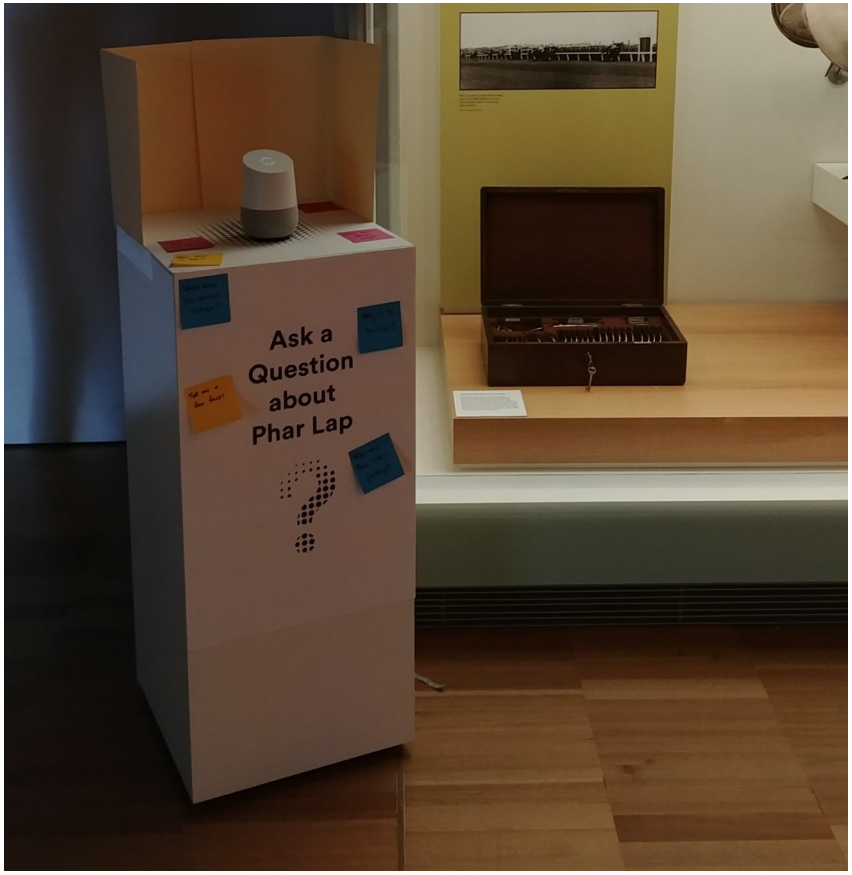
The Age of Ask in Melbourne Museums: Fostering an Interactive Experience through Voice-Activated Technology



Abstract

The motivation for this project was to improve visitor engagement both inside and outside of Melbourne Museum. To do so, our project team evaluated the potential of voice-activated technology for use in museum exhibits as well as off-site applications. We researched the affordances of digital technologies in museums, including voice-activated technology, and we then developed and tested a voice-activated application for a popular exhibit, Phar Lap. User testing the prototype with 45 groups of visitors and four focus groups of museum staff revealed that people enjoy interacting with the technology and there is potential for it to be used in the exhibit. Our observations and feedback from focus groups and visitors suggested that young visitors in particular were interested in playing with the device to ask questions, learn, and socialise. However, we noted several functional limitations of the technology and made recommendations to mitigate the difficulties and work around these obstacles. We saw the potential for using this technology to further help visitors socialise and have fun, so we developed some additional concepts. The first was a short museum trivia game that visitors can play remotely after their visit or play in the museum. Secondly, we developed concepts for an adventure game, using voice-activated technology to place the visitor in a museum-related storyline. From feedback on these various concepts, we recommend that Museums Victoria develop an application for personal use that would package all of these concepts, as well as add functionality to buy museum tickets, access interactive directions to anywhere in the museum, and generate a custom museum experience.

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MUSEUMS VICTORIA

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WPI

The voice of visitors: A new era of interaction

Museums have had a dynamic role in society and education since antiquity. The first institution that could be considered a museum is often cited as the Museum at Alexandria in the third century BC.[1] However, it was more like a university (i.e. a gathering place for scholars) than a museum as is commonly known today: a building or institution in which objects of historical, scientific, artistic, or cultural interest are preserved and exhibited [1] (Figure 1). Museum exhibitions—both their content and their medium—must always adapt to reflect societal changes.[2] Museums in the past have been considered places of elitism and scholarship [2], but contemporary museums attract a larger variety of visitors, ranging from those looking to learn to those looking to socialise.[3] Many museums now do more than display artifacts with some supplementary text. To become gathering places for people, they have added cafes and restaurants. To enhance learning and entertainment, they have added interactive elements to make exhibits more engaging (Figure 1).

Interactivity means engaging more of the human senses than just sight. Museums have created tactile models, mixed soundscapes, and even sometimes produce aromatic samples. Recently museums have been focusing on how they can use digital technology to improve their exhibits. Museums Victoria is one institution that has been adding a variety of digital technologies to their galleries.

As the largest public museums organisation in Australia, Museums Victoria has to be on the forefront of innovation to maintain its status, and they have an attitude of seeking constant improvement to give their visitors a new and exciting experience. The museum aims to "create an inquisitive, inclusive and creative environment,"[6] positively impacting Victoria. This is seen in their constant efforts to be innovative and engaging for all. They have held temporary exhibits that showcase never-before-seen artifacts from their collections (e.g. Inside Out). They also utilise audio-video technology to create exhibits that appeal to the senses (e.g. a Bit na Ta), and they even have a nightclub-esque experience to appeal to young adults, called Nocturnal[7] (Figure 2). Museums Victoria does not limit their museums to traditional expectations.

With the rise in popularity of consumer voice-activated devices, Museums Victoria now looks towards implementing similar technology in their exhibits. To help them do so, our project team aimed to develop a proof of concept for the technology in a museum setting and determine its feasibility. Our plan was as follows:

1. Identify the potential of digital technologies, particularly voice-activated technology, for museum engagement.

Figure 1. The Egyptian room in the 19th century British Museum [4] (left) and interactive Petroleum Museum [5] today (right).

Figure 2. Nocturnal experience at Melbourne Museum [8] aimed to appeal to adults.

2. Select an exhibit in Melbourne Museum in which voice-activated technology might be implemented.
3. Develop a prototype for interactive technology for the exhibit.
4. Test and refine the prototype accordingly
5. Use this experience to further understand future applications of this technology for the museum.

We first looked to justify use of voice-activated technology by identifying its affordances and potential. We also examined how other museums use types of digital technology for various purposes. Afterwards, we selected an exhibit within Melbourne Museum in which a prototype could be tested, utilising information from interviews with tour guides, surveys from visitors, and observation of visitors. From there, we used an iterative design-feedback process to create the voice application. The design was refined until the final prototype was satisfactory among visitors and museum staff. From data collected throughout the process, we were able to give recommendations about how to extend our work to best benefit museum visitors.

"Interactivity means engaging more of the human senses than just sight."

Museums use digital technology to engage visitors

Museum visitors & their motivations

To design appealing museum exhibits, we needed to understand the diversity of the museum audience—particularly their motivations for attendance. One important factor to consider is age, as the Smithsonian Institution has found that individuals who attend museums at an early age are more likely to continue to attend as they grow older.[9] However, visitors can be categorised by more than just age alone. Museums Victoria has studied its visitors and categorised them into six segments, or groups, based mainly on their drivers for attending the museum.[10] The Museums Victoria segments are named and described in Figure 3. Each group has different drivers for visiting and different expectations of their museum experience, but we can broadly categorise them into three groups: those who have the desire to learn at the museum, those who go to be social, or those who want entertainment. Figure 3 shows these more general groups in distinct colours. Groups that primarily desire a learning experience value insightful information and challenges in their experiences, and they like to feel a sense of accomplishment afterwards. Visitors who mainly look for a social experience seek to relate to something, be it with like-minded people at the museum or content that feels highly relevant to them. Lastly, individuals whose main driver is fun or interesting experiences are the easy-going. Museums Victoria must keep these drivers in mind, particularly when designing exhibits, so that they can more thoroughly cater to the various needs of visitors.

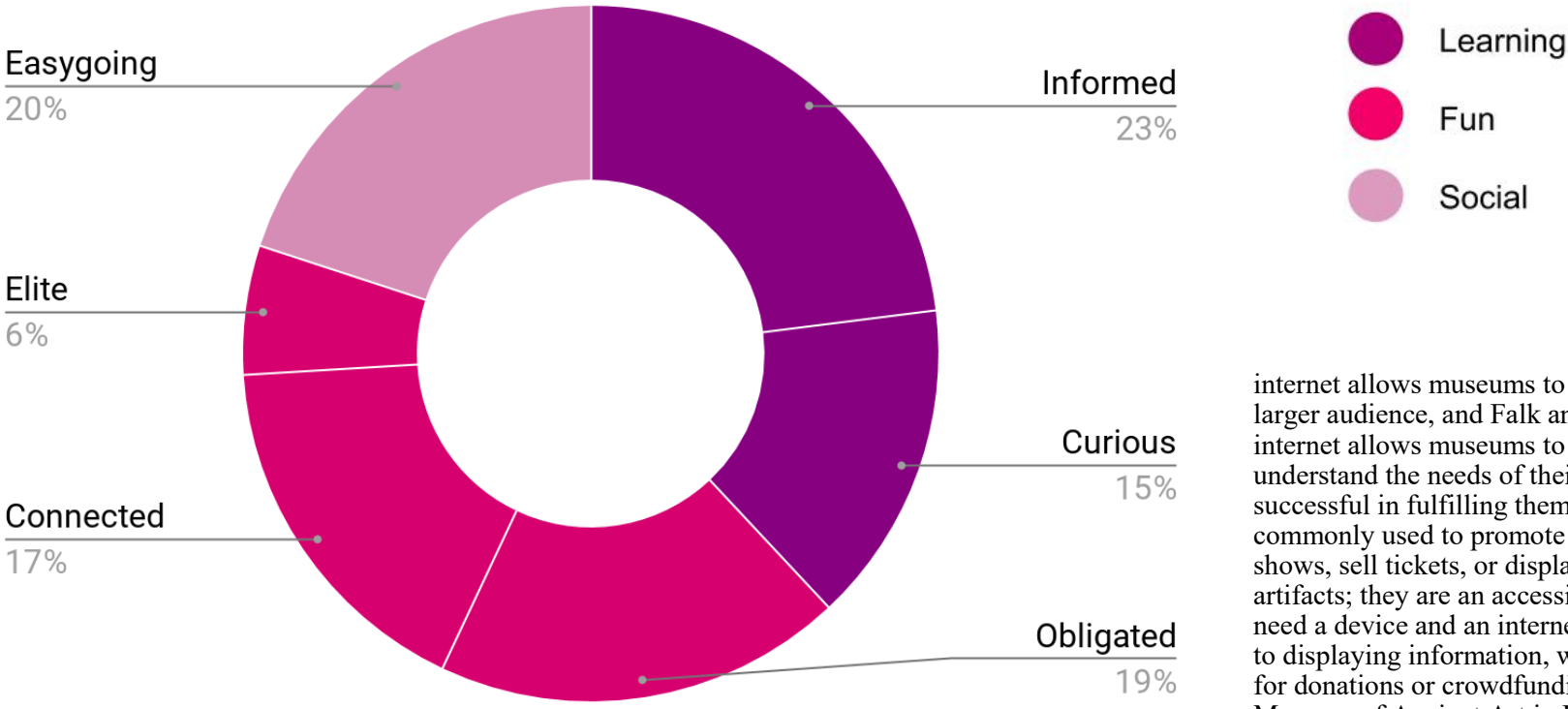

Figure 3. Types of Museums Victoria visitors and their motivations.

