary users of this technology (ie. those that interact with it)? Is there anyone you wish was also served by this service? Is there anyone you thought would use it and isn't?
3. What range of uses have you found for the Cube since its installation?
4. How does content get created for the Cube? Who creates it? Who owns it?
5. How was content developed without the physical wall? What challenges did you encounter in this process, specifically planning for facilities not yet in place that require testing, troubleshooting software?
6. Have options for user-generated content been explored?
7. What is the schedule for the content or exhibits on the Cube and how is it prioritized?
8. Is Cube content preserved in some way at the Science and Engineering Center or is it leased as a temporary exhibit?

9. Who is responsible for the Cube operations and programming? Does the Cube as service fall under a particular department or center?
10. Can you estimate the FTE (full time equivalent) of staff members involved in supporting the Cube, both directly and indirectly? Can you please describe their roles? What does indirect support entail for this project?
11. In your experience, what kinds of skills or labour are necessary in order to support this service?
12. Can you explain the nature of the residents in relation to the Cube and the Science and Engineering Center? Do they research, produce, and/or promote content for the Cube?
13. Have partnerships with other organizations producing content to be exhibited been established or explored?
14. What challenges have you encountered in providing this service?
15. What have been some keys to the successes in supporting the Cube as a service?
16. What has been the biggest success of the Cube and what has been the biggest disappointment?
17. Are there any other institutions you suggest we contact to learn more about similar technologies?

Digital Exhibits Environmental Scan Interview Questions: Vendors

1. What is the relationship between creative studio and hardware/fabrication? Do you do everything or work with AV integrators instead to put together touch interactives?
2. Who have been the primary users of the interactive exhibits and projects which you have completed?
3. Who writes the use cases when creating a digital interactive exhibit?
4. What types content is supported by the technology (video, images, audio, maps, text, games, 3D, all of the above?) Do you see a rise in interest for 3D and game-like environments and do you have internal expertise to support it?
5. Where is content created for the exhibits and how is this content managed? Who curates?
6. What timespan or lifecycle do you design for?
7. How big is your team? How long to projects typically take to create?
8. What types of expertise do you have in house? What might a project team look like?
9. To what extent is there a goal of sharing knowledge back with the company from clients or users?
10. What challenges have you encountered in providing this service?
11. What have been some keys to the successes in supporting this service?

Appendix B. Community Consultation Survey

Purpose and Context
In 2020, the Stanley A. Milner Library will reopen after extensive renovations to both the interior and exterior of the building. As part of the interior renovations the Edmonton Public Library will have installed a 2-storey digital interactive display wall, modelled after Queensland University of Technology's The Cube located in Brisbane, Australia. To view a video of The Cube in action, please click here.

Digital interactive display walls allow for a variety of interaction between the display and individuals, including audio, touch and motion. In anticipation of this new resource, EPL would like to understand the current interest from Edmonton's arts, cultural, non-profit and community organizations in terms of ability, interest and potential to collaborate on digital exhibits to be displayed on this wall. Please take a few minutes to complete this survey to provide the Edmonton Public Library valuable feedback on developing this community asset.

Your participation in the survey is voluntary. Your input will help define needs and interests in our communities for new technology services specifically related to using the digital interactive display wall. If you have any questions or would like to discuss this project further, please contact Lydia Zvyagintseva, Digital Exhibits Intern Librarian at **780-496-8832** or **lzvyagintseva@epl.ca.** Thank you!

Please state your organization's name: _____

Please provide your name: _____

What is your title or position in the organization? _____

Please provide your email address: _____

Please provide your phone number: _____

Who is the primary audience for your organization? _____

In a potential collaboration to create interactive exhibits, what expertise would you describe your organization to have? Please select all that apply:

- subject specialization (ie. local history knowledge, visual arts, robots)
- software development skills
- web development skills
- game development skills
- access to digital content that can be organized, modified or curated
- access to print/physical materials that can be digitized
- access to other resources (media, software, performance)
- ability to provide metadata (contextual information about collections or content)
- financial capacity to support digital exhibits
- partnership on grants to support digital exhibits
- promotion and partnership with other organizations to further digital exhibits
- other: _____

