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LearnPads for Schools

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LearnPad Content Development at The Postal Museum

An Interactive Qualifying Project submitted to the Faculty of
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Abstract

The Postal Museum of London purchased a set of tablets intended to support engagement during primary school group visits. Our team's goal was to identify how The Postal Museum might deploy these tablets to improve the effectiveness and consistency of the in-gallery experience. We identified industry benchmarks by conducting observations and interviews at museums offering digital programs for schools. Next, we assessed the needs of our target audience through interviews and focus groups. Based on our findings, we created and tested a functional alpha prototype outlining activities for use in The Postal Museum gallery. In addition to the prototype we delivered a set of recommendations detailing how to implement and maintain the tablets most effectively.

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Executive Summary

The Postal Museum of London provides many offerings for visiting student groups ranging from a ride on the Mail Rail, an underground train ride, to facilitated workshops. Through feedback from visiting school groups, members of the Access & Learning team at The Postal Museum are aware that primary school students' level of engagement is variable during in-gallery sessions. The museum attributes variability in engagement to the unpredictable ability of chaperones to be actively involved in the school visit. Recently, The Postal Museum purchased a set of educational tablets known as LearnPads to assist with the student engagement issue they identified. Our team performed research into what potential activities and content the museum should incorporate into a LearnPad application to standardize the experience for visiting students.

The goal of this project was to identify how The Postal Museum might deploy LearnPads to improve the effectiveness and consistency of the in-gallery experience of school groups visiting the museum. To achieve this goal, the team identified three main objectives: (1) Establish current practices in the use of digital technologies for school groups visiting museums and evaluate their effectiveness. (2) Assess the needs and expectations of The Postal Museum and its target audience (teachers and students) for the LearnPad technologies. (3) Design, develop, and evaluate appropriate content and activities for delivery on the LearnPad technology. The team carried out a mixed methodology of desk-based research, gallery observations, interviews, focus groups, content design, prototype development, and user testing to provide an informed recommendation to The Postal Museum on how they should model a potential application.

The team established current practices by identifying connections, interviewing relevant development staff at other museums, and observing school programs that incorporate tablets. Our team coordinated with three museums throughout our project: the British Museum, the Museum of London, and the Victoria and Albert Museum. Through these methods, we found that museums often task students with creating a product based on what they have learned. This process refines students' knowledge, and museums may deliver these products, using proper security measures, to teachers through digital services. Students also work well in small groups, and are adept at using tablets. Tablet use also involves complications in maintenance and the

handling of sensitive information. The findings from these museum visits helped us to form our recommendation for the incorporation of LearnPads into The Postal Museum's gallery sessions.

To assess the needs and expectations of The Postal Museum and its target audience, the team conducted a series of observational studies and focus groups. We found that students were more engaged with interactive exhibits than with text-based exhibits. Students would also skip over an exhibit if it was too crowded or required waiting to use. We produced findings based on student group dynamic, chaperone involvement, and incentivizing tablet use. Teachers agree that students are adept at using tablets, and believe that students should have an experience that is exclusive to The Postal Museum. In order to make tablet use worthwhile, teachers recommended including gamified activities, incorporating resource collection, and delivering post-visit material. Some teachers also held the concern that integrating tablets into the in-gallery session would detract from the rest of the experience by taking away from the time that students would otherwise spend exploring the gallery. Findings gained from this objective allowed the team to enter the development phase of the project.

The designs that our team developed detailed the structure that we believe The Postal Museum should use in their application. The LearnPads should direct students to selected areas in the gallery through the use of a scavenger hunt. Once there, the students should receive activities that relate to the museum content in that area. To expand upon our idea, the team created a detailed paper storyboard. We outlined ideas for specific activities and put them on paper so that we could better analyze them.

The team developed a digital prototype that was functional on LearnPads. The structure of the prototype was a scavenger hunt which directed children to find areas of the museum and complete activities. The activities featured find its, multiple choice questions, and describing the user's surroundings. It was important for our content to prompt students to interact with the museum exhibits, rather than be entirely self-contained. Our program directed students to look at museum content, read information, and relate it to their own experiences.

We evaluated our prototype during a student focus group at The Postal Museum. Students showed visible engagement and excitement while using LearnPads within the gallery. After the time in gallery, we conducted a feedback session in which the students shared their experience and favorite activities. The students enjoyed a large majority of the activities, and gave us positive feedback. We also asked the accompanying teacher and chaperones what they thought of

the students' experience. They gave us a positive response, saying that the visit engaged the students well, and they had a good time. We used the feedback we received to make changes to our prototype so that we could create a more refined final product.

Our team synthesized our findings into conclusions and a set of recommendations tailored for use by The Postal Museum. Museums may develop original content for tablets or use pre-existing third party applications. Original content allows museums to provide a unique experience closely tailored to their gallery content, however the development process is often costly and time consuming. Pre-existing applications have limited uses in the gallery, but are cost-effective and require less maintenance. We recommend that The Postal Museum develops an original application for use within their gallery.

In regards to the application's target audience, we recommend that The Postal Museum develops an application that is flexible and adaptable to both key stage 1 and 2. Implementing tablets in the gallery requires maintenance on both the physical devices and the application. A member of staff at The Postal Museum should be in charge of upkeep to ensure proper use of the devices and timely updates of the software, even if The Postal Museum outsources development to a third-party company.

When school groups visit a museum they want to provide students with experiences they cannot experience in the classroom. Applications developed for in-gallery use must involve the physical exhibits as much as possible and encourage students to explore the gallery. These applications should avoid relying on chaperones, and should generate post-visit material to reinforce learning and provide a memento of the visit. These take-homes should be sent back to the school using methods such as email and storage websites. We believe that by following these recommendations, The Postal Museum can create an application that augments the in-gallery experience for visiting students and maintains a high level of student engagement.

Authorship

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Chapter 2: Background		
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2.2: Digital Learning in Museums	MF	GC
2.3: Current Offerings of The Postal Museum	GC	MF
2.4: LearnPad and Content Development	GC	MF
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Chapter 1: Introduction

The British postal network stretches back over 500 years. In recognition of its rich history and national significance, Queen Elizabeth II opened the first postal museum in 1969. Originally built to house an award-winning British stamp collection, its offerings have since expanded into programs, exhibitions, and education resources. Over the following decades, the collection had several homes before finally settling at a brand-new facility in Clerkenwell. Rebranded as The Postal Museum, the museum opened in a £26 million state-of-the-art facility in 2017. The space includes galleries, an archive open to public research, an interactive play space, an event venue, and Mail Rail, an automated, underground train system that formerly distributed mail among depots across London.

The Postal Museum seeks to foster innovation and education while conveying the importance of Britain's postal heritage. The Postal Museum offers a variety of educational programs for primary, secondary, and special needs school groups that develop communication, critical thinking, and problem-solving techniques which align with national curriculum standards. It is becoming increasingly difficult for museums in London and the rest of the UK to attract school groups due to changes in the school curriculum and constraints on school budgets. Data indicated that the number of children visiting museums in England fell 6% in 2016-17 from the previous year. Often, children visit museums solely as part of a school group and when schools stop going, children stop going (Sharp, 2018). While museums offer informal learning opportunities, schools increasingly emphasize rigid curriculums and standardized testing to demonstrate the achievement of national curriculum benchmarks (Mulhearn, 2014). To attract school groups, museums must be able to show, therefore, that they offer programs and activities that tie closely to the curriculum and have demonstrable impacts on learning.

In an effort to address this problem and encourage school visits, The Postal Museum designs its programs around the national curriculum standards and provides supplemental materials for teachers to use before, during, and after their visit. The Postal Museum is always exploring new ways to engage students and help teachers maximize learning experiences. To accomplish this, the museum recently acquired a set of 20 LearnPads. The LearnPads will engage students through quizzes, games, and other activities that connect the museum exhibits with the curriculum and students' personal experiences. The museum hopes that the tablets will

enable teachers and chaperones to accommodate the varying needs and interests of students in large groups more effectively.

The goal of this project was to identify how The Postal Museum might deploy LearnPads to improve the effectiveness and consistency of the in-gallery experience of school groups visiting the museum. To achieve this goal, the team identified three main objectives with associated tasks: (1) Establish current practices in the use of digital technologies for school groups visiting museums and evaluate their effectiveness. (2) Assess the needs and expectations of The Postal Museum and its target audience (teachers and students) for the LearnPad technologies. (3) Design, develop, and evaluate appropriate content and activities for delivery on the LearnPad technology. Our background research revealed several gaps in our understanding of the use of digital technologies for school groups. We supplemented this gap in our research by observing several programs at museums in London. We used a combination of interviews and observational studies at The Postal Museum to determine the needs and expectations of Postal Museum staff and their target audience. The team will provide the museum with a final recommendation based on the findings gathered throughout this project.

Chapter 2: Background

Introduction

Electronic devices have increasingly become an important part of the museum experience. They are prevalent throughout galleries and serve purposes such as playing video and audio relating to an exhibit, producing games for visitors to play, and providing a source for more detailed information on a subject. For the purposes of creating our own applications for visitors, our team must first establish how learning occurs in museums through informal learning methods. In a similar fashion, we will ascertain how learning occurs using digital technologies and analyze the efficacy of its use in the informal learning environment. This includes an analysis of sample studies focusing on the integration of technology in museums with a focus on school groups.

2.1: Museum Learning

2.1.1: Overview of museum learning

The museum has always served as an opportunity for visitors to engage with unique content in a more personal and comprehensive way than is possible in a traditional learning environment. For as long as museums have existed, their dual purpose with respect to learning has been to create new knowledge through research and spread information through education (Hawkey, 2004). Museums have continuously evolved to meet changes in education standards along with their shifting role in the education process. The rapid technological advances of the past decades have presented an entirely new challenge; the social and cultural structure in which education takes place has drastically changed, creating an entirely new set of expectations for museums to meet (Hein, 1998).

The traditional approach to museum learning is largely didactic in nature. This educational theory is associated with the formal learning which occurs in schools. The learners are treated as passive recipients of the information being presented (Cipi, 2014). Didactic learning is broken into expository and stimulus response education (Hein, 1998). Figure 1 shows the structure of these education theories. Museums organized around didactic expository have sequential exhibits with a beginning and end, specific learning objectives determined by content, and labels and panels describing what should be learned. Stimulus-response oriented museums

provide positive reinforcement to reward correct learner behavior in addition to the components of a didactic expository museum. The straightforward and often restrictive presentation of artifacts based on didactic learning became antiquated as objects became secondary to the message. A new generation of exhibits directed at a wide variety of audiences, including school groups, emerged (Hawkey, 2004).

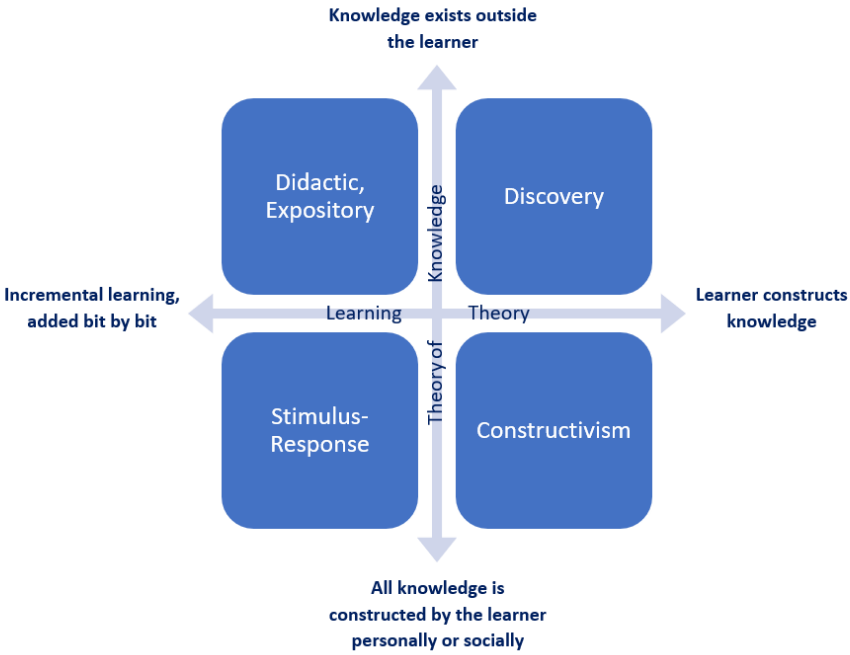


Figure 1: Hein's structure of education theories (Hein, 1998)

To meet the increasingly diverse and technologically centered needs of museum visitors, exhibit design has moved towards an approach aligned with informal learning and constructivist theory. Constructivism is the idea that learners construct knowledge and true meaning for themselves based on their individual context. This view focuses entirely on the learner rather than the teacher (Hein, 1991). For constructivist learning to occur, the learner must actively participate to shape their understanding. Additionally, the validity of the learner's conclusions is based on whether they "make sense" within their constructed context, rather than on an external standard of truth.

Constructivist exhibits will contain some of the following elements (Hein, 1998):

- Many entry points, no specific path and no beginning or end;
- A wide range of active learning modes;
- A range of points of view;

- An opportunity for visitors to connect with objects (and ideas) through a range of activities and experiences that utilize their life experiences; and
- Experiences and materials that allow students in school programs to experiment, conjecture, and draw conclusions.