Digital technology in museums

Digital technology allows museums to connect with more and different types of people, both remotely and on-site, expanding their influence [11] and creating more engaging experiences. Visser asserted that interactive and engaging museums are more fun, and without interaction, museums would likely lose some visitor interest to the countless other stimuli in the information-overloaded world.[11] Since digital technology comes in many forms, it provides opportunities for many different types of interaction, along with various other affordances. To understand if the benefits of voice-activated technology can best align with our goals for visitor engagement, we investigated the affordances (Table 1) of different forms of digital technology, along with how these technologies are currently being used in various museums globally. We found that these implementations have improved museums in many ways, such as through crowdfunding to buy collections [12], creating interactive exhibits [13], and holding engaging shows.[14]

Websites

A significant development in digital technology for museums has been the internet. The internet allows museums to reach further and to a larger audience, and Falk and Dierking argued that the internet allows museums to get feedback to better understand the needs of their visitors and be successful in fulfilling them.[15] Museum websites are commonly used to promote special exhibits, announce shows, sell tickets, or display online collections of artifacts; they are an accessible resource as users only need a device and an internet connection. In addition to displaying information, websites can also be set up for donations or crowdfunding. For example, the Museum of Ancient Art in Italy connected with over 5,500 people online, holding a successful crowdfunding campaign to purchase an additional collection of artwork.[12]

Smartphone applications

Museums can use smartphone applications (apps) to provide direct and personalised information to visitors. Many people in the developed world have a smartphone.[16] Apps offer the opportunity for visitors to access museum information on their own device, and therefore content is not limited by the physical space of the galleries. Similarly to websites, one of the ways that museums have made use of smartphone apps is allowing visitors to explore additional content that is not physically on display. For example, the American Museum of Natural History in New York

Table 1. Digital technologies in museums and their affordances.

Affordances	Smartphone applications	Audio	Augmented reality	Touchscreens	Instant messaging	QR codes	3D models	Motion detection	Games	Video projection	Voice-activated technology
Low barriers to interaction		✓	✓	✓			✓	✓	✓	✓	✓
Unbounded features	✓			✓							✓
Easy access to information	✓	✓	✓	✓	✓	✓				✓	✓
Active participation	✓		✓	✓	✓		✓	✓	✓		✓
User control	✓		✓	✓	✓		✓	✓	✓		✓

City uses the "Explorer" app to wirelessly connect with the visitor's location in the museum [17], give visitors access to content that is not on display, provide fun trivia games and other puzzles, and act as a museum tour guide.[17] Some institutions, such as Museums Victoria, have apps meant for off-site use that serve as field guides for flora and fauna as well as landscapes in the local area.[18] Even Google has developed two relevant apps: Google Lens and Google Arts & Culture. Google Lens allows for identification of subjects using the phone camera [19], and Google Arts & Culture lets users learn more about artwork around the world.[20]

Table 1 Key: Definitions

- **Low barriers to interaction:** easy for visitors to interact with the technology without prior experience or other devices
- **Unbounded features:** ability to use features that aren't physically on display
- **Easy access to information:** access to information does not require extensive searching
- **Active participation:** visitors have an active experience with the technology
- **User control:** visitors can choose what information they obtain from the technology

QR codes

An extension of smartphone use in museums is the use of QR codes, which are unique, square-shaped patterns that a mobile phone user can scan to access digital content. Their simplicity has allowed them to become common; Museums Association found that 22% of museums in the United States and 30% of museums in the UK use QR codes.[21,22] QR codes often lead the person to a page with more information about the displayed items in the museum, but there are several additional ways in which they can be used. For example, the Erarta in St. Petersburg, Russia has QR codes for several pieces of art in its gallery. Visitors can scan the code of a particular artwork to access more detailed information about the piece and its artist, order a reproduction for themselves, or even read other visitors' thoughts on certain works and share their own.[23] QR codes provide a relatively simple way for people to explore extra museum content that is not physically on display, and they also allow the content offered to be easily updated, as one only has to modify the web page to which the code routes the user.[24]

Instant messaging

Similarly to apps and QR codes, instant messaging can also be used to request additional information from the museum. The difference, however, is that almost any visitor with a mobile phone can send a text message without requiring the download of an app. Additional content is therefore more accessible to general visitors. Information retrieval and response to text message requests can be either automated or manual. The San Francisco Museum of Modern Art (SFMOMA), for example, automates their responses to share artwork that they

are unable to display in their exhibits because of space constraints.[25] Users can text SFMOMA "Send me…" followed by a phrase or emoji related to what they would like to see, and SFMOMA automatically responds with a piece of artwork (Figure 4). For example, visitors could text "Send me something pink" and SFMOMA would respond with art such as Stephen Frykholm's "Herman Miller Summer Picnic poster."[25] In contrast, the Brooklyn Museum employs people who respond to text messages, answering questions that visitors have sent using "Ask", a smartphone app with instant messaging capabilities.[26] In both examples, visitors are able to quickly obtain more content at their request.

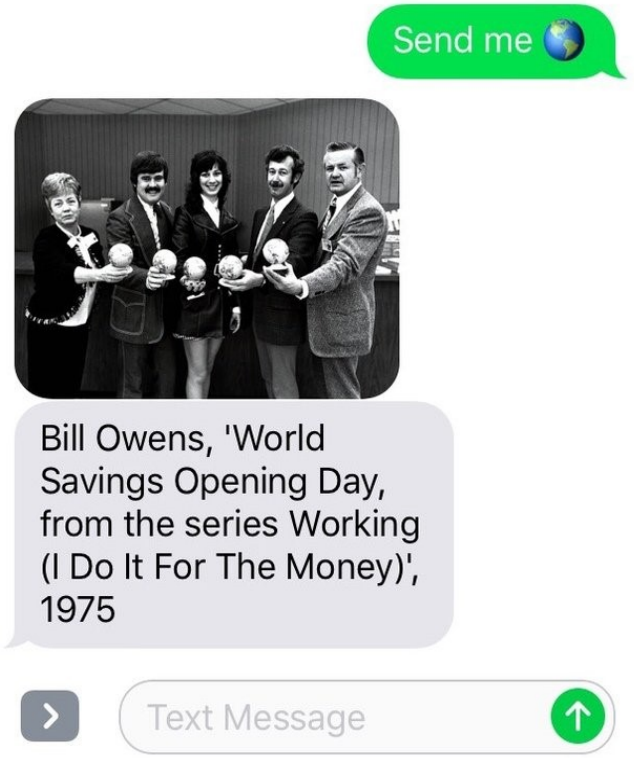

Figure 4. Instant messaging with SFMOMA to receive artwork.[25]

Audio tours and soundscapes

Before many people had smartphones, much additional information for museums could be delivered via audio tours on dedicated devices. Audios tours are a common feature of modern museums, providing visitors with more detailed information about different exhibits or artifacts, typically at their own pace. This medium can offer primary recordings, like a tour of Ellis Island Museum that provides additional narration and first-hand accounts of immigrants.[27] The medium can also provide entertainment, such as in the Soundscape exhibit in the Fort Collins Museum of Discovery, in which music is created according to visitors' movements, so people can experiment and explore to create different tunes.[28] Audio implementation adds depth, engages an additional sense for visitors, and is also versatile.

However, audio tours also have the disadvantage of requiring much of the visitor's time. A study done by Mannion, Sabieuscu, and Robinson on the British Museum showed that while nearly 160,000 visitors use the museum's provided audio tours annually, this number amounts only to three percent of its annual attendance;[29] the researchers concluded that visitors perceived audio tours as too time-consuming. It seems that capturing the attention of visitors through audio requires the right balance of content depth and volume.

Augmented and virtual reality

Augmented and virtual reality (AR and VR, respectively) are technologies that can engage visitors' visual and auditory senses even further, providing truly immersive experiences. AR is broadly defined as virtual projections or inserts into reality, typically interactive, while VR is a fully virtual world. Both these technologies allow visitors to interact with virtual objects, but AR is easier to implement. They are appealing because they allow for a more immersive view of exhibits that may not exist physically (e.g. fully restored historical ruins).

AR can come in several forms, such as in smartphone apps, interactive projected exhibits, or holograms. For example, ABBA The Museum in Stockholm, Sweden uses holograms to virtually put the members of ABBA on stage with a visitor while they perform the band's songs (Figure 5), and visitors can virtually try on ABBA costumes using the same technology.[13] SFMOMA also uses AR, but through smartphones, to bring sculptures to life.[25] Additionally, to let people virtually experience the Everglades, the Frost Museum of Science in Florida has an interactive display of the Everglades that responds to human motion.[30] Many more museums are using AR in similar ways to add more dimension to their exhibits [31], and visitors have had an overwhelmingly positive reaction.[25] With graphical processing becoming more powerful and common, technology like AR and VR can also become more accessible and commonplace.

