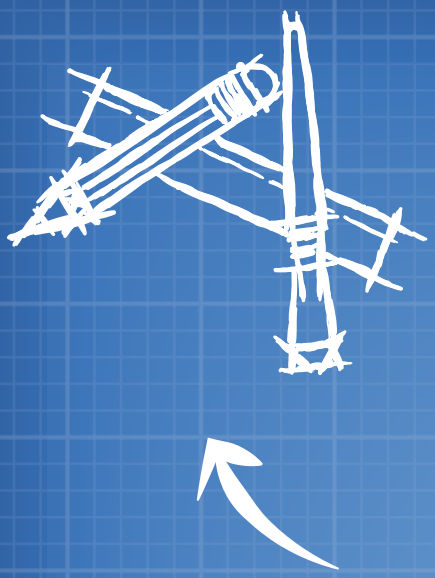


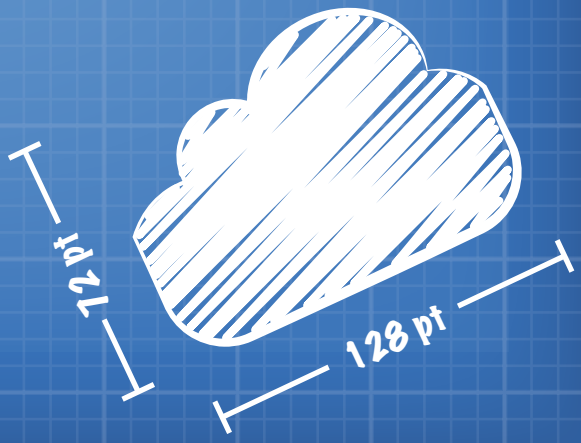
DESIGN MOBILE APPS FOR MEANINGFUL SHARED EXPERIENCE IN EXHIBITIONS

153

BIN HUANG

MFA THESIS

MAY 7TH, 2012



MASTER OF FINE ARTS, MUSEUM EXHIBITION PLANNING + DESIGN
THE UNIVERSITY OF THE ARTS, PHILADELPHIA, PENNSYLVANIA

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April 26th, 2012

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2 Methodology

3 Application

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Special thanks to the ones who have loved me and supported me all along.

Thank you for dedicating your time to help with my personal growth.

Museums, as public places, have been striving to provide environments conducive to shared experiences among visitors - either among a social group, or among people who have no social engagement with each other before. Museums try to break the social barriers visitors have between each other in the physical space, to facilitate social interactions among the visitors who desire or are open to social engagement. Social interactions in museums have also been suggested as facilitating meaning making, thus learning in exhibitions.

introduction

Meanwhile, the recent booming of social networking has made the Internet a more social venue than ever before. There are less social barriers on the Internet than face-to-face communication. Additionally, social interactions on the Internet are much easier and more efficient, as it is not constrained by time or locations. It is more so with the assistance of mobile devices, as they help people stay connected to their social networks all the time.

This thesis intends to invite people to bring ubiquitous learning and social interaction that they are familiar with in daily lives, into museum exhibitions, with their personal devices. It aims to break the isolation from others while using personal devices, and encourage visitors to actively engage in interacting with the exhibition and with each other through mobile apps in museums.

John Falk's learning model of meaning making is adopted to analyze where social interactions happen in museum learning, and what mobile devices can mainly assist with meaningful social interactions that would lead to learning. The thesis proposes an adjusted model that focuses on learning through shared experiences, both during and after the visit to the exhibition. Mobile apps can contribute to three levels of users' social engagement, which leads to meaning making and learning in exhibitions – spectating, participating, and providing new context.

The thesis then applies the model of mobile and social learning to design concepts of new apps for the exhibition at American Museum of Natural History, Beyond Planet Earth: The Future of Space Exploration. After analyzing the exhibition and its original iOS app designed for the exhibition, Beyond Planet Earth Augmented Reality app, the thesis proposes two concepts of potential new apps: Stories, an app that allows visitors to follow and create various narratives in and outside the exhibition, which is a more general solution that can be adapted for other exhibitions; Space Command, an app that creates a space race among several players, and encourages players to engage with the exhibition and with each other, which is specifically designed for the exhibition.

The thesis concludes with a summary of how apps can facilitate different levels of meaningful social engagement in museum exhibitions through different forms. It also gives suggestion on how to design apps as instrument that would motivate visitors to actively engage with the exhibition and with each other.

background

MARKET ANALYSIS

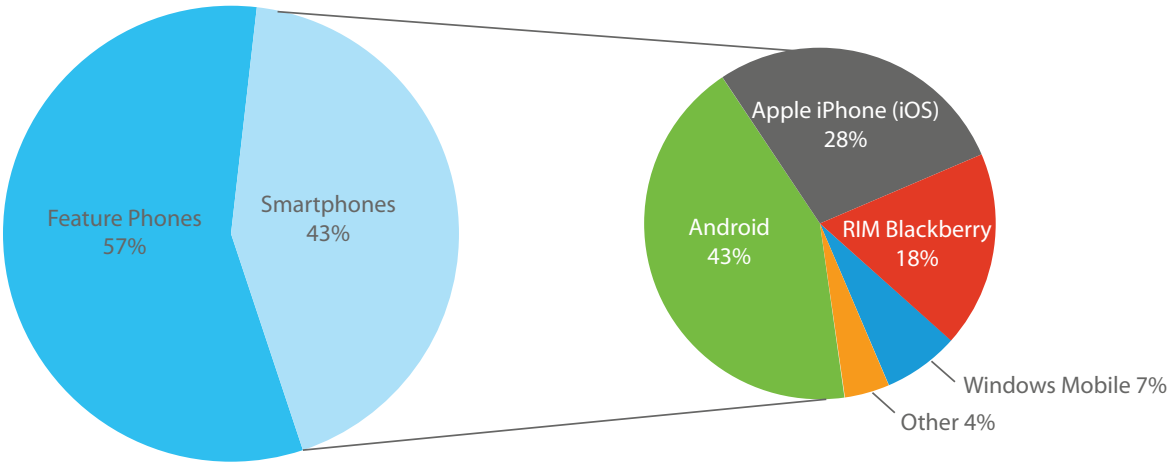
Connected devices, including smartphones (see Nomenclature 1 for definition), tablet computers (see Nomenclature 2 for definition), and Wi-Fi-enabled portable media players (see Nomenclature 3 for definition), are permeating people's daily life. The latest survey conducted by Nielsen found that 43% of all US mobile phone subscribers own a smartphone, a rapid rise from 29.7% in October 2010.[1] In the mean time, tablet computers, or tablets are on the

Smartphone Penetration and OS Share

Source: Nielsen Wire

Smartphone Penetration and OS Share

Q3 2011, U.S.



rise providing a brand new mobile experience to people. These devices tremendously reshape the way we stay connected to the Internet and acquire information.

Most mobile devices are equipped with multiple sensing hardware, such as multi-touch screen, digital compasses, cameras, gyroscope, accelerometer, proximity sensor, light sensor, etc., not to mention the ability to connect to the Internet almost anywhere. These devices seem to be ideal for museum interactives, and open doors to many more possibilities for interactives, which could not have been achieved by traditional PC and touch screen computers. As Nancy Proctor best summarized it, "Mobile's disruptive power comes from its unique ability to offer the individual intimate, immediate and ubiquitous access combined with an unprecedented power to connect people with communities and conversations in global, social networks: mobile is both private and public, personal and political."[2]

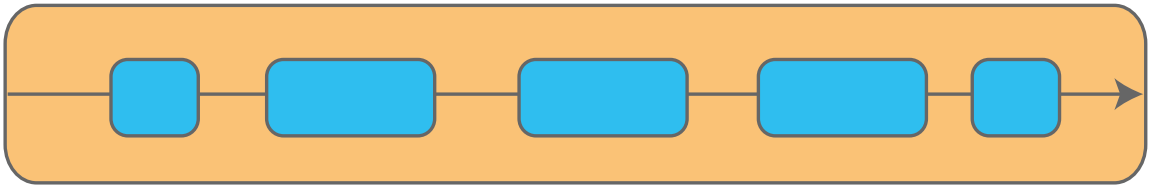
Applications, or apps (see Nomenclature 4 for definition), are the units on these connected devices. They execute programs or carry sets of information. According to Gartner's forecast, worldwide mobile application store downloads are forecast to reach 17.7 billion downloads in 2011, making a revenue that surpasses $15.1 billion[3].Apps are driving the

Internet Usage Prior to and With the Smartphone (Connected Devices)

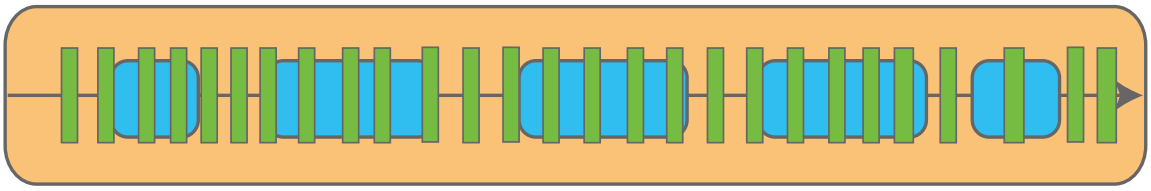
Source: Ericsson ConsumerLab MBB Service Quality Study 2011

Internet Usage Prior to and With the Smartphone (Connected Devices)

Internet usage throughout the day prior to the smartphone (connected devices)



Internet usage throughout the day with the smartphone (connected devices)



changes connected devices bring to communication and entertainment in our daily lives.

One of the most significant changes apps engender is our habit of accessing the Internet and acquiring information. Before the connected device, people tended to use the Internet in "chunks" – they would tend to confine their Internet activities to when they had an opportunity to sit in front of a computer. In contrast, connected

devices allow people to go online on impulse. The ability of these connected devices to access the Internet almost anywhere and anytime allow people to have better control of their lives. Apps people use show their interests and the subcultures they subscribe to, such as fitness apps, video games, music, photography, etc. People also manage their social lives with apps through messaging and social networking apps. Moreover, apps enable people to access another level of infrastructure - the society itself, including public transport system, shops and restaurants, and cultural facilities, etc. It gives people better control over their everyday activities and tasks.

Most apps are intuitive to use: they hide most complexity from users. They require little or no navigation through file structures, no inputting addresses, and no searching or clicking links. The task is straightforward and focused. The user expects to see useful content immediately. In other words, apps give users direct access to the content or online service of their choices. Meanwhile, many apps are delivering curated content directly to users, without them having to search through the Internet. This is the mode that museums have been using for years. These changes result in people's new learning habits: they choose what to learn, they learn along with conducting activities, they learn through interactions, they learn anytime, they learn on the go, and they learn through sharing[4].

While people's learning habits are changing, they would bring the spontaneous and interactive learning styles into museum exhibitions, and expect the exhibition environment to be conducive to the customizable learning experience. According to Nielson's survey, more than half of the people aged 18 to 44 own a smartphone, which constitutes the majority of museum visitors. Chances are the percentage of smartphone ownership among museum goers is even higher. This means that majority of visitors to museums are bringing in their connected devices during their visit. Museums have to cater to the changes of people's learning habits, which has been a great challenge that museums are facing. Apps have the most potential to engage visitors in most innovative ways. Since the smartphone penetration in other age groups is increasing as well, it is likely that apps will extend to engage visitors in other age groups.

MOBILE DEVICES IN EXHIBITIONS

Museums have generally been cautious about the usage of mobile devices in exhibitions. The main concerns include: using mobile devices are distracting visitors' attention from exhibitions, as well as isolating them from interacting with each other. However, as more and more museums are open to using mobile devices and photographing in exhibitions, mobile devices are becoming instruments for interacting with the exhibition and each other in museums. For example, taking photographs with mobile devices in exhibitions is not only a way in which visitors interact and connect with objects in exhibitions, but it directly involves social interactions if visitors are taking photographs of their companions or helping others take photographs.

Therefore, there are solutions for mobile devices to become an instrument that encourages visitors to engage with the exhibition and with each other. It requires careful strategic planning so that interacting with mobile devices stays as the means, rather than becoming the goal and distracting users.

APPS OR WEBSITES?

There are several ways of accessing information on mobile devices. One is through native apps; another is through a traditional web browser. The question then rises: should museums adopt native apps or mobile-optimized websites? The following is a brief comparison between native apps and mobile-optimized websites:

	Native Apps	Mobile-Optimized Websites
Basic Touch	Tap, Double Tap, Pan, Flick, etc.	Tap, Double Tap, Pan, Flick, etc.
Multi-Touch	Pinch, Stretch, Rotate, etc.	No
Use Sensors	Accelerometer, A-GPS, Proximity Sensor, Camera, Compass, Gyroscope, Light Sensor, etc.	A-GPS, Compass
Focus	Usually very focused on few tasks. The user expects to see useful content immediately.	Allows the user to conduct more tasks. It is less immediate and requires more navigation.
Customizations	Native customizations on the device, such as through system setting.	Usually needs the user to sign in to the website to change personal preferences.
User Interface Design	Navigation-based, OpenGL ES, Split View-based, Tab Bar, Utility, View-based	Navigation-based, Split View-based, Tab Bar (Design with Frameworks and Tables)
Information Stored	Can be stored locally on the device, or accessed online.	Can only be accessed online.
Display	More flexible in presenting sophisticated animated and other multimedia content by utilizing device graphic chips	Limited in presenting sophisticated animations due to website interface and internet connection limitations
Commitment	App is downloaded and stored on the device. It asks for user's commitment.	The biggest commitment is to bookmark the website/page.
Universality	Usually not universal across different platforms. Needs to be developed for individual platforms.	Can be accessed on almost any kind of connected devices, with less compromise in terms of format and design.
Cost	Development costs quite much as now.	It is relatively much cheaper than developing apps.
Software Update	Software updates usually need to go through app store, and the user has to download the update.	No software update is involved. Website redesign can be accessed online, no need to download any update.
Content Update	Unless the app stores content online, all content that is stored locally on the device needs to be updated through software update.	No need for user to download anything. Content update is accessible online instantly.
Notifications	Can be integrated into the device operating system.	No notifications.
Responsiveness	When the content of the app is downloaded and stored locally, it does not rely on the Internet. The app responds quickly.	It relies on the responsiveness of the Internet.
Generate Revenues	App purchases, in-app purchases, advertisements, etc.	Mainly advertisements.

APPS FOR MUSEUMS

Compared with traditional websites, including mobile-optimized sites, native apps can take full advantage of mobile devices, such as sensors, gesture controls, and device hardware. However, the more prevalent model of apps is now storing information on the Internet. It gives the app more flexibility in updating content, while preserving the advantages of apps to take full advantage of device hardware. Even though at this moment, the cost of developing and maintaining apps is keeping museums at bay in developing sophisticated apps for the institution or specific exhibitions, apps have the potential to create interactive and engaging experiences in museum exhibitions, if they are strategically planned and developed.

The 2011 Mobile Technology Survey, commissioned by American Association of Museums, found that "museums are enthusiastic about the potential of mobile technology".[5] Most museums agree that mobile technology is important to visitor strategy, and that it is here to stay. Among the new mobile technology platforms that museums are planning to introduce in their institutions, apps (smartphone and tablet apps) are forecasted to constitute about one third of the growth.

However, despite the fast growth of mobile apps, most of them only serve as complements to the experience museums provide: way finding, audio-tour, museum events, general information, etc.

The motivation is questionable to spend tens of thousands of dollars migrating printed and audio material to mobile devices. Some museums go a little further by allowing users to search through the collection database, which can be convenient for many visitors, yet not suffice to justify developing an app.

NOMENCLATURE

smartphone

A high-end mobile phone built on a mobile computing platform, with more advanced computing ability and connectivity than a contemporary feature phone.[6] One of the most significant differences is that advanced application programming interface (APIs) on smartphones for running third-party applications (native applications) can allow these applications to have better integration with the phone's operating system and hardware than is typical with feature phones.

tablet (computers)

A complete mobile computer, larger than a mobile phone or personal digital assistant, integrated into a flat touch screen and primarily operated by touching the screen. It often uses an onscreen virtual keyboard, a passive stylus pen, or a digital pen, rather than a physical keyboard.[7]

wi-fi-enabled portable media player

The media player that runs mobile computing operating systems, and can only access the Internet through Wi-Fi network. Its major difference from the smartphone is that it is not connected to any cell phone network. Examples are Apple's iPod Touch, and other Android-based media players.

apps (applications)

The term apps has been used as shorthand for "application" in the IT community for decades, but became newly popular for mobile applications, especially since the advent of Apple's App Store in 2008.[8] It is often thought of as a small program or set of information.[9] In this thesis, app is used to describe a small program or set of information not specifically linked to a specific kind of device.

context-awareness

In computer science, context awareness refers to the idea that computers can both sense, and react based on their environment. Devices may have information about the circumstances under which they are able to operate, and based on rules or an intelligent stimulus, react accordingly.[10] [11] Human factors related context is structured into three categories: information on the user (knowledge of habits, emotional state, bio-physiological conditions), the user's social environment (co-location of others, social interaction, group dynamics), and the user's tasks (spontaneous activity, engaged tasks, general goals). Likewise, context related to physical environment is structured into three categories: location (absolute position, relative position, co-location), infrastructure (surrounding resources for computation, communication, task performance), and physical conditions (noise, light, pressure).[12]

storytelling

A commonly used technique in museum exhibitions. Traditionally, curators/developers work with designers to form and present a cohesive story, along with smaller individual stories throughout the exhibition. Traditional storytelling supports have been signs, text labels, graphics, exhibit catalogues, guided tours, audio tours, videos, etc.[13] Crucial elements of stories and storytelling include plot, characters, and narrative point of view.[14] A classic structure constitutes a continuous sequence of beginning, middle, and end.[15] Contemporary storytelling is also widely used to address educational objectives.[16] The prevalence of connected devices has provided museums with opportunities for new methods of storytelling in exhibitions. It enhances the storytelling experience through dynamic presentations, customizability, and interactivity. In this paper, storytelling, or narrative, is defined as, but not limited to the act of presenting stories in the exhibition by exhibit developers and designers, as well as visitors' act of meaning-making through forming narratives.