The Postal Museum exhibit design aligns with many principles of the Constructivist theory. Exhibits feature interactive elements, various forms of media, and activities that allow the visitor to connect with objects.

How an individual creates meaning from their museum visit is divided into three overlapping contexts: the personal context, the sociocultural context, and the physical context, and "all museum visits, as well as the meaning brought to and taken from them, can be understood as occurring at the intersections of these three contexts" (Falk and Dierking, 2012, p.26). Figure 2 visualizes this structure. Each museum visitor possesses a unique personal context which includes their experience and knowledge of the museum they are visiting, preferred mode of learning, and individual interests and motivations. This context exists prior to the museum experience and influences the visitor's expectations. In terms of sociocultural context, each individual holds different perceptions of the museum based on their cultural background (race, ethnicity, socioeconomic status, etc.), and this will influence how they experience the museum. The other aspect of this context changes based on social interaction factors. Who the visitor walks through the museum with creates a different environment for them based on their companion's age, knowledge, and level of interest. The physical context is the museum building itself and encompasses architecture, overall feel, and the objects contained within it. The Postal Museum environment is rich in detail, and creates interest using visual and aural elements. The Contextual Model, as it is formally known, represents a dynamic, individual-specific system which allows the visitor to construct context and assign meaning to the museum experience.

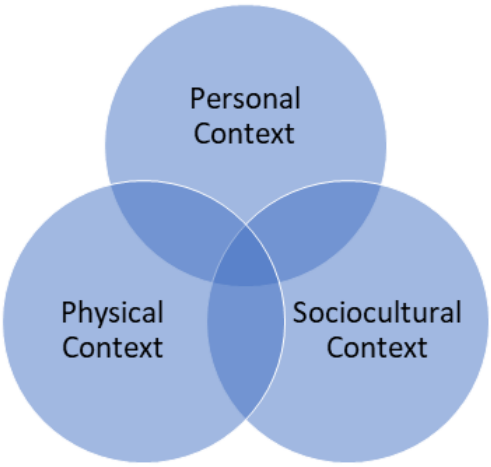


Figure 2: The contextual model of learning (Falk & Dierking, 2012)

Museums promote informal learning while schools are structured around formal learning. Formal learning is "institutionalized, intentional and planned through public organizations and recognized private bodies" and is generally used in the education system (UNESCO, 2011). This type of learning is based on specific measurable achievements. Learning outcomes are student-centric and developed to meet a specific program of study. Students are assessed against a baseline to evaluate their achievements (Moussouri, 2002). In the context of museums learning has a much broader definition and aligns with an informal or "free choice" approach. Informal learning occurs in environments outside the classroom and often involves more interactive activities. This type of learning challenges many perceptions about traditional learning including:

- Learning is a dull process by default;
- Learning requires a defined curriculum;
- Learns must acquire factual knowledge for learning to occur;
- And learning involves the transmission of knowledge from teacher to learner (Hawkey, 2004).

Conversely to informal museum learning, formal learning meets educational benchmarks using a rigid curriculum, often in the form of standardized testing, and emphasis is placed on keeping to a schedule (Mulhearn, 2014). To attract school groups, museums must be able to show that they offer programs and activities which link to the curriculum and have demonstrable impacts on learning.

2.1.2: Informal learning standardization

Museums must adopt a different outlook on learning due to the wide variety of audience members that attend museums. Museums present a unique opportunity for a visiting school group to participate in informal learning that expands on formal curriculum presented in the classroom setting. The aspects of informal and formal learning can apply to museum learning or the specific learning activity shown in Figure 3. This figure presents the idea that it is possible to experience formal and informal learning when a school group visits a museum, and this idea serves to reinforce the importance that a school group's museum visit should relate back to school curriculum. For a school group to have a standardized informal learning experience, a museum should provide supplementary material to the museum visit that directly relates to the school group's curriculum. This allows individuals in a school group to draw connections between curriculum and their museum experience, strengthening their learning outcome. For resources to be useful for teachers they should be:

- Linkable to the National Curriculum;
- Adaptable to suit the teachers' needs; and,
- Understandable for all students of different learning abilities; (Hobson & Robinson, 2010).

It is important that a museum provides resources to teachers that can connect to a student's everyday school learning experiences. This material should assist in furthering the informal learning experience upon visiting the museum rather than guiding it. Through increased attention on informal learning, it is possible to redefine the perception of informal learning, removing misconceptions such as learning is an activity limited to schools (Hawkey, 2004).

		Activity	
		formal	informal
Affiliation	formal	Lectures for groups of students	Free-choice exploration of exhibits
	informal	Adult education courses	Interactions with gallery characters

Figure 3: Formal vs. informal learning in museums (Hawkey, 2004)

Unlike formal education, it is possible for a museum to tailor its educational experience to a wider variety of learning styles. The museum setting allows visitors to engage in user guided learning, and this is especially beneficial when teaching to large audiences with numerous different learning styles. There are many differing opinions on the theory of different types of learning, but Perry presents one accepted ideology on the types of learning and how they apply to different intelligences. "She highlights four 'types' of learning, the majority of which lie broadly in the affective domain:

- sparking an interest
- delayed learning
- visceral learning
- wrap-around learning" (Hawkey, 2004).

These four types of learning strengthen a student's want to engage in informal learning by motivating the student to self-guide their own learning outcomes at a museum. The Arts Council in England puts forth a framework to measure informal learning outcomes known as the Generic Learning Outcomes. These differing types of learning relate back to the Generic Learning Outcomes used to guide informal learning and provide insight into the development of this criteria for informal learning. One of the key concepts behind informal education is the idea of active learning, and how it applies to different learning styles. Students visiting museums can relate new information back to prior life experiences allowing the student to take control of

his/her learning outcome. One characterization of the active learning process is construction, conversation, and control established by Sharples (2003). An active learner must construct his/her own understanding, question prior learned concepts, and interpret the results based upon his/her own educational exploration. Through the exploration of an active learner, the student becomes empowered as a learner as he/she can control the learning process rather than passively consuming the information (Sharples 2003).

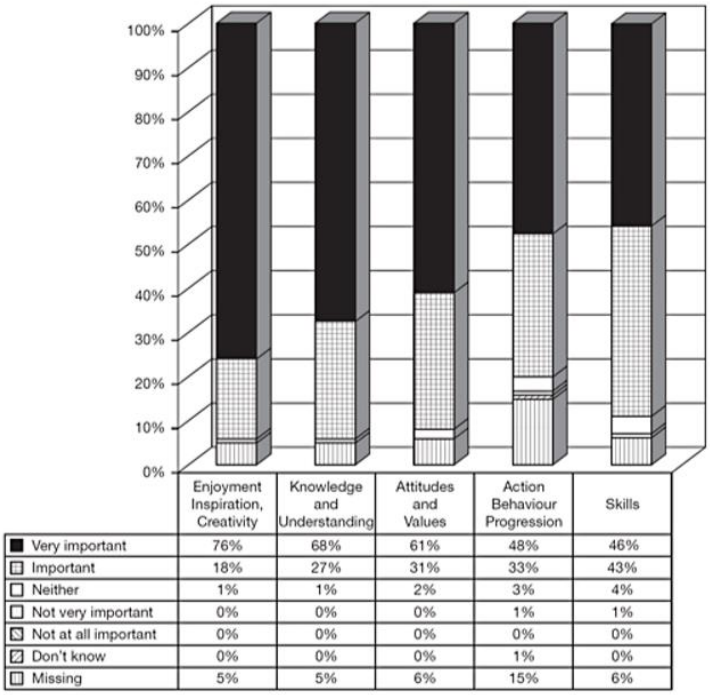
2.1.3: Key stages

The British government established the National Curriculum in 1988 to standardize learning, provide students with a broad and balanced curriculum, and ensure school accountability. It consists of subject based "key stages" which each cover the core subjects of English, mathematics, and science, as well as subjects such as art, geography, history, music, physical education, and technology. Schools teach students the curriculum from ages five to sixteen and each key stage is accompanied by a program of study detailing targets for teachers to meet (House of Commons, 2009). This project focused on creating content for students in key stages 1 and 2. Key stage 1 is taught to students aged five to seven in years one and two. Key stage 2 is taught in the following four years to students aged between seven and eleven. In the years subsequent to its implementation, the National Curriculum underwent periodic revision to ensure the needs of students and teachers were being met. The government introduced a new set of revisions beginning in September 2014 which slimmed down curriculum content to concentrate on the essential knowledge and skills every child should have (BBC, 2014). Under this new, less flexible curriculum structure, museums must work to remain a relevant part of the education system. Offering programs that directly relate to the guidelines of the National Curriculum makes teachers more likely to devote learning time to museum visits. It is important for museums to connect their collections back to key stage targets and have activities that give students a meaningful experience beyond what they would get in the classroom.

2.1.4: Use of generic learning outcomes

In 2008, the Museums, Libraries, and Archives Council developed the Inspiring Learning for All framework to assist informal learning institutions. The Museums, Libraries, and Archives Council transferred the framework over to the Arts Council in 2011. This framework serves as the foundation for the Generic Learning Outcomes used to gauge learning outcomes for informal learning organizations. The five categories of Generic Learning Outcomes are knowledge and understanding; skills; attitudes and values; enjoyment, inspiration, and creativity; and action, behavior, and progression. (Hawkey, 2004) Professor Brown states "none of the GLOs actually measure learning directly, rather they measure indirect factors associated with learning such as whether the experience was enjoyable, inspiring, or interesting" (Brown, 2007). Brown elaborates that the Generic Learning Outcomes are only subjective measures of performance. The closest they get to direct measurement of learning is by examining what visitors say about their own learning or the learning of those they were with. This does not mean that informal learning institutions cannot collect data and evaluate their learning offerings based on the Generic Learning Outcomes. The Arts Council provides several checklists and data evaluation guides for informal learning institutions to improve their learning outcomes.

The Generic Learning outcomes create a set of criteria for informal learning, but it is important to relate these criteria back to formal education. Teachers play an important role in developing the informal learning skills in their students by further facilitating pre-visit and/or post-visit material into their school curriculum as well as facilitating students' visits to museums. For school groups, museums offer a particularly engaging type of informal learning through workshops and active learning sessions. Since it is common practice for teachers to attend museums with their school group, their opinion on informal learning is of great importance. The teacher's opinion on informal learning is important since they will aid in the informal learning process with their students by the teacher's involvement in the museum activities along with engaging their students after the museum visit. Hooper-Greenhill evaluates a teacher questionnaire used by three Research Centre for Museums and Galleries studies on teachers' view of the importance of The Generic Learning Outcomes, presented in Figure 4.



	Enjoyment Inspiration, Creativity	Knowledge and Understanding	Attitudes and Values	Action Behaviour Progression	Skills
Very important	76%	68%	61%	48%	46%
Important	18%	27%	31%	33%	43%
Neither	1%	1%	2%	3%	4%
Not very important	0%	0%	0%	1%	1%
Not at all important	0%	0%	0%	0%	0%
Don't know	0%	0%	0%	1%	0%
Missing	5%	5%	6%	15%	6%

Figure 7.1 Responses to the teachers' questionnaire: Form A, Q.19: 'For each of the following potential outcomes from the use of the museum, please could you rate the importance of each one in your view?' (RR2:2005)

Figure 4: Museum learning outcome importance ranking (Hooper-Greenhill, 2009)

Most teachers ranked each of the five Generic Learning Outcomes as ‘very important’ when visiting a museum, and this indicates that the majority of teacher’s view a museum visit as a learning experience for their students. It is important to teachers that their museum visit provides clear links to school curriculum. Hooper-Greenhill explains, “It is very clear that primary school teachers consistently regard the five potential types of outcome as more important than do the secondary teachers” (Hooper-Greenhill, 2009). This difference in opinion may stem from The British Government requiring primary school teachers to follow a set curriculum. Primary school teachers find it easier to connect the Generic Learning Outcomes to their curriculum as primary school students are not as concerned about memorizing facts as they are developing into future learners. Teachers facilitate many students’ opportunities for informal learning, and this means that teachers must value the Generic Learning Outcome framework for it to be effective.

2.2: Digital Learning in Museums

2.2.1: Benefits of digital learning

Digital technologies are a tool that more and more museums are adopting to enhance the learning experiences of their visitors. Many modern museum visitors are exposed to technology from a young age and have developed the skills to use many different forms of technology (Gallardo-Echenique et al., 2015). Young people's experience with technology is very applicable to school groups, particularly those with younger children. Although an increase in technological competence might create a sense of opportunity for museums, they must also consider the overall effectiveness of digital learning

Some major advantages of using digital technologies are the potential to strengthen several key aspects of museum learning. Two important aspects that digital learning can assist with are participation and collaboration (Hawkey, 2004). In a traditional museum style, visitors receive information from an exhibit without much of an opportunity to contribute. There is also less opportunity for social interaction between visitors. Digital technologies allow visitors to participate in a more active way, and often make collaboration and social interaction easier (Hawkey, 2004). For example, visitors can use devices to learn actively by creating something related to an exhibit, or by working with other visitors to solve a problem. Another notable benefit of digital learning is the opportunity for personalization. A study done at the National Gallery of Denmark explored how digital technologies affected the experiences of individual people (Myrczik, 2014). The study found that many visitors were able to successfully use technology to satisfy their personal needs. The technology acted as a tool for connecting the knowledge users were receiving to the knowledge they already had. The study also found that the use of technology raised enthusiasm among users (Myrczik, 2014). If informal learning can help students make connections between incoming knowledge and existing knowledge, it helps teachers tie the museum material back to their curriculum.