3D Printing and Scanning

Similarly to AR and VR, 3D printing and scanning can also allow visitors to interact with items indirectly or virtually. Some museums already have tactile models; for example, the Melbourne Museum has a model heart of the race horse, Phar Lap, that visitors can hold. 3D printing allows for a more direct way of creating models for visitors. The Smithsonian uses 3D printing to give visitors an opportunity to virtually explore artifacts.[32] Similarly, the Field Museum in Chicago used a medical CT scanner to create a feature that allows visitors to "unwrap" a mummy and examine what lies underneath the wrapping [33], a unique experience that is only possible with this technology. They also sent field workers to obtain a 3D scan of a cave in Greece, which museum visitors could then interact with virtually to experience a natural wonder that they normally would not have the chance to explore, especially while in Chicago.[33] 3D scanning can be used in combination with AR and

Figure 5. ABBA Museum's augmented reality on stage.[13]

VR to provide an immersive experience of inaccessible objects.

Voice-activated technology

The currently trending feature is voice-activated technology. Voice-activated technology is technology that allows for tasks to be executed using voice recognition, in that distinct words or phrases can be converted into specific commands for the device. The technology has been conceptualised and developed since the 1950s by Bell Labs [34], though until now, the technology has been primitive and not widespread among consumers. One of the reasons for this was weakness in voice recognition software, which caused limitations on machine ability to interpret voice. In recent years, however, voice-activated technology has been popularised by Google Home and Amazon Echo as advancements in the software have allowed for less restrictive or specific phrases. Contextual interpretation (e.g. referencing people or objects with pronouns instead of names) creates more natural conversation and improvements in machine learning have helped devices interpret variations in command better.

With the technology improving, the popularity of such devices continues to rise, as IFTTT found that 98% of existing users of voice-activated devices think they would continue to use the technology in five years.[35] It is also important to note that voice-activated technology is not limited to dedicated devices; iOS and Android devices also come with Siri and Google Assistant built in. According to Business Insider's survey in 2016 (Figure 6), voice assistants have become very popular for helping people complete tasks (e.g. set a timer) and giving people information when asked (e.g. daily weather).[36] These tasks are especially helpful in situations where the user's hands are otherwise occupied (e.g. while cooking or driving).

While many smartphones have built-in voice assistants, dedicated voice-activated devices have a role to play as well. They may carry out the same functions of setting tasks or interfacing with smart appliances but they are also built with higher quality microphones and speakers, allowing for more reliable voice recognition and greater physical range. These devices are designed to be stationed in one place and act as a hub for information and action. Businesses around the world have found an interest in these standalone assistants because they can be customised to connect to a database and answer specific questions from the customers. For example, a liquor store in New York City uses an Amazon Echo to assist customers in making a selection.[37] Indeed, even rudimentary voice-recognition has been used by businesses; many customer service phone lines are automated using such technology. With room for creativity, business may adopt the technology, especially for customer interaction.

Museums are beginning to adopt voice-activated technology as well. New York's Museum of Modern Art (MoMA) is one early adopter.[38] MoMA has stations around the museum where an Amazon Echo has been programmed to respond to custom commands, such as giving directions around the museum and dispensing information about artists and their works by drawing from the museum's database.[38] Although it is easier for the user to tailor his or her experience with this than with an audio tour, this experience is still far from immersive. It adds little to the experience of viewing the art itself, which may be in the best interest of preservation, as there are inherent limitations to incorporating digital

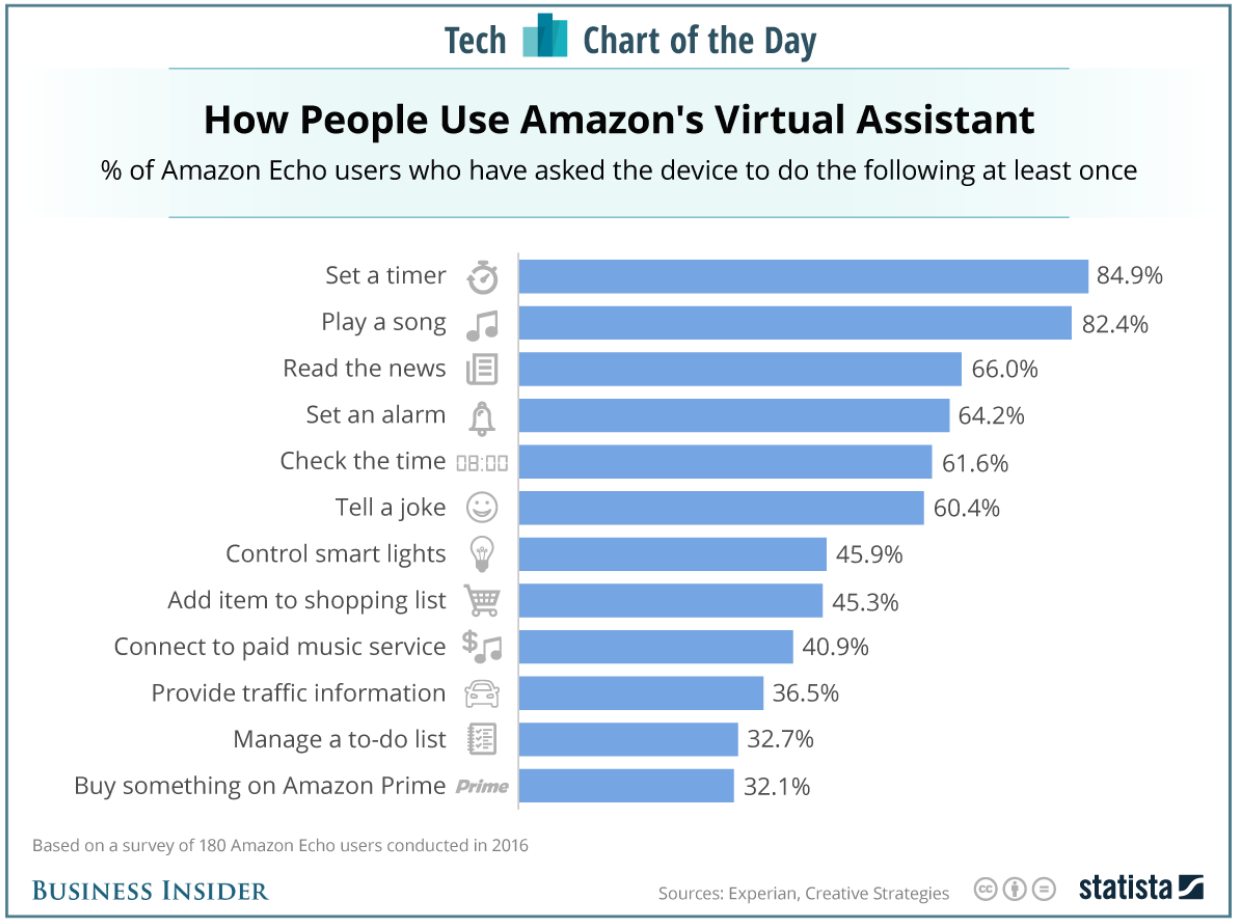

Figure 6. How people use the Amazon Echo, according to BusinessInsider.[36]

technology without altering the art pieces themselves.

Museums Victoria's three museums have a unique opportunity to take advantage of voice-activated technology. Popular consumer voice products have only just been released in Australia, whereas in the USA they have been available for quite some time. Google Home was released in October 2017 in Australia, while Amazon Echo was released later in February 2018.[39,40] This means that, by adopting these systems quickly, Museums Victoria can create a more immersive experience, and they will also have a unique feature that they can use in marketing and promotional materials. Our project team worked alongside them to achieve this.

Designing a voice-activated application

Museums Victoria wanted to create a unique and interactive experience for visitors, and they asked us to analyse the potential of using voice-activated technology to do so. In what follows, we discuss our objectives, the methods we used to achieve them, and the results of our research and design. Figure 7 summarises methods for the entire project.

Determining the potential of voice-activated technology

Our first objective was to determine the potential that digital technologies, particularly voice-activated technology, hold for museum visitors. To do so, we performed a literature review and produced the affordance summary chart discussed in our background section (Table 1), which affirmed how different types of digital technology improve engagement in museums. The affordances of voice-activated technology included low barriers to interaction, user control, active participation, and easy access to information. Once we arrived at Melbourne Museum, we further explored the potential of voice-activated technology specifically by surveying 24 visitors about their current use of and attitudes towards it. We asked them about their experience with voice-activated technology to determine where and how they use the technology (see Supplemental Materials D). The results of our survey showed that most people were familiar with voice-activated technology, despite the fact that many of them were not using it themselves. Out of the 24 people we surveyed, nine people had concerns about technology

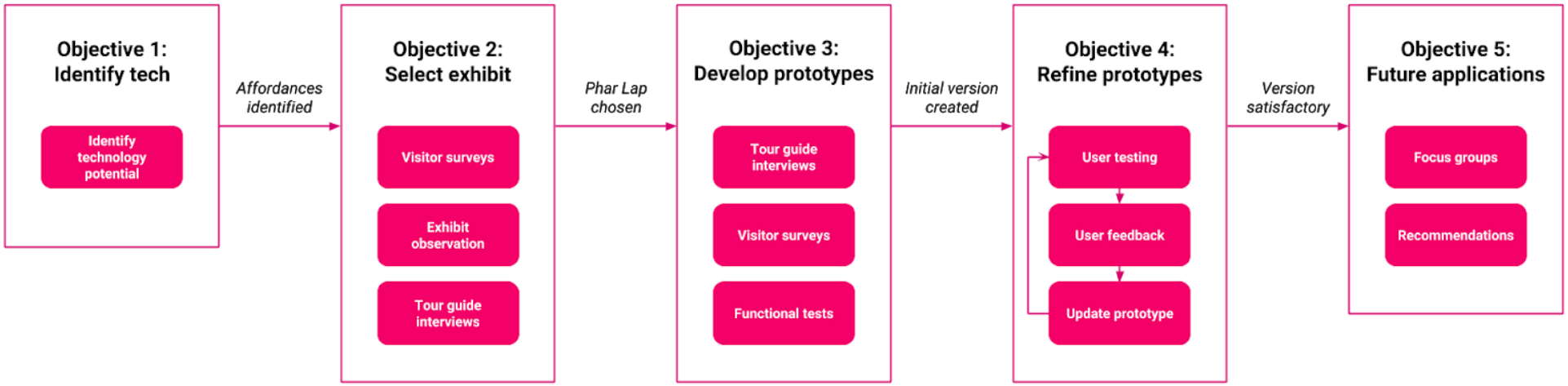

Figure 7. Methods overview.