What role would your organization want the Edmonton Public Library to play in terms of a digital interactive exhibit service? Please rank them in order of importance to your organization, with 1 being the highest priority and 8 being the lowest priority:

- provide space and time to showcase work created by your organization
- host workshops or programs using the video wall as teaching tool
- provide a venue prototype projects and gather feedback
- partner on grants to create exhibits
- provide technical expertise to create projects or adapt existing projects for the wall
- organize content on behalf of the organization, make content accessible
- digitize physical materials or other media
- host special events

If there are other roles you see the Edmonton Public Library playing in terms of a digital interactive exhibit service, please state them below: _____

What types of experiences would you want to have with the digital wall in the renovated Milner Library? Please select all that apply:

- Touch interaction (ie. smartphone style touch-screen on a bigger scale)
- Motion interaction (ie. Kinect-style movement sensor)
- Special device interaction (ie. stylus, brain-wave reader, etc)
- Mobile interaction
- Gaming and simulated environments, including 3D and virtual reality
- Web content
- Video content
- Audio content
- Ability to plug in own laptop, tablet, phone
- Ability to connect wirelessly using a mobile device
- Other: _____

What kinds of projects would you like to see on the digital video wall? Please list as many as you wish and provide brief descriptions. (For example, local history digital tours, First Nations storytelling, science and technology school-age programming).

Is there anyone else you suggest we contact in the Edmonton community?

Is there anything else you wish to add?

Thank you for taking the time to provide your input!

Appendix C. Digital Content Publishing Guidelines

Organization Name	Guidelines Website
Deakin University Library	http://www.deakin.edu.au/library/projects/sparking-true-imagination
Duke University	https://wiki.duke.edu/display/LMW/LMW+Home
Griffith University	https://intranet.secure.griffith.edu.au/work/digital-signage/seemore
North Carolina State University Library	http://www.lib.ncsu.edu/videowalls
University Colorado-Denver	http://library.auraria.edu/discoverywall
University of Calgary Library and Cultural Resources	http://lcr.ucalgary.ca/media-walls
University of Waterloo-Stratford	https://uwaterloo.ca/stratford-campus/research/christie-microtiles-wall

Appendix D. Environmental Scan Study Population

Organization	Date Interviewed
All Saints Anglican School	July 25, 2016
Anode	July 22, 2016
Belle & Wissell	July 26, 2016
Bradman Museum	July 10, 2016
Brown University Library	June 3, 2016
University of Calgary Library and Cultural Resources	June 2, 2016
Deakin University Library	June 14, 2016
University of Colorado-Denver Library	June 24, 2016
Duke University Library	August 17, 2016
El Paso Museum of History	June 24, 2016
Georgia State University Library	June 10, 2016
Gibson Group	July 16, 2016
Henrico County Public Library	August 9, 2016
Ideum	July 26, 2016
Indiana University-Bloomington Library	May 31, 2016
Interactive Mechanics	August 2, 2016
Johns Hopkins University Library	June 20, 2016
Nashville Public Library	July 22, 2016
North Carolina State University Library	June 8, 2016
University of North Carolina-Chapel Hill Library	June 2, 2016
University of Nebraska-Omaha	June 16, 2016
Omaha Do Space	July 11, 2016
University of Oregon Alumni Center	June 7, 2016
Philadelphia Museum of Art	August 10, 2016
Queensland University of Technology	June 30; July 29, 2016; August 16, 2016
Société des Arts Technologiques	August 8, 2016
Second Story	July 28, 2016
St. Louis University	July 4, 2016
Stanford University Library	July 22, 2016
University of Illinois Chicago	June 22, 2016
University of Mary Washington	July 7, 2016
Visibull	August 12, 2016
University of Waterloo-Stratford	June 22, 2016
Yale University Center for Science and Social Science Information	July 13, 2016