2.2.2: Use of mobile devices in museums

A growing number of museums want to seize the opportunity to implement digital learning, but they need to consider carefully how they might do so. An important one is that there are numerous different styles and methods to choose from when implementing digital

learning (Hawkey, 2004). for a museum to facilitate digital learning effectively, it must first select an appropriate method of implementation. Using the wrong type of technology or using technology in the wrong situation will decrease the benefit received from digital learning and detract from the overall visitor experience.

The Postal Museum has selected mobile tablets as their device of choice for the implementation of digital learning. Mobile devices such as smartphones or tablets have several advantages. One advantage that they are very familiar to most visitors. As of 2017, 94% of UK adults between the ages of 16 and 24 own a smartphone, and 60% of that demographic own a tablet (Communications Market Report, 2017). Mobile devices are also portable which gives them greater flexibility in terms of what types of content they can offer. One static screen or set of content does not limit them, so each user can have their own individual experience using a mobile device. There is doubt, however, as to their usefulness in a formal learning environment (Thinley et al., 2014).

Whether or not mobile devices in museums are educationally effective has been the question at the center of several studies. The National Museum of History in Taiwan performed one of these studies in 2014 (Hou et al., 2014). The study involved college students visiting the museum using three different learning modes and taking a test afterwards. Some students experienced a traditional museum visit, some used paper learning guides, and others used mobile devices as a guide. The study found that the group using mobile devices had a measurably better experience than the other two (Hou et al., 2014). The mobile group scored significantly higher on the post-visit exam, even though they did worse on the pre-visit exam. They also exhibited more engaged and active behavior than the traditional group (Hou et al., 2014). Although it does not include the target demographic of The Postal Museum, this study shows that mobile devices can aid in the learning process.

Although they have been shown to work in some cases, not everyone agrees that mobile devices are a good way to implement digital learning. Sigurd Gronemann conducted a study across five museums in Denmark which suggested that tablets do not have a strong positive effect on students (2016). Students tested prototyped digital content provided to them on a tablet, and then participated in a focus group interview. Gronemann stated that students questioned the usefulness of the tablets and many had a generally apathetic response to the technology. He also

posited that using tablets could subvert some student's expectations of what their museum experience would be like, which can create tension. Ultimately, the study concluded that students see digital technologies differently than adults and are prone to question and challenge its worth (Gronemann, 2016).

There exists research that suggests that digital learning is beneficial, and research that casts doubt as to the educational benefits of giving tablets to students. Whether the use of digital technologies will be beneficial for The Postal Museum is an important question, but it is not one that can be answered with secondary research alone. After conducting further primary research, the team will address this question.

2.2.3: Best practices of museum technology

There is limited research regarding the development of applications which promote engagement and interactivity in museums. Few studies have assessed museum technologies created to enhance user experience (Pallud and Monod, 2010, p.563; Meisner et al., 2007). Our studies also include the use of electronic devices throughout museum exhibits to understand further the benefits of its incorporation.

Koula Charitonos et al. performed a study in 2012 that tracked student's usage of social network site Twitter during their visit to the Museum of London. The purpose of the study was to encourage the students to tweet about their experience with the exhibits and engage with other students' posts. The study found that students remained engaged in their self-guided tours even when given access to the internet in such a way (Charitonos et al., 2012). Technology served as a major point to facilitate the students' internalization of the information gained through the galleries while holding their attention despite the potential wandering Twitter allows. In addition, students were able to derive more meaning from exhibits when reacting to others' posts than they would have without access to Twitter (Charitonos et al., 2012). This suggests that recording and presenting student interactions through technology aids students in engaging with exhibits and retaining information. Although this study involved a group of year nine students, the implications still hold merit for use with a younger audience and provide invaluable insight into mobile technology use within school groups.

In museums, visitors may interact with exhibits through user performances. These performances heighten the appeal for visitor activity not only for those interacting directly, but also for onlookers (Meisner et al., 2007). Integrating technology in a way that promotes performance allows exhibits to reach and engage audiences more thoroughly. to facilitate performances and interactions, Meisner et al. found that the interfaces of devices should "take into consideration the complex and contingent nature of social situations arising in museums" (Meisner et al., 2007, p.1550). Contrary to traditional design practices which include simplifying interfaces as much as possible for new users, implementing complexity in museum applications promotes thought in visitors.

Beyond assessing interactions, experts have described the purposes that technology should fulfil in museums. A forum conducted by the Exploratorium Museum details that implemented electronics should offer an experience different from what you could find in the museum (Exploratorium, 2001, p.8). Technology can evoke a response from viewers through varying its content and applying an experience that is unobtainable in person. The Exploratorium also found that implemented technologies may effectively fit into four different categories within the museum;

- Informer which provides more information on a topic. This includes activities intended to derive learning from interactivity
- Suggester which provides suggestion on what to do or where to go next based on what the user is currently and has already done
- Communicator which provides interaction with other visitors
- Rememberer which provides an experience outside of the museum to remember and incite future visits

By remembering the roles that an application should fulfil the developer may more easily drive the program to assist the visitor. Technology also serves a role of reinforcing the atmosphere of the museum. Both the forum produced by the Exploratorium as well as a study performed to test the use of an electronic quiz system in a museum in Japan assert that integrating devices should not disturb the social environment of the museum (Electronic Guidebook Forum, 2001; Yatani et al., 2010). Being in a museum includes being surrounded by

others who are appreciating the same works and exhibits. This allows visitors a chance at discussion or to take their surroundings into consideration when taking meaning from what they see. The use of a device while in a museum should not detract from this frame of mind. Myrczick asserts that museums must implement technology in a way that is familiar to a user to provide ease of use as well as maintaining structure in a museum (Myrczick, 2014). Familiarity acclimates users to their environment quickly and will draw visitors past the distraction of viewing a screen to the content within. A good application will draw on the user's expectations and affordances to facilitate use. When implemented poorly, technology draws attention away from the exhibit. Applications that require extended time to master basic functionality or betray user expectations hinders user progress.

2.3: Current Offerings of The Postal Museum

2.3.1: Gallery content

The Postal Museum strives to educate the public on the history of postal services in England and provide access to their vast collection of historic letters and postal antiques. The Postal Museum describes their mission through their website this way: "We exist to showcase our stories and collections and reveal the fascinating story of Britain's postal heritage in an engaging, interactive, educational and fun way." In July of 2017, The Postal Museum opened a new facility with a larger space to display their collection of pillar boxes, posters, delivery vehicles, and more. A winding hallway contains the main gallery featuring important eras in the history of the postal service.

The museum divides its main gallery into five sections that they refer to as zones. Zone one details the origins of the postal system and the early lifestyles of postmen. Zone two describes how the postal system changed to allow commoners to send mail and introduced the first stamp. Zone three chronicles the post office's efforts in times of conflict. This includes conveying the importance of arming postmen with weapons, allowing women to fill jobs, and delivering messages during wartime. Zone four describes the postal service's major remodeling and shift in marketing strategy in the mid-twentieth century. The section includes a small theater that plays a selection of short films related to the postal service. Zone five details how Royal Mail transitioned into modern times and includes stories from past and current postal workers.

Each zone serves to teach visitors about the importance of the postal service during their respective times. In addition, the end of the gallery includes a space featuring temporary exhibit pieces. The current temporary exhibit, *Voices from the Deep*, describes the sinking of the S.S. Gairsoppa and the preservation of letters found at the bottom of the sea. Figure 5 shows the layout of the zones within the gallery.

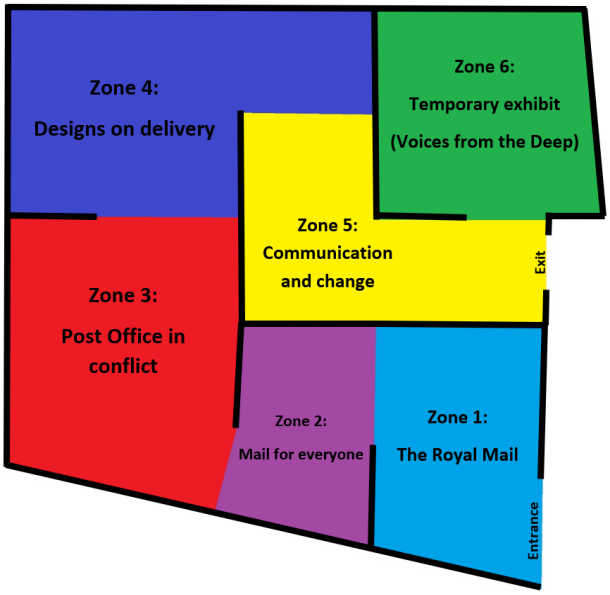


Figure 5: Exhibition layout

2.3.2: Options for educators

Educators have a multitude of options available when planning to visit the museum. The Postal Museum provides many programs which offer additional learning for various key stages. Included are storytelling sessions and presentations on the relevance of the postal system during times of war (The Postal Museum, 2017). These pre-scheduled activities provide more structured learning than the gallery exhibits allow. The programs vary in content based on the intended audience, which ranges from the younger foundation stage and key stage 1 children to the older key stage 2 students and beyond. In contrast to the structured, tailored offerings of the special programs, the museum allows groups to conduct self-guided tours through the gallery. This section contains many displays showcasing the vast collection of postal items that are kept there and at the museum's storage facility. According to a detailed brief pertaining to our project, The Postal Museum describes how "feedback from schools has indicated that the quality of

engagement within the school visit is not consistent" (*WPI Student Brief*, 2018). The brief cites the differences between the structured, engaging programs with museum staff and the chaperone-led, unstructured in-gallery experience leading to varying degrees of engagement in the latter section. The museum believes that LearnPads are the means to bridge this divide.

The Postal Museum implements technology throughout its facilities to enhance the experience of students and visitors. *Mission Colossus* is a game made by the museum to teach players about the creation of a code breaking machine used during World War II named Colossus. Using technology to play this game allows students to have an almost hands-on experience and gain unique insight into the topic. The gallery is also filled with various interactive screens which allow visitors access to additional information. For example, *Journey of the Mail Coach* is a story-based game which guides viewers through the responsibilities of a postman delivering the mail around the year 1800. The gallery also includes a table with a touchscreen interface which allows visitors to interact with various objects on display. Dragging an object to the center the screen displays further information on related subjects.

Several of these implemented technologies serve as a new source of information for visiting students. Our project aimed to implement technology to enhance the student's gallery visit without infringing on the experience already provided. to meet this goal, The Postal Museum invested in new, interactive devices: LearnPads.

2.4: LearnPads and Content Development

2.4.1: Device overview

LearnPads are educational, Android tablets used in coordinating lessons and allowing ease of use in facilitating many students at once. The Postal Museum has 20 units for visiting school groups to use.

LearnPads are specialized tablets generally used in classroom settings. The tablets allow teachers to create lesson plans that provide students with resources in a straightforward manner. ClassConnect is the online interface used to create these lesson plans, as well as track groups of LearnPads that are on the same Wifi network. The site can display information on each connected tablet allowing a teacher to control the devices remotely. ClassConnect also

incorporates distribution and collection of files from the LearnPads as a substitute for physical handouts and submissions.

2.4.2: Museum relevance

LearnPads include many built-in applications that are beneficial in educational environments, including an office suite for editing various file types, a workspace for keeping notes, and other standard resources. Many of the pre-existing resources provided through the LearnPad include links to websites and applications specifically produced for classrooms.

The LearnPad comes equipped with front and back-facing cameras making it especially effective at taking pictures. The devices also include a QR code scanner which allows the teacher to download lessons directly. This capability introduces the possibility to provide content related to specific exhibits easily without requiring an overpopulated and confusing menu system.

There are some premade applications which may be beneficial when used on LearnPads in the museum setting. The program PicCollage allows users to take pictures and create their own collage for submission or sharing. Animator is an application that allows the user to create stop-motion animations by taking pictures. These programs provide students with a creation-based experience that could facilitate learning in the museum gallery. The abundance of available applications provides a flexible means to cater to different learning styles.

One point of concern in relation to available applications is that many of them include some material or advertisements not suited for a learning environment. Although the company behind LearnPads advertises the ability to install applications directly to their devices (avantissystems, 2012), the tablets no longer support this feature. Installing original apps requires a user to upload their application to the Google Play Store, download it to each LearnPad, and add a shortcut to the app in the lesson.