methodology

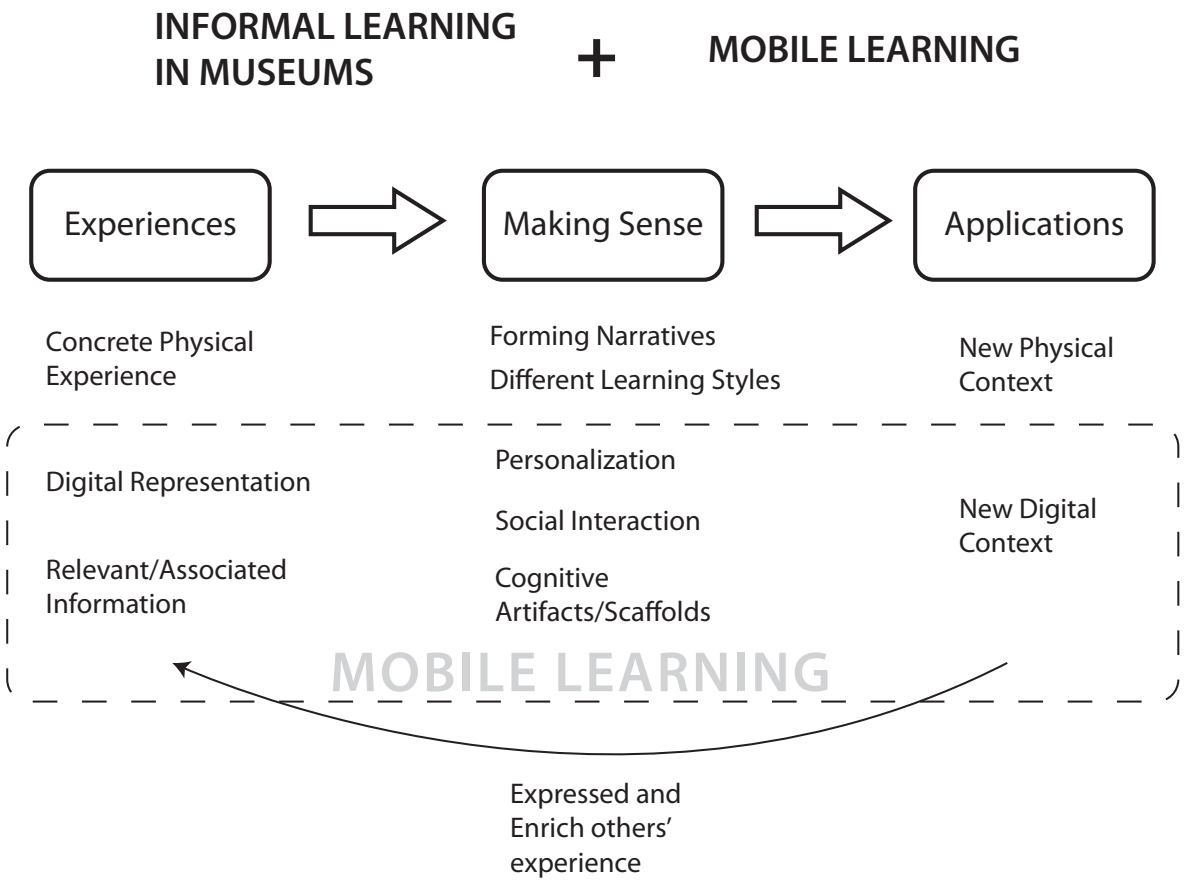
LEARNING MODEL

Over centuries, various educational theories have been proposed and advanced about informal learning. John Dewey stressed that education begins with experience. He considered museums, along with libraries, of central importance to public education. Informal learning can be distinguished from formal learning by the intentions and structure of the learning experience. In his book Learning from Museums, John Falk provides a definition of free-choice learning that illustrates the characteristics of informal learning: free-choice learning tends to be nonlinear, is personally motivated, and involves considerable choice on the part of the learner as to what to learn, as well as where and when to participate in learning.[17]

Informal learning is motivated

Diagram

Informal learning in museums enhanced by mobile learning.



by humans' innate need for meaning-making, which leads to acquisition of knowledge. Informal learning takes places in various venues, situations, and forms. Two of the major venues nowadays are museums and the Internet. Museums are one of the major physical venues that facilitate informal learning, whereas the Internet is the major virtual venue, where significant amount of informal learning happens.

Museums have been central physical locations for informal learning. The process of meaning making plays out in museums in many ways: visitors need to orient themselves in space, explore that which is novel, to prepare themselves mentally for what is to come, and to make overall sense of the museum environment.

Psychologist Jerome Bruner states that human beings make sense of the world and themselves through narrative, because we are natural storytellers.[18] The process of making sense, or making meaning, manifests in museums as visitors react and respond to the objects and settings in the physical space, through absorbing information and forming narratives on their own.

In addition, the physical context of the museum extends beyond the museum walls. In the context outside the museum after the visit, people recognize and associate elements from the museum context with new situations. This is when learning truly takes place and expresses itself.

The Internet has risen to the central virtual venue for informal learning in the past two decades. Most people get information on the Internet in a nonlinear fashion, compared with linearly organized curriculum designed for formal learning in schools. It is either self-motivated or incidental learning. People are in control of what, where and when to learn. They actively seek and filter information on the Internet, which through the process of meaning making, becomes personal knowledge.

With the fast development and permeation of connected devices, mobile learning becomes more and more prominent in the realm of informal learning in daily lives. Experiential and discovery learning , which has been the contemporary informal learning model in museums, can be enhanced by digital representation in mobile learning.[19] Mobile devices can provide digital representation of contextually relevant or associated information to explain actions and supplement curated information in museum exhibitions[20 21], and serve as cognitive artifacts or scaffolds for learning in exhibitions. Together with interactives in the exhibition, mobile devices allow visitors to experience phenomena and explore concepts and relationships through physical and digital artifacts[22]. Additionally, after the visit to the exhibition, through mobile devices, people can still create appropriate context within which the patterns and associations stored in the head express itself.

While the museum exhibitions mainly provide concrete physical experience, along with some digital artifacts, mobile devices enhance the experience with more digital representation and communication.

experience

As mentioned before, education begins with experience. Museum exhibitions utilize objects and multimedia to create multi-sensory experiences for visitors in physical space. Connected devices can provide more digital experience in addition to visitors' experience in the physical space, which is usually constrained by the limit of space and physicality. Additionally, they can link the visitor's experience in the physical space with relevant or associated information in digital representation, which gives the visitor the option to expand or enhance the experience.

making sense

Meaning making is the major motivation behind learning. Human beings make meanings of their experience through the process of forming narratives.[23] This process can be highly personalized with mobile devices, according to

different learning styles. Some prefer forming their narratives through reading a large amount of textual stories or explanations, while some prefer looking at images (verbalizer versus imager in Riding and Cheema's model of cognitive personality[24]); some prefer independent learning, while some prefer collaborative learning.[25] Apps can cater to different learning styles, such as allowing the user to choose the form of additional media content (words versus images), asking the user whether or not to participate in collaborative gaming, etc. Therefore, apps can personalize visitor experiences in the museums.

More importantly, museums, as public education environment, aim to facilitate learning through shard experiences. Such shared experiences can be achieved by social interactions inside and outside museums, including but not limited to: participating and spectating, co-participating, co-visiting, etc. The advantage of connected devices is that almost anytime and anywhere, they allow the user to connect to the Internet, where there is unlimited database of information, as well as to connect with each other, making co-participation possible. Connected devices can become crucially instrumental for creating meaningful shared experiences in museum exhibitions.

applicaiton

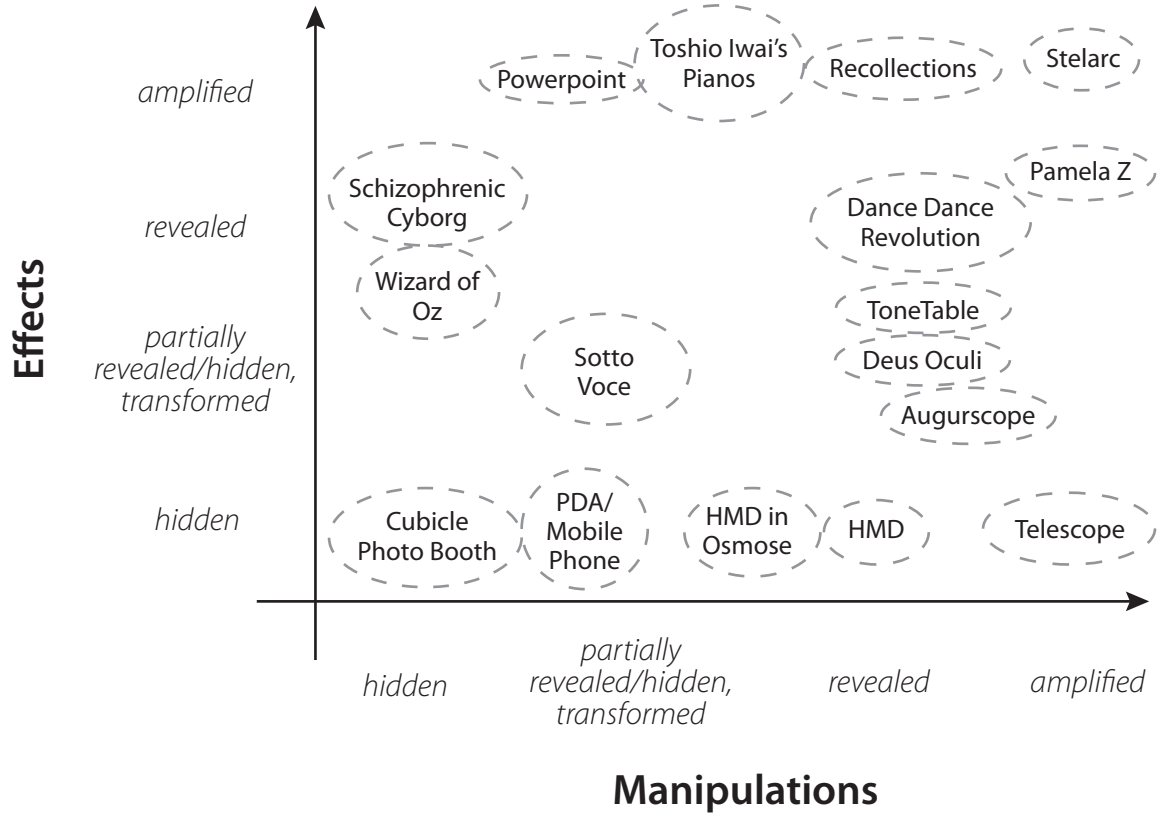
Informal learning is not complete until the acquired knowledge is applied and expressed in new contexts. Usually these contexts happen beyond museum walls, and it is unpredictable when one will associate the new context with what one has learned in the museum. An example given by John Falk is that a woman learned the mechanism of lift bridges in Cleveland Children's Museum, and she never used it until one day she saw a bridge lifting up and coming down on the Cuyahoga River while she was waiting to cross through the bridge. The new context in the real world reminds and reinforces what she has learned in the museum, which is further reinforced by her describing the lift bridge in action to her husband on the phone with bridge and engineer terminology.

Because of the prominence of mobile learning, chances of coming across new contexts, either in physical or digital form, that remind and reinforce what we learn in museum's physical space have increased dramatically. Mobile devices enable users to record the new contexts and applying knowledge in the new contexts.

Additionally, the ubiquitous connectivity of mobile devices allows users to share the new context with their friends or with the museum. It not only helps users to reinforce what they have learned by recounting and recreating, but also enriches others' shared experiences.

Examples of Four Categories of Spectating

Source: Reeves, Stuart, et al. "Designing the Spectator Experience.

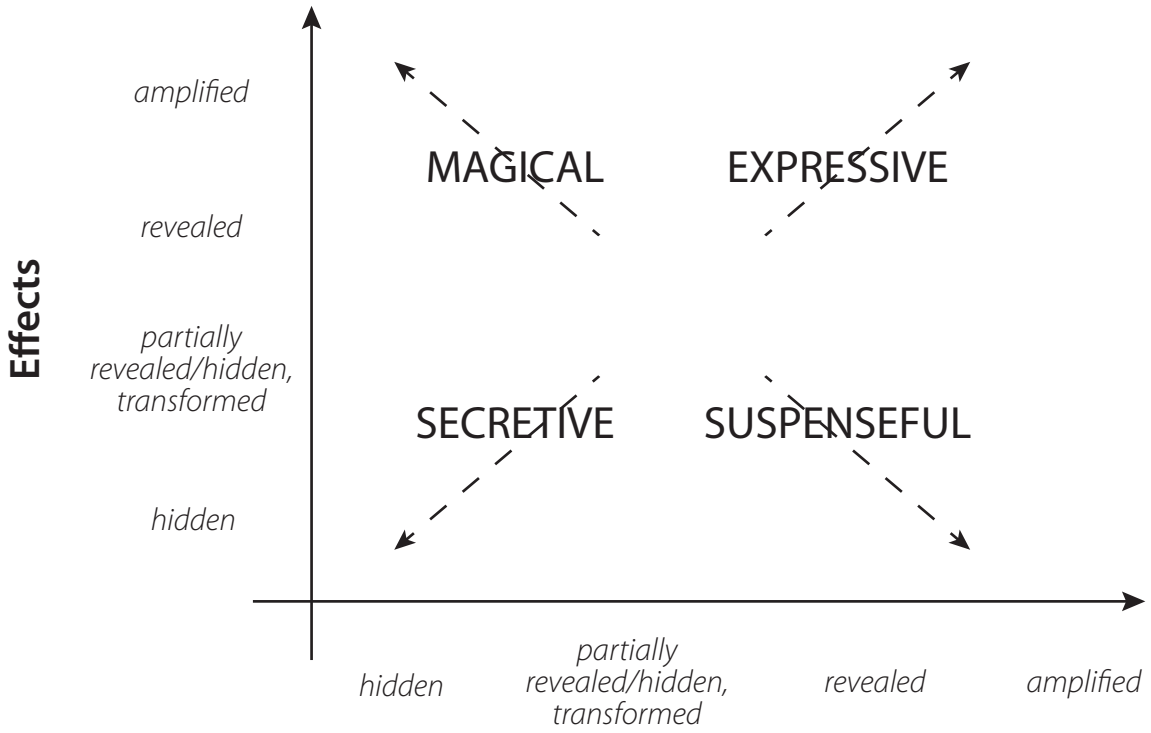


SOCIAL INTERACTION THROUGH CONNECTED DEVICES

By enhancing informal learning in museums with the theory of mobile learning, connected devices will become the critical instrument of what is in essence a shared experience for the user in the exhibition. These connected devices become the vehicle that drives visitors' social interaction in the exhibition in one way or another. The engagement in social interaction facilitated by connected devices can be categorized into three levels: spectating, co-participating (including parallel individual participation and collaborative participation), and sharing new contexts.

Four Design Strategies Taxonomy

Source: Reeves, Stuart, et al. "Designing the Spectator Experience.



first level: spectating

The first level of social engagement in museum exhibitions is watching others participating, especially interacting with the exhibit.
At museums, people immerse themselves in the exploration of mysteries, scrutinizing and interacting with objects that are profoundly different from things they encounter in everyday life.[26] Museums are public places where people have the sense of wonder and the curiosity to constantly look around. Spectating could lead to the next level of social engagement, which is co-participating, or it could simply stay on this level, yet remaining enjoyable and meaningful, depending on visitors' learning styles.

This level of social engagement could happen among a social group, such as family and friends; it could also happen with people one has no former social engagement with before. It is becoming increasingly recognized that visitors take notice of or even study the actions of others in order to make sense of certain aspects of an exhibit and its functioning.[27] Study done by Heath, Luff, vom Lehn, Hindmarsh and Cleverly discusses how people discover the functionality of an interactive art installation through their interaction with others nearby.[28]

This "spectator experience" is also discussed in Stuart Reeves, et al.'s paper.[29] Reeves describes people who are watching as "spectators". He describes the participant's (who is interacting with the exhibit) use of an interface in terms of manipulations which lead to effects. He shows that the spectator's view of events can be described in terms of the extent to which they experience participant's manipulations versus their effects. The major four categories

Affordances of Connected Devices

Possible manipulations of digital content on connected devices through apps.

determined by the extents are hidden, partially reveal/hidden (transformed), revealed, and amplified.

Four broad design strategies can be located on this taxonomy: secretive, where both manipulations and effects tend to be hidden; expressive, where they are revealed; magical where effects are revealed but the manipulations that caused them are mainly hidden; and suspenseful, where manipulations are apparent, but effects only get revealed when the spectator gets to take their turn as a participant.

Connected devices, especially mobile phones, can be tricky in terms of design. Due to the relatively small screens, the participant's manipulations and the effects can both be hidden from spectators (secretive), which in most of the contexts in daily uses, is what the user desires. However, when the interaction is strategically designed, even mobile phones can become the stage of a performance, especially for the spectator close by. In most cases, the effects of the interactions should tend to be revealed or amplified, in order to attract people's attention. Suspenseful design can be potentially a smart solution to encourage participation, since spectators will not see the effects until they participate themselves via their own devices.

As of now, connected devices afford the participant with the following manipulations of the digital content to achieve the following effects through native applications.

Content (Media)	Manipulations (Gestures)	Sensors	Effects (Presentation)
Text, images, animations, audio, videos, games	Basic touch (tap, double tap, pan, flick, etc.), multi-touch (pinch, stretch, rotate, etc.), tilt, rotate, shake, blow	Accelerometer, A-GPS, proximity sensor, camera, microphone, compass, gyroscope, ambient light sensor, moisture sensors, etc.	Digital , augmented reality, game control (mobile devices as consoles), projection (wired or wireless)

These sensors, with better accuracy in the future, along with potentially more to come, such as thermometer, distance sensor, are far surpassing the current technology utilized in museum exhibitions in terms of providing immediate feedback and corresponding reactions. They extend our perceptions of the environment beyond human's five senses, and expand the possibilities of human-computer-interaction (HCI).

Possibilities are that the user will be able to get unique content and interact with it, such as pinch and expand charts, zoom in photos to examine details, watch illustrative animation that explains a physics phenomenon, pause and playback a behind-the-scene interview. The interactive can serve as a cognitive artifact that guides visitors through the organization of the exhibition, and helps them remember what is in the exhibition, what they have seen, etc. Such interactives can be a timeline, a historic map that maps out the landscape or the distribution of the artifacts.

In addition, these connected devices can become game consoles that control interactive games in the exhibit. It should take advantages of the various sensors available for the devices, promote different kinetic movements that dramatize the participant's engagement and attract more attention from other visitors to initiate their social engagement.

The first level of engagement includes watching, as well as spectators conversing or discussing about what they see. Research has shown how by simply watching, visitors can make sense of the function of interactives, even learn the content.