(Figure 8). In particular, visitors expressed the most concerns about privacy (Figure 9). However, these visitors also noted that their concerns for privacy would not be as important in a public setting such as a museum. Additionally, although only nine of the museum visitors we surveyed were currently using voice-activated devices, nearly everyone surveyed could see potential for voice-activated technology in Melbourne Museum (Figure 8). This showed promise, suggesting that people in the museum would be open to using this technology.

Selecting an exhibit: Methods and results

Our second objective was to select an exhibit in which to prototype a voice-activated experience. To begin, we explored Melbourne Museum to determine potential exhibits that could benefit from voice-activated implementation. We considered exhibits that were permanent, as these tend to have more available information. Therefore we considered Phar Lap, Forest Gallery, and Wild exhibits.

To help inform our decision of which exhibit we would design for, we surveyed 24 museum visitors across three exhibits, asking them what questions they had about that exhibit in particular (see Supplemental Materials D). We performed content analysis of open-ended question responses to look for commonalities. After analysing the results, we eliminated Forest Gallery as an option because it proved to be a more reflective space, rather than an exhibit where people were looking to interact and have their questions answered. Wild and Phar Lap were much busier than Forest Gallery, and people who participated in the survey had questions that could be answered from a database. Table 2 summarises questions that people had about each exhibit.

We wanted to select an exhibit that was popular, but we also needed to be cautious of the noise level to ensure the voice-activated device would

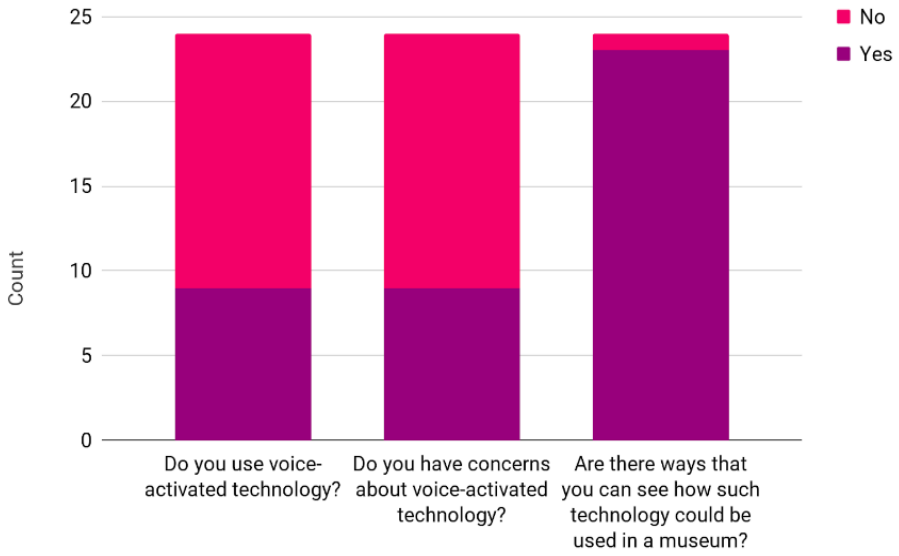

Figure 8. Use and attitudes regarding voice-activated technology.

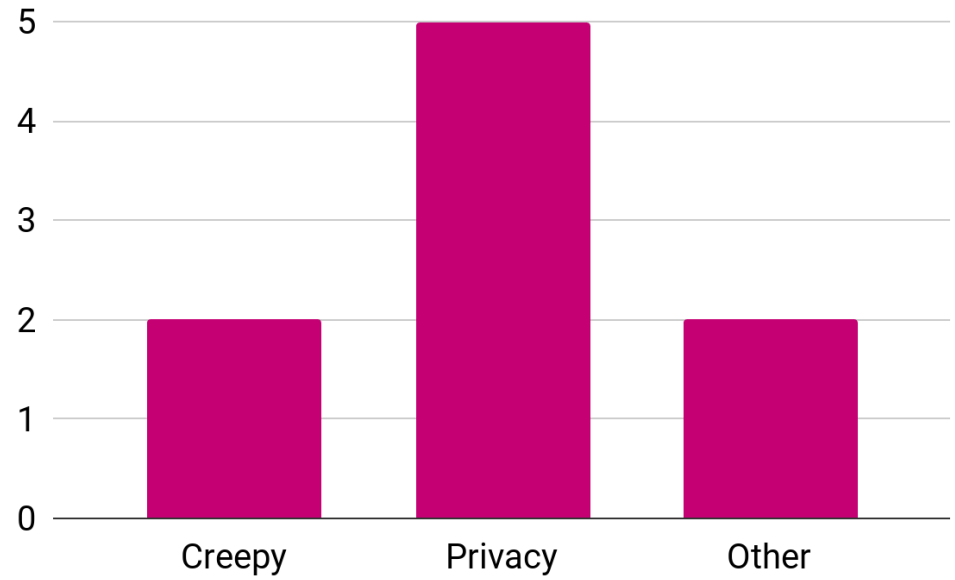

Figure 9. Visitor concerns regarding voice-activated technology.

work in the space. In order to determine popularity and noise levels, we observed foot traffic and measured sound in both the Phar Lap and Wild Exhibits. To measure foot traffic, we counted visitors present in the exhibits every five minutes in a 20-minute period once a day, and we iterated over three days to get a general idea of each exhibit's overall popularity. Sound levels were examined using the mobile application SoundMeter for Android, which measures decibels in the surrounding environment. The average sound level over 30 seconds was recorded every five minutes within the same 20-minute intervals as the foot traffic observations. We collected data at a different time each day to obtain more comprehensive information. In addition, we took a photo of people in the exhibit during observation (Figure 10) to allow us to determine where in the space a prototype would be most visible and useful.

Table 2. Visitor questions from initial survey.

Phar Lap	**Wild**
Who is he? Where is his heart? I want to know more about his heart. I don't know who he is. At first, I didn't know who he was so I didn't understand why he was here.	Where do the animals live? What do the animals eat? What was the ecosystem like before the animals went extinct?

Figure 10. Photos from observation in Wild and Phar Lap exhibits.

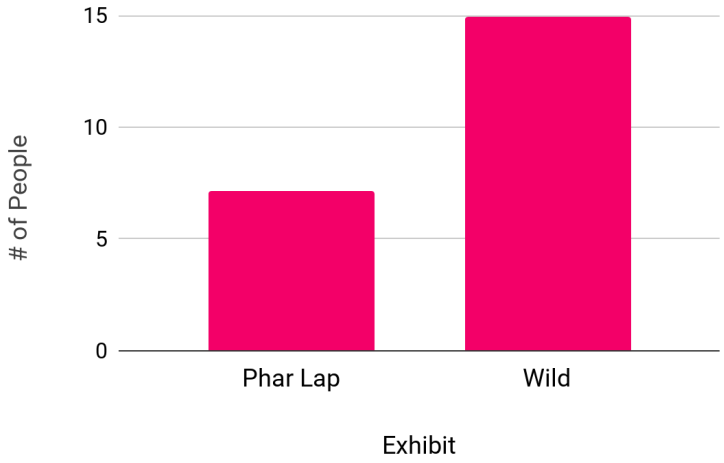

Figure 11. Average foot traffic in Phar Lap and Wild exhibits.

The results of our observation are summarised in Figures 11 and 12.

Our results did not significantly point us in either direction. We found that Wild had greater foot traffic on average than Phar Lap, but the sound measurements showed that there was not a great difference between the average noise levels in the two exhibits. However, it was noteworthy that Wild had a greater difference between its minimum and maximum volume. In addition, from observation, we found that more school groups would come to Wild, leading to periods with large school groups, during which the number of visitors present and the noise level may be inappropriate for voice-activated devices. Therefore, while these results did not provide compelling arguments for either exhibit, it was noted that the higher peak sound level in Wild could make using voice-activated technology more difficult.

After observation, we interviewed three tour guides to determine which exhibits typically generate the most queries from visitors, along with what kinds of queries those were. We asked them the following questions (see Supplemental Materials E for full protocol):

- How long have you been a tour guide at this museum?
- In your tour experiences, what are the top 3 exhibits that visitors tend to ask questions about?
- What are the most common questions for each of those exhibits?
- Which of these exhibits do you think is the most interesting to visitors overall?
- Which exhibit do you personally find the most interesting?

Table 3. Summary of responses from tour guide interviews.

Years of Experience	Top 3 exhibits where visitors have questions	Common question topics	Most interesting exhibit to visitors	Most interesting exhibit to you personally
6 years	Dinosaurs, **Phar Lap**, the museum itself	Ages of the dinosaurs	**Phar Lap**	Dynamic Earth
16 years	Science and Life Gallery, **Phar Lap**, Forest Gallery	What animals and birds live in the Forest Gallery, facts about spiders, facts about **Phar Lap**	**Phar Lap** or Science and Life	Bunjilaka
7 years	The tours are all different, so it is hard to choose a top three	Questions vary by group demographics, many ask if the dinosaurs are real	Forest Gallery or **Phar Lap**	World War I, **Phar Lap**

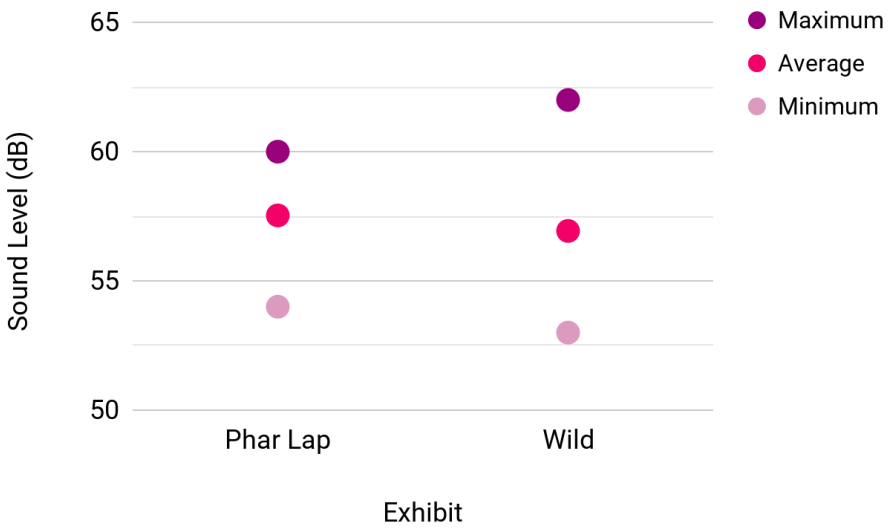

Figure 12. Maximum & minimum sound level in Phar Lap and Wild exhibits.