Museums promote an informal learning environment that allows visitors to absorb information in ways different from schools. This environment augments the educational capabilities of modern, digital devices. The Postal Museum offers a wide variety of structured school programs while presenting an unstructured gallery visit. Classroom use is the primary application of LearnPads, however they are also capable of providing children with a more structured and valuable experience within the informal gallery setting. When examining studies

related to the use of technology in museums, there is a gap between available sources and our own objectives. Many studies focus on the use of digital interfaces when incorporated into specific exhibits. Others analyze the effectiveness of mobile devices as guide tools for general visitors. Our methods will strive to fill the gaps between these areas and our target audience by finding ways to engage key stage 2 students using technology while meeting national learning objectives.

Chapter 3: Methods

The goal of this project was to identify how The Postal Museum might deploy LearnPads to improve the effectiveness and consistency of the in-gallery experience of school groups visiting the museum. To achieve this goal, the team identified three main objectives with associated tasks:

1. Establish current practices in the use of digital technologies for school groups visiting museums and evaluate their effectiveness.
2. Assess the needs and expectations of The Postal Museum and its target audience (teachers and students) for the LearnPad technologies.
3. Design, develop, and evaluate appropriate content and activities for delivery on the LearnPad technology.

The Postal Museum planned a set of focus groups with Information and Communications Technology (ICT) lead teachers and their students. The team conducted focus groups within the first three weeks of the project and the outcomes of these focus groups were the primary source of feedback from our target audience. The team also made visits to other relevant museums to assess technology implementation for school groups across the museum sector.

The staff at The Postal Museum facilitated every interaction with teachers and their students. Prior to conducting any research, the team received permission from the teacher or the leader of the relevant school group. No students were interviewed, photographed, or recorded. Additionally, we collected no identifying information from the students. The team presented different potential activities for the LearnPads during the focus group to gather written and verbal feedback from the students.

3.1: Objective 1- Identify industry benchmarks

Our first objective was to establish effective uses of digital technologies in museums. We supplemented our background research on this topic by visiting several museums which integrate digital interfaces into their exhibits and school programs. While visiting museums, we observed how each museum used the technologies and interviewed the staff members responsible for developing and implementing the interfaces. We explored how the applications combine audio

and visual elements, how multiple users can interact with them at once, and how museums incorporate them into into physical exhibits. The team established benchmarks and development goals by observing the effectiveness of techniques used by other museums. We incorporated these findings into our own design to ensure that our recommendation meets the needs of The Postal Museum.

Our team performed observations at different museums chosen in conjunction with our sponsor to establish industry benchmarks. We chose these museums because they have adopted some of the most innovative technology interfaces, especially with respect to school groups. This list includes the following museums in London:

- Museum of London
- The British Museum
- Victoria and Albert Museum

These museums all offer programs for schools which feature technology as a major part of the informal learning experience. Our team conducted a combination of site visits, observations, and interviews at these museums. Each interview tailored to the offerings of the specific museum. Appendices A, B, and C contain the specific questions asked at each museum.

The interviews conducted with each museum differed in structure and content to fit the different offerings and information available prior to our visit. We conducted our first interview with the Museum of London and incorporated questions pertaining to the museum's use of tablets for school programs. In the following interview with the British Museum, our team included new questions which surfaced during our time with the Museum of London. These questions pertained to specific applications used on devices and privacy related issues. The team worked through a similar process for our final set of questions developed for the Victoria and Albert Museum.

In addition to interviews, the British Museum and the Museum of London allowed our team to observe student sessions that incorporate smartphones and tablets. The program at the Museum of London, create a Great Fire animation, consisted of students handling objects recovered from the Great Fire of London, as well as creating an animation that related to the fire. The program at the British Museum, decoding ancient Egyptian tomb paintings, had students

answer questions on phones and use tablets to create their own “tomb paintings.” The students used photos of themselves taken in front of a green screen and superimposed them onto a background of their choosing. The British Museum also let us try out one of their self-led school sessions called achievements of the Shang dynasty. We did not observe students, but we did get to run through the entire program and see what the students would be seeing.

Appendix D provides the template the team used to record observations on these sessions. This assessment is split into three parts: exhibit information, group structure, and the Leuven Scale for Involvement. We designed the first section to gather more information on the devices and applications that the students engage with during the session. The second section records the structure of groups when using devices. The final section uses the Leuven Scale to determine the engagement of students while interacting with the provided application. The Leuven Well-Being and Involvement Scales is a two-part system used to observe and document a person’s emotional state and level of engagement. The system ranks individuals on a scale of one to five for their level of well-being or involvement. Well-being refers to being at ease and free from emotional tension. Involvement refers to being intensely engaged in activities (Plymouth City Council, 2011). Our assessment uses only the scale for involvement to determine how interested students are in the program they are given. For this application, the scale for emotional well-being is irrelevant. This assessment allowed our team to observe student engagement with and handling of digital devices.

3.2: Objective 2- Evaluate needs and expectations

Before developing content for the LearnPads, the team assessed the needs of The Postal Museum and visiting school groups, as well as what they expect from LearnPads. To accomplish this objective, the team evaluated current practices in The Postal Museum and determined how well these practices meet expectations of students and teachers. Additionally, the team identified what teachers would require to participate in a program utilizing LearnPads and what types of activities would appeal to students.

Current educational offerings at The Postal Museum include facilitated school programs as well as an interactive exhibit space. The team used observational studies as a preliminary way of becoming familiarized with The Postal Museum’s offerings and assessed how well they were

meeting the needs of school groups. The team focused on observing school groups in the exhibit space rather than in facilitated programs because this is where The Postal Museum aims to implement the LearnPads.

During observations of in-gallery visits, the team worked to answer a set of research questions. The team collected data from multiple key stage 2 groups visiting The Postal Museum. Appendix E contains methods of data collection including field notes and an engagement scoring table. This table assigns point values to positive and negative behaviors exhibited by visitors to quantify observations. Positive behaviors include interacting with the exhibit or starting a conversation based on the exhibit. Negative behaviors include completely passing by the exhibit or engaging in unrelated phone use. We analyzed the data collected from the observational studies using thematic analysis. A full outline of the research questions along with the anticipated observational study procedure is in Appendix F.

To evaluate the expectations of teachers and students and determine how well these expectations are being met, the team utilized multiple focus groups and a semi-structured interview. To get a preliminary perspective on teacher opinions regarding digital learning and teacher expectations for a museum visit, the team conducted a semi-structured interview with Claire Brown, the Head of School at Winton Primary School. We conducted the interview via phone and structured it around a set of questions found in Appendix G. We also used the interview to assist the team with structuring subsequent focus groups.

To determine which games and other types of digital content students are familiar with as well as discover what types of activities students find engaging, the team conducted an hour long focus group with a class of Year 5 students from Winton Primary School. The teacher of this class and a member of The Postal Museum staff supervised the focus group. We supplied students with Post-It notes and markers to write their responses to various questions. After each activity, we gave the students the opportunity to share and put their Post-It notes on a large sheet of paper at the front of the classroom. This allowed the team to gather feedback for later analysis. First, we asked the students to write down their favorite museum or place to visit and why it was their favorite. This activity served as an icebreaker and allowed the team to create rapport with the students. Next, the team asked the students if they use tablets or phones, where they use them, and what their favorite online activities are. The purpose of this exercise was to determine how familiar students are with digital technologies and what they like to do with it. Students then

wrote down their favorite digital games and why they liked them. Like the first activity, we gave students a chance to share and then place their Post-It notes on a new piece of paper. To guide the conversation, the team prompted students with questions such as:

- What is your favorite part of the game?
- How long do you spend playing the game?
- Are there different levels that you can win?
- Who do you play as in the game?
- Can you compete with friends in the game?
- What do you play the game on?

The final activity was the most involved and introduced the students to potential LearnPad content. We placed students into small groups and each group was overseen by a member of the team. The team created five activities based on findings from museum program benchmarking. We presented each activity to the groups and at the end asked students to write down their feedback. Students could not complete each full activity due to the time constraint of the focus group.

The activities we presented to the students are as follows:

1. **"Find-It"-** Students viewed a prompt-based scavenger hunt in which they would find different items around the gallery. (Appendix H)
2. **Quiz-** Students studied an example of a multiple-choice quiz based on items and information from The Postal Museum. (Appendix I)
3. **Collage-** Students looked at a sample collage made from pictures of items found in The Postal Museum exhibits. An actual collage would be created by students using pictures they had taken during their visit. (Appendix J)
4. **Puzzle-** Students assembled a puzzle from pieces of a picture related to history of the British post. (Appendix K)
5. **Postcard-** Students viewed sample postcards. They would draw their favorite place on the front and write as if they are describing the place to someone who has never seen it on the back. (Appendix L)

After presenting all the different activities, we asked students to rank them. Following ranking, we asked students to give feedback including what they liked and disliked for each. This focus group exercise allowed the team to determine what draws students to specific activities and how students react to different styles of learning. A full timetable of the focus group can be found in Appendix M.

The team conducted a teacher focus group to assess teacher opinions on the use of digital learning in the school environment and the museum environment. Eight teachers with expertise in Information and Communications Technology (ICT) participated in an hour and a half long session led by the team. First, we asked the teachers if they had visited The Postal Museum before, how their experience was, and how they would tie a visit to the museum into their classroom curriculum. This allowed the team to establish how much the teachers knew about The Postal Museum and their general opinion about it. Second, we asked the teachers about the digital games their students play at home and if they have tried to integrate them into the classroom in an educational way. We also asked if they were familiar with LearnPads. This set of questions served to gauge if there was a disconnect between the way students and teachers view digital activities, as well as discover general opinions towards LearnPads. Next, the team led a discussion about digital learning. We prompted teachers to share their experiences with digital learning and its influence on their careers, how teachers should use digital learning in informal learning environments (i.e. museums), and how digital learning in museums should tie back into curricula.

We structured the second half of the focus group around LearnPad content and the implementation of tablets in The Postal Museum. The team developed and presented two example activities on the LearnPads. We provided each teacher with a LearnPad preloaded with a lesson containing two activities: a structured multiple-choice quiz and a creation-based collage. The team gave the teachers time to familiarize themselves with the LearnPads and try each option. After completing both activities, we asked the teachers a series of feedback questions to determine what type of approach would be most fitting for a student group application. Our team asked teachers questions about tablet related privacy concerns, pre-visit and post-visit supplemental material, as well as how students should share tablets. As a final exercise, we asked the teachers to discuss what would make them consider using tablets during a visit to The Postal Museum. This allowed the team to determine the unique selling point of The Postal Museum

with respect to LearnPads. A full timetable for the focus group and a set of accompanying questions can be found in Appendix N and Appendix O. The findings from the teacher interview, the student focus group, and the teacher focus group gave the team critical insight into how to proceed with the third objective of the projective.

3.3: Objective 3- Design, develop, and evaluate

This objective focused on the manifestation of our research into potential LearnPad content for school groups visiting The Postal Museum. The team developed content for LearnPads using the software development life cycle depicted in Figure 6. The team compiled a list of criteria based on findings from our research prior to designing content. Next, the team worked towards creating prototypes for potential content by working through iterations of mockup designs and storyboards. After creating a final prototype, the team conducted user tests and gathered feedback. Based on this feedback, the team made recommendations to The Postal Museum about what type of LearnPad content to implement for visiting school groups.

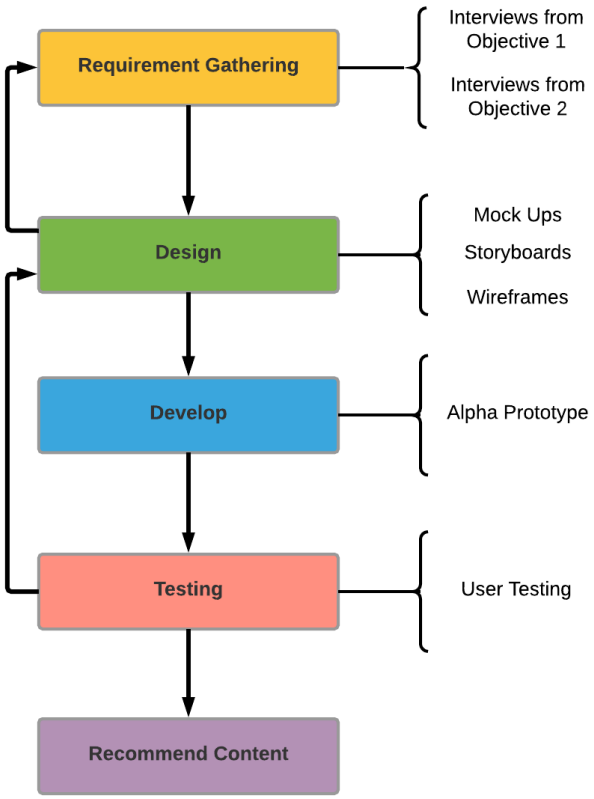


Figure 6: Software development life cycle flowchart

To accomplish the design phase of our third objective, the team compiled a list of potential features and user interface styles based on findings from objectives 1 and 2. We developed this list through a series of brainstorming sessions which promoted lateral thinking and allowed for the expansion of our ideas. Next, the team identified promising ideas and created preliminary designs for LearnPad content using iterations of sketches and storyboards. Once the team settled on a final interface design, we transferred the design over to a storyboard. The storyboard allowed us to outline our ideas and show features which would be too complex to make in an alpha prototype. Appendix P presents a copy of the paper storyboard.