Different design strategies can evoke different spectating. A magical performance, in which manipulations are hidden or partially hidden/revealed, and effects are revealed or amplified, tend to evoke spectator's curiosity that would lead to discussions, inquiry, and participation. An expressive performance, in which both manipulations and effects are revealed or amplified, could be quite entertaining and attractive for the spectator. It is also usually easier for the spectator to make sense of the interactive and its content, thus learning through watching. A suspenseful performance, in which manipulations are revealed or amplified, and effects are hidden or partially hidden/revealed, could be an interesting way that may result in interactions between the participants and spectators, such as conversations and discussions, and even may encourage the spectators to engage in an initial level of participation and collaboration through giving advice, guidance, or possible solutions to the participant. A secretive performance, in which both manipulations and effects are hidden or partially hidden/revealed, could evoke curiosity of the spectator to engage in inquiry with the participant, and even participate in the interactive to find out what it is.

The flexibility of connected devices allow designers to create different kinds of impact they would like to achieve in terms of social engagement of the spectator. The following is a simple guideline for different design strategies:

Mobile Design Strategies

Manipulations and effects of digital content through mobile devices.

	Content	Manipulations (Gestures)	Effects (Presentation)
Magical	Images, animations, audio, videos, games	Basic touch, multi-touch, tilt, rotate	Augmented Reality, game control, projection
Expressive	Games	Tile, rotate, shake, blow	Game control
Suspenseful	Images, animations, audio, videos, games	Tile, rotate, shake, blow	Digital, Augmented Reality, game control
Secretive	Text, images, animations, audio, videos, games	Basic touch, multi-touch, tilt, rotate	Digital, Augmented Reality, game control

second level: co-participating

The second level of social engagement mainly refers to co-participation. Co-participation includes parallel individual participation that eventually gets shared among the social group, and collaborative participation. This level of social engagement usually takes place among each social group, such as among family members, friends, etc. Social interactions between people who have no previous interactions with each other are relatively less likely to happen on this level, which, however, is possible to evolve from the first level of social engagement as discussed earlier.

Parallel Individual Participation

Parallel individual participation refers to participations that happen simultaneously in a social group. The interaction is mainly individual's interactivities with connected devices and the exhibit. Social interaction takes place when participating members of the social group discuss about their experiences during and after the process, and share their individual outcomes in the end. Compared with interactives installed in the exhibition, which most of the time do not allow all the members in a social group to participate at the same time due to resource constraint, interactives on mobile devices have the advantage of reaching to all the members in a social group and allowing them to participate without interference.

Firstly, it is individual participation. Therefore, it allows participants to personalize their experience according to their preferences and learning styles. Each individual completes the task own their own, and their interactions with the interactives do not affect other people's interactions. It is self-paced and personal. It usually results in effective learning experience, since it is goal-oriented and personalized. Participation can range from the scale of a single interactive, to the entire exhibition. However, the advantages of mobile devices truly

stand out when the participation is on a larger scale than a single interactive, since these devices are mobile and able to carry through as a continuous experience.

Secondly, it needs to facilitate social interaction during and after individual participation in order to create shared experiences. Therefore, it is essential that participants in the interactive share common interests or goals. It is recommended that even with customizations to cater to personal preferences, the goal of the interactive be made clear, yet open-ended to encourage diverse results and methods to achieve the goal. For example, the task of the interactive can be using smartphone to collect a series of snapshots of artifacts in the exhibition to tell stories. Users share the common goal to tell stories with a series of photographs, but the content of the story and the perspectives vary, since the interactive is open-ended.

To ensure sharing experiences among participating members of a social group, the designer can design an interactive station towards the end of the exhibition, where participants can compile their outcomes, and even presented on a larger screen for the whole group to see. It may also allow participants to download the compiled results to their personal devices for records. If resource is constrained, simple design such as communal seating areas can come a long way in helping participants share and discuss their experiences.

Another form of parallel individual participation is competition. This could be fun and effective learning process, as participants are focused and goal-oriented. The design of the interactive has to make sure the goal and rules are simple, easy to learn and follow in a short period of time, possibly to be drawn of similarities from familiar games. Competitions would require multiple users to participate, thus most likely to facilitate interactions among users. Competitions can be parallel individual participation, as well as collaborative participation (discussed next), depending on whether individual's decisions impact others' outcome or not.

Collaborative Participation

Collaborative participation can be achieved by interactive tasks or challenges that need to be completed by more than one participant. It involves human-to-human interaction facilitated by computer interactives throughout the whole process, as each participant needs to get constant feedbacks from other participants. A task or challenge to be done by multiple participants is similar to an online multi-person challenge. It could also be an interactive in which new challenges are constantly proposed by participating members for other members to take on, which is similar to such social games as Pictionary.

Quest-Oriented Collaboration
Collaborative participation should be flexible about the number of participants as long as it is no less than two. All participants should share a common goal, establish simple rules, and work together as a team. Usually the narrative is carefully designed for participants to follow in order to complete the quest. Mobile devices allow participants to keep connected all time, so that they can give and take immediate feedbacks, collaborating with team members, without the constraint of respective locations. This opens up brand new opportunities for collaboration: participants can collaborate with people locally in the exhibition, and they can also collaborate with people who are not physically present in the exhibition. Through instant communication, they can complete challenges in a museum with others virtually participating.

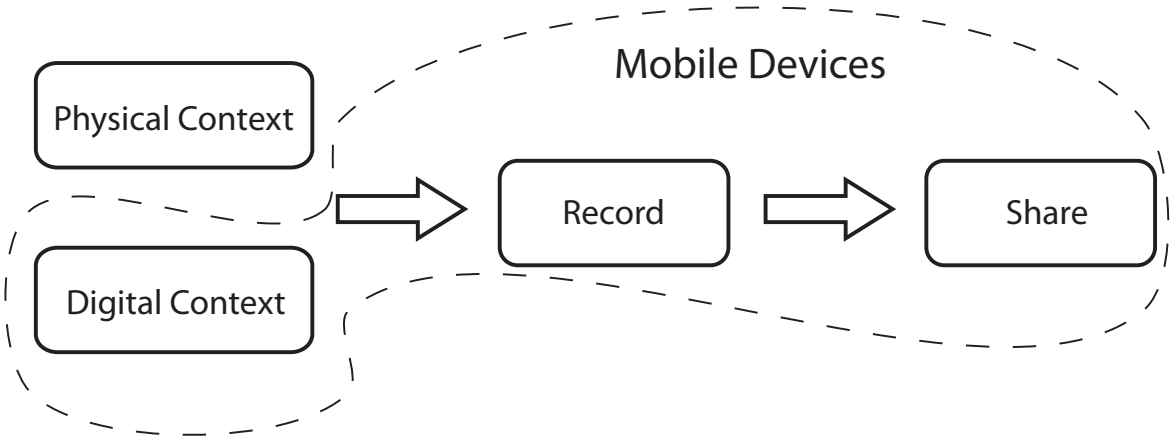
Besides instant communication, mobile devices can also serve as personal tools, such as a map, a flashlight, a guide that provides clues, hints, a console to control video games, etc. Each device provides specific context for the user, as the user works his/her way towards the shared goal collaboratively with other participants.

Non-Quest-Oriented Collaboration
These could be the interactives where participants come up with the content and narrative to interact with each other. However, all participants need to agree on the rules that facilitate and limit the scope of the game. For example, in Pictionary, participants can come up with the words for others to guess, and there is no designed narrative, or limited ways for players to reach the goal, such as how they should draw their pictures. However, all participants need to agree to only describe the words with their drawings, instead of words, and usually agree to a time limit as well.

Mobile devices can serve as the platform, or the board as usually recognized in board games, where most of the activities take place. The games that follow this model, such as Draw Something, Words with Friends, have been highly welcome for social interactions. Museums have been experimenting social gaming, such as social tagging. It is difficult to motivate visitors to participate, since this kind of co-participation has little reward.

Mobile Devices in the Process of Application

Providing digital context, recording context, and sharing context.



third level: sharing new context

The third level of social interaction happens mostly post visit and outside of the museum. Essentially participants in this level of social engagement are sharing the new contexts they come across outside of the exhibit, where they can apply what they have learned in the museum to real life scenarios. Participants take the true ownership of the knowledge by applying it and recount it to others. To use the example of the woman who shared the lift bridge story with her husband again, the ownership happened when she recounted the process of the lift bridge in action to her husband, through a conversation via her mobile phone. In the meanwhile, the woman's husband gained shared experience through the account of the lift bridge in action. Therefore, the benefits are reciprocal.

Nowadays, mobile devices afford much more in terms of how she can recount the story. For example, she can record and describe the scene of lift bridge in action, and send it to the children's museum. The footage will become new contexts for other visitors in the exhibition, even though the social interaction only happens in one direction. Potentially through the museum, it could enrich other people's experiences in the exhibition by providing them with new contexts.

The following is a diagram that illustrates how mobile devices come into play for the third level of social engagement. Museums should provide the channel and the platform for sharing. An app can be a convenient medium.

SOCIAL INTERACTION IN THE ENHANCED LEARNING MODEL

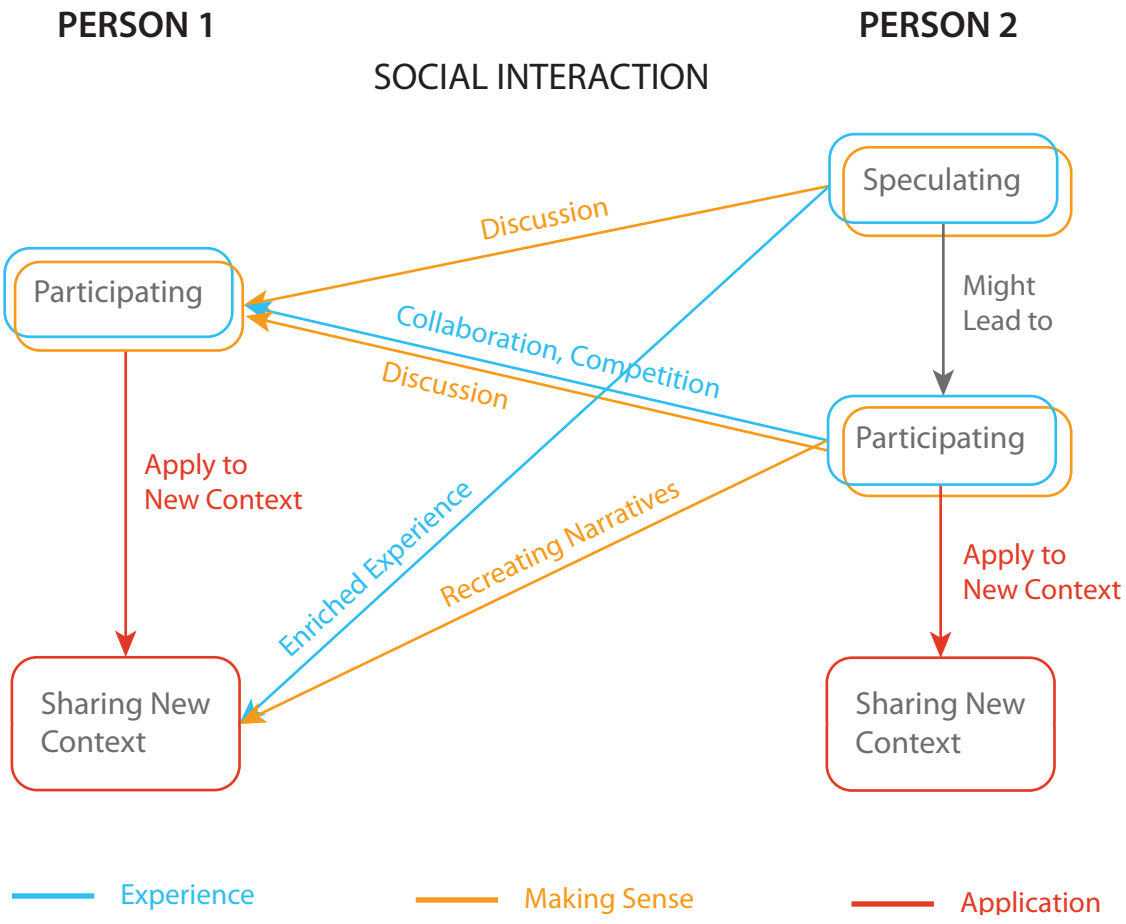
To explain the social interactions, let us suppose there are two parties present. Person 1 starts with participating in the exhibition (social engagement level 2), while person 2 starts with watching person 1 participating (social engagement level 1). Person 1 goes through the learning process of experience to making sense during the participation. While person 2 can go through the same process during watching person 1 participating, chances are person 2 will interact with person 1 by having conversations or discussions, through which he or she makes sense of the exhibit. Person 2's speculating could also lead to his or her participation, if inspired and interested. Person 2 can co-participate with person 1, either parallel participating that leads to discussions, or collaborative participating (collaborating or competing).

Person 1 moves to the next stage of applying what he/she has learned in the exhibition in the new context. By sharing the new context (social engagement level 3), person 1 gets the knowledge reinforced. The new context enriches person 2's experience, and allows person 2 to recreate narratives and make sense of the context. Person 2 can move from stage 2 of learning to stage 3 as applying knowledge to and sharing back the new context with the museum.

Diagram: Learning Model + Social Interaction

How three phases of learning are taking place in social interactions in museums.

ENHANCED LEARNING MODEL + SOCIAL INTERACTION



application

EMPIRICAL RESEARCH

Apps for museums are sprouting in the market, mostly for art museums at this moment. Some of the examples include Museum of Modern Art (MoMA) app, ArtClix for High Museum of Art, and San Francisco Museum of Modern Art (SFMoMA) apps. Most of the apps feature brief introductions to artworks. Some apps incorporate printed guides and audio materials (audio tours and soundtracks), as mentioned earlier in the thesis. Some of social interaction elements in these apps are highlighted and analyzed here:

Snapshots: MoMA app and ArtClix

both feature snapshot function, which is a simple way for the user to interact with artworks. MoMA app allows the user to take pictures of artworks and send it as museum postcards. ArtClix uses image recognition technology to identify the artwork the user takes a photo of, in order to call for relevant information from the database. Image recognition can be especially magical that would attract other visitors to participate. Taking photographs allows the user to engage with the artworks, and other visitors to speculate in different methods, be it getting a post card, or see the magic of image recognition. Therefore, it facilitates the first level of social engagement – speculating, while encouraging the user to engage with artworks at the same time.

Comments: ArtClix, along with some other apps that are not mentioned in this thesis, allows users to leave their comments and reactions to artworks in the app. This simple form of asynchronous social interaction, as one leaves the comment for others to read later through mobile devices, is in fact not quite effective. Major reasons include lack of motivations and meaningful experiences for both the contributors and spectators. The lack of guidance and mediation also leaves users clueless and uninspired. In addition, the wishes ArtClix has to engage users to comment on one another's comment is not realistic, because it is too much commitment to ask from users, especially in museums, where the attention should be mainly be on the artifacts. Although comments and reactions from visitors are valuable and worth recording, the process needs to be more natural and spontaneous. In other words, the comments and reactions from visitors should be recorded without them having to

type. They should be recorded as visitors interact with the app and others.

Games: One of SFMoMA's apps, SFMoMA Families, developed by Night Kitchen Interactive, creates social games that encourage visitors to experience art together with others. It is essentially ask the user to move, react, and match their experiences with others in fun ways. Users move in interesting and funny ways. They use gestures and sounds to act like artworks, and match moods, colors, sounds, memories, and so on with artworks. The game asks for physical movements, discussions, and participations among groups of visitors.

The amplification of manipulations can be very attractive for spectators. However, some movements, such as moving like penguins in the gallery, might be a bit too much to ask from visitors. Aside from the first level of social engagement, it facilitates the second level of social engagement as well. The game usually needs more than one participant to play. There is collaboration, as well as co-participation. There are variables in the game, thus allowing certain amount of repeated plays without repeating the same tasks. It also creates unique paths of experiences for different groups of visitors. The game aims to generate alternative fun ways for visitors to experience art. There is almost no information imparted through the game, which is a scenario art museums have the luxury to embrace. The user cannot access the records of other people's reactions to artworks. Therefore, the app does not create the third level of social engagement of sharing new context.

In summary, art museums are using the apps to facilitate social interactions, and guide visitors to react to artworks with emotions, thus appreciating art. When they set these goals, art museums can let go of the role of a didactic information carrier.

What about museums of natural history or history, which focus on storytelling through artifacts? Is it too much for visitors to engage with the story, the artifacts, and people around them?

American Museum of Natural History is a pioneer among natural history museums to explore using apps in exhibitions. So far, the institution has created several apps, such as Explorer, the general museum guide, Dinosaurs, mosaic presentation of different dinosaur pictures,

Cosmic Discoveries, a similar mosaic presentation of pictures of the universe, and Beyond Planet Earth, an app designed specifically for an exhibition (discussed later). Explorer and Beyond Planet Earth apps are designed to be used in the museum, while the other two are designed for use outside the museum, which are more similar to textbook style.

According to the customer reviews online, users do appreciate flipping through the Dinosaurs and Cosmic Discoveries app. Even though there is no data on when and where people use the apps, the reviews suggest that people use the apps mainly outside the museum. On the other hand, Explorer and Beyond Planet Earth are mainly used in the museum. However, Explorer only gives information of museum maps, user's location, and general introductions to exhibitions. Beyond Planet Earth app does not provide a compelling experience for visitors to dedicate their time in the exhibition to.

Therefore, it is quite clear that natural history museums are still facing big challenges in creating engaging and informative app, while being informative is not so much of worries for art museums.

Meanwhile, geo-location based apps that enhance outdoor experiences are witnessing fast growth. The major factors that result in the success of these apps are delivery of content based on locations and less density of information. In other words, visitors are not spreading their attentions thin among artifacts, apps, and their companions in an indoor space saturated with objects and information. It is good reference for designing apps for indoor exhibitions, such as delivering content tailored to locations, and personal interests, instead of bombarding users with too much information.

Overall, apps for natural history and history museums are suffering from not being able to facilitate social interactions, as they focus on delivering information to visitors, instead of steering visitors to looking at artifacts and engaging with people around them. In this section, new concepts of apps are proposed based on the enhanced learning model in order to created meaningful shared experiences in natural history museums.

Timeline Graphic at Introduction Section

Courtesy of American Museum of Natural History.

App Concept Design for Exhibition

Beyond Planet Earth – The Future of Space Exploration

EXHIBITION ANALYSIS

Beyond Planet Earth: The Future of Space Exploration is a current temporary exhibition designed by and held at American Museum of Natural History in New York City. Through immersive environment, engaging interactives, and multi-sensory experiences, the exhibition offers a vision of the future of space travel, as it explores human's next steps in exploring the solar system and beyond.[30] The exhibition features a retrospective of the last 50 years of human's endeavor of space exploration, and predictions of future expeditions to the moon, the asteroid, Mars, and beyond our solar system. The exhibition is divided into 7 parts: Introduction, Solar System Theater, Returning to the Moon, Exploring Asteroids, Voyaging to Mars, Reaching the Outer Solar System, Beyond Our Solar System.