Appendix E. Job Postings List

Job Title	Organization	Location
3D Designer	Gilbert Displays	Melville, NY
3D Generalist	Moment Factory	Montreal, QC
Community Services & UX Design Librarian	Trenton Free Public Library	Trenton, NJ
Content Project Manager	ByteManagers	Chicago, IL
Contract Developer	Belle & Wissell	Seattle, WA
Coordinator of Creative Heritage Activation	Hobson Bay City Council	Hobson Bay, Australia
Creative Coder	Moment Factory	Montreal, QC
Creative Project Coordinator	Sacramento Public Library	Sacramento, CA
Creative Technologist	Local Projects	New York, NY
Curator of Education Good Museum of Art	Dartmouth College	Hanover, NH
Curator of the Beatrice M. Haggerty Gallery	University of Dallas	Irving, TX
Data Visualization Coordinator	Brown University	Providence, RI
Data Visualization Designer and Consultant for the Arts	Virginia Tech University Library	Blacksburg, VA
Data Visualization Services Librarian	University of North Carolina at Chapel Hill	Chapel Hill, NC
Digital Content Strategist	Oak Park Public Library	Oak Park, IL
Digital Curator	Texas Woman's University	Denton, TX
Digital Curator	Wiener Library	London, UK
Digital Designer	RMG Networks	Dallas, TX
Digital Engagement Librarian	University of Nebraska at Omaha	Omaha, NE
Digital Experience Librarian	Deakin University Library	Geelong, Australia
Digital History Project Manager	Colgate University	Hamilton, NY
Digital Library Visualization Engineer	Stanford University Libraries	Stanford, CA
Digital Media Manager	Frye Art Museum	Seattle, WA
Digital Media Specialist	University of Colorado Denver	Denver, CO
Digital Scholarship Projects Librarian	Georgia State University Library	Atlanta, GA
Director of Digital Experience	Pierce County Library	Tacoma, WA
Director of Digital Experience	New York Public Library	New York, NY
Director of User Experience/User Interface	Kiswe Mobile	New York, NY
Director of Visualization Services	North Carolina State University Libraries	Raleigh, NC
Educational Content Developer	Virginia Tech University Library	Blacksburg, VA
Emerging Technologies and Digital Media Specialist	United States Court of Appeals for the Second Circuit	New York, NY
Exhibit Designer	PRD Group	Chantilly, VA
Gameplay Programmer	BioWare	Edmonton, AB
Graphic Designer	Health First Network	Burlington, ON
Graphic Designer	Moment Factory	Montreal, QC
Graphic Designer	PRD Group	Chantilly, VA
Head of Collections and Exhibition Manager	Arts Center Melbourne	Melbourne, Australia

Job Title	Organization	Location
Head of Digital Experience	Archives of American Art	Washington, DC
Interactive Coder	Moment Factory	Montreal, QC
Interactive Designer	Moment Factory	Montreal, QC
Learning Spaces Technology Coordinator	University of Colorado Denver	Denver, CO
Manager of Digital Experience	Westport Library	Westport, CT
Motion Designer	Stantec	Edmonton, AB
Motion Graphics Designer	Some Spider	New York, NY
Motion Graphics Director – Lead Designer	Local Projects	New York, NY
Multimedia Applications Developer	Moment Factory	Montreal, QC
Multimedia Director	Moment Factory	Montreal, QC
Principal UI/UX Designer	Harman	Shenzhen, China
Project Curator, Natural Sciences	Auckland Museum	Auckland, New Zealand
Public Services Manager - Digital Experience	Jefferson County Public Library	Lakewood, CO
Senior Art Director	Second Story	Portland, OR
Senior Exhibition Graphic Designer	Local Projects	New York, NY
Senior Graphics Developer	BioWare	Montreal, QC
Senior Interactive Designer	Peabody Essex Museum	Salem, MA
Senior Interactive Designer - SOS	SOS Design	Toronto, ON
Senior Visual Experience Designer	Local Projects	New York, NY
Senior Web Developer	Top Draw	Edmonton, AB
Systems Architect	Moment Factory	Montreal, QC
Technical Architect	Metropolitan Museum of Art	New York, NY
UI Designer	Potato	London, UK
UI Programmer	BioWare	Edmonton, AB
UI/UX Designer	Moment Factory	Montreal, QC
Usability Analyst	Weilll Cornell Medicine	New York, NY
User Experience Designer	Peabody Essex Museum	Salem, MA
User Experience Designer	Yale University	New Haven, CT
UX Content Strategist	California Digital Library	Oakland, CA
UX Designer	SmartBug Media	Newport Beach, CA
UX Project Manager	Wanderlust	Brooklyn, NY
Visualization and Digital Media Librarian	North Carolina State University Libraries	Raleigh, NC
Web Developer, Interactive Media	Minneapolis Institute of Arts	Minneapolis, MN
Web UI/UX Designer	Blinklist	Berlin, Germany