Next, the team moved on to the creation of an alpha-prototype based on the design structure of the storyboard. Using the web application Proto.io, we developed a prototype with basic functionality that students could use in the gallery. We also used this prototype to determine what activities and design choices students liked. The prototype included a variety of activity types including:

- Answering multiple choice questions;
- Looking around the gallery and describing what you see;
- Choosing your favorite posters from the wall in zone four;
- Searching for items in the gallery based on a poster clue;
- Counting items in an exhibit (eg. novelty stamps);
- Selecting vehicles used to deliver the post, and;
- Listing your favorite games displayed in zone four

These activities related to material from all five zones of The Postal Museum. The team selected material based on conversations with relevant museum staff and an archivist. Appendix Q contains the full student focus group prototype and Appendix R presents the accompanying screen diagram for the prototype.

The team presented the prototype design to a group of potential users during a student focus group at The Postal Museum. The group of students consisted of the same class that participated in the first student focus group. As part of their school visit, we presented our final design to the students and gathered feedback. We structured the focus group to consist of two sessions, an in-gallery session using LearnPads and a separate feedback session. During the in-

gallery session students walked through the exhibition in pairs using a LearnPad loaded with the alpha-prototype. We placed students into groups of two prior to them entering the gallery, and gave each pair a LearnPad. The in-gallery session lasted approximately an hour and students did not have a time limit for how long they could use the LearnPads.

The team structured the afternoon feedback session around a set of activities designed to evaluate the effectiveness of the LearnPad application. For the first half of the session the team worked with the students in a large group. First, the team asked students to write down their favorite part of their visit. This served as an icebreaker activity and a way to review what students had seen. Reviewing the students' visit also allowed the team to bring the focus back to the morning gallery session. The team presented screenshots detailing different aspects of the LearnPad activities. This allowed us to evaluate the students' experience with the activity and determine what specific features they enjoyed. In the second half of the feedback session, the team organized students into four small groups and each team member facilitated a group. Students began by ranking the different activities within the LearnPad application, allowing the team to determine which one was most engaging. For the final activity, students discussed a set of facilitated questions relating to their overall experience. Students took turns choosing a notecard with a question, reading it to the group, and leading a discussion based on the prompt. This allowed the team to evaluate students' retention of The Postal Museum's content. Appendix S details the timetable for the second student focus group and questions used to structure our discussion. To gather feedback from the teacher and accompanying chaperones the group distributed a post-visit survey during the small group portion of the session. This survey contained questions relating to the visit quality and chaperone opinions towards the LearnPad activity. Appendix T displays the full survey that the teacher and other chaperones received.

This preliminary user testing concluded the final section of our third objective. The team completed objectives one and two in preparation for providing content and recommendations for the LearnPads. These objectives tied into the design section of Objective 3 and allowed us to bring our ideas to fruition. Based on this design process, the team was able develop a prototype to provide proof of concept to The Postal Museum. In conjunction with the other methods described above, the findings resulting from these methods allowed the team to evaluate and identify how The Postal Museum might use LearnPads to improve the school group experience.

Chapter 4: Findings

Our team worked to accomplish each of our objectives using the methods outlined in the previous chapter. The outcomes of these objectives and their associated tasks produced the findings detailed in this section.

4.1: Objective 1- Establish current practices

This objective of our research focuses on how museums are using digital technologies to help improve the experience of school groups. In order to gather this information, the team visited museums that incorporated technology into their school programs. We observed relevant school programs and interviewed staff members responsible for creating these programs.

4.1.1: Museum of London

At the Museum of London, we interviewed two staff members who work to incorporate digital technologies into school programs. They believed that devices should promote creativity rather than provide supplemental information. The Museum of London staff also felt that students were more engaged when they could create something of their own, as opposed to being given more information. Some examples of things that students might create at the Museum of London include collages, videos, animations, and mind maps. The staff members also noted that their programs primarily featured pre-existing apps, instead of ones created specifically for the museum. They felt that finding creative ways to repurpose existing apps was a more effective use of time and money than developing original apps.

Not only were their answers useful, but they also brought up several points that we had not considered. For example, the Museum of London staff members spoke about the challenges of charging and prepping tablets prior to each session. They stated that having a dedicated member of staff assigned to handle this would be optimal, but it is not always feasible because of the potential strain on the IT department. Another concern that the staff brought up was how to handle sensitive information, particularly photos of children. Many school programs that use digital technology often have students taking pictures on the devices they are using. Storing photos taken by students, especially those of themselves or other students, poses a privacy risk. Museums must remove photos from the devices regularly, whether manually or automatically.

This concern also ties into the previous idea of having a dedicated person to manage the devices. If there was a dedicated staff member handling the devices, they could manually clear the photos, but this is still expensive and difficult. Appendix U outlines our full list of key findings from this interview with the staff at the Museum of London.

In addition to the interview, the team also got a chance to observe the create a Great Fire animation program at the Museum of London. The students created animations which told a story related to the events of the Great Fire of London using an app called Puppet Pals HD, which seemed to work well and kept the students engaged. From this observation, the team learned about how digital content is effectively mixed with physical and historical content. The facilitator kept the tablets out of view while not in use, and only presented them when it was time to complete an activity with them. This created a "wow factor" for the students, which got them excited and made them instantly engaged. We learned that chaperone involvement is important and needs to be consistent. When some chaperones are more involved than others, it affects the students' experience. Appendix V details the full list of observations the team documented during this session.

4.1.2: The British Museum

At the British Museum, we interviewed an education manager for the Samsung Digital Learning Program and talked about various topics relating to digital learning. We discussed the concept of using tablets in groups and found out that two or three students is the optimal group size. The team also inquired about using existing apps versus developing specific ones and learned that the British Museum does some of both. Some of their school programs rely on pre-existing apps, some use apps developed by the museum, and others use apps that the museum paid a third party to develop. The museum was shifting more towards in-house development, since that was the most cost-effective option that worked for students. They also stated that they preferred to develop apps only for exhibits that were either permanent, or ones that were unlikely to change for a long time.

During our interview at the British Museum, we discussed some of the concerns brought up by staff at the Museum of London. When asked about the concept of having an individual assigned to managing the tablets, the staff member at the British Museum said that they did not find that to be necessary. They felt that with some basic training, most staff members could get

the tablets ready for school visits. He stressed that it was important to keep maintenance simple, to minimize room for error. If all that a staff member must do is plug in the tablets and pull up a screen, it makes it easier to find someone to do the job. We also found that the museum used multiple approaches to address the concern of sensitive information being stored on devices. After a facilitated session inside the Samsung Digital Discovery Centre, the teacher of the visiting school group leaves their email address. The program facilitator sends student-created content directly to the teacher, and then manually removes all photos from the tablets. Disabling the camera when students use the devices in a non-facilitated gallery session removes the need to delete photos, making maintenance easier. Appendix W presents the full list of key findings from this interview with a member of staff at the British Museum.

When observing the decoding ancient Egyptian tomb paintings session, we saw a lot of strategies that worked well and kept the students engaged. The first thing that stood out was how clear the facilitator was about behavioral expectations. The facilitator reminded the students multiple times that they needed to treat the phones and tablets with care, and it seemed to help the students to act carefully. The students worked in groups of three, which worked well for most groups, but not perfectly. The students shared the tablets well, but a couple of students were left out of discussion and decision making. This was in a single room, so group dynamics may be different in a gallery setting. We also noticed that mentioning phones or tablets generated interest among the students and got them excited. Students used the app, Photolayers, to make their "tomb paintings." This app is not specific to the British Museum. It appeared to work well for the students, and the team found it intuitive when we tried it ourselves. We also saw that students navigated from the tablet home screen into the app themselves and did not have a problem figuring it out. As a matter of fact, students had no trouble using any technology during the session, even though they were only key stage 1. Appendix X provides the full list of findings from this observation session.

The team also ran through a self-guided program at the British Museum intended for key stage 2 school groups. It involved using tablets to explore a small section of one of their galleries to make the user think critically about the artifacts they were viewing. The program takes roughly between forty minutes to an hour to complete and covers artifacts in two display cases. The main observations the team made had to do with the way the program tied museum content to the activity. Students must make observations and read the artifact descriptions to answer

questions and complete tasks. Once they complete a task, the program provides supplemental information that students read before continuing. There were six tasks in total, each of them appealing to different skills and learning styles, whether it be reading, counting, acting out, etc. This helps to ensure that the program is engaging for a wide variety of students. The museum designed the session for groups of two, which we thought worked well. The team also liked the way the program prompted users to share the tablets. The students enter their names at the beginning and receive prompts to switch between users. The program presented the prompts in an unobtrusive way, and it did not interfere with the user experience. Another thing that we wanted to examine was how in-house development compared to third-party development. The British Museum developed the program we tested in-house, and while it achieved many of the objectives it set out to do, it was not as crisp or as clean as a third-party app would be. The webpage was often slow and unresponsive, and even crashed once. A third-party application would provide a less frustrating user experience, even if the content was the same. Overall, we thought the program was not without its faults, but it was effective and did a good job of tying the activity to the museum galleries. Appendix Y provides a complete list of our findings from this in-gallery session at the British Museum.

4.1.3: Victoria and Albert Museum

In the team's interview with a representative from the Victoria and Albert Museum (V&A), we discussed the implementation of tablets in a gallery setting. We found that the V&A does not often use tablets with key stage 1 and key stage 2 groups. They do most of their digital learning with older audiences, usually outside of formal education. Nevertheless, we still discussed some ideas for effectively using tablets in museums in general. Being an art and design museum, they typically use tablets in a creative sense. Participants often engage in some form of drawing, sketching, or photography while in the galleries. The representative stated that we should be careful not to design a program that is too immersive, especially since children are the primary audience. He said that there is a real risk of students spending all their time in the galleries with their attention consumed by a device, ignoring the actual museum content. The other main point that he shared with us was that it can be beneficial to have multiple different types of activities. Most school groups will have students with a variety of learning styles, and it is important to cater to as many as possible.

4.2: Objective 2- Assess needs and expectations

The second objective of our project was to assess the needs and expectations of The Postal Museum and its target audience (teachers and students) for the LearnPad technologies. The team conducted a teacher interview, a student focus group, and a teacher focus group to determine how to implement the LearnPads within The Postal Museum effectively. Performing these tasks showed the team ways to standardize student engagement of visiting school groups at The Postal Museum.

4.2.1: The Postal Museum gallery observations

To gauge the effectiveness of current offerings at The Postal Museum with respect to maintaining student engagement, the team conducted in-gallery observations of school groups from key stage 2. The team used a combination of field notes and an engagement scoring table for data collection. Appendix Z presents key findings from the field notes.

The student groups maintained a higher level of engagement with interactive exhibits as opposed to text-based exhibits. On average, the interactive touch screen exhibits appeared to hold the students' attention the longest. For example, the exhibit where someone can take a picture and use it to design a stamp was one of the few exhibits which students would wait to use. Students would skip over most exhibits if they were too crowded or if they were required to wait their turn to use them.

Students went through the in-gallery sessions in small groups overseen by a chaperone. The students further divided themselves into groups of two or three and looked at exhibits that interested them. The team observed that students explored in small groups and they were rarely alone. After completing our in-gallery observations at The Postal Museum, the team determined that students required interaction with museum exhibits to maintain engagement, and that students preferred to go through the gallery in small groups.

4.2.2: Winton Primary School interview

To gather a teacher's perspective on digital learning and their expectations for school visits to museums, the team conducted an interview with the head of school at a local primary school. This interview provided us insight into how much experience students have with digital technology, as well as what materials teachers need to facilitate a successful school visit to a museum. This interview also allowed the team to familiarize themselves with the school they were going to be working with. From this interview, the team found that students often come into school with prior exposure to digital technology. This allows students to use tablets in the classroom or school visit setting with little instruction on how to operate them.

Additionally, the head of school provided their opinion on what materials museums have supplied for visits in the past, and what teachers require to consider a visit successful. Museums often provide pre-visit material in the form of a PDF document that is accessible online via the museum's website. This type of document outlines the school session at the museum and details which key stages the session ties in with. The head of school had not visited any museums which sent material for after the school visit, however they were interested in having anything the students created during their visit sent back to the school by email. The head of school could then relay this material back to their students. Appendix AA details a list of our findings from this interview. The team sought out insight on what makes a successful school visit to a museum and how much exposure students have to digital technologies so that we could assess the needs and expectations of teachers and students when attending a school visit.

4.2.3: Student focus group (activity evaluation)

A student focus group assisted the team in establishing the needs and expectations of students when attending a school visit. During the focus group, we presented multiple activities in consideration for use on the LearnPads in a gallery setting. The findings allowed the team to determine what attracts students to specific activities and how students react to different styles of learning.

The students enjoyed the range of activities presented to them, and this enforces the idea that a program involving digital technologies should utilize a variety of activities. The students

also mentioned that they would rather overcome a challenge than take in basic information. Prior to our focus group, the students visited the British Museum on a school visit and completed a scavenger hunt activity on smartphones. The students spoke highly of the British Museum's scavenger hunt session because they found it to be fun and challenging.