Since the tour guides had extensive experience interacting with visitors, they provided valuable information regarding how our project could benefit the museum's exhibits. The responses from tour guides are summarised in Table 3.

Considering all of our findings, we chose Phar Lap as the exhibit in which we would prototype voice-activated technology. All three guides mentioned that Phar Lap was popular, with one explaining that some people have come to the museum just to see him. Our survey data also suggested Phar Lap was a good candidate because people generally had simple questions that a device could answer by retrieving information from a database. Additionally, from a practical perspective, the Phar Lap exhibit was generally quieter than Wild, and this would allow the device to more easily pick up voice commands and visitors to more easily hear the outputs.

Developing the Phar Lap prototype: Our iterative design process and results

Before we started developing the prototype, we had to choose which voice-activated device to use as a platform. We selected the Google Assistant because its documentation is extensive, it has been in Australia the longest (as compared to Amazon's Alexa), and it is the easiest to program. For our purposes, we initialised the Google Assistant application so that it listens for a defined list of questions, which prevents people from getting the

device off-track or engaging in inappropriate web activity. This is especially important for interactions with children or other individuals who might explore the device beyond its intended usage. Additionally, using a local application means that if the internet malfunctions, the voice assistant would still be able to draw from the localised programmed database.
To begin the iterative design process, we developed a list of questions to be answered by our agent, inspired by the responses from surveys, observations, and interviews. Some of these questions are provided in Figure 13.

We programmed our application to answer 40 questions using Dialogflow, a conversational interface developed by Google. We manually inputted user prompts (user questions or sentences) and appropriate device responses to train our app (refer to Supplemental Materials F for the questions and responses). Figure 14 outlines the flow of information between the user and the device. While programming the questions and answers, we routinely tested the app's functionality through our phones. For more information about the Dialogflow interface, refer to Supplemental Materials J.

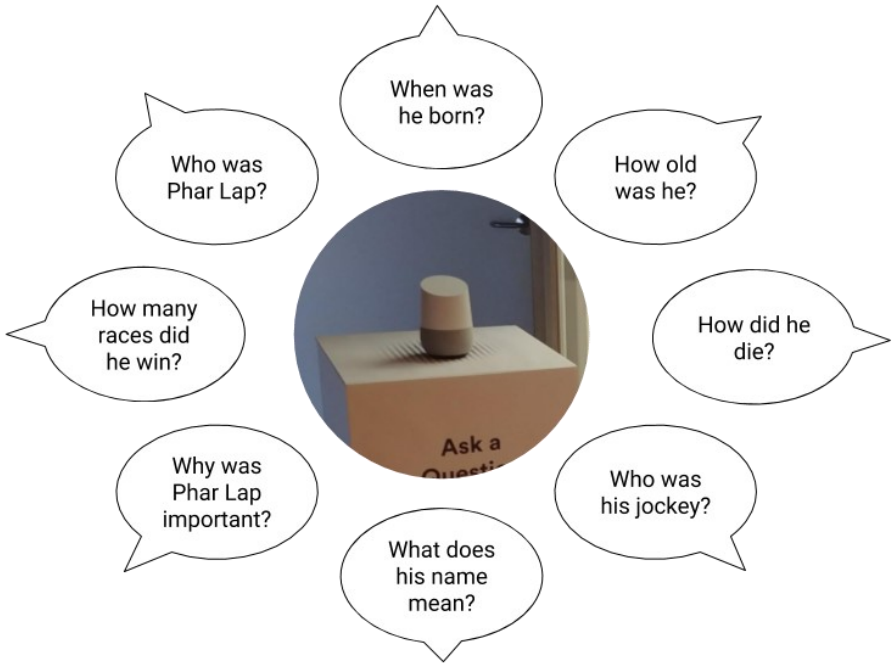

Figure 13. A small sample of questions programmed for our app.

User testing to refine Phar Lap prototype

Once a first functional iteration of a prototype was created (Figure 15), we moved on to user testing. We observed 45 groups interacting with the prototype over six days for a total of 6.5 hours; we recorded 134 total queries asked by visitors. Two members of our team stood with the device and invited visitors to try our app while one member recorded written observations and the other recorded the session on video. Observation categories included time spent with the prototype, questions that the person asked it, any observed difficulties, any noticeable reactions, and any additional notes (see Supplemental Materials G for full observations). For more in-depth feedback, we conducted four focus groups consisting of staff members from the digital

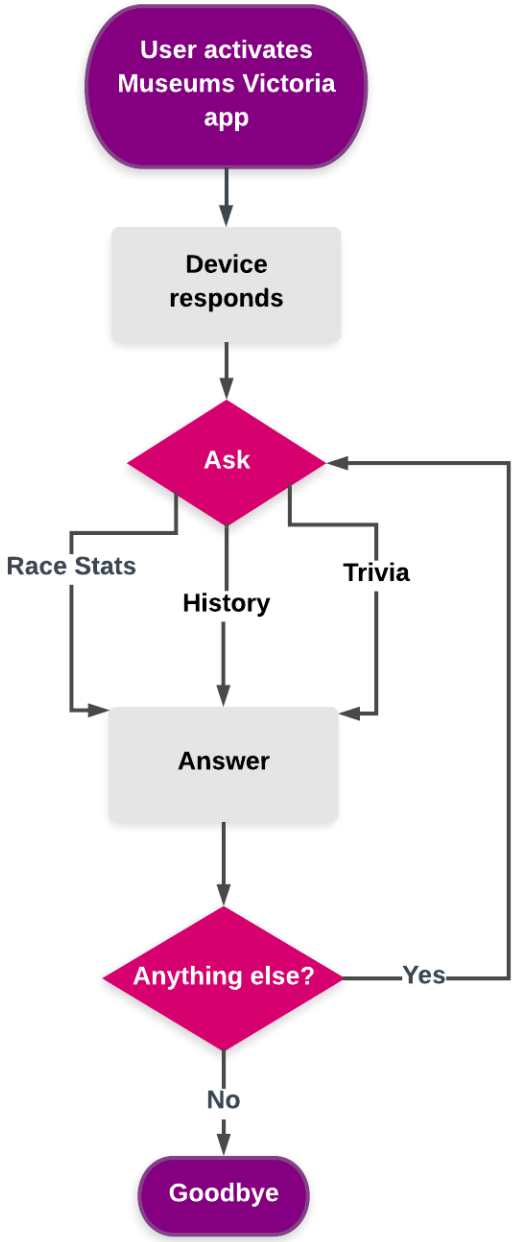

Figure 14. Logic flow of information between user and voice-activated technology.

Figure 15. Voice assistant setup in the Phar Lap exhibit in Melbourne Museum.

technology department, exhibition design department, marketing department, and events department (see Supplemental Materials I for focus group data). We asked these groups to interact with our prototypes and then answer questions and discuss their potential. These data allowed us to identify areas for improvement and future application.

Visitor testing indicated that people had a generally positive experience with the device; 34 out of the 45 parties expressed notable enjoyment (e.g. laughter), were impressed (e.g. made positive comments), or connected socially with others as they used the device. In one case, a young boy ran back and forth several times, asking the device questions and relaying the answers to his grandmother. The average number of questions asked by each party was 3.4, and most of the interaction came from children. We also noted that many visitors would at least notice the device setup, even if they did not approach it. It is worth noting that we conducted user-testing during school holidays, which meant that more families were visiting and no school groups were present.

Although the reaction was generally positive, we did find functional problems. Up to 44% of questions asked experienced at least one difficulty. A common cause for many of the issues seemed to be ambient noise. For example, most difficulties consisted of the Google Home being unable to hear the user or understand the question, or the agent answering the wrong question after only being able to pick up on parts of a query (Figure 16). The greatest limitation we observed was the agent's inability to distinguish similar questions when there was ample ambient noise. This is suggested by the fact that throughout the week, as we programmed more questions into our agent, its ability to distinguish them weakened. In the first 30 instances of parties interacting with the device, there were only six occurrences of the device wrongly interpreting their questions, but in the last 15 instances (after adding additional questions) there were eight occurrences, indicating that this issue had worsened. For example, "Where was Phar Lap born" and "Where did Phar Lap die" could trigger the same response if the Google Home recognises only the words "where" and "Phar Lap." This problem will potentially grow as the question pool increases and includes more questions of similar wording. However, this could be mitigated if the background noise is reduced. During our focus groups (conducted in a controlled environment), the device recognised commands well and only failed to deliver the correct response when asked an unfamiliar query; in one case, however, the device produced a rare unspecified error.

To address the issue of ambient noise, we suggest using a physical setup that would block background noise. We tested a simple shroud (Figure 17) designed to both block external noise from behind the device and amplify the user's voice. After testing this design, however, we found that it was inconclusive whether it improved the ability of the device to recognise speech, as the error rate had not improved. We hypothesise that a larger enclosure might be helpful, however, and could also provide a more immersive experience for visitors if it housed touchscreens or enabled other sensory experiences (Figure 18).