Appendix F. Community Consultation Organizations

Organization Name	Organization Name
ABC Head Start	Historian Laureate Program
Alberta Foundation for the Arts	iHuman Youth Society
Alberta Railway Museum	Latitude 53
Alberta Teachers' Association	MacEwan University, Art and Design
Art Gallery of Alberta	MacEwan University, Design Studies
Athabasca University, Royal Architecture Institute of Canada	MacEwan University, Communication Studies
Ben Calf Robe Society	MacEwan University Library
City Hall School	MacEwan University Social Innovation and Entrepreneurship Hub
City of Edmonton, Citizen Services	Media Architecture Design Edmonton
City of Edmonton Archives	Music Media Technology
City of Edmonton, Open City and Innovation	National Centre for Truth and Reconciliation
Concordia University of Edmonton, Edmonton Institute for Community Research	National Film Board of Canada
Concordia University of Edmonton Library	Nina Haggerty Centre for the Arts
Design Students Organization of MacEwan	Northern Alberta Institute of Technology
Digital Scholars Group, University of Alberta	Norwood Child and Family Resource Centre
Edmonton Arts Council	Onlea Corporation
Edmonton City as Museum	Parkland School Division 70
Edmonton Digital Arts College	Provincial Archives of Alberta
Edmonton GameCamp	River Valley Alliance
Edmonton Heritage Council	Royal Alberta Museum
Edmonton Public School Board	Taproot Edmonton
Edmonton Symphony Society	TEC Edmonton
Edmonton Valley Zoo	The Student Design Association
EgoAnt Productions Inc.	University of Alberta, Computing Science
Film and Video Arts Society of Alberta	University of Alberta, Humanities Computing
Gather Ventures	University of Alberta, Urban Planning
Glenbow Museum and Archives	

Appendix G. Events, Conferences and Communities of Practice

GDX Edmonton
URL: http://www.gdxedmonton.com/about
What: GDX is a celebration of games and game development in Alberta that brings together game creators, computing scientists, artists, writers, musicians, producers, and business development talent. Sponsors include Bioware, Microsoft, TEC Edmonton, Extra Life, GameCamp, MADSOFT Games, Ladies Learning Code, the University of Alberta, and others.
When: May
Where: Edmonton, AB

Liberact
URL: http://liberact.net/2016
What: Liberact conference brings together thinkers, leaders, creators, and builders of digital interactive experiences worldwide.
When: October
Where: worldwide

Global Game Jam
URL: http://globalgamejam.org
What: The Global Game Jam® (GGJ) is the world's largest game jam event (game creation) taking place around the world at physical locations. It can be described as a hackathon for creating games over an intense 48-hour development cycle. The GGJ encourages people with all kinds of backgrounds to participate and contribute to this global spread of game development and creativity.
When: January
Where: Edmonton, AB and around the world

IX
URL: http://ix.sat.qc.ca/
What: IX brings together artists, designers, researchers, developers, producers and enthusiasts of immersive experiences. The program is open and participatory, with an emphasis on workshops, demonstrations, blitz talks and premieres of groundbreaking artworks. These are all examples of the best practices in the immersive experience creation and distribution ecosystem. It is put on by the Société des Arts Technologiques.
When: June
Where: Montreal, QC

Eyeo Festival
URL: http://eyeofestival.com
What: Eyeo is a celebration of art, interaction, and information. The event begins with workshops and a summit, followed by keynotes, inspirational talks, demos, labs and networking opportunities.
When: June
Where: Minneapolis, MN