Another activity the students enjoyed was the collage, but they also provided suggestions on how to improve the activity. The students liked using a combination of pictures they took of themselves along with stock gallery photos to make the collage, rather than only using pictures of the gallery. Overall this student focus group allowed the team to gather feedback on potential activities for use on LearnPads during in-gallery school visits to The Postal Museum. Appendix AB shows a detailed list of our key findings from the student focus group.

4.2.4: Teacher focus group

The team gathered teachers' opinions on the use of digital learning in the school environment and the museum environment through a teacher focus group. The focus group consisted of nine teachers with various expertise on key stage 2 and digital learning. Having a group of teachers specializing in these areas allowed the team to gauge what teaching strategies are the most effective when using digital technology along with what technologies are currently being employed in the classroom. The team found that many teachers have differing opinions on the use of digital technologies.

The teachers in favor of digital technologies being used for teaching purposes suggested that student engagement increases when a program is gamified and offered potential suggestions for game design. Students enjoy the instant gratification that many games offer, and this element helps to hold the attention of students. Students also favor games that incorporate resource collection, which gives them a sense of progress throughout the activity. Avatars were another potential feature some of the teachers believed would help with student engagement. Students like projecting themselves into games, and the customization aspect that an avatar offers would accomplish this. Avatars also offer a chance to incorporate post-visit material into the program by sending the teacher the students' avatars after the session is complete.

The teachers at the focus group were in favor of post-visit material as long if it did not require more classroom time. Some teachers suggested the distribution of post-visit material using a teacher email address or a cloud sharing service. The teachers were also interested in

potentially sharing the post-visit material through social media or posting it on the school's website or blog. They brought up one concern about post-visit material, and this was regarding privacy and legal rights if the material involves pictures or names of the students. The teachers also pointed out that the post-visit material did not necessarily need to be digital.

Some of the teachers held a concern that incorporating tablets into the in-gallery session would detract from the rest of the experience. They felt that the students may spend too much time on the tablets rather than exploring the entirety of the gallery. The teachers provided the team with several potentially beneficial practices when incorporating digital technology into learning, as well as potential pitfalls to avoid when designing content. Appendix AC presents a complete list of our findings from the teacher focus group.

4.3: Objective 3- Design, Develop, and Evaluate

4.3.1 Second student focus group

During this focus group, we presented a prototype of our activity on the LearnPads to the same class of students we worked with in the first group. Students spent an hour in the gallery exploring and using LearnPads preloaded with our prototype. Some pairs of students moved through the gallery as quickly as possible, but a majority of pairs spent time looking around and moved at a slower pace. Some pairs split apart quickly, and only interacted with each other when the application told them to switch players. Students seemed to enjoy find-it style activities, especially the more difficult ones with open-ended questions. Some students did not realize that the prompts moved them through the gallery in chronological order, and backtracked while searching for items. Outside of the LearnPad activity, the most visited interactives included the phone booth, dress up area, rotary phones, and pneumatic tubes. The basic structure of our application seemed to function well in the gallery environment; it kept students engaged without being too intrusive.

In the afternoon the students returned for a structured feedback session. The team learned that students enjoyed looking around and describing what they saw. Students also liked the activity based on selecting their favorite posters and the activity where they found something in the gallery based on a picture. Their least favorite activity was the vehicle selection question. Students perceived it as patronizing due to the simple nature of the answer choices. Appendix

AD contains a full summary of the focus group findings. The team used information gathered from user testing and student feedback to refine our final design.

4.3.2 Museum content

The Postal Museum's gallery features a lot of exhibits contained within a small space. There is a lot of museum content that may catch a student's attention, but it is important to ensure that students are receiving valuable educational takeaways. Our team selected pieces from the gallery that we felt best told the stories of the post, and incorporated many of them into our final design. For example, one museum element we found useful was The Jolly Postman character that students could find throughout the gallery. It helps students to explore parts of the gallery they might not normally see, and provides students with clear, age-appropriate explanations of some of the museum's key messages.

The first two zones of the gallery have a lot of relevant and interesting stories that students can connect with. However, they also have a lot of interactive elements already in place. For example, in zone one students can play dress up, listen to a post horn, and play a game where they protect the post. In zone two students can explore stories from the past through the medium of postcards and try on various postal uniforms. Students have a lot to interact with physically, and our previous gallery observations indicate that these interactive elements engage students already.

Zone three poses a challenge because some of the subject matter is not appropriate for key stage 1 and 2 students. Students in this age group have not covered this material in class and some of the exhibits feature fairly in-depth descriptions of battlegrounds and bombings. We felt that the most appropriate museum content in this section was the content that conveyed the concept of war and conflict and related it to the post, without focusing on violence. We thought that the Post Office Rifles exhibit, the George V pillar box, and the display of medals all fit this description.

Zone four contains content that students can more easily connect with. The wall of posters advertising services offered by the Royal Mail is a great space for students to complete an activity. It is a fairly open space, and the posters allow the students to visualize postal history easily. The posters clearly display their messages in a way that students can understand. We also felt it would be beneficial to include the airmail section. It emphasises the scale of the

postal system, which is something that not many students would normally consider. Stamps are another key concept that the museum wants to familiarize students with. We felt that the novelty stamp panel and the Machin stamp series exhibit could help accomplish this. The novelty stamps feature recognizable characters and figures which children are likely to be familiar with, and the Machin stamp series features the current queen. This familiarity makes it easier for children to connect to the stamps and engage with them.

The stories in zone five are from recent decades and therefore are potentially more relatable to students. We believed the case of toys and games would be engaging because children associate those types of objects with fun. We noted that the rotary phone and phone booth engaged students during our observations. The team thought that students would be interested in exploring some of the information related to them, and maybe listen to some of the stories they tell. The video at the end of zone five relating to parcels is another element that relates to student's lives. Parcels are a growing part of the postal system, and many children may already be more familiar with parcels than they are with letters.

4.3.3 Final prototype

The final design for the team's prototype was an application featuring a scavenger hunt that leads students through The Postal Museum gallery. Appendix AE includes a final prototype including many of the activities and design elements that accomplish these ideas, and Appendix AF contains the accompanying screen diagram. When designing the final prototype, the team prioritized an "eyes up" approach to the application. We chose this approach because of our earlier findings, which stated that utilizing tablets within the gallery may detract from the exhibitions by being too immersive. The team found that a scavenger hunt provides enough structure to the application without placing a heavy emphasis on the tablets, and lends itself well to guiding students to specific points in the gallery. The application moves students through the scavenger hunt structure by periodically interspersing screens throughout the program which prompt students to find different objects in the gallery. In addition to the scavenger hunt structure, the program also incorporates screens with The Jolly Postman. These screens build off of the preexisting images of The Jolly Postman in the gallery. The team found it was important to incorporate direct and indirect guidance into the program as every student group will have a variety of learning styles. The direct guidance of the program exposes students to

museum content that communicates the main takeaways from the gallery, while the indirect guidance allows for open ended exploration.

As a reward system, the prototype awards students stamps upon their completion of various activities. This gives students a sense of instant gratification and a sense of accomplishment. Students can view the stamps they earned by pressing a button located in the top right corner of most screens. This button brings up a screen where students can view the stamps they have earned.

The team designed the prototype for groups of two students. Prior findings indicated that most students prefer to work in groups rather than individually when completing a task. We also found that working in groups also promotes collaboration and sharing. The team found that groups of two is the optimal group size. A large group makes it difficult for all students to engage with the tablet.

The prototype begins by prompting the students to enter each of their names. The program uses the students' names throughout the activities to create a personalized experience. The team found that many students need prompting to share when using tablets as they have an inherently immersive affect. To combat this issue, the team integrated screens periodically throughout the program instructing the students to pass the tablet to their partner. The team found that it is important to highlight certain behavioral expectations to students when incorporating digital technology into their museum visit. These expectations help maintain order and promote a respectful learning environment. This is especially important when students work in groups. The program incorporates a screen reminding students to walk through the gallery, use their indoor voices, and be nice to their peers.

The team chose the various activities included in our final prototype based on the ideology that the activities should allow students to engage with the exhibits directly rather than digitally. The team decided that the focus of the program should be on zones three, four, and five. The physical layout and content of these zones makes them suitable for a scavenger hunt. Zones one and two are content dense and include many interactive exhibits. The team decided it would be most beneficial to have students explore these zones at their own pace. Each of these zones had a screen prompting students to explore the exhibition and describe their surroundings in an accompanying text box. This allows students of varying learning styles to develop their own conclusions regarding each exhibition, and reinforces our "eyes up" approach.

The prototype incorporates more structured activities when students enter zone three. The first of these activities is a set of multiple choice questions. Each question requires the student to be at the appropriate exhibit to find the correct answer. The team found that multiple choice questions hold student engagement because students enjoy the instant gratification gained from correctly answering the question. Another type of activity incorporated into the prototype asks students to identify a part of the gallery based on a cropped image. The screen instructs students to click on the image once they find the pictured location in the gallery. The image then expands and presents the students with information regarding the specific area of the gallery. The team found that students appreciated the challenge that this type of activity provides, and this allows the application to provide easily digestible material about specific areas of the gallery.

The prototype also includes an activity where the students can select their favorite posters. The students view these posters on a wall located in zone four. This activity further reinforces our team's "eyes up" approach, and adds a personalized experience. The team also incorporated an activity where students count the number of novelty and commemorative stamps found on a specific wall in zone four. This activity promotes student engagement with the physical gallery, and familiarizes them with an important piece of museum content.

The prototype also includes an activity involving the rotary phones found in zone five. This interactive activity instructs students to call a number to listen to an excerpt of a past postal museum employee's experience working for the post. The students record what they hear in text boxes. This activity engages students with another interactive gallery exhibit and regroups the students so that partners stay together.

Another activity included in the prototype leads the students to a glass case which has novelty toys and games. The activity prompts the students to list three of their favorite games found in the case. The students gain a sense of personalization by potentially relating these games back to their own lives. The prototype further aims to connect the gallery experience back to students' life experiences through an activity asking what some objects they would send in a parcel are and who they might send the parcel to. This activity allows the students to come up with creative answers as well as provide answers relating to their own lives.

Chapter 5: Conclusions and Recommendations

5.1: Conclusions

This chapter details the conclusions drawn by our team based on our findings. Our team focused on developing conclusions which apply to museums in general. We then tailored these conclusions to The Postal Museum as our final recommendations.

5.1.1: Viability of LearnPads

LearnPads are devices that are specifically tailored for use in a classroom setting. The Postal Museum purchased these devices for use in a museum gallery. Our team found that while many of the functions advertised are unreliable, the devices can still sufficiently fit the needs of museums.

We found the features including the ability to monitor device activities, restrict access to websites, and create lesson plans tailored to certain activities to be practical for use in a museum. However, we also found that many of these features can be faulty. Monitoring devices using ClassConnect offers little control over the desired tablets and is ineffective when many devices are in use at once. Website restrictions keep children from reaching harmful and distracting sites but also create difficulties when incorporating sites into a lesson. Using websites requires whitelisting of all desired web pages either manually or automatically, and the automatic process may inadvertently allow access to unwanted pages or sites. Finally, the main feature advertised for LearnPads is the ability to create lesson plans for use in the classroom, but the feasibility of a lesson plan for an in-gallery program at a museum is limited. For many museum visits, students tour galleries for less than an hour at a time. It is often impractical to develop digital content to be used for the duration of the visit. It is more practical to create an application that includes all necessary content, rather than creating multiple lesson plans. LearnPads are still beneficial for use in museums, even though some of the features on the tablets cannot directly connect to the museum setting. For example, they offer fast and reliable QR code scanning which can be useful depending on the application. We have found that many museums offer school programs which use tablets including pre-made applications available on any application store. In this regard, LearnPads offer the same experience that another android tablet would.

5.1.2: Device usage in gallery

In addition to gallery tours, museums frequently use tablets during programs that mimic a classroom setting, and the incorporation of these devices into an in-gallery experience presents a different challenge. We based our conclusions on the structure of The Postal Museum's gallery session in which students and chaperones participate in self-led tours through the five zones and temporary exhibition space for about one hour.

Museums may develop original content for tablets or use pre-existing apps adapted for use in-gallery. By using content developed in-house (or contracted by a third party), museums can tailor their application to provide both a unique experience and information specific to their gallery content. By using pre-existing apps, museums can save money and reduce the amount of required maintenance. Both options present benefits which differ between museums.

Teachers are interested in providing their students with activities that they could not experience in a classroom. Many classrooms utilize tablets, allowing students to play educational games and view educational videos. The value of a museum visit stems from the unique offerings for different learning styles that are part of the visit experience. Applications developed for in-gallery devices must involve the physical exhibits as much as possible and motivate students to discover parts of the gallery.

On each school visit, several teachers and chaperones accompany the student group. Creating an application which gives control of the tablet to an accompanying chaperone gives students the freedom to move about the gallery uninhibited while also receiving guided instructions. For example, the LearnPads could prompt chaperones to question students on facts found in the gallery allowing the children to explore the gallery. Although this concept has its merits, our team also found that the number of adults in visiting school groups is inconsistent, even when given a required minimum ratio between chaperones and students. Although consistent chaperone involvement or guidance prevents students from becoming too focused on tablets, museums should avoid applications that rely on chaperones.