The device faltered when encountering unfamiliar queries. When this occurred, the device would give a fallback response, and it would then be unclear to the user whether the device had failed hear the question or simply had no response to it. As a

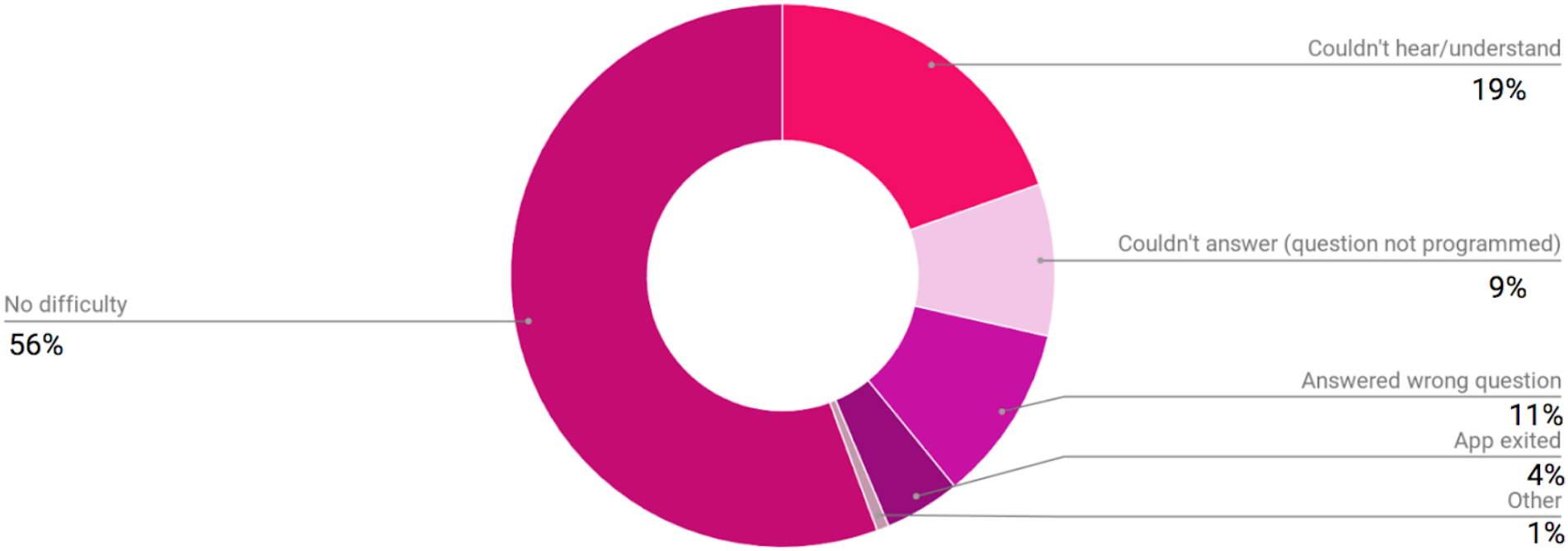

Figure 16. Summary of difficulties experienced during user testing.

result, some users would repeatedly ask the same unfamiliar question until the device failed three times to answer and subsequently exited the application. To address this, we suggest a response that states that the answer is not known to make it clear to the user that the device heard the query, but could not answer it. Alternatively, there is also the option for these questions to be relayed to a human operator, who could broadcast their answer through the device. This would allow for a higher degree of flexibility as unfamiliar questions could still be answered. We also recommend that the museum directly connect the agent to a local database of answers rather than hard code the specific questions and answers. This will make the agent more robust and easily scalable, and from here, follow-up queries may be more easily introduced.

Our Google Home also often had a delay in response, which made the experience more frustrating and made it feel less natural. several focus group participants noted this as something that should be improved. We hypothesise these delays may have happened due to connection quality of the Wi-Fi network. Rarely, the device would exit out of the app due to an unspecified error. Our focus group participants noted that these glitches would act as a barrier to their engagement and enjoyment. This is a problem we anticipate will be fixed as the technology improves.

A common concern for the technology was making the device sound more natural and conversational (two of four focus groups mentioned this). A potential solution is to introduce better contextual follow-up phrases beyond the currently programmed “What else you would like to know?”. These phrases could lead into related topics or the same topic in more detail (Figure 19). Leading into more detail would be helpful in providing an additional affordance - users could then choose how

much information they want to hear and avoid being underwhelmed or overwhelmed. Additionally, it is important that users know whether the device heard them or the question simply does not have a prepared answer. This can be done formally (e.g. "Unfortunately, I can only answer questions about Phar Lap.") or informally ("Excuse me, what would you like to know about Phar Lap?"). One of the goals of the technology is for users to feel comfortable talking to it, which means that it has to feel natural and conversational.

Three of four focus groups mentioned another concern—potential visitor embarrassment to use the device, and we observed this hesitation in the user testing sessions as well. According to our focus groups, this embarrassment comes from seemingly talking to nobody as well as the risk of having to repeat themselves or the device not working as intended. To address this, we suggest a setup with a motion detector to trigger an audio invitation to interact with the device once the visitor enters the enclosure. This invitation would serve as a prompt for users to ask the device questions in a more private space.

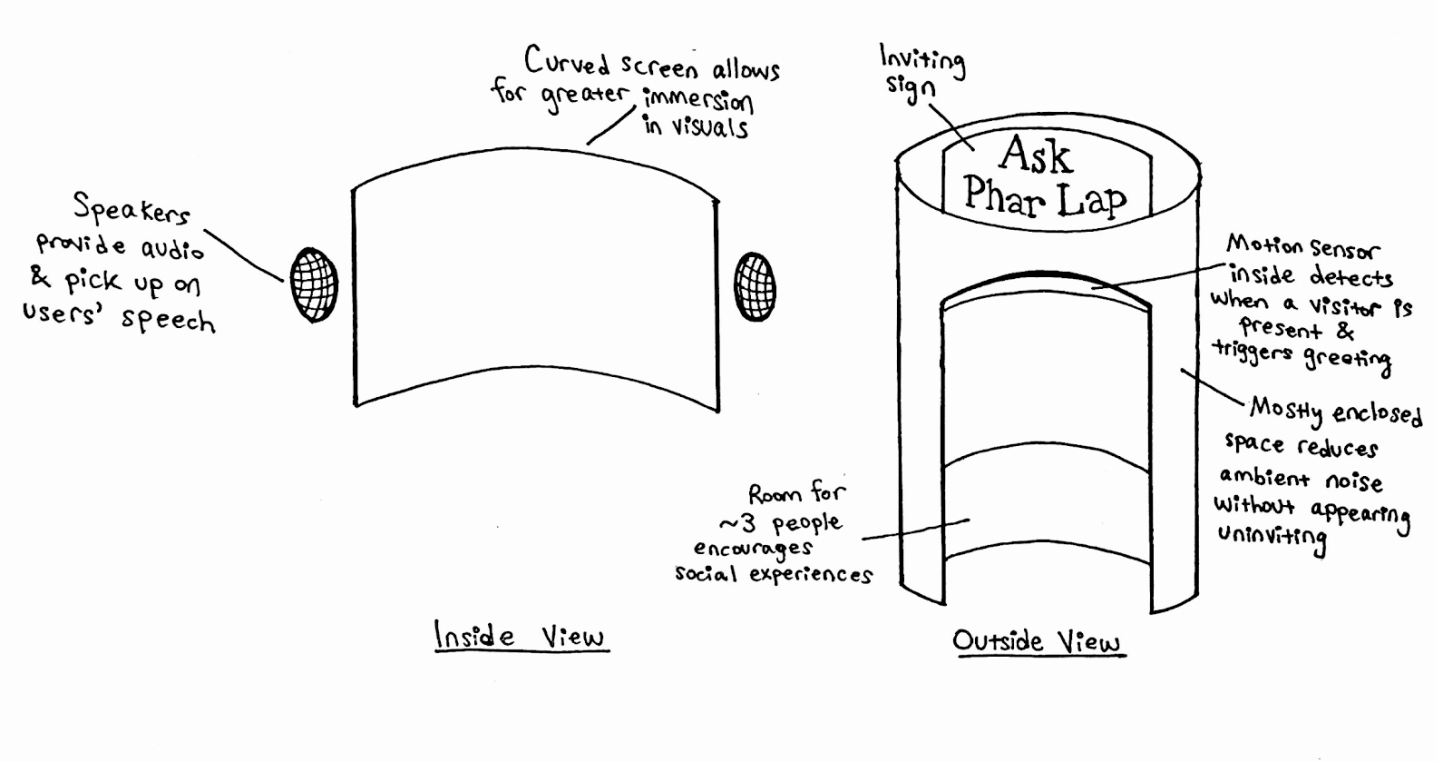

Figure 18. Concept sketch for physical space for Phar Lap agent.

Figure 17. Physical modifications to technology stand in Phar Lap exhibit.

In addition, installing other forms of digital technology to accompany the device would also improve the user experience. The Google Home could be expanded to connect with other devices in the space. A user could request a specific video or audio clip to be played on a nearby screen, or specific parts of the exhibit could be illuminated on a screen to show the user where to find more information on the topics that they asked about. Combined, this provides for an experience that engages several of a visitor's senses. It is clear that in itself, this application of voice-activated technology requires additional extensions in order to be appealing beyond its novelty factor.

> *"The Google Home could be expanded to connect with other devices in the space...this provides for an experience that engages several of a visitor's senses."*

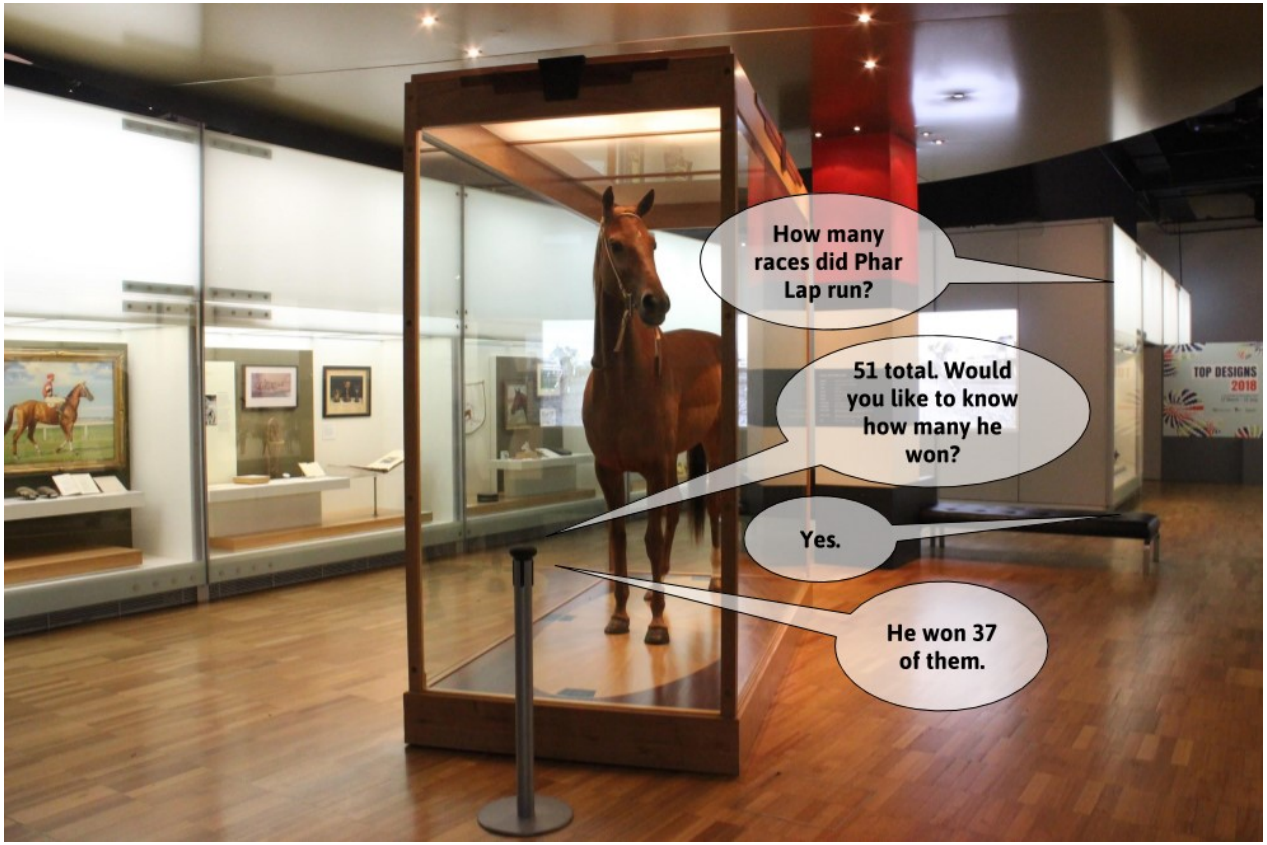

Figure 19. Example of follow-up queries.