Floorplan of the Exhibition

Courtesy of American Museum of Natural History.

introduction

The exhibition opens with a retrospective of historic manned and unmanned space missions. It displays a few historic artifacts, such as astronauts' gloves, the Vostok capsule, etc. The exhibit uses a few timelines that mark the significant events in the history of space exploration. However, each topic features a timeline, such as Soviet Space Pioneers, Walking on the Moon. It is difficult for visitors to put each event into perspective to see its place in history, and compare the event and draw connections with others.

In addition, most narratives are covered by graphic panels and audio excerpts from conversations via radio transmitters. The methods used for the narratives in this section are a bit monotonic. The presentations of the historic objects are relatively static, as the audios do not help put the artifacts in their contexts, nor do the graphic panels do justice to tell the dynamic stories of the artifacts. It is understandable that the exhibit designer made the design choices, the argument being this is the opening section of the exhibit, and that there are not sufficient film records available for the museum due to technological and political constraints. However, there could still be ways to make the overarching narrative of the section more coherent and dynamic, such as connecting the individual stories and putting them in the historic context of space race and current space competition.

solar system theater

This is a transitional section that bridges historic and current space expeditions with predictions of human's future space endeavors. A video presentation introduces visitors to future manned and unmanned space missions to the Mars, Jupiter's moon Europa, and

Wall Graphic of the Solar System

Courtesy of American Museum of Natural History.

Station on the Moon Diorama

Courtesy of American Museum of Natural History.

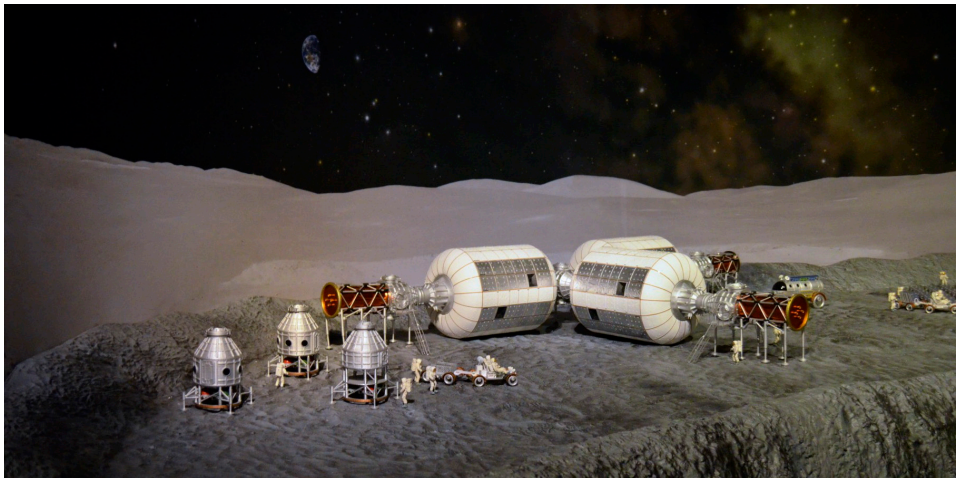
beyond. In this section, there is a large size wall graphic that maps out the major planets, satellites, and the star in the solar system, and marks the ones that human beings have explored.

This section features large-scale presentations, where it is easier for visitors to aggregate and have conversations. The solar system graphic, especially, provides ample opportunities for discussions, and also gives an overview of the major components of the exhibition – space explorations within the solar system. Therefore, the map of the solar system would be a terrific guide for the visitor to take with on their mobile devices, and refer to in the rest of the exhibition.

returning to the moon

This section presents the current scientific findings, and the potential activities human beings are planning to conduct on the moon in the near future, such as inhabitation, space elevator for transporting mined materials, etc. The exhibit incorporates many three-dimensional models, varied in scales, from miniature models of human habitat on the moon to a floor-to-ceiling model of a space elevator.

These various three-dimensional models set up wonderful stages for lively scenes, such as ones imagining what it is like to live on the moon, which visitors can bring themselves into through simulations. It would also be an opportunity to facilitate social interaction as visitors simulate together building a community on the moon. The lunar elevator and liquid mirror telescope can be the context for some interesting interactives as well.



Interactive: Deflecting the Asteroid

Courtesy of American Museum of Natural History.

Movies and Literature about Asteroids

Courtesy of American Museum of Natural History.

exploring asteroids

This section discusses the potential threats and opportunities of asteroids. They are constantly threatening to hit the earth and cause doomsday catastrophes, and at the same time, they contain valuable minerals that human beings can potentially use. The exhibition creates a fantastic immersive environment that is a recreation of a near-earth asteroid Itokawa, and the Japanese Hayabusa spacecraft that rendezvoused with it in 2005. This section also features the first electronic interactive in the exhibition. Visitors take on the challenge of destroying an asteroid before it reaches the earth using different methods, including hitting, burning, throwing, blasting, and towing. There are also displays of literature and stills from motion pictures about asteroids.

Although it might be relatively easy to implant the touch-screen interactives into personal mobile devices, it might be more interesting to design the installed interactive to be controlled by mobile devices. For example, throwing can be drawing trajectories on the smartphone, or the smartphone sensing and calculating the trajectory of the user's arm movement of a throwing gesture. Additionally, the displays of literature and stills from motion pictures give apps great opportunities to provide additional experiences for visitors who are interested to learn more about them.

Interactive: Mars Explorer

Courtesy of American Museum of Natural History.

voyaging to mars

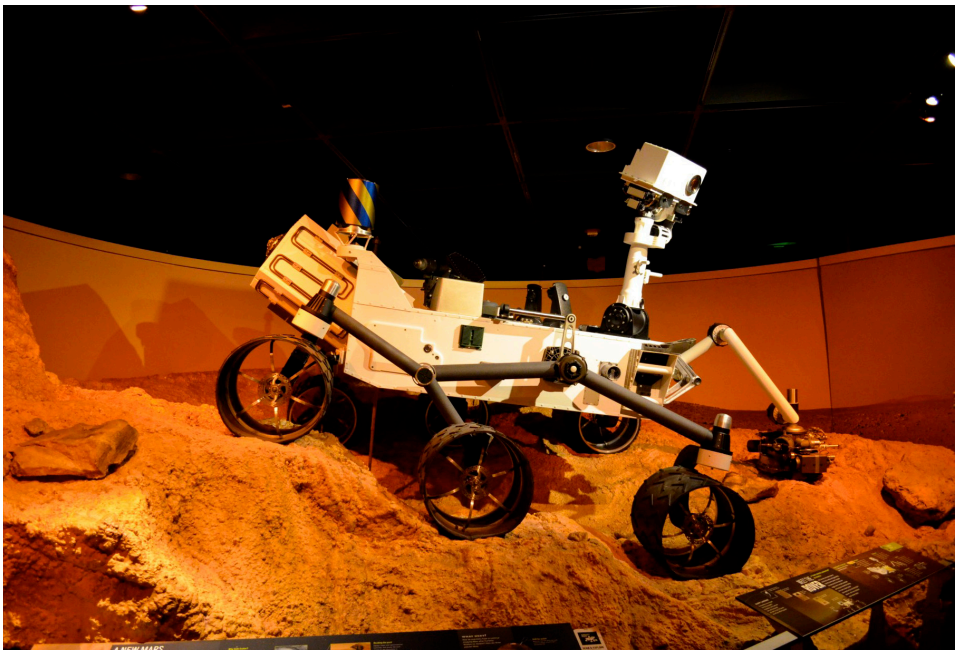
Mars has been the most tempting destination to human beings, since it is the most likely planet to harbor other life in the solar system. The section starts with visitors walking through an area that looks like a space command center, where there are miniature dioramas portraying lives on Mars Spacecraft, and three interactive stations for fly-over simulation, called Mars Explorer console. Mars Explorer allows visitors to zoom in on locations such as the Gale Crater, the landing spot for the Curiosity Rover, and Olympus Mons, the largest volcano and largest mountain in the solar system. Next is the Mars Personality Test, where visitors can test out whether their personal characteristics make them suitable for becoming an astronaut traveling to Mars. While the Mars Explorer interactive tends to be parallel individual participation, the Mars Personality Test tends to elicit conversations between the participant and the spectators.

This section also features a full-scale model of the 9-foot-long Mars Science Laboratory Rover, Curiosity, recently launched to look for whether conditions would have been favorable for supporting microbes on Mars[31]. It is placed on a large-scale diorama of the Martian surface. The full-scale model and the diorama of Martian surface are both visually spectacular, which attracts many visitors to take photographs. One mother asked her son to stand in front of the Mars Rover so that she can take a picture of him. She said: "Go stand over there (in front of the Mars Rover). I'm gonna take a picture of you, so that you can bring and show it to your friends in school." The photograph would provide the son a "ticket to talk"[32] with his friends. Besides the collaborative participation of the mother and the son, the potential conversations between the son and his friends fall into the first level of social engagement, as the son is the participant, and his friends are the spectators, only outside the museum. Their interactions, especially the son's account of his experience at the exhibition, might arouse his friends' interests to visit the exhibition. The same would happen with the space suit cutout, where visitors take pictures of their company "wearing" the suit.

Another interactive in this section is the Mars

Full Scale Model of Mars Rover Curiosity

Courtesy of American Museum of Natural History.

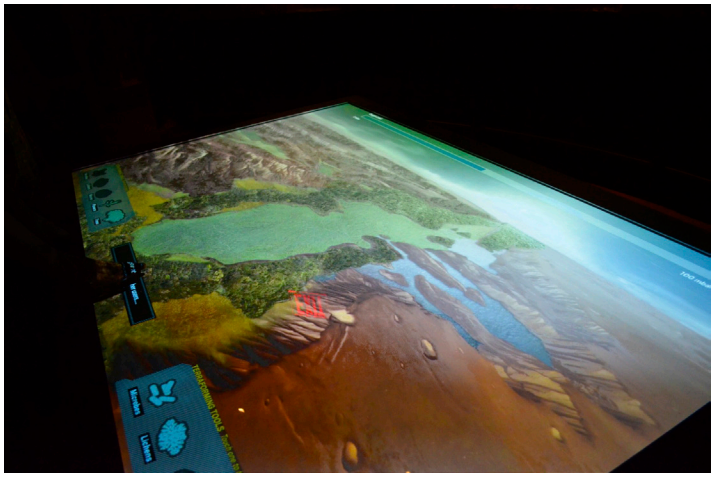


Interactive: Terraform the Mars

Courtesy of American Museum of Natural History.

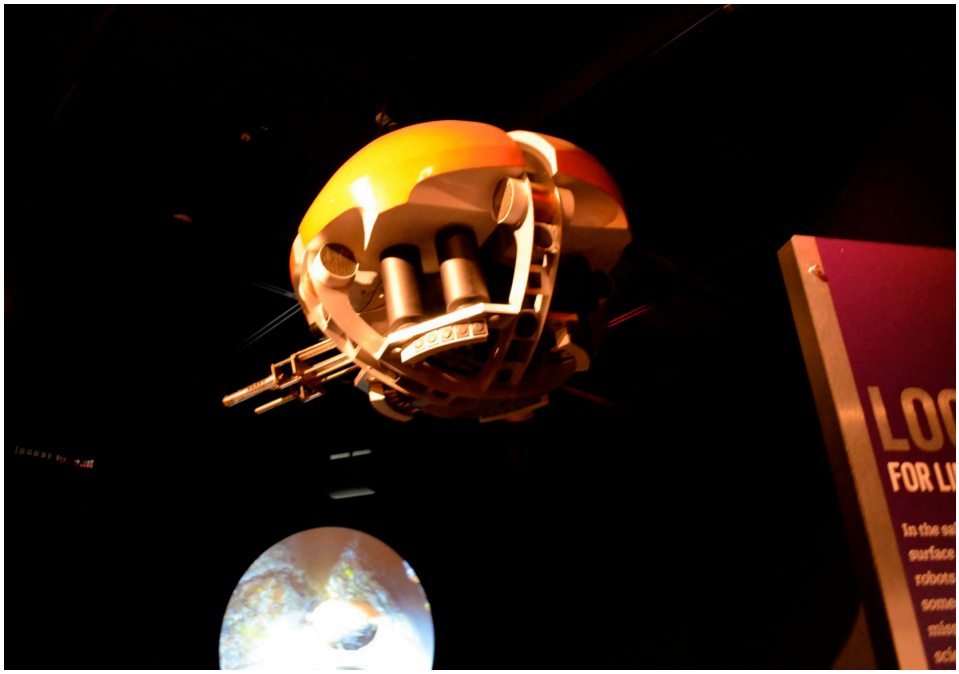
terraforming table on a multi-touch table. It allows three visitors to engage in an interactive "game" at the same time to transform Mars from a frozen, thin-aired environment into an Earth-like planet, a process known as "terraforming." This PlayStation 3 powered game requires all three participants to finish their individual tasks, which in fact are the same: to transform the designated area with living organisms, such as microbes, lichens, trees, etc. The quest is not complete until three players all finish their individual tasks. Even though the quest requires three participants, there is no true collaboration during the process. Essentially, it is more parallel individual participation, although the multi-person challenge does facilitate conversations, especially guidance as one shows another what to do.

This section provides plenty of social interaction opportunities, in different levels of engagement, from spectating to participating, through interactives of different sophistication levels, from simply taking photos, to multi-person video game challenge.
Are there still opportunities for mobile devices to complement or facilitate more social interactions?



Model of Robotic Submersible to Europa

Courtesy of American Museum of Natural History.



reaching the outer solar system

This section features a video that discusses the mission of a robotic submersible to Jupiter's moon Europa to search for life, along with a replica of the robot. As this is towards the end of the exhibition, and there is little information about Europa and the expedition, content and activities in this section are relatively less.

Wall Graphic of the Milky Way

Courtesy of American Museum of Natural History.

beyond our solar system

This section includes holograms of detected stars in the universe, and a long curve graphic panel of the Milky Way. Similar to the last section, there is little information presented. The final section is a more artistic presentation that elicits awe and admiration. What can apps add to the presentation of the beauty of the universe? How can apps help inspire and express our imaginations? How can apps make this contemplative experience social and interactive?

conclusion

The exhibition Beyond Planet Earth – The Future of Space Exploration at American History of Natural Science, focuses mainly on projecting human's future endeavor of space exploration. The exhibition engages visitors with multi-sensory experiences. It features plenty of three-dimensional models and dioramas, as well as historic artifacts, through which the narratives are built on and unfolded. Interactives range from simple cutout photo booth to sophisticated video games. The interactives, videos, and exhibits together tell good stories, and facilitate different levels of social interactions among visitors. However, space exploration is such a grand and interesting topic, that more information with more flexible presentations would help enhance visitor experiences, through facilitating more social interactions, as well as expanding the experience beyond the museum to the night sky outside, where more real-life contexts will surround the visitors.

Augmented Reality Label on a Panel

Courtesy of American Museum of Natural History.

ORIGINAL APP ANALYSIS

Developed by American Museum of Natural History, in collaboration with MadaTech, Israel, Beyond Planet Earth Augmented Reality App focuses on collecting augmented reality "cards". The app is built for Apple iOS platform, which works on most of Apple's connected devices. The user can use the camera on their iPhone, iPod Touch, or iPad, to activate the icon and unlock the animations, empowered by the technology of Augmented Reality.

Using Augmented Reality App

Source: http://www.flickr.com/photos/amnh/6732440091/sizes/o/in/photostream/

There are eleven icons scattered in the exhibition. The designer makes them as visible as possible. There are several labels on the graphic panel for each icon to increase the chances of visitors encountering them. Meanwhile, the museum makes sure visitors know about the app, and encourages them to use it: dedicated advertisement on the graphic panels to encourage visitors to use the app, as well as on the visitor's guide and website. There are also signs on the floor throughout the exhibition, encouraging visitors to download and use the app right in the exhibit (the museum provides free Wi-Fi in the building), from at the entrance of the exhibition, to anywhere there is an icon to be activated in the exhibition.

Despite the museum's big effort to promote the app, throughout the exhibit, there are not many visitors spotted using the app on their devices. The use of Augmented Reality technology is purely for the sake of Augmented Reality. The animation is too small, pixelated, and not interactive. Since the

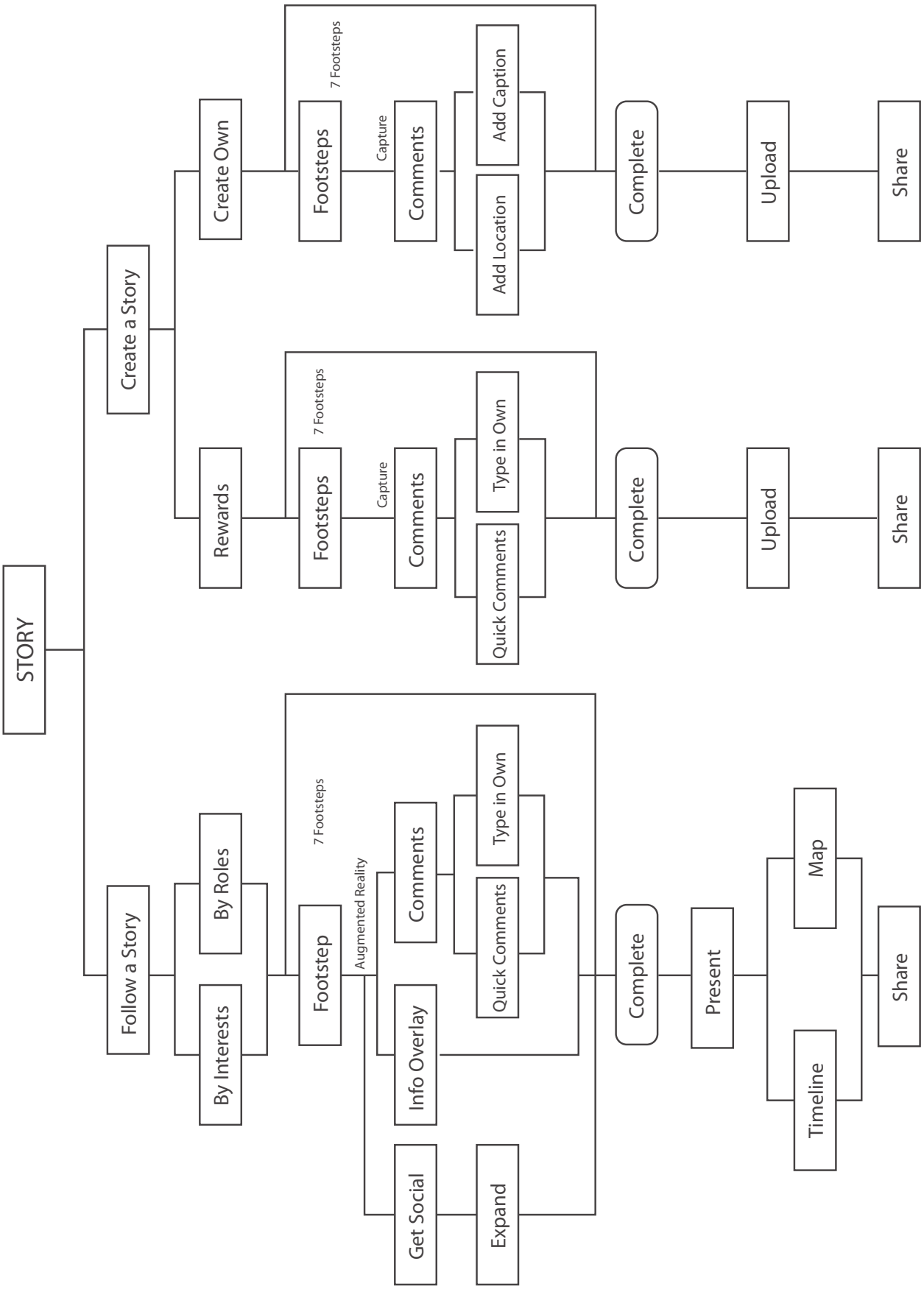
user is pointing at a black label rather than the object itself, Augmented Reality's advantage of superimposing information over the context gets lost. It could have literally been achieved by the QR code technology. Additionally, the animation and information incorporated in each icon provides nothing new to the user. The app provides primitive social networking sharing function, by simply taking a snapshot of the animation, and sharing through Facebook, Twitter, Email or saving to local disk. However, the content to be shared, both the picture and the text is out of context and not so interesting.