When school groups visit museums, teachers want their students to leave the program with a better understanding of the material covered. Museum programs offer post-visit material that students can take home with them. This material acts as both a culmination of their learning and a memento of their visit. Galleries offer a great opportunity for students to create and take home information they discover during their visit. Many teachers prefer this product to be

physical, but these options are less economical for the museum. Museums can offer materials that utilize electronic methods such as email and storage websites. Section 5.1.4 discusses the privacy risks of these options.

5.1.3: Group use

It is not feasible to give every student in a school group their own tablet for practical and economic reasons. Visiting groups can reach sizes of roughly thirty students, making the cost of purchasing and maintaining enough tablets high. In addition, museum environments should promote discussion and interaction between visitors. Forming small groups allows students to use tablets to enhance their visit, while incorporating interaction with their peers. Our team found that groups of two provides the most beneficial combination of these two properties. Teachers will have students work in groups of two in the classroom when necessary, while the museums we visited used a combination of groups of two and three during school visits.

Based on our observations at the British Museum and Museum of London, we found that younger students have difficulty sharing devices amongst group members. Although this is particularly a problem with groups of three, the British museum used a trading system to prompt students when it was time to switch the tablet. This strategy is an effective means to ensure fair use without relying on students' or chaperones' judgements. Applications developed for gallery use should prompt users to switch control of the tablet at regular intervals.

5.1.4: Privacy

When children are the target audience, it is important for museums to consider the privacy risks involved when developing or using existing applications. Schools must ensure that students are safe, and that the museum securely handles any information connected to the children. There are several options that schools accept for delivery of material created by students. Museums may upload files to a website such as Dropbox or Flickr and share private links to specific folders with schools. Teachers can directly receive small take-homes after providing their email during the visit. Both methods ensure that only museum personnel and teachers have access to files containing sensitive material.

Once the school receives any material created by the students, the museum must delete all sensitive information from the devices. The simplest method is for a member of staff to go through each device and delete the content manually. Although this method guarantees the deletion of all necessary files, the process is time consuming and requires trained staff. Museums should instead use applications which automatically and consistently delete any stored data once a session ends or not store information locally.

5.1.5: Maintenance

Electronic devices require proper maintenance to keep applications functioning and up-to-date with gallery content. Staff members must oversee the devices' use and upkeep.

Keeping applications up-to-date requires expertise in development. Third-party developers provide the simplest means to create and maintain applications through changes in software and content, provided funding is available. Museums relying on in-house development suffer from a drainage of resources and an over-dependence on staff with proper training.

Different parts of a gallery are more suited to use with tablets than others. Our interviews with museum personnel revealed that sections of the gallery that remain the same for long periods of time are best suited for use with tablets. Applications tied to long-lasting exhibits require less updating than those which include information about temporary exhibits.

5.2: Postal Museum Recommendations

Our recommendations to The Postal Museum describe the considerations that they should make during professional development of an application. These include its basic structure, content, privacy, deliverables, and maintenance. We based the recommendations on the conclusions established in the previous section while including content and activities specific to The Postal Museum.

5.2.1: Application structure

The application structure that we recommend The Postal Museum develop consists of an interactive guide through the gallery that make use of a timer, features a scoring system, and varies the order of LearnPad content.

The gallery is split into five distinct zones with an additional area housing temporary exhibits. As shown previously in Figure 5, visitors enter each zone in ascending order. The application should follow this ordering and have students complete all activities within a zone before moving onto another. Following this sequence avoids requiring students to pass through zones unnecessarily, which would disturb other visitors and increase the difficulty of monitoring children. Within each zone, the application should direct groups to different areas in order to improve the flow of traffic through the gallery. The application will begin groups at different exhibits and have them finish each activity in the zone. This progression will ensure that the students are evenly distributed while still able to view every exhibit.

The application should feature a timer for some activities to structure the time spent in each zone. Each screen should include a button to proceed to the next screen. While the timer counts down, pressing the button would display a message stating, “Not so fast! Keep looking around.” Once the timer counts to zero, pressing the button would advance the user to the next screen. This feature would ensure that students spend sufficient time in each zone and promote the further exploration of nearby material without relying on the LearnPads.

Implementing a scoring system throughout the gallery helps to hold students’ attention and motivates them to progress. To prevent students from focusing solely on the tablets, the scoring system should award points for interacting with the exhibits without requiring any further input, such as spending in-app currencies. Our team included a system where we award virtual stamps to the students upon completing a question or activity. Students may then view these stamps in a gallery, providing further information on the origin of each design. This reward system provides instant gratification to students while also incentivizing them to continue.

Pairs of students should operated the application used in the gallery. As stated in our conclusion, providing tablets to every student is an expensive option on the budget of a museum. In addition, LearnPads are heavy devices that would prove difficult for a student to carry for the entirety of the visit. In groups of two, students have the opportunity to use the device while also being able to switch control when necessary. Working in pairs promotes interaction and discussion between children.

Providing LearnPads to school groups should be an option The Postal Museum gives to teachers when planning their visit. Based on the teaching styles and prior exposure to digital technologies in classrooms, teachers vary in their willingness to use tablets during a gallery tour.

Allowing students to complete the visit without using LearnPads will better accommodate more teachers and incentivize those against device use.

5.2.2: LearnPad implementation in the gallery

Our first consideration when developing material for the LearnPads pertains to which zones of the gallery The Postal Museum should direct students to in the application. In order to traverse the gallery, students must visit the zones in order. This means that children receive tablets either before entering zone one, or part way through the gallery. Handing out the devices in the middle of the gallery presents challenges related to forming pairs, positioning staff, and disrupting the students' experience. Distributing the devices prior to entry prevents interruption part way through and coordinates staff and students in a more efficient manner. Therefore, we recommend that The Postal Museum give students the LearnPads for the entirety of the gallery visit and incorporate each zone into the application. We also recommend that LearnPads should prompt students to explore zones one and two on their own, since these areas already include many interactive exhibits.

In zones three, four, and five, LearnPads should include more structured activities than in the previous zones. In addition, the activities included on the LearnPads should incorporate mostly permanent museum content to reduce the need to update the application when the museum introduces new exhibits. The best way to include a temporary exhibit in the application would be for students to complete activities that do not include information directly from the exhibit. The activities should apply to many different exhibits without needing modification. These activities could include prompting users to find parts of the temporary exhibit that interest them or directing them to explore the area within a time limit.

The LearnPads offer a means for students to apply their knowledge by creating their own take-home material. Zone four of the gallery contains a wall covered with posters advertising the postal service. This collection allows students to observe the designs and identify effective and appealing examples of advertisements from the past. Students could then use these observations to create their own posters on the LearnPads. The application would include pre-loaded images that students could place on a canvas.

In regards to the application's target audience, we recommend that The Postal Museum creates an application that they can adapt to both key stages 1 and 2. For example, one of our

recommended activities involves finding a section of the gallery using an edited image for reference. The museum could make this section easier to find for younger students by including a less edited image or an image from an easier to find exhibit. School groups from both key stages visit The Postal Museum, and the museum's content does not have a significantly stronger connection to either key stage's curriculum. The Postal Museum should alter content for the application to fit the learning outcomes of each target audience.

5.2.3: Information privacy and post-material delivery

Protecting visitor information remains a high priority for The Postal Museum, especially when the information relates to children. The best strategy for ensuring proper handling of sensitive material is to avoid collecting that material altogether. The Postal Museum should provide students with a means to create their own take-home within the gallery that does not require personal or identifying information. The poster activity outlined in Section 5.2.3 is an activity that creates a secure deliverable by only using resources from The Postal Museum. Other activities, such as taking pictures or asking personal questions, require further considerations to mitigate the privacy risks involved. If the museum must store sensitive material on the LearnPads, the museum will need to manually examine each LearnPad to delete it.

The Postal Museum also has several options to deliver students' creations to their teachers. The best solution is to use an online storage service, such as Dropbox, to store files from a school session. Once the museum uploads these files, teachers can access the content by using a link provided by the museum. Only those with the link may access the folder containing the students' work. This method has proven successful in other museums. A staff member can also put deliverables into a zipped folder and email them directly to teachers, who provide their email address while visiting the museum. Although this method is secure, only small file sizes can be sent, which limits the possibilities for take-home content.

5.2.4: Staffing and maintenance

Implementing tablets in the gallery requires maintenance on both the physical devices and the application. A member of staff at The Postal Museum should handle upkeep to ensure

proper use of the devices and timely updates on software, even if the museum outsources development to a third-party company.

We recommend having two sets of staff to implement and maintain the LearnPads. The first group must distribute the devices to school groups, teach children how to begin their gallery visit, and collect the tablets when finished. This supervision ensures that students handle the LearnPads correctly and they have access to help if necessary. It is important that there is a trained member of staff that is able to handle the devices confidently.

The second set of staff should handle updates to the application to match updates to the gallery. This requires knowledge of both the gallery and LearnPad content. A member of staff should be responsible for ensuring that the devices themselves receive the necessary updates.

5.2.5: Activity proposals

Our application recommendations are frameworks that The Postal Museum may tailor specific content to in the future. We have designed our recommended activities to be adaptable to different kinds of material within the gallery.

Our final prototype discussed in section 4.3.3, features many of the activities and materials we recommend that The Postal Museum include in their application. In addition, our storyboard, features additional activities that we were not able to include in our final prototype due to our time and software constraints.

Within the gallery, The Postal Museum should include three activities incorporating the poster advertisements, medal collection, and Air Mail exhibits. The poster activity requires students to create their own collage. The Postal Museum should pre-load LearnPads with edited images showing small parts of the posters on display that students can use to create original designs based off of the advertisements they see. The Postal Museum can incorporate this activity into any section that includes pictures. Finally, we recommend incorporating the medal activity detailed in our storyboard into zone three. This activity involves students sorting images on the LearnPads to match the ordering of medals on display in the gallery, ensuring that the users have reached the correct section of the gallery. The Postal Museum may adapt this task to any section that orders objects, such as uniforms or stamps. The Air Mail activity has students simulate sending mail to various parts of the world using the LearnPads. This activity demonstrates content that relates to more specific sections of the gallery.

LearnPads present an opportunity for The Postal Museum to provide a structured experience for students in their gallery. Our team performed research and evaluations to determine the most effective way to implement LearnPads in a museum environment. We believe that if The Postal Museum creates an application that follows our recommendations, LearnPads will become a seamless addition to students' visits, creating a structured, engaging experience for all students.

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Appendix A: Museum of London benchmark interview questions

Interviewees: Ashley March, Rhiannon Looseley
Position: Digital Editor (Learning), Digital Learning Project Manager
Date: 14 March 2018

Industry benchmark interview (for museum staff)

1. Do you have any educational programs specifically in place for school groups?
    a. If yes, do these programs incorporate digital learning?
    b. If yes, how long have these programs been in place?
2. How have you implemented digital learning in museum exhibits?
    a. How was it received?
    b. Who is the target audience?
    c. What changes would you make to improve its use?
    d. What purpose does the technology fulfil as part of the exhibit?
3. When incorporating technology into exhibits, what role should the technology play?
    a. Should the technology be the main focus?
    b. Should the technology provide additional information only?
    c. Should the technology involve multiple users at once?
4. What methods have you used for gathering museum feedback?
5. Do you know of any other museums which are using educational tablets in new and innovative ways?
6. What can you tell us about your digital learning project with Culture24?
7. Could we potentially set up a time to observe school groups participating in your digital learning programs?

Digital Futures

Work with Cracking Codebreakers and Mission Colossus

Appendix B: British Museum benchmark interview questions

Interviewee: Ed Lawless
Position: Education Manager: Samsung Digital Learning Program
Date: 16 March 2018

Industry benchmark interview

1. Do you have any educational programs specifically in place for school groups?
    a. If yes, do these programs incorporate digital learning?
    b. If yes, how long have these programs been in place?
2. How have you implemented digital learning in museum exhibits?
    a. How was it received?
    b. Who is the target audience?
    c. What changes would you make to improve its use? - What types of issues have you encountered?
    d. What purpose does the technology fulfil as part of the exhibit?
3. When incorporating technology into exhibits, what role should the technology play?
    a. Should the technology be the main focus?
    b. Should the technology provide additional information only?
    c. Should the technology involve multiple users at once?
4. Do you think tablets are better for separate workshops or use within the gallery?
5. What methods have you used for gathering museum feedback?
    a. What testing was done during development?
    b. How was feedback gathered from the target audience?
6. Do you know of any other museums which are using educational tablets in new and innovative ways?
7. What types of activities are students doing on the tablets and what apps do these use?
8. Have you had any difficulties related to consent when emailing content?
9. Do you have dedicated staff to maintain the devices?

Programs to ask about:

- A gift for Athena
- Sutton Hoo headline
- Greek temples
- Science investigators

Appendix C: Victoria and Albert Museum benchmark interview questions

Interviewee: Alex Flowers
Position: Digital Team Leader
Date: 3 April 2018

Industry benchmark interview

What are the different programs offered in the Samsung digital learning classroom?

What other current programs do you offer that incorporate digital devices?

- What activities are done on these devices?
- How long do these programs last?
- Do these programs tie into gallery content?
- Are the devices used directly in gallery?
- What is the target audience of these programs?
- What types of pre and post visit material do you offer?