Future applications for voice-activated technology

After considering the feedback we received and referencing our background research, we developed additional concepts that might use voice-activated technology. In what follows, we discuss these concepts and make recommendations for Museums Victoria to expand on our research.

Extending questions and answers: Conceptualising a voice-activated trivia game

Drawing inspiration from the popularity of trivia, we used Google Assistant resources to create a prototype trivia game and collected some feedback about its potential. The goal is to appeal more to visitors who want more fun and social experiences, who may find a question and answer app such as the Phar Lap exhibit prototype less appealing than a game on their personal device. A game like this could be played with a family driving back from the museum or a group of friends socialising after work. Our prototype would ask users multiple-choice trivia questions regarding different subjects in the museum collection. The user then scores points when he or she gets the answers correct. Music, applause, and positive reinforcement accompanies correct answers. Figure 21 outlines the flow of information between the player and the agent (see Supplemental Materials K for back-end guide). We initially intended this application to provide a post-museum visit experience, appealing to a wide variety of visitor segments.

Feedback from our focus groups supported the idea that a voice-activated trivia game could be fun. Three of the four groups enjoyed the trivia game because the quiz concept was engaging and the agent's personality (e.g. words of encouragement, funny remarks) made it fun. Each group cited the personality as a feature they particularly enjoyed because it gave the game an extra dimension that was lacking in the question and answer agent for Phar Lap. Participants also noted that they enjoyed being challenged and working together to answer the questions. We noted the potential of the game to provide a more complex social experience, in that it could be expanded to include a multiplayer option so players can compete against each other.

We also found that the trivia game could have potential within a museum exhibit. Three of the four groups said that they would actually be more likely to use it while at the museum, but kids might have a different perception. For an on-site application, a physical space could be built around the device, one similar to the proposed Phar Lap enclosure, and this setup could include other sensory elements such as screens or tactile objects. Alternatively, users can use it on their mobile devices as they move around the museum searching for answers. In this way, it could also be turned into a scavenger hunt in which players explore the museum to find the answers and then

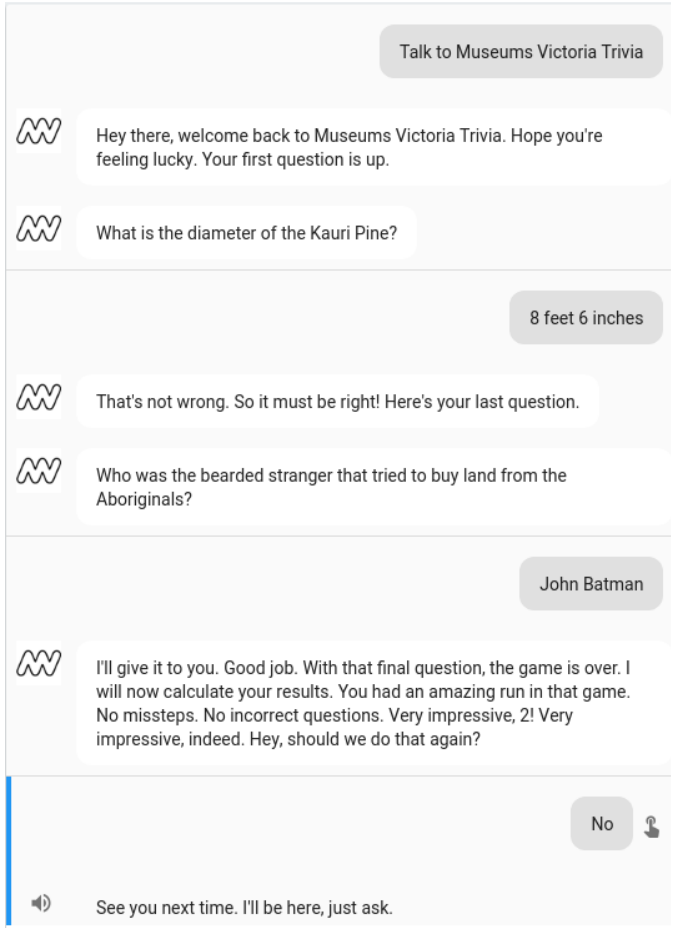

Figure 20. Input and output from the trivia game.

report to their device. This could encourage visitors to explore exhibits in a novel way.

Focus groups did mention some limitations of the trivia game. One group mentioned that users may not be in the museum mindset when they are not in a museum, which would impact the use of the application off-site, even if they have already visited it. Secondly, a selection of trivia topics and levels of difficulty would help appeal the game to more people, as players would then be able to choose the topics that they learned about in the museum or simply are more interested in, and they could decide how much of a challenge they want. Focus groups mentioned that the ability to select the appropriate topic and difficulty would reduce frustration. Lastly, a rewards system, such as the opportunity to receive a physical prize or coupon if the visitor answers all questions correctly, could incentivise more visitors to play the game.

An interactive voice-activated adventure

After creating concepts for applications of voice-activated technology that are educational and fun, we focused on creating a concept that would focus more on entertainment. Drawing inspiration from classic choose-your-own-adventure books and video games like Oregon Trail, we conceptualised a voice-controlled game that allows for the player to make choices that lead to a variety of outcomes.

We wanted to create an immersive experience on a voice-activated medium. Since one of the advantages of voice-activated technology is that it gives users control over what information they receive through a unique method (i.e. their voice), we wanted to take that advantage and implement it in a simple yet entertaining way. We used the idea of voice recognition as the control system for the player, so the player could play the game and advance the plot through their voice. In our game, the user role-plays a gold miner in 1852 who has just arrived in Victoria, hoping to strike it rich. The miner is challenged with making decisions about what to bring on the journey (a weapon, a cloak, or extra supplies) and where to go (well-travelled path or through the bush). Along the journey, the miner is faced with conflicts (such as bandits or

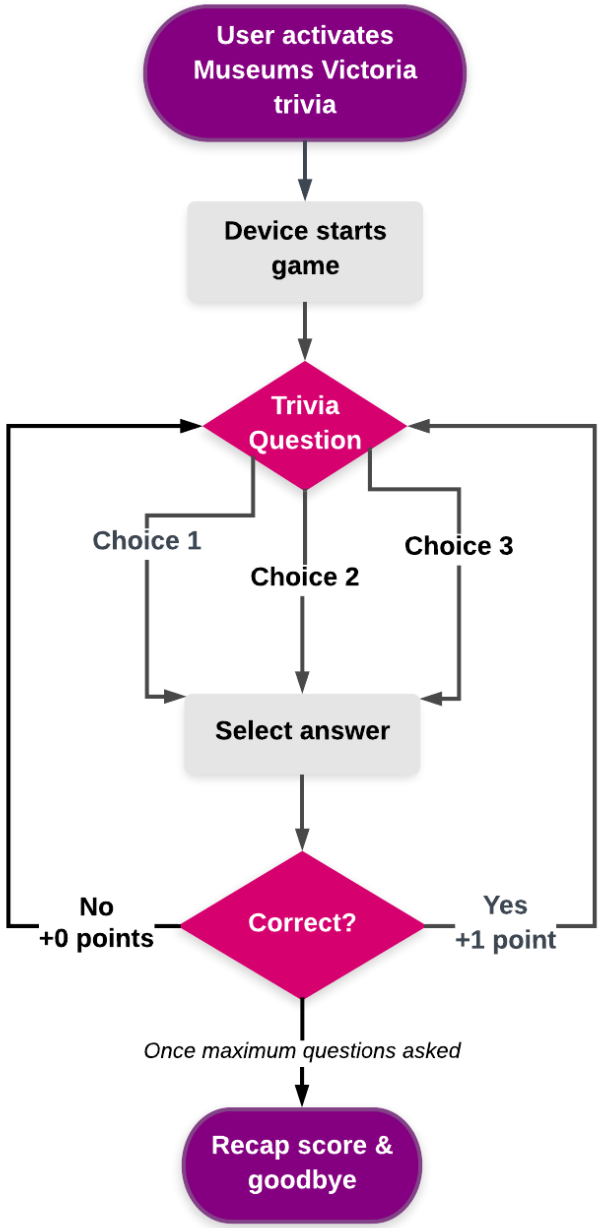

Figure 21. How the voice-activated museum trivia game works.

fire) and has to make choices in the hopes of succeeding. Our concept was of a specific plot, but since the medium is versatile, there is the opportunity to create other narratives for it as well.

We considered how the concept would work in both on- and off-site settings. We wrote the story and possible plot twists and outcomes, and we created visual pseudocode that would form the backbone of the concept (see Supplemental Materials L). For an off-site application, this could be purely an audio experience through a voice-activated device. If the device has a screen, the game could include visuals of the choices being made. Again, focus groups noted that the on-site applications for both this and the other apps would benefit from additional features such as visual elements.

For an onsite adventure, we recommend combining the voice-activated system with animated visuals that display the various scenes and events that happen to the character and provide a more sensory experience. Like with the Phar Lap application, the device would function best in an area with low ambient noise, so we designed a physical enclosure for the game (Figure 22). With this, visitors would be able to engage in an immersive and interactive experience on the museum floor as well as on their own devices.