Nonetheless, the app does highlight the major content of the exhibition for the visitor. By simply looking at the eleven icons and reading their label texts on their mobile devices, visitors who have gone through the exhibition can get a review of the synopsis of the exhibition. It might be helpful for the visitor to make meaning of the exhibition through getting an overview of the thread of the narrative. This, in fact, should be further developed to enhance visitors' learning and social experience.

Overall, the official app of the exhibition lacks content development, despite the fact that the task is clear for the user. It is not appealing to most visitors, but it is taking the first step towards creating shared experiences for visitors. Additionally, the museum's effort to develop and promote mobile apps shows its faith in great potentials of apps in museum exhibition environment.

Flow Chart

App Concept Design: STORY



Learning + Social Engagement

The design strategy of the app Story, laid out by three phases of learning and three levels of social engagement.

CONCEPTS FOR NEW APPS

app 1: story

an app applicable for other exhibitions

Inspired by the theory of making sense of exhibitions through forming narratives, the first concept is an app that asks the user to collect pieces of a story, and connect them to make sense of the story. Each function and visitor behavior inspired by the app derives from the combination of three phases of learning and three levels of social engagement. In this case, speculating is in fact by following stories through mobile devices.

	Speculating	Co-Participating	Sharing New Context
Experience	Follow a Story: guided experience.	Get Social: watch others following other stories. Building collective experience.	Create a Story with a new context, and share back with the museum.
Making Sense	Actively connect pieces and make sense of the story.	Discuss and collaboratively make sense of each story. Combine and build a bigger story at the end.	Make sense of the created story in the new context, to reinforce knowledge.
Application	Allow the user to follow other stores with different contexts for the exhibition.	Combine created stories. In other words, create a story collaboratively.	The museum adopts created stories by users for other visitors to follow. Enrich their experiences.

Story is an app that captures seven pieces of a story the user collects in the exhibition. The seven footsteps collectively tell a story that is relevant to the exhibition.

The app starts with two categories: Follow a Story, and Create a Story. The two categories vary in terms of open-endedness and social interactions. In each mode, the user needs to fill up seven footsteps with a thread/storyline. The app is based on the model of enhanced informal learning in museums: it enhances the experience and provides tools for meaning making through forming narratives and social interactions; and it helps expand the experience beyond the exhibition, where users gain and share new contexts to reinforce learning.

STORY: Welcome Screen

Confirm the exhibition the user is in.

STORY: Options

Choose either to Follow a Story or Create a Story.

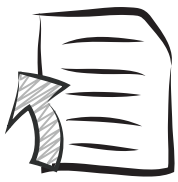
WELCOME TO STORY!

You are currently at

Beyond Planet Earth:
The Future of Space Exploration

OTHERS... CONFIRM

WOULD YOU LIKE TO...



FOLLOW A STORY

CREATE A STORY

TYPE IN YOUR NAME JACK

Follow a Story

Follow a Story is the first challenge of the app. It provides various paths and roles visitors can take on to experience the exhibition, and allows them to look at the exhibition from different perspectives and in different contexts. It is mediated, focused, and linear, rather than open-ended. Each series of footsteps has a specific theme and storyline. Instead of passively following a story, the user is using the existing clues and threads to recount and reinterpret the story, through actively collecting and capturing the seven pieces of the story throughout the exhibition.

At the beginning of the exhibition, the user can choose a story to follow. The user can choose to turn on the guide and resort to hints , or turn off the guide and complete the quest on his/her own. The user can collect snapshots, see details and other additional information, and stick on preset comments in an entry of a footstep.

The stories can be specific topics that the user is interested in. Some examples for this exhibition could be:

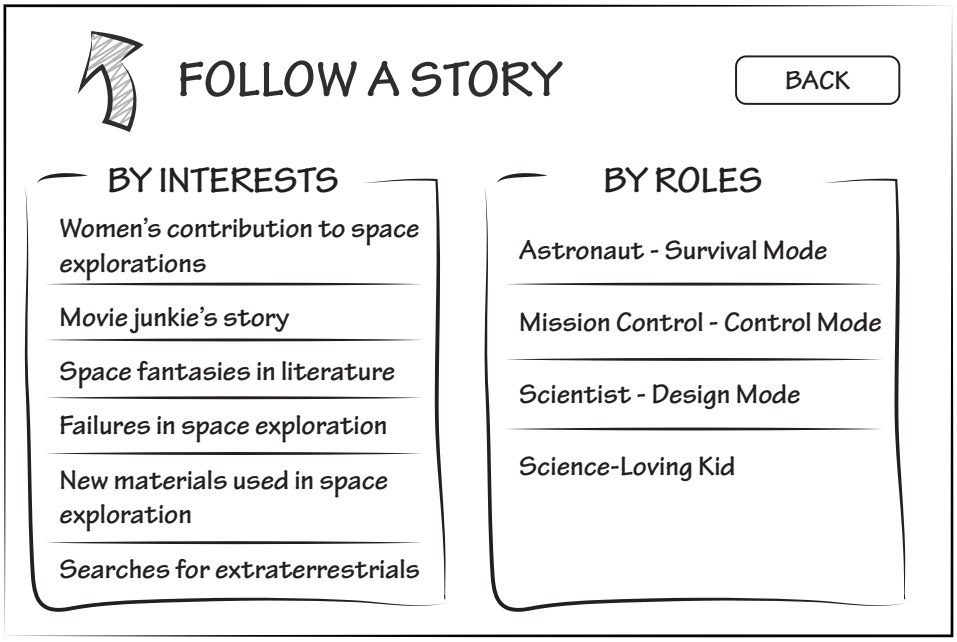
- Women's contribution to space explorations
- Movie junkie's story
- Space fantasies in literature
- Failures in space exploration
- New materials used in space exploration
- Searches for extraterrestrials

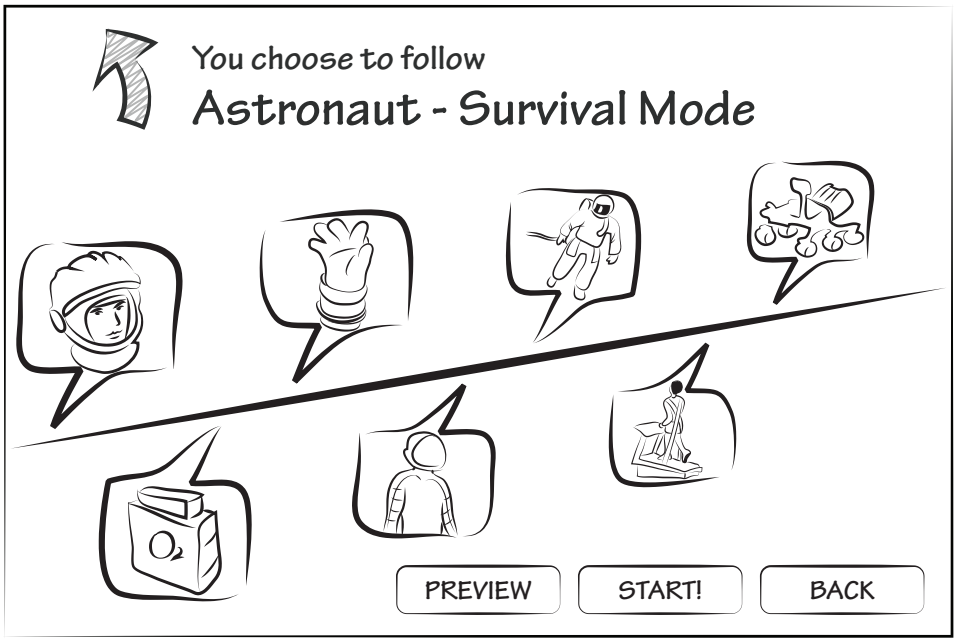
STORY: Follow a Story Options

Choose a story to follow, either by interests or by roles.

STORY: Preview the Chosen Story

A preview of the seven footsteps in the story before the user decides to start.





Stories can also derive from perspectives of specific roles. The concept of role-playing in museum exhibitions has been commonly practiced in narrative-based exhibitions. Mobile devices enable the exhibition to cater to visitors' personalization on a higher level. It not only allows the exhibition to deliver content to the user according to their role (interest), but also allows the user to actively shape the exhibition to extract information and create experiences to his/her preferences. Because some of the experiences are only available to a certain role the user takes on, they encourage spectating, and sharing experiences through exchanging conversations about roles among visitors in the exhibition. For this exhibition, some of the roles that the user can take on are:

• **Astronaut – survival mode:** collect the necessary equipment for space travel, moon landing, etc. How have equipment changed and how do they benefit astronauts? How has the environment inside the capsule improved, and what does it mean for astronauts? What do astronauts need to prepare for a space walk or planet landing? These are the potential questions posed for the astronaut role.

• **Mission Control – control mode:** allow the user to do simple control of some space robots in the exhibition by connecting the user's device to the robot. Watch exclusive videos of rocket launching and orbiting.

• **Scientist and Engineer – design mode:** how can different environments on various planets potentially threaten the lives of astronauts? What are the new materials for space traveling?

• **Science-Loving Kid:** what are you learning and what do you need to learn in school to become a scientist one day, even specifically to become a space scientist? What are the different fields that are involved in space science? What would you like to become in the future?

sample script for follow a story: astronaut – survival mode

Because visitors can get unique information according to the story they choose to follow, they personalize their experience. Since the information the user gets from the story is more concentrated, it is easier for the user to make sense of the narrative and gain information through storytelling. This also encourages repeated visitations so visitors can take away with different information each time they follow a different path.

1 First Man in Space:
Find the first man in space, by collecting it, the app calls for additional information such as the space the man has when sitting in the capsule, the characteristics of the space suit he wore, etc.

2 Oxygen Tank – A Must for Astronauts:
Find a scenario where the astronaut is threatened by the lack of oxygen (it lies in the label of Dangerous Mission – Apollo 13 Mission). Real life radio transmitted conversation regarding the oxygen issues during Apollo 13 Mission can be accessed once the user collects this footstep.

3 Latest Glove:
Find the newly designed gloves! Once collected, the user can see side-by-side comparison of an old glove and the new glove, and how it has improved for safety and efficiency purpose.

4 New Space Suit:
Find the new space suit with the latest technology (at the Mars diorama section). The user can capture himself/herself "wearing" the suit with the cutout prop in the exhibition. The user can see a video introducing the new space suit with new technology, and how it is going to help astronauts.

5 Perform a Space Walk:
Identify the major components of the space suit needed for space walk (at Hubble section in the exhibition). Once collected, the user can see a dissembling illustration of the space suit to look at the key components, and learn how to prepare for a space walk. The user can also see a video of a real space walk.

6 Life in Space:
Find the artificial gravity environment, where living in space can become more similar to living on earth (at Mars Spacecraft section in the exhibition). Once collected, the user can see animated illustrations of what it is like when it is zero gravity, and what it is like when it has simulated gravity.

7 Where There is No Man:
Find the manned robot (at Curiosity in the exhibition). Once collected, the user can see what it would be like if we send men to Mars. What is required, and what is at risk? Are you qualified to travel to Mars (similar to Mars Personality Test interactive in the exhibition)? How much more efficient for astronauts to perform a task in space than robots?

STORY: Next Mission

Give the user instructions as for what the next footstep of the story will be.

STORY: Turn on the Guide

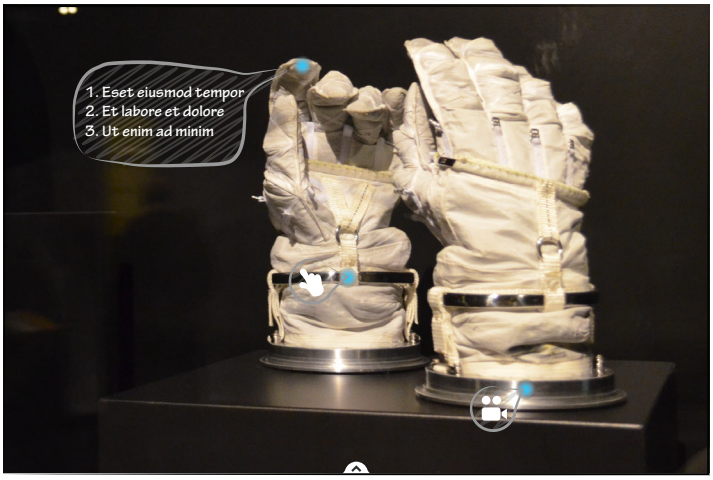
Guide that gives hints to how far the user is away from the element.

STORY: Information Overlay

Callouts that link to additional content appear when clicking the glowing dots

STORY: Comment Tool

Drag preset or customized comments into the picture.



Note that the story is not told in the same linear order as the exhibition. The user might need to go back and forth to follow the footsteps. It is an example of how the story can be organized according to its own logical order of storytelling, and changed the course of how visitors experience the exhibition.

The user can turn on the guide in the app. By identifying the geo-location of the element, the app gives hint to the user in terms of how far he/she is from the element of the current footstep.

When in a footstep, the user can "collect" the element with Augmented Reality. User can click the hot spots on the object to access information, such as text, interactive, video, etc. The user can choose to learn the content in different forms they enjoy the most. It is a method for the user to personalize the experience according to the learning styles.

By sliding up the arrow on the bottom of the screen, the user pulls out the comment tool. The user can drag up the preset comments, to simplify the process while being able to express his/her reaction to the objects. The user can also add customized comments as well, if adding an edible comment call-out into the picture.

The footsteps can walk beyond the museum's walls and relates to what is happening outside the museum. The artifacts or objects are not the ones on pedestals, but ones in everyday life, which relate to the exhibition and provide new contexts for people. This can also provide opportunities for collaborations among institutions. For example, the artifacts/objects at Houston Johnson Space Center can become the footsteps of a story about the history of mission control. The user accesses this story in the exhibition can associate it with the events mentioned in the exhibition, such as photographs of mission control taken during the mission of first moon landing, and photographs of current Mars Rover mission control center, etc.

STORY: Select Others' Stories to Track

Track friends following other stories in the exhibition.

STORY: Stack Stories

Main screen when the user is tracking others' footsteps.

STORY: Expand to See Details

Expand each stack to see the detailed footsteps of others.

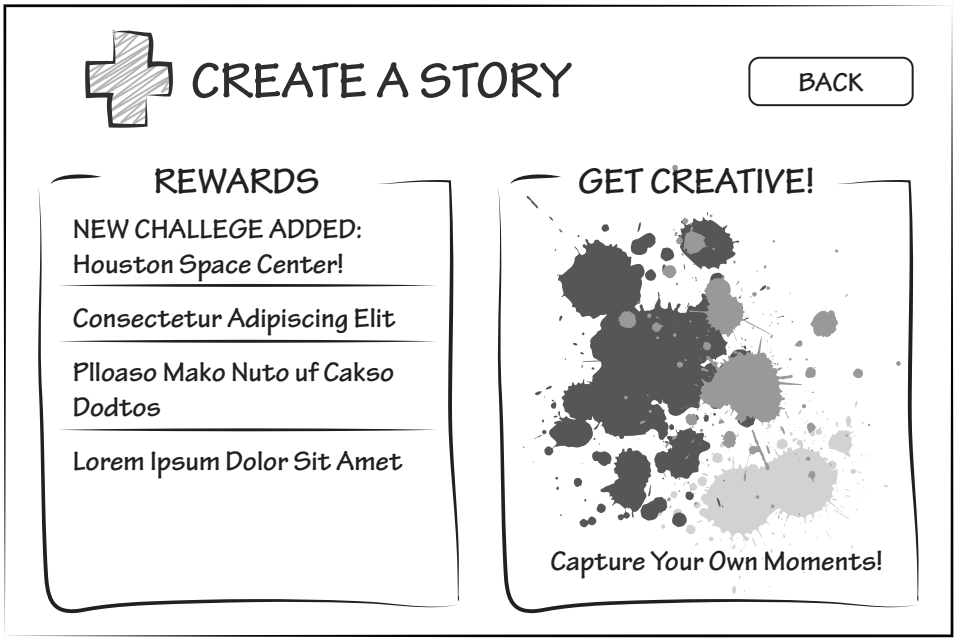
Get Social: while the user is following a story, he/she can follow other current participants' footsteps, as long as both parties agree to share their stories. Because each user can only follow one story at a time, he/she gets motivated to see other stories recreated by other users, thus learning more stories in the exhibition.

The interface then becomes seven stacks of footsteps, with the user's own footsteps on the top of each stack. While the user is collecting his/her own footsteps, he/she gets notified when someone whose story the user is following fills up a slot. Therefore, the user gets instant updates of other people's stories in the making progress. The user can expand a certain footstep to view the thumbnails of others' entry along with the user's own entry. By clicking a certain thumbnail, the user can check the details of the entry. The user can choose to stack others' entries to his/her own storyline.

At the end of the exhibition, the user can upload his/her story to the interactive station, either via the Internet or docking the device. The user's companions – family or friends, can upload their stories at the station as well. Different stories will be combined into one, organized according to the chronological orders, or the geographic locations of the collected objects/artifacts. The large screen will present a bigger story to the participants. In order to preserve the interface and the guarantee fast computing, the system would allow 3 users to upload different stories and see a combined one. The magnified physical presence of users' participations will hopefully elicit discussions and conversations among the users, and possibly spectators as well. The user can send the combined as well as the individual stories to their emails, or share them on social network sites.