INSTINT
URL: http://inst-int.com
What: The event brings together artists, designers and technologists to explore the intersection of art, technology and interaction. Topics include interactive experiences in space, architecture, bodies, and online. Programming consists of workshops, artist talks, demos, panels and social events.
When: fall, winter
Where: Minneapolis, MN; New Orleans, LA

Particle + Wave Media Festival
URL: http://emmedia.ca/2016/12/particle-wave-media-arts-festival
What: This festival consists of exhibitions, installations and performances by local and national artists, along with a workshops and artist panels. It is organized by the EMMedia society.
When: February
Where: Calgary, AB

Designing for Digital
URL: http://designingfordigital.com/
What: Designing for Digital is a three-day conference that brings together hands-on workshops and information sessions for practitioners of user experience, discovery, design and usability initiatives both in and outside of libraries.
When: April
Where: Austin, TX

NIME: New Interfaces for Musical Expression
URL: http://www.nime.org
What: The International Conference on New Interfaces for Musical Expression gathers researchers and musicians from all over the world to share their knowledge and work on new musical interface design. The conference started out as a workshop at the Conference on Human Factors in Computing Systems (CHI) in 2001. Since then, an annual series of international conferences have been held around the world, hosted by research groups dedicated to interface design, human-computer interaction, and computer music.
When: May
Where: worldwide

Appendix H. List of Vendors

Creative Agencies

Name	URL	Description
Local Projects	https://localprojects.net/	Interactive media installation company for museums and public spaces
Moment Factory	https://momentfactory.com/home	Multimedia entertainment studio specializing in creating and producing immersive environments
Perceptual Engineering	http://perceptual.engineering/	Film, media, commercials, live events, art, installation company
Lumo Interactive	http://www.lumoplay.com/	Company specializing in interactive displays and projections for floors and walls
Motion Magix	http://www.motionmagix.com/	Company specializing in interactive playground equipment, including floor and wall systems, projection software
Second Story	http://secondstory.com/projects/browse/featured-work	Creative studio that designs and develops interactive media experiences for public and private organizations
Belle & Wissell	http://www.bwco.info/the-work/interactives/	Seattle-based studio that designs and produces media art installations, multi-touch interactives, films, exhibitions, web experiences, mobile applications
Interactive Mechanics	http://interactivemechanics.com/	Interactive user experiences designed and developed for cultural, educational and care organizations
Gibson Group	http://www.gibson.co.nz/	Digital creative experiences
Ideum	http://ideum.com/our-story/	Develops hardware and software for interactive displays
Anode	http://anode.com	Digital and interactive design studio
Prendi Digital	http://www.prendi.com.au/	Designs and integrates hardware, content and software for interactive experiences
Creative Arts	http://creativeartsinc.com	Design and manufacture for analog and digital exhibits
Onlea	https://www.onlea.org/	Produces interactive learning experiences online and digitally
Moment Research	http://www.momentresearch.com/	Research, grant funding consulting and installation engineering company for interactives, data analysis and visualization

Hardware and Software Specialists

Company Name	URL	Description
22Miles	http://www.22miles.com/	Digital signage company
Beautiful Data	http://www.beautifuldata.eu/	Data visualization and analytics company
Christie	https://www.christiedigital.com/	Micro-tile displays, interactivity kits
Cinemassive	https://www.cinemassive.com/	Video walls, controllers, software, consulting
Connexient	http://www.connexient.com/	Digital signage company
Dataton	http://www.dataton.com/watchout	Makers of Watchout, a media/video curation and management tool
Fathom	https://fathom.concord.org/	Software for teaching data analysis and stats
Four Winds Interactive	http://www.fourwindsinteractive.com	Digital signage company
ImmersaView	https://www.immersaview.com/	Edge blending, image warping, and video streaming & recording software solutions for any type of content
InfoComm	http://www.infocomm.org	Large, high-profile tradeshow for AV/IT for information services
Jibstream	http://www.jibestream.com/	Indoor mapping/navigation (digital kiosks)
Leyard	http://www.leyard.com/en/	Digital displays and signage company, parent of Planar
Matrox	http://www.matrox.com/en/	Software for management of in-house designed multimedia, including information playlists to be run at specific times and dates.
Mechdyne	http://www.mechdyne.com/	AV, IT, hardware
Microsoft Surface Hub	https://www.microsoft.com/microsoft-surface-hub/en-ca	Touch TV/display hardware
MultiTaction	https://www.multitaction.com/	Multi-touch display manufacturer
NanoNation	http://nanonation.net/	Digital signage, interactive kiosks, creative services
Periscope	http://www.periscopic.com/	Data visualization
Planar Systems	http://www.planar.com/regions/	Digital display and signage
Reality Interactive	http://realityi.com/	Digital merchandising
Scala	http://scala.com/digital-signage-software/content-manager/	Digital signage company
Sensory Technologies	http://sensorytechnologies.com/	Audio-visual integration
Stamen	http://stamen.com/	Data visualization
Visibull	http://www.visibull.tv/	Digital signage company
Visix	http://www.visix.com/	Digital signage company
Xibo	http://xibo.org.uk/	Digital signage company
youRhere	http://yourhere.ca/	Digital signage company