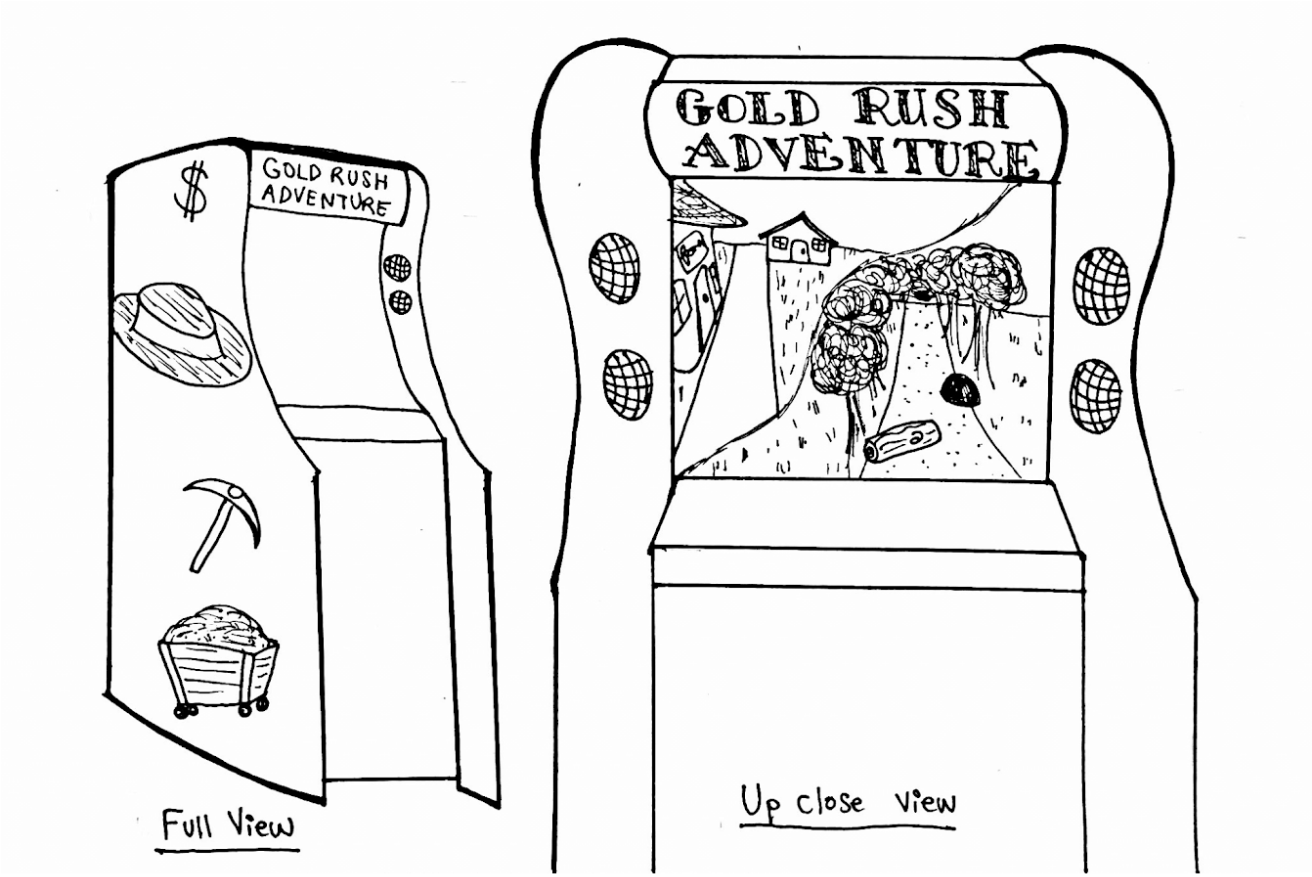

Figure 22. Concept for adventure game physical space.

We believe that this game would engage many of the audience segments and tap into the learning, social, and fun concepts we have been targeting. A game like this one is versatile because it can be adapted to a range of topics showcased in the museum, including marine life, dinosaurs, and bush life. There are many creative opportunities because the storylines can follow any kind of progression. The game would likely attract children and students, but could also be very popular at events such as Nocturnal. We recommend developing this concept and piloting it either on the floor with visitors or perhaps with staff and members at home.

Packaging voice-activated technology and other features

From this point, we wanted to package the concepts for voice-activated applications to create an experience with various functionalities that could be used both on- and off-site. We developed concepts for a mobile web app that would include voice-activated technology (Figure 23). These concepts would be located in the Explore tab, where users would be able to use their voice to play games relating to the museum, to ask questions about exhibits, and to get directions. For a more personalised experience, one feature of the app, available in the Customise tab, would ask about visitor motivations and interests to provide recommendations for their visit. In addition, the app would include an option to buy exhibit hall tickets and to access an interactive map. This application would be a comprehensive site for visitor planning and engagement, on or off-site.

Focus groups unanimously agreed that the mobile app would be beneficial for museum visitors. They liked every feature in the concept, and many of them were curious why the museum does not already

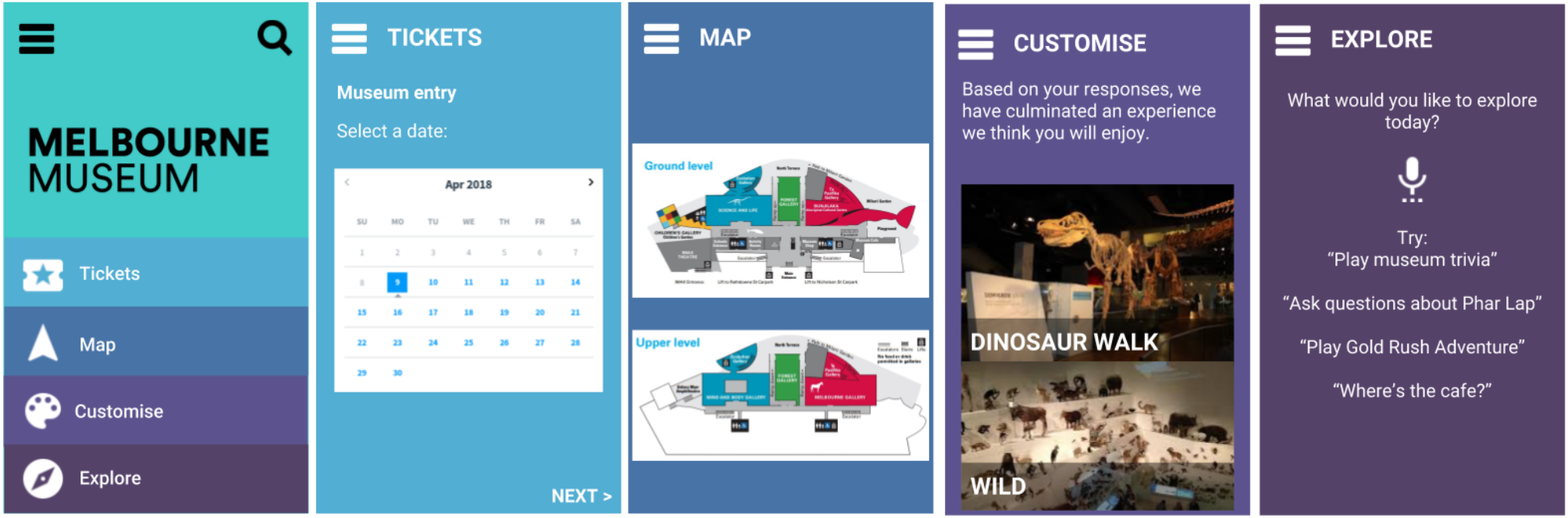

Figure 23. Concept design for smartphone application.

have a similar implementation. We found that three out of four focus groups agreed that off-site use could benefit ticket purchasing for purchasing tickets, but they also expressed concerns over whether users would find it appealing to use other features off-site, when the museum may not be on their minds.

The focus group participants suggested the app could be useful as a platform for future additions. Navigation elements were discussed in each group and they agreed that directions to lifts, toilets, exits, and parking would be useful in addition to directions to specific exhibits. Additionally, there was a suggestion of including a collection browser to view and read about all of the objects in the museum's collection. Overall, the feedback we received from our focus groups indicated that this concept was worth pursuing.

While initially the concept for the app was for a conventional mobile application that is typically downloaded, after discussing with our focus groups we reimagined the concept as a web app. Web apps would not require users to download an additional app to their devices as they can be loaded through their mobile web browsers. This would improve accessibility and lower the barriers for use.
From this we would recommend further development and testing into the implementation of museum mobile app to increase the institutions mobile presence.

Ok Google, where can we go from here?

Throughout our work at Melbourne Museum, we have found that voice-activated technology has many potential uses. The technology can, at its most basic level, be used to answer questions, such as in the Phar Lap prototype, but it can also be used much more creatively. Using voice-activated technology for game style experiences looks very promising for museums because it would appeal to even more visitor segments. Games are fun and social but can also potentially enhance learning, providing visitors with a fully entertaining and educational experience. Further, games can be developed for off-site use as well.

Our research and results have revealed some limitations to the technology, including sound recognition in noisy spaces and response time. We recommend testing and refining the prototypes to mitigate these issues as much possible, but platform improvements over time will likely minimise these problems.

Another considerable limitation was that we did not find a way to lock the device into a specific agent. The device would always be in its default, open

state before receiving any interaction, so we had to activate the specific app we wanted to use each time. The device would also revert to this open state if the app was exited out of for any reason. As is, this means that visitors would be able to access the Google Assistant and the internet in its entirety, rather than just the programmed app experience, whenever they desire to. Any potential prototypes would need to have a feature to prevent exiting in order for any of the agents to be used on the floor without staff monitoring.

Many of the participants in our focus groups brought up the robotic nature of the technology, and, unfortunately, this is the state of the art and certainly is a limitation to creating an immersive and engaging experience for visitors. While artificial voice synthesis is improving, the current consumer level of the technology offers only this kind of experience for now. In the future, it may be possible to have more natural voices with a variety of personalities.

Finally, because the technology only offers audio, combining it with other technologies that stimulate other senses would enrich the experience. Although the technology has limitations, we have demonstrated its potential, and we ultimately recommend continuing to explore its possibilities for on- and off-site applications and in combination with other types of digital technology.

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Supplemental materials for this project can be found at:

wp.wpi.edu/Melbourne

Our project was conducted on the traditional lands of the Wurundjeri people, and our project team wishes to acknowledge them as Traditional Owners. We would also like to pay our respects to their Elders, past and present, and the Elders from other communities who may be there today.

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- **Jonny Brownbill**
- **Carmel O'Keeffe**
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