STORY: Create a Story

Either to take on the museum's challenge or to create a personal story.



Create a Story

Create a Story is the second section of the app, where the user can take on the challenge to create a path telling a story that is part of the exhibition. Compared with Follow a Story, this level of challenge is more open-ended. Because it might be more challenging for visitors, playing the first level – Follow a Story can help the user get familiar with the app and get some inspiration. The museum can post challenges for visitors to create stories, and reward the user who lives up to the expectation of the museum for the story. It can also become open-ended for the user to create stories for the whole exhibition or certain parts of the exhibition. Therefore, the stories can vary from linear to divergent.

The museum can inspire the visitors to create stories by posting challenges, and provide incentives and rewards to encourage creativity. Another incentive is that the good stories created by users will be adopted in the app, which can be later followed by other visitors.

Create a Story allows the museum and visitors to add more depth and dynamics to the exhibition. Compared with programs planned for exhibitions that require people to be on site at a certain time, this kind of depth and dynamics is not constrained by time or space. Visitors also get to participate in enriching other people's experiences in the exhibition.

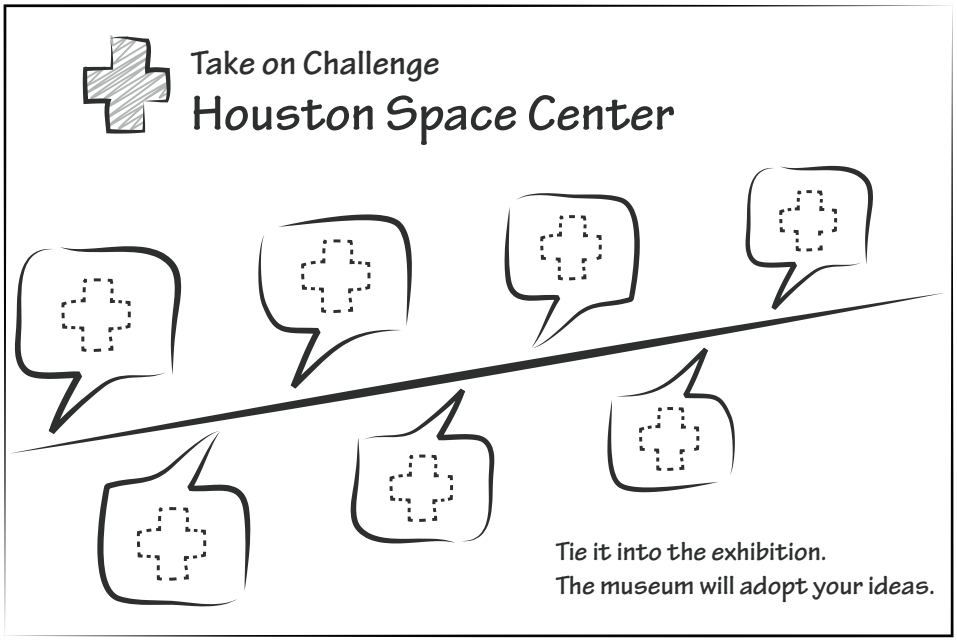
Additionally, sometimes the user does not want to take on challenges to create a story; rather he/she just wants to capture some moments in the exhibition. The app would allow the user to take photos and store information. These stories visitors create become more personal. Therefore, Create a Story is more open-ended than Follow a Story.

STORY: Take on the Challenge

Create a relevant thematic narrative, either in the exhibition or outside.

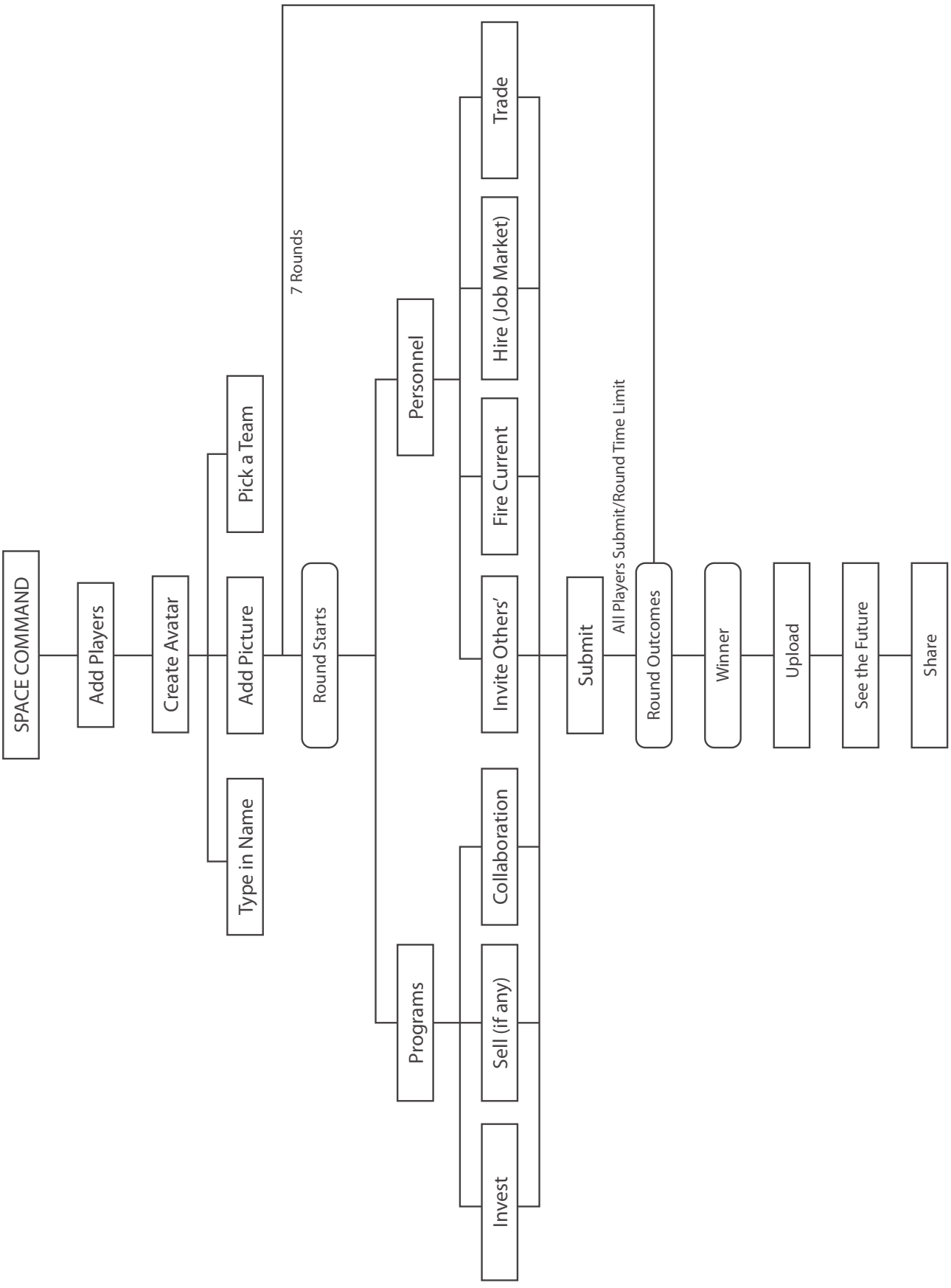
STORY: Create one footstep

Capture the new context, and caption or add location to it. Photo Source: http://uk.ask.com/wiki/Johnson_Space_Center



Conclusion

The app allows the user to experience a unique aspect of the exhibition from a certain perspective. The context awareness allows the app to deliver unique content to the user, when following stories. By instantly follow others' footsteps at the same time, the user is engaging in co-participation. The final presentation in the exhibition of a combined story is an example of collaboration, where individual stories collectively tell a bigger story of space exploration, both in science and art; and it allows others to spectate, and even gain the interest to participate themselves.


SPACE COMMAND
Add Players
Create Avatar
Type in Name
Add Picture
Pick a Team
7 Rounds
Round Starts
Programs
Sell (if any)
Invest
Collaboration
Personnel
Invite Others'
Fire Current
Hire (Job Market)
Trade
Submit
All Players Submit/Round Time Limit
Round Outcomes
Winner
Upload
See the Future
Share

Learning + Social Engagement

The design strategy of the app Space Command, laid out by three phases of learning and levels of social engagement.

	Speculating	Co-Participating	Sharing New Context
Experience	Watch the narrative collectively built by all players in the end at the exhibition.	Compete and collaborate with others in space programs.	The game keeps creating new context by responding to the changes players have made each round, which other players can access to.
Making Sense	Make sense of the collective narrative formed by the players through playing the game.	Learn the benefits and risks involved in each program in the exhibition and outcomes of each round.	Players have to constantly make sense and respond to the outcomes of each round, in order to make new decisions.
Application	The spectator puts what he/she has learned in the exhibition to interpret the narrative formed through game playing.	The player applies what he/she has learned in the exhibition to making decisions in the game.	Players apply what they have learned in the exhibition to responding to contexts created by others' manipulations.

app 2: space command

an app designed specifically for the exhibition

Space Command is a multi-player game. Through game playing, users work together to build a narrative of the future of space exploration. Space exploration, as an innately competitive human endeavor, can be represented in the exhibition as a multi-person competition. It also helps people understand that the aspiration to be the first and the best in space exploration is a major motivation that drives the fast development of space programs. Additionally, there are many decisions to make when it comes to funding space programs. In this game, users take on the role of funders who need to constantly make decisions based on what they have learned in the exhibition; and different decisions they make will have different outcomes that could possibly influence the next round of decision-making.

The space race game aims to engage players in understanding just the surface of the complexity of space exploration, the risks involved, and the significance of human's space endeavors. It is a reflection of the current situation of space explorations internationally, as the countries collaborate and compete with one another at the same time.

The game is similar to the classic board game Monopoly. The game requires multiple users to play at the same time. Each user starts the game with an avatar of his/her pick and an initial funding. After each round, as all users make their decisions, the app will reveal the variable results for each user's choices. Each user is given a comfortable amount of time each round to learn about the exhibition and make informed choices. The winner will be the one who has the most amount of fund at the end of the game.

Space Command also follows the model that combines three phases of learning with three levels of social engagement, in this case, both from the perspectives of participants and spectators.

SPACE COMMAND: Welcome Screen

Ask the user to find others around to play the game together.

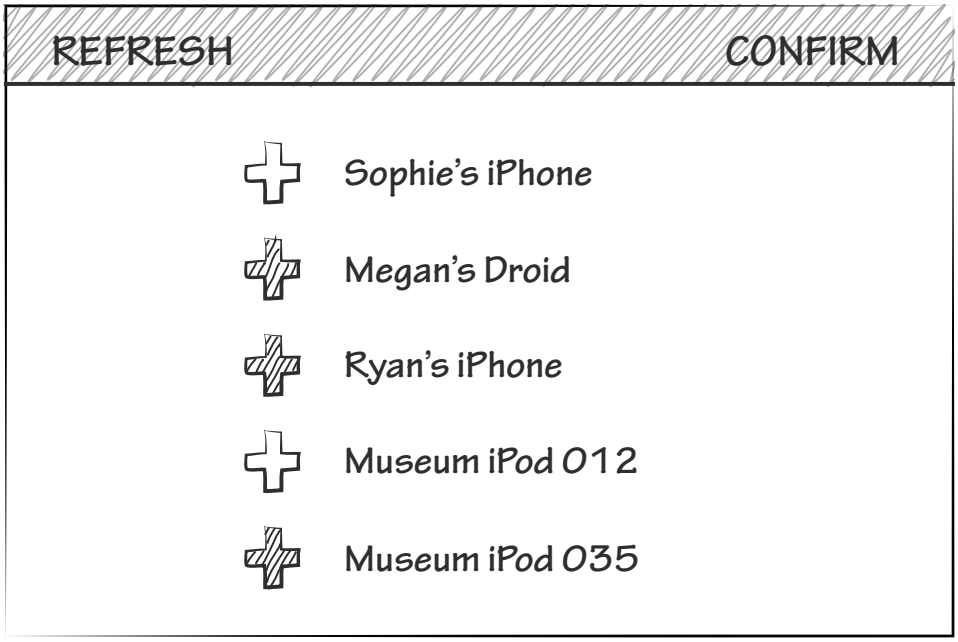
SPACE COMMAND: User List

Send invitation to other users to join the game.

The variables in the game are based on the topics dealt with in the exhibition, such as International Space Stations, Space Travel, Mars Rover, etc. However, the possible outcomes of each variable are only designed for the purpose of the game. Some outcomes are exaggerations of real risks involved in certain ventures. Therefore, it is critical to make clear to the user beforehand what is novelty and reality in the game.

The game starts with the welcome interface, and asks the user to find others to play the game together.

Once the user decides to proceed to find new players, the app searches for and lists out the nearby users. Once the user confirms all the players he/she wants to add to the game, the app sends out invitations to the players. After one minute or all the players respond, whichever comes first, the app goes into the next stage to ask each player to create an avatar.

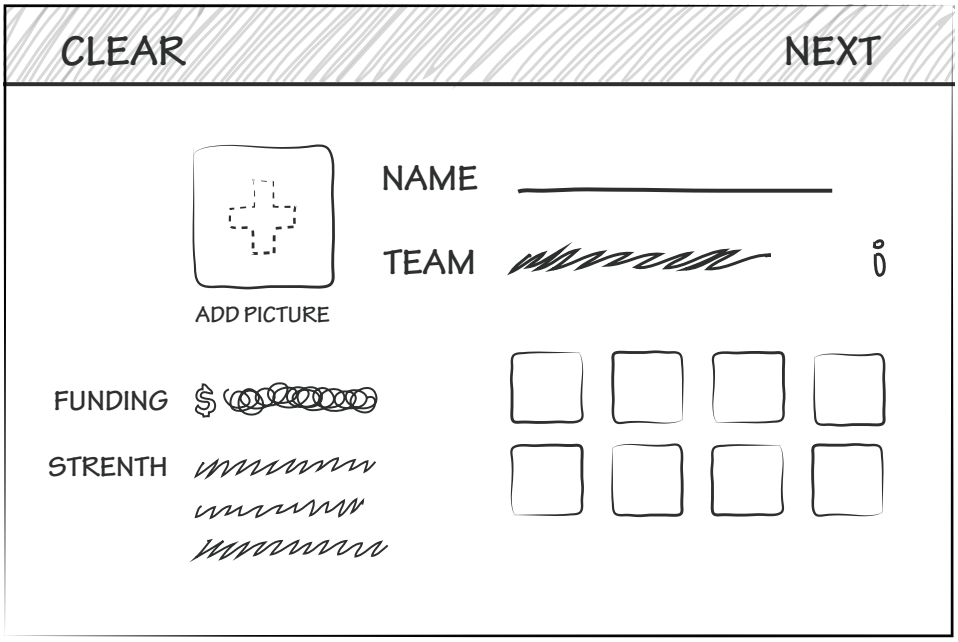


SPACE COMMAND: Create an Avatar

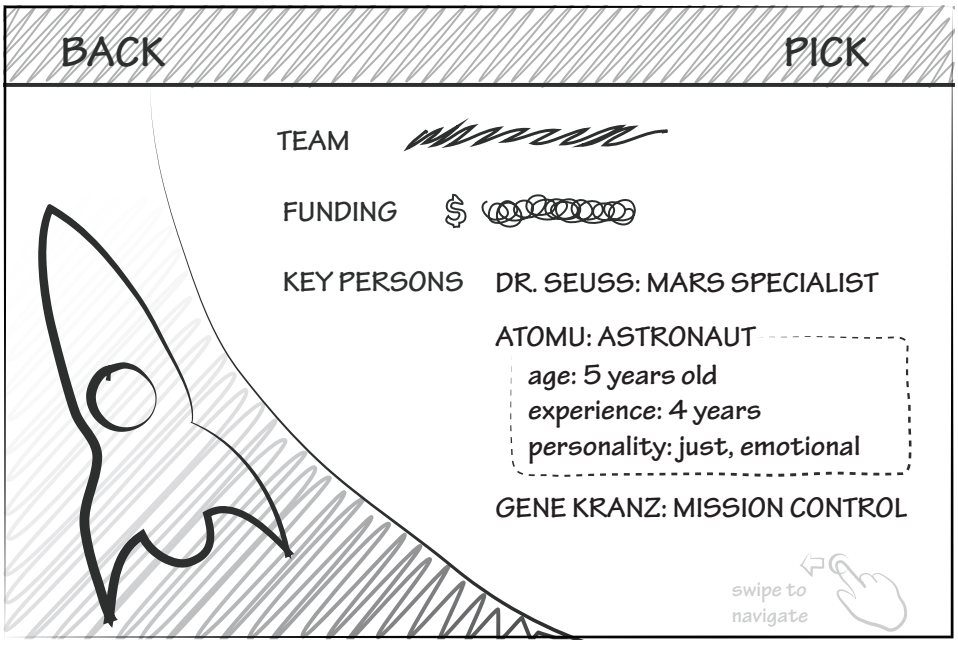
The player type in the name, pick the team, and add picture for the avatar.

SPACE COMMAND: Team Details

Click in each team to check the details of the preset team.



The avatar the user creates needs a name, headshot, and a team. The user can choose a preset image, or upload his/her own headshot, name the avatar, and pick a preset team to start with. Each team comes with slightly different amounts of initial funding, as well as different personnel . Therefore, each team starts with unique strength in certain fields and programs, such as space robot developing, new space material research, etc. The user can click on the logo of each team to read more details of each team. Swipe to navigate through teams, and pinch to get back to the main screen of creating avatar.



The user proceeds to the instructions of the game, along with the explanation about the reality and novelty of the game. In this game, novelty is the events happen in each round, which, even though reflecting real risks and threats in space programs, are exaggerated in probabilities for the sake of the game. The potential benefits of each program are explained in the exhibition. Therefore, players need to learn and make informed decisions by weighing the opportunities and threats.