Appendix I. Platforms and Tools

A number of software applications, programming languages and digital platforms have come up in literature review, interviews, community consultation, case studies and other avenues as part of the research process. These tools and platforms are defined below for future reference and organized thematically.

3D design, animation and modelling

- **Affinity Designer** (https://affinity.serif.com/en-us/) – proprietary, vector graphics editor that supports, PDF, Adobe Photoshop and Illustrator files and exports to SVG and EPS formats
- **Autodesk 3DS Max** (http://www.autodesk.ca/en/products/3ds-max/overview) – 3D computer graphics software for making 3D animations, models, games and images
- **Autodesk Maya** (http://www.autodesk.com/education/free-software/maya) – 3D computer graphics software for Windows, Mac or Linux.
- **Blender** (https://www.blender.org) – free, open source 3D computer graphics software for creating animated films, visual effects, art, 3D models, video games, interactive applications
- **Cinema 4D** (https://www.maxon.net/en/products/cinema-4d/overview/) – 3D modelling, animation, motion graphic and rendering application
- **Houdini** (https://www.sidefx.com/) – 3D animation application software
- **Realflow** (http://www.realflow.com/) – fluid and dynamics simulation tool for 3D and visual effects
- **Sketchup** (http://www.sketchup.com/) – 3D modeling software used by architects, illustrators and designers
- **Vectorworks** (http://www.vectorworks.net/) – software developer for architecture, landscape and entertainment industries

Game design and programming

- **Adventure Game Studio** (http://www.adventuregamestudio.co.uk/) – open source, cross-operating system tool for creating graphic adventure games targeting intermediate-level designers. The tool also provides an integrated development environment based on C language.
- **Construct2** (https://www.scirra.com/construct2) – game creator tool built in HTML5 designed particularly for 2D games and aimed at non-programmers featuring a video editor and behavior-based logic system to power the engine
- **GameMaker** (http://www.yoyogames.com/gamemaker) – game creation system for cross-platform 2D and 3D games
- **GameSalad** (http://gamesalad.com/) – visual, drag-and-drop tool for creating video games, often used for educators, as it teaches behavior-based logic, computer science concepts and problem solving skills. The games can be published for a variety of platforms and has a large community of users.

- **Pico-8** (http://www.lexaloffle.com/pico-8.php) – fantasy console for creating, playing and sharing small, light-weight video games and similar computer applications. Written in Lua, Pico-8 has a limited 16-colour display and a 128x128 pixel screen reflective of interest in retro games
- **Tynker** (https://www.tynker.com/) – HTML5 and JavaScript-based educational programming platform that teaches kids to code through drag-and-drop code blocks. Unlike Scratch, it is a commercial product and not open source.
- **Unity** (https://unity3d.com/) – game engine, primarily for 3D games
- **VR Juggler** (http://www.vrjuggler.org/) - cross-platform virtual reality application development framework developed at Iowa State University