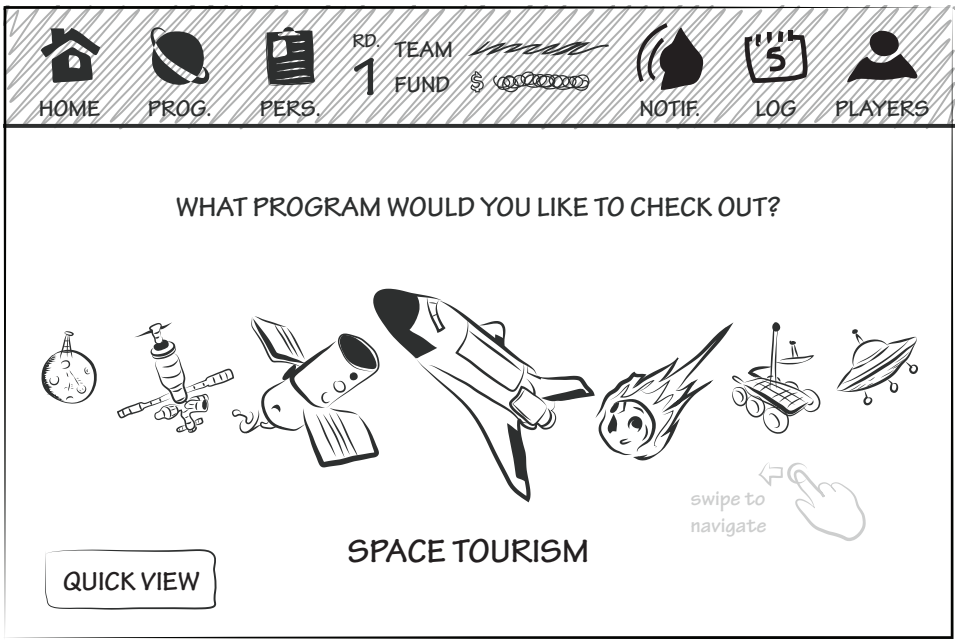
SPACE COMMAND: Main Command Screen

Main screen that allows the player to manipulate programs or personnel.

SPACE COMMAND: Programs

List of the programs in the game the player can invest in.

The players read the instructions while waiting for all parties to get ready. Once everyone is ready, the game proceeds to the main command interface. The main navigation bar is on the top, including buttons of Home, Programs, Personnel, Notification, Log, and Players, along with the user's team name, current funding, and the round number. The game invites the player to start playing either with Programs or Personnel, the two parts that the player needs to manage throughout the game.



Programs

The player can invest in different space programs, get funding from corporate, start a collaborative program, and sell space programs. In this exhibition, the space programs and the respective opportunities and risks (concepts) include the following:

Programs' Opportunities and Risks

List of the seven programs and their opportunities and risks involved.

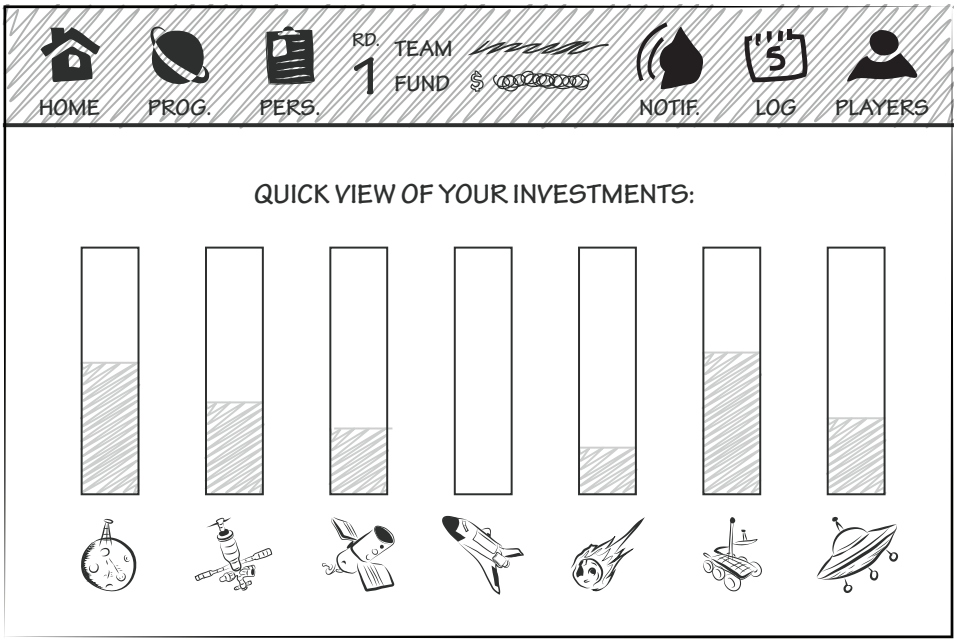
Programs to Invest	Opportunities	Risks/Variable Outcomes
Back to the Moon	Mining – new materials, valuable materials	No new or valuable materials found
	Lunar Elevator – transporting materials to earth	Cannot lower the cost by volumnizing transportation
	Colonizing (Inhabiting) – economic inhabitation	Fail to lower the cost of inhabitation
	Liquid Mirror Telescope – cheaper solution for space observation than regular telescopes	Fail to overcome the physical limitation; accidental damages
International Space Stations	Various science experiments for new findings – new genetic modified food, zero gravity experiments, etc. Cheaper investment, less risks, and steady profit.	No useful/commercialize findings; Rocket launching accidents.
	Collaboration – beneficial for all parties	Disputes among nations, bailout, etc.
Launching Satellites	Attract commercial users, such as Google, Cisco, etc. Less but steady profit.	Rocket launching accidents, dispute, spying, etc.
Space Travel (Tourism)	Highly profitable, less risks involved	Profit curve (it is not the more, the merrier), random numbers of people decide to participate space travel
Asteroids	Monitoring – precautious investment	Possibly hitting the earth, become more and more expensive to destroy as it approaches the earth
	Mining - new and valuable materials	Miner fails to land on the asteroid; no new/valuable materials found
Mars Exploration	Mars Rover – new materials	Mars Rover get lost; Mars Rover prematurely breaks; Mars Rover does not find anything; unable to initiate terraforming either alone or through collaboration
	Find evidence of life – unlock the ultimate mode of terraforming (needs large amount of funding, but can be extremely profitable), whoever finds the evidence of life has the advantage to initiate terraforming program, thus gaining the major profit	
	Send astronauts to the Mars – cheaper investment in developing robots, more efficient in completing tasks, higher chances to get positive results	More expensive for traveling (food consumptions, etc.), higher security needed for insuring astronauts to return, etc.
Wild Card – Searching for Extraterrestrials	Europa Exploration and other planets - Find evidence of life: ultimate rewards (lottery-like amount of profit)	Robot gets lost; no evidence of life; possible ultimate destruction

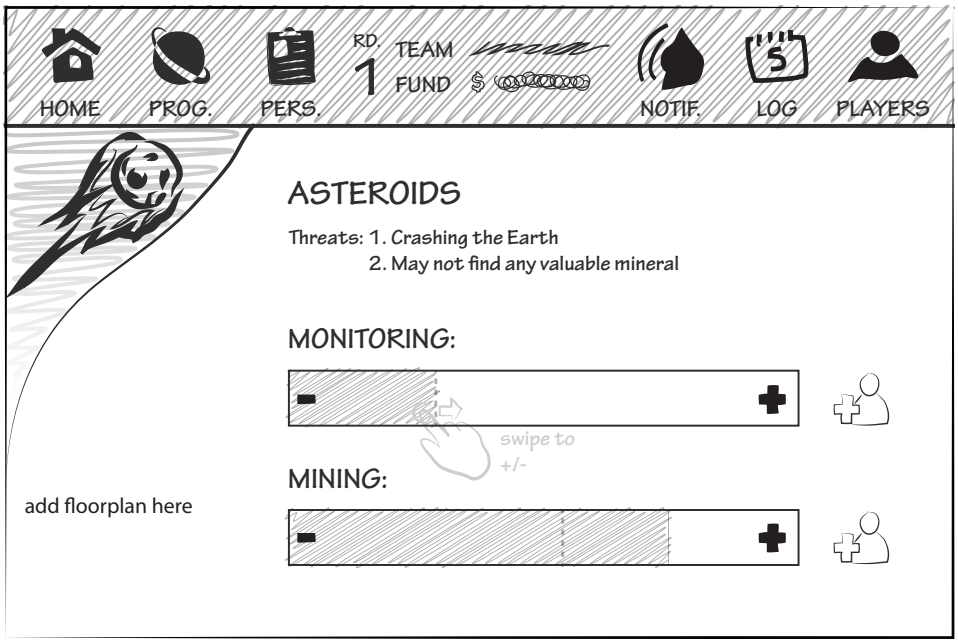
SPACE COMMAND: Programs Quick View

Quick view of the player's investment in different programs.

SPACE COMMAND: Edit a Program

Invest or sell shares in a program. Learn benefits of the program in the exhibition.



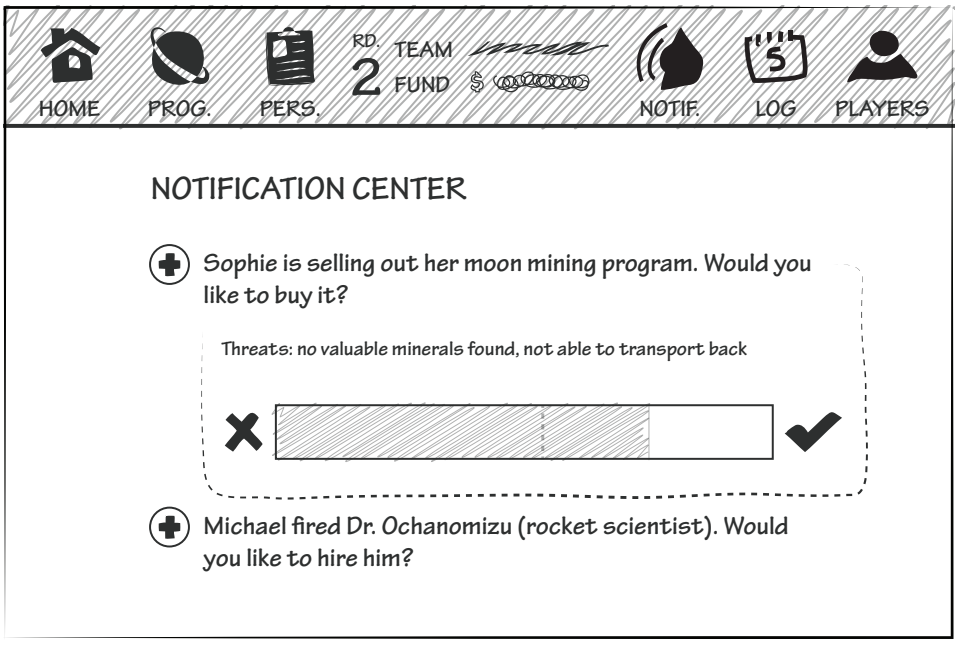


SPACE COMMAND: Sell Programs

The player can sell a program that other players can buy in.

The player can choose to initiate programs on his/her own. Various amounts of minimal funding are required for different programs in order to initiate a program. The initial funding allows the player to start two programs individually. The other option is to propose a collaboration/joint investment for a program, in which case, it could fail to initiate because not enough funding is collected. Profit from a joint investment will be divided according to the shares of each player.

The player can also decide to sell the shares or the whole space program, based on the outcomes/profits of the program. The up-for-sale programs/shares can be purchased by other players in order to continue the program; otherwise it would go into limbo. The outcome may change in the next round: it could be totally turned around by another player, or keep deteriorating.

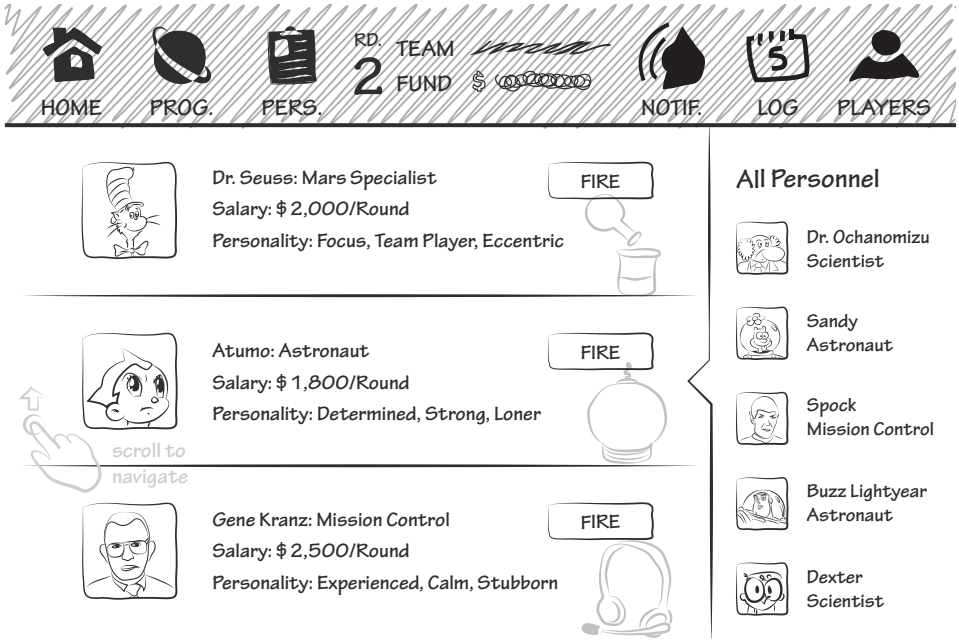


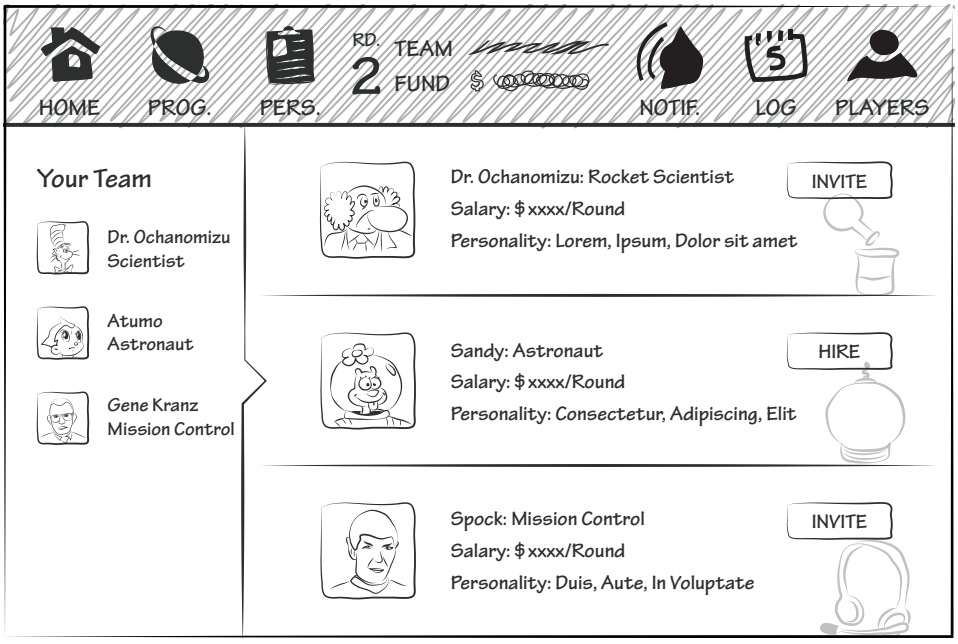
SPACE COMMAND: View All Personnel

View all personnel from other teams and the job market.

SPACE COMMAND: View Player's Personnel

View the player's personnel.



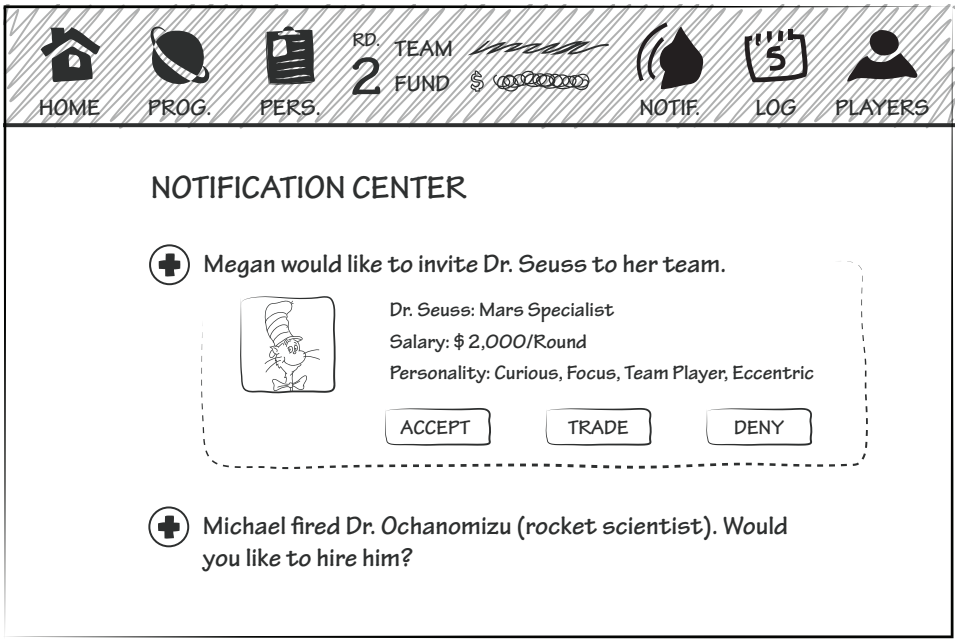


Personnel

The player can manage his/her team, including scientists, mission control, and astronauts. The personnel can influence the profit of the players' investment in different programs, by either lowering the investing cost, or increasing the chances of getting positive outcomes. For example, if there is a mission control veteran on the team, chances of control mistakes that might lead to accidents or disasters are reduced. If a material scientist invents a new material for

SPACE COMMAND: Personnel Changes

The player can decide what to do with the personnel changes.



space travel, the cost of traveling to the moon will be lowered down.

Each round, the total funding will be deducted by personnel's salaries. The player can invite other player's personnel to join his/her team, according to the needs of the player's programs. The other player on whose team the personnel is has the option to accept the offer to let go of the person, in trade of freeing the funding set aside for the person's salary and a certain amount of contract buyout fee. The other player can also propose for a personnel trading to exchange team members, or decline the offer. The player can fire certain people on their team, and hire people that are in the job market.