Interactives and exhibit design

- **AnyPixel** (http://googlecreativelab.github.io/anypixel/) – open-source software and hardware library that facilitates the design web-based large, interactive displays using everyday objects like light switches, balloons, light boxes or LED lights
- **GestureWorks** (http://gestureworks.com/) – development framework and touch point cluster analysis system for multitouch surfaces developed by Ideum, a hardware and software vendor for interactive display tables
- **IntuiFace** (https://www.intuilab.com/) – software for creating interactive digital experiences without programming
- **MaxMSP** (https://cycling74.com/products/max) – visual programming language for building complex, interactive programs
- **Multitouch Cornerstone** (https://cornerstone.multitouch.fi/) – software development kit for creating multi-touch display applications. Developed by the hardware maker, Multitaction, the SDK allows configuration of the display set up as a single surface and adjust for bezels at the edges of display screens
- **OpenExhibits** (http://openexhibits.org/) – multi-touch software development kit; set of libraries for interactive digital content that can be triggered through multiple input devices such as touch screens, Leap Motion, Kinect, TUIO and others; includes gesture analysis engine and Gesture Markup Language libraries.
- **OpenKinect** (https://openkinect.org) – community and sets of libraries for using Xbox Kinect with PCs and other devices
- **Tangible Engine** (http://tangibleengine.com/) – authoring software for object recognition on touch surfaces, developed by Ideum, a hardware and software vendor for interactive display tables
- **Touch Designer** (http://www.derivative.ca/) – visual programming language and visual development platform for real-time interactive multimedia content like graphics, creative code and installations
- **TUIO** (http://tuio.org/) **-** open framework defining a common protocol and API for tangible multi-touch surfaces

Web technologies and creative coding

- **Bokeh** (http://bokeh.pydata.org/en/latest/) – Python interactive visualization library for modern browsers, graphics in the style of D3 and extend with high performance interactivity for large datasets.
- **Cinder** (https://libcinder.org/) – free, open source library for creative coding in C++
- **Lua** (https://www.lua.org/) – lightweight, embeddable scripting language; receiving critical mass in game industry
- **Marvel** (https://marvelapp.com/) – free, browser-based tool for designing, prototyping and sharing mockups for web and mobile applications
- **OpenFrameworks** (http://openframeworks.cc/) – open source toolkit for creative coding based on C++ language
- **Processing** (https://processing.org/) – open source programming language and development environment for the digital arts, new media art, and visual design, built for learning how to program in the visual context.
- **Starling** (https://github.com/starling/starling) – lightweight server for reliable distributed message passing and queuing that can be used for processing touch interaction data
- **VVVV** (https://vvvv.org/) – hybrid visual/textual live-programming environment for easy prototyping and development; handles large media environments with physical interfaces, real-time motion graphics
- **WebGL** (https://developer.mozilla.org/en-US/docs/Web/API/WebGL_API) – JavaScript API for rendering interactive 3D and 2D graphics in the browser

Data management digital library tools

- **Articulate Storyline** (https://articulate.com/360/storyline) – software for creating responsive-design e-learning projects, presentations and courses
- **BiblioBoard** (https://www.biblioboard.com/) – digital library platform for accessing ebooks, audio, video and other digital content
- **Compendium** (http://compendiuminstitute.net/download/download.htm) – software for designing learning activities using a flexible visual interface
- **Luna Imaging** (http://www.lunaimaging.com/) – Software for scanning digital heritage content
- **Omeka** (https://omeka.org/) – free, open source web-publishing platform popular in libraries, museums, archives, special collections and exhibitions

Sound art and performance

- **Puredata** (https://puredata.info/) – visual or “data flow” programming language similar to Max, often used by media, sound and other artists
- **ChucK** (http://chuck.cs.princeton.edu/) – cross-platform audio programming language for real-time composition, synthesis and performance, favoured by sound and performance digital media practitioners

- **SuperCollider** (http://supercollider.github.io/) – free, open source functional programming language and a development environment for real-time audio synthesis and digital composition
- **Open Sound Control** (http://opensoundcontrol.org/osc) – protocol for creating a network among computers, synthesizers and other multimedia technologies for musical performance or controlling shows. Software written in ChucK, Processing, Pure Data and Max can be implemented using this protocol