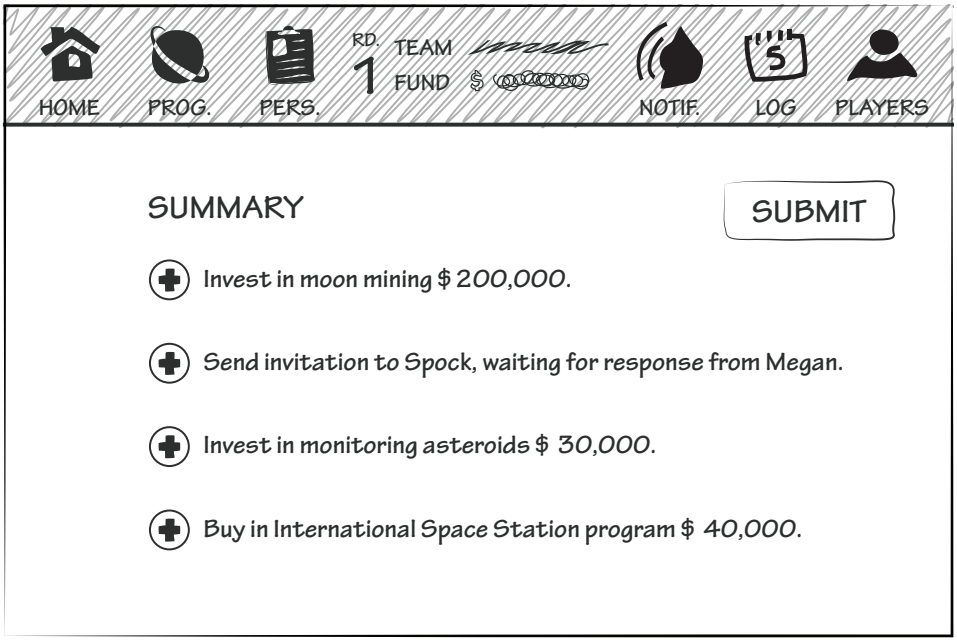
There is also risks involved in personnel, such as scientists fail to find new materials, certain person sells confidential information to other players, or personal incidents that influence the performance of the person at work, etc.

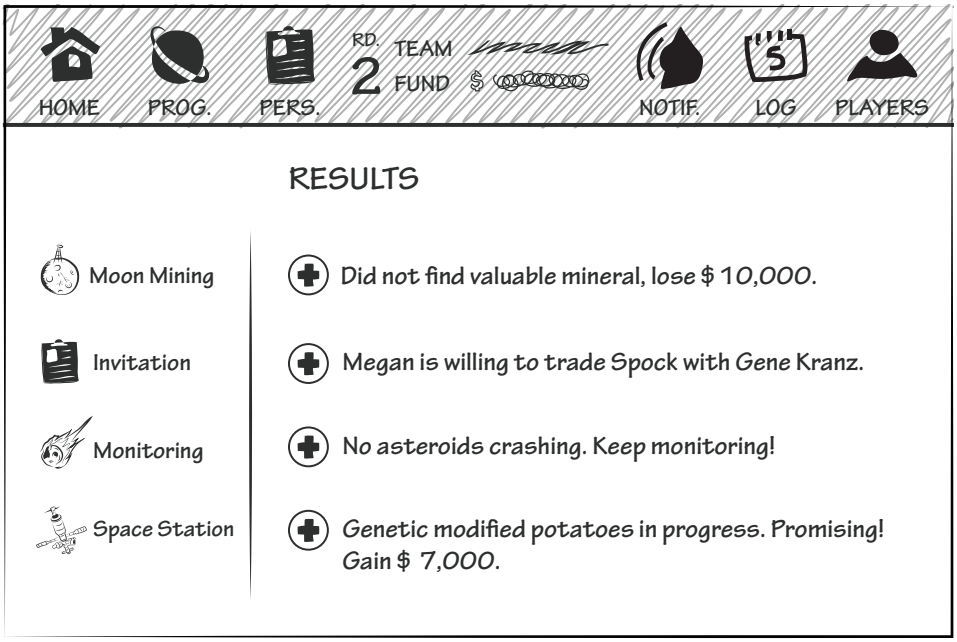
SPACE COMMAND: Summary of Changes

Go back to the home screen after any manipulation and see the summary.

SPACE COMMAND: View Results

Results are revealed after each round (all players have submitted their changes.

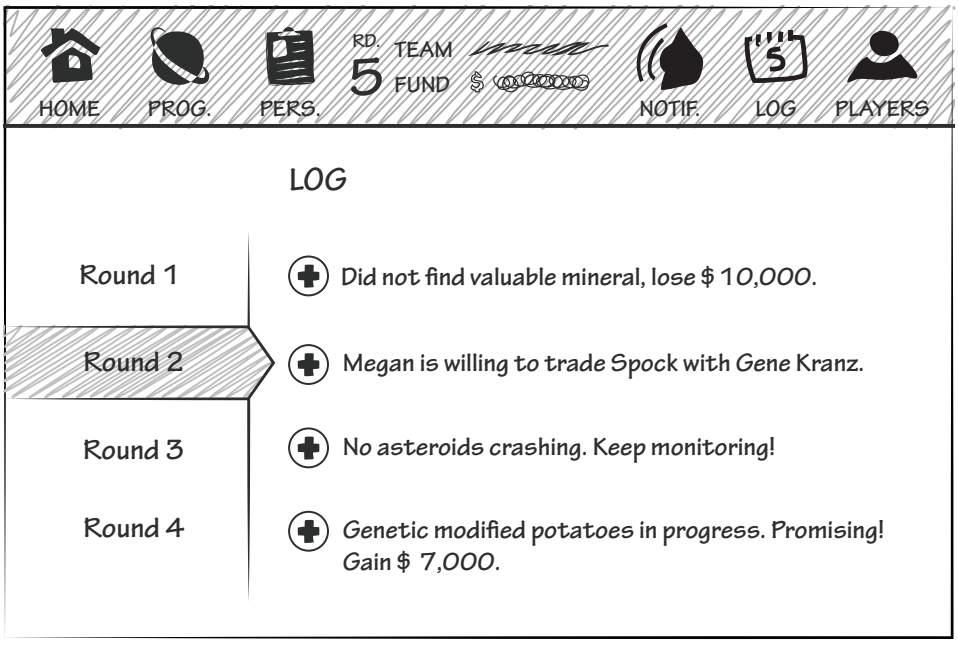




SPACE COMMAND: Log

Review the log of resultes of each round.

The player has a time limit each round to manipulate his/her programs and personnel. The time limit can derive from experimenting with test groups. After any change has been made, when returning to the home screen, the player can review the summary of the changes he/she has made. The player can submit their changes, and wait until all the players to submit, or the round reaches its time limit, whichever comes the first.



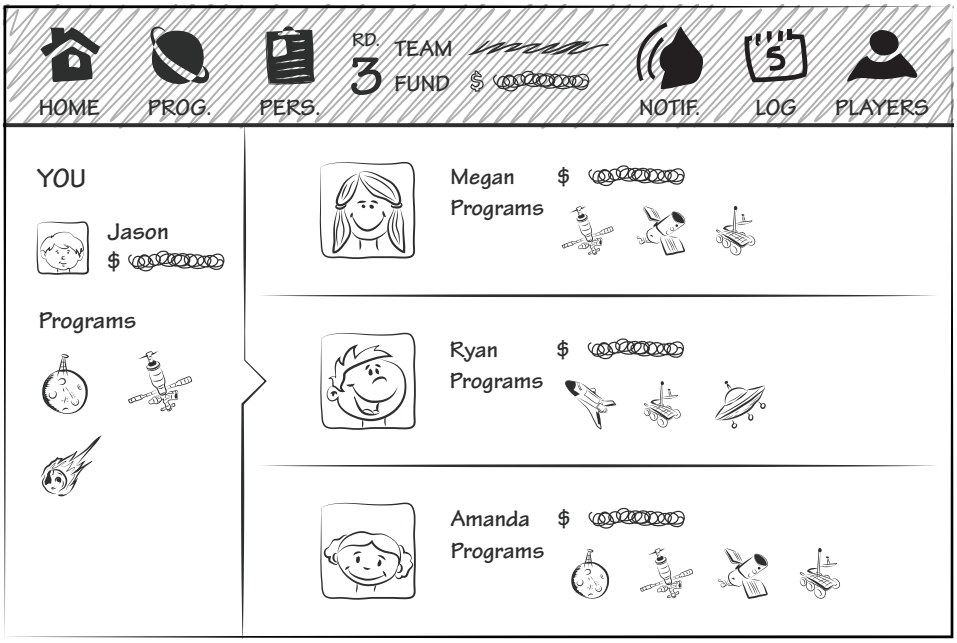
All the outcomes will be revealed after the round, and each player's funding will change according to the outcomes. The player can review the outcomes of the changes he/she has made each round in the Log section.

SPACE COMMAND: Players

View the status of other players.

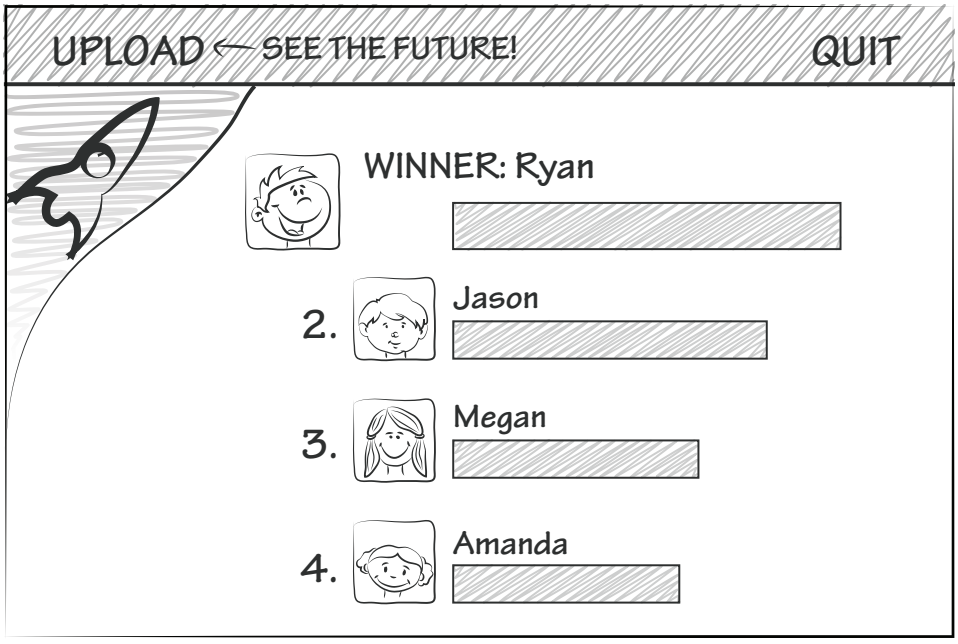
SPACE COMMAND: Final Results

Final results that can be uploaded to the exhibition and see the narrative of future.



The Player section allows the player to review other players' status, including their funding, major personnel, and location in the exhibition.

The winner is decided after seven rounds. After the last round, all players should converge at the end of the exhibition. The players can upload the final results of the game on the big screen. Besides revealing the winner of the game, ranked by the final fund of each player, the big screen can display the future of space exploration according to the results of the game, with all players' contributions included. The players can see how their decisions have shaped the future of space exploration, such as building lunar elevator, meeting or in wars with aliens, human race exiling to and inhabiting another planet because an asteroid has hit the Earth, etc.



Conclusion

The Space Command game is specifically designed for this exhibition, although it might be adapted for other similar themed space exploration exhibitions. The game requires co-participation, both competing and collaborating. The players will see how their decisions can shape the future of space exploration, which is unique in each game because of uniqueness of players' actions and random outcomes. It promotes the significance of space exploration among players.

Content wise, it is closely tied with the content in the exhibition, which discusses different space programs in the future. It encourages the players to actively seek for information in order to make informed decisions in the game. The game makes an impact in the exhibition, as the narrative built by the players collectively will be exhibited on the screen in the exhibition.

From the social interaction perspective, the players are actively engaged in the second-level of social engagement, namely co-participation. The narrative played on the screen in the exhibition not only motivates the players to participate and actively shape the story, it also allows conversations and discussions among players, as well as with spectators. Adding the phenomenon that players actively engage with the exhibitions throughout, it is probable to attract spectators to socially engage in meaning making through watching and conversing (first level of social engagement), and even to participate themselves (second level social engagement).

This concept design is cost efficient for permanent exhibitions. Although the example used for the concept design in this thesis is a temporary exhibition, it is treated as a permanent exhibition for the sake of preserving the efficiency of the study. The scale and the value of this exhibition at American Museum of Natural History can be justified as a permanent exhibition.

The game is fun and engaging for both first-time players and repeated players, because every time the narrative is uniquely shaped by all players and the variable outcomes. The design of the physical exhibition should be conducive to the game, such as providing graphic clues/highlights in the exhibition that is directly tied to the content in the game, and designing an amplification of the final outcomes/ narratives in the exhibition. It makes playing the game in the exhibition a truly unique experience the player cannot get outside of the exhibition. The game can be repeated, thanks to the variable outcomes. The game is also sustainable, as new space programs, new personnel, and new variations of outcomes can all keep the game fresh.

conclusion

Mobile devices have the following major characteristics: mobile, ubiquitous connectivity, personal, and interactive. Native applications on mobile devices maximize the last two characteristics – personal and interactive.

Personal: the app can easily remember the user's activities without the user having to sign in. It allows the user to tailor the content and interactivity on the mobile device according to his/her preferences. It is self-paced and familiar for the user. It is easy for the user to customize the app and thus his/her experience in the exhibition.

Interactive: as analyzed in the thesis, native apps are capable of utilizing all sensors, and recognize various motions and multi-touch gestures. Apps should take advantage of the sensors in order to reach the full capability of mobile devices.

However, using mobile devices can isolate users in exhibitions; whereas the museum, as a public place, is encouraging people to socialize with their companions and other visitors. Therefore, it is important to design apps that aim to create shared experiences in exhibitions. By adapting John Falk's learning model that emphasizes on the three steps of learning as experience, meaning making, and application, the thesis derives a model that cultivates shared experiences on each stage of learning with the use of mobile devices, especially native apps.

The thesis categorizes the shared experience in three levels according to the social engagement of one party in the shared experience: spectating, participating, and sharing new contexts. The thesis discusses how mobile apps can facilitate the three levels of social engagement, thus creating meaningful shared experiences

that would lead to learning in and outside exhibitions.

The thesis then applies the adjusted model to developing new concepts for a current exhibition at American Museum of Natural History, called Beyond Planet Earth: The Future of Space Exploration.

The first concept is a more universal approach, applicable for both permanent and temporary exhibitions. Story is a social storytelling app, that generates shared experiences as visitors peak into others' footsteps in the exhibition while following footsteps of a narrative on their own, and create narratives for other people to follow. It personalizes each visitor's experience, as people experience the exhibition from different perspectives and with different storylines. In the meantime, by watching how other people follow other stories in the exhibition and combining stories at the end of the exhibition, it hopefully elicits human-to-human interactions via human-to-computer interactions.

The second concept is a more specific approach to the exhibition, assuming it would be a permanent installation. Space Command is a social gaming app that creates shared experiences in the exhibition. Players learn from the exhibition about different space programs, and make informed decisions to invest their funding to different programs, which involve risks that would affect the outcomes of players' investments. Through competing and collaborating with each other, players create a unique narrative that projects the future of space exploration. Therefore, the game achieves the goals to engage visitors with the exhibition and with each other through mobile apps.

DESIGN CONCEPTS

Certainly, there are other concepts of mobile apps for museum exhibitions. In order to ensure human-to-human interactions, it is essential to examine different forms of social engagements visitors have in exhibitions, and explore how mobile apps can facilitate these engagements. The followings are a few additional examples of what apps can do to facilitate different levels of social interactions in and outside museums:

Social Interactions through Mobile Devices

Affordances of mobile devices in terms of three levels of social engagement.

Level	Social interactions through apps
First Level: Spectating	Control interactive components with mobile devices to attract spectating. It is magical if it is gesture controls on the device; and it is expressive if it is controlled by motions (devices as consoles)
	Augmented Reality to attract spectating. It is mainly magical, sometimes secretive, as the user needs to lift up the device to point at objects.
	Mobile devices are connected to or projected in the exhibition to amplify the content/ results in the physical space, to elicit discussion, conversations, and spectating that would lead to participating and learning.
	Building narrative: thanks to the mobility of the device, interactives can become mobile in and outside the exhibition. Visitors' actively moving around and interacting with the exhibition via their devices is likely to attract other visitors' attentions and spark their curiosity.
Second Level: Participating	Strategy game: asks visitors to make informed decisions by learning from the exhibition. The decisions individual player makes may or may not impact other players' game.
	Social tagging: app that allows users to exchange tags, comments and thoughts they have in their museum experiences.
	Scavenger hunt race: app that asks visitors to follow the clues and make connections to objects in exhibitions. It can be collaborations or competitions.
	Collaborative narrative building: visitors work together to create and make sense of a narrative, which could be totally arbitrary and entertaining.
	Photo sharing: app that promotes visitors' capturing moments, especially ones that visitors feel connected to and inspired by in the exhibition, and sharing with others.
Third Level: Sharing New Context	Capture photos or videos outside the exhibition, and send back to the museums to provide new contexts for other visitors.
	Provide supplementary information that asks visitors to associate real-life contexts to what they learn in the exhibition, and expand their experience beyond the museum.

DESIGN STRATEGIES

Design strategies are also crucial in implementing these concepts to succeed in facilitating social interactions in and outside exhibitions. Here is some suggestion that will help designers to make apps more "social":

1. Amplify the manipulations. It is attractive and entertaining. Design cross machine interactions, such as mobile devices controlling components in the exhibition. Try to use body kinetic control rather than multi-touch gestures so that the manipulations are visible to others.

2. Amplify the results. Have outcomes or results projected in the exhibition, so that the user feels the impact of what he/she has done in the physical space. Additionally, it will attract other visitors' attention and spark their curiosity to participate. If limited resources do not allow to project content in the exhibition, outcomes displayed on the mobile devices should be graphic content rather than textual, because graphic information is easier to be noticed and observed by other visitors.

3. Design continuous experience on mobile apps. The user goes through the entire exhibition with their mobile devices. It has advantage over stationary interactives in the exhibition, when it comes to providing a continuous interactive experience. Therefore, mobile apps can be a good tool for providing threads of exhibition narratives, allowing users to collect the dots, serving as learning assistant, etc.

4. Mobile devices are flexible. Users can use them spontaneously, without having to wait for their terms or worrying about other people waiting. Therefore, it is crucial to design responsive apps, which can also be paused and resumed when needed. Additionally, apps should be flexible in providing various options and supplementary content to the exhibition. It would allow people to customize their learning experiences, and share their experiences with each other since they acquire slightly different information.

5. Encourage users to stay connected and communicate with each other through the devices. Mobile devices allow constant and immediate communication between people. Therefore designing apps that requires collaboration and competition would take advantage of the mobile devices.

6. Rent devices in the museum so that no visitor will be excluded because of their socio-economical status.

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Dr. Seuss, *Dr. Seuss*, created by Theodor Seuss Geisel.

Tetsuwan Atumu, *Astro Boy*, created by Osamu Tezuka.

Professor Ochanomizu / Dr. Packidermus J. Elefun, *Astro Boy,* created by Osamu Tezuka.

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