When incorporating technology into exhibits, what role should the technology play?

- Should the technology be the main focus?
- Should the technology solely provide additional information?
- How many students share a single device at once?

What testing or feedback gathering have you done in the past with relation to technology in programs and the gallery?

How do you incentivize schools to participate in programs with technology?

- Is technology a selling point for the museum?
- Is the V&A website the only way you market these programs?

Appendix D: School program observation guideline

*For use if observing school groups in a facilitated program environment

Evaluation of digital interfaces in use with school groups

Name of museum:

Part 1 (Exhibit information)

Type of activity:

creative play guided tour interactive reference
puzzle/mystery role-play/storiessimulation
Other:

How is information presented? (circle all that apply):

Audio Video Text Other:

Who is the intended audience?

Is it made for a single user or multiple users?

Does the program encompass exhibits from the entirety of the museum?

What was the objective of the session?

Session Description:

Part 2 (Group structure)

What age group are the students in?

How many students used the interface at once?

Did using the interface require adult supervision?

Part 3 (The Leuven Scale for involvement)

Level	Well being	Signals
1	**Extremely low**	Activity is simple, repetitive, and passive. The child seems absent and displays no energy. They may stare into space or look around to see what others are doing.
2	**Low**	Frequently interrupted activity. The child will be engaged in the activity for some of the time they are observed, but there will be moments of non-activity when they will stare into space or be distracted by what is going on around.
3	**Moderate**	Mainly continuous activity. The child is busy with the activity but at a routine level and there are few signs of real involvement. They make some progress with what they are doing but do not show much energy and concentration and can be easily distracted.
4	**High**	Continuous activity with intense moments. The child' activity has intense moments and at all times they seem involved. They are not easily distracted.
5	**Extremely high**	The child shows continuous and intense activity revealing the greatest involvement. They are concentrated, creative, energetic, and persistent throughout nearly all the observed period.

Other Comments:

Appendix E: Behavior scoring table

Engagement table for The Postal Museum*

Visitors observed engaging in a positive behavior = +1
Visitors observed engaging in a negative behavior = -1

To receive a score, at least half of the visitor group must be observed exhibiting the behavior

Behavior	Score	Comments
Positive		
Close to exhibit		
Spent extended time at exhibit		
Engaged conversation relating to exhibit		
Interacted with exhibit		
Took a picture		
Negative		
Disengaged conversation unrelated to exhibit		
Unrelated phone use		
Passed by exhibit		

Total Score:

Other Comments:

*Table adapted from: Aldrich, E., Bessette, K., Mueller, P., and Prakash, M. (2016). *Evaluating Digital Learning Resources for International Students at the British Museum* (Undergraduate Interactive Qualifying Project No. E-project-042716-190959). Retrieved from Worcester Polytechnic Institute Electronic Projects Collection: https://web.wpi.edu/Pubs/E-project/Available/E-project-042716-190959/

Appendix F: Observational research outline

Observational research outline

Research questions:

1. How do school groups interact with museum content and each other?
    a. How do teachers interact with students?
    b. How do parent chaperones interact with students?
2. What is the typical student to adult ratio?
3. Are students divided into supervised groups or allowed to explore on their own?
4. How engaged are students during their visit?
5. What positive or negative behaviors do school groups exhibit?
6. How is digital learning already implemented in exhibits?

Research site: School program sessions and in-gallery visits at The Postal Museum

Participants: Students, teachers, and parent chaperones on school trips

Other relevant parties: Postal Museum employees involved in school programs

Methods of data collection:

1. Observations (as many school groups as the team is given access to)
2. Field notes
3. Behavior scoring table
4. Informal conversations with visitors

Data analysis: Coding of observation notes and thematic analysis

Appendix G: Winton Primary School interview questions

Interviewee: Claire Brown
Position: Head of School Islington Council
Date: 22 March 2018

Digital learning

1. What key stages have you taught?
2. How has your overall experience with digital learning in the classroom been?
    a. What technology have you used in the classroom?
    b. Why were these technologies chosen?
    c. Have you found using this to be an effective method of teaching?
3. What types of museums have you visited with pupils and have any implemented forms of digital learning?
    a. If yes, was the digital learning tailored to school groups or was it based on exhibit?
    b. What types of activities have you found to be effective on fieldtrips?

Museum visit content

4. How do you want the visit to tie into key stages?
    a. What types of pre and post visit material is helpful for proving KS criteria has been met?
5. What skills would you like to see students practicing during a gallery activity?
6. How independent from adult assistance/supervision should students be when completing the activity?
7. What types of activities do your students tend to engage well with? (ex: games, quizzes, puzzles, etc.)
8. How long do students typically stay engaged in a single activity?
    a. What strategies do you use to keep students engaged for longer?

TPM questions

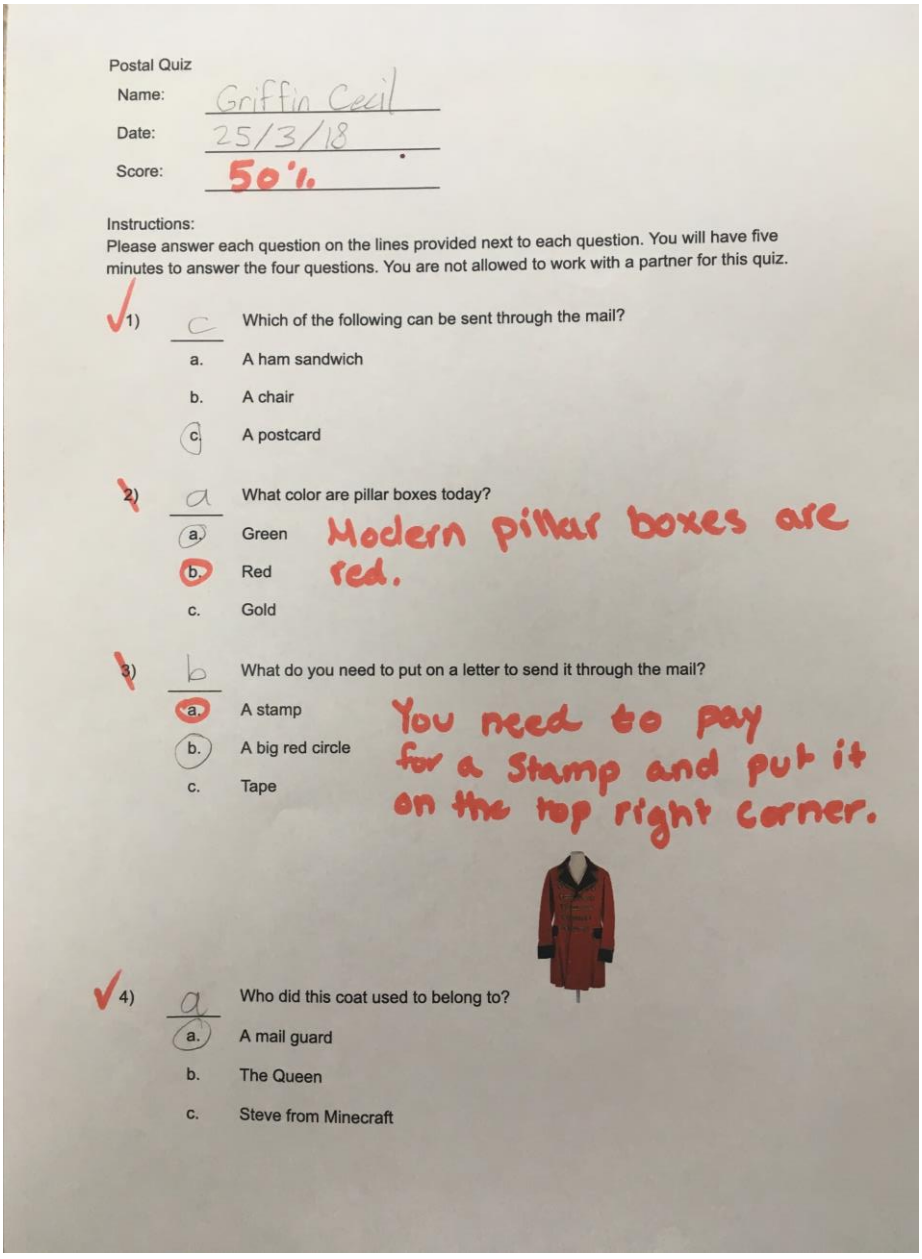
9. Are you familiar with LearnPads?
10. What made you interested in The Postal Museum?
11. Have your classrooms taught material related to the postal system or are you planning to?

Appendix H: Find it example

This five wheeled contraption was used to deliver mail in 1882

Pentacycle

Appendix I: Example quiz



Postal Quiz

Name: Griffin Cecil

Date: 25/3/18

Score: 50%.

Instructions:
Please answer each question on the lines provided next to each question. You will have five minutes to answer the four questions. You are not allowed to work with a partner for this quiz.

✓ 1) c Which of the following can be sent through the mail?

a. A ham sandwich
b. A chair
(c) A postcard

✓ 2) a What color are pillar boxes today?

(a) Green
(b) Red
c. Gold

Modern pillar boxes are red.

✓ 3) b What do you need to put on a letter to send it through the mail?

(a) A stamp
(b) A big red circle
c. Tape

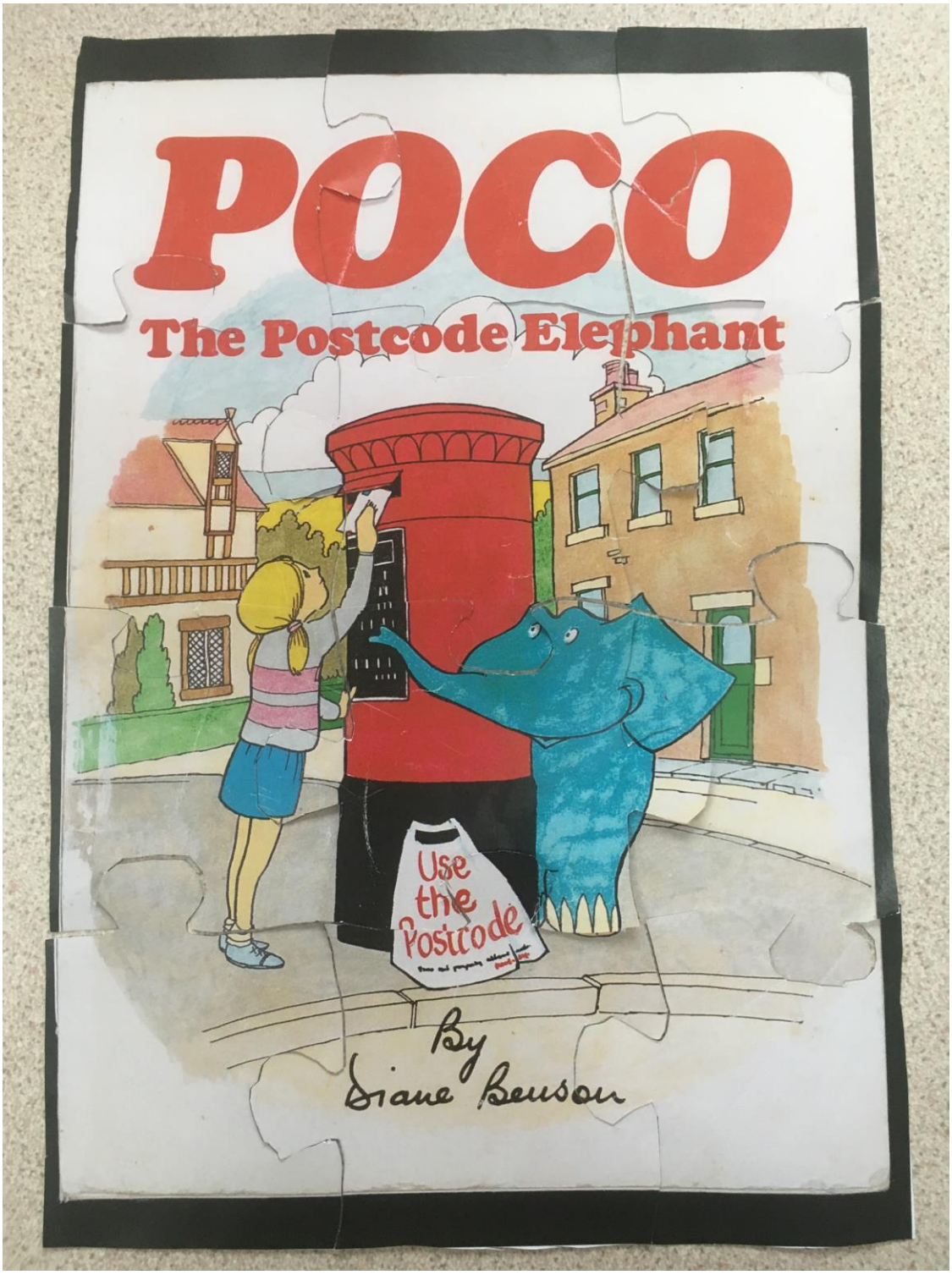
You need to pay for a stamp and put it on the top right corner.

✓ 4) a Who did this coat used to belong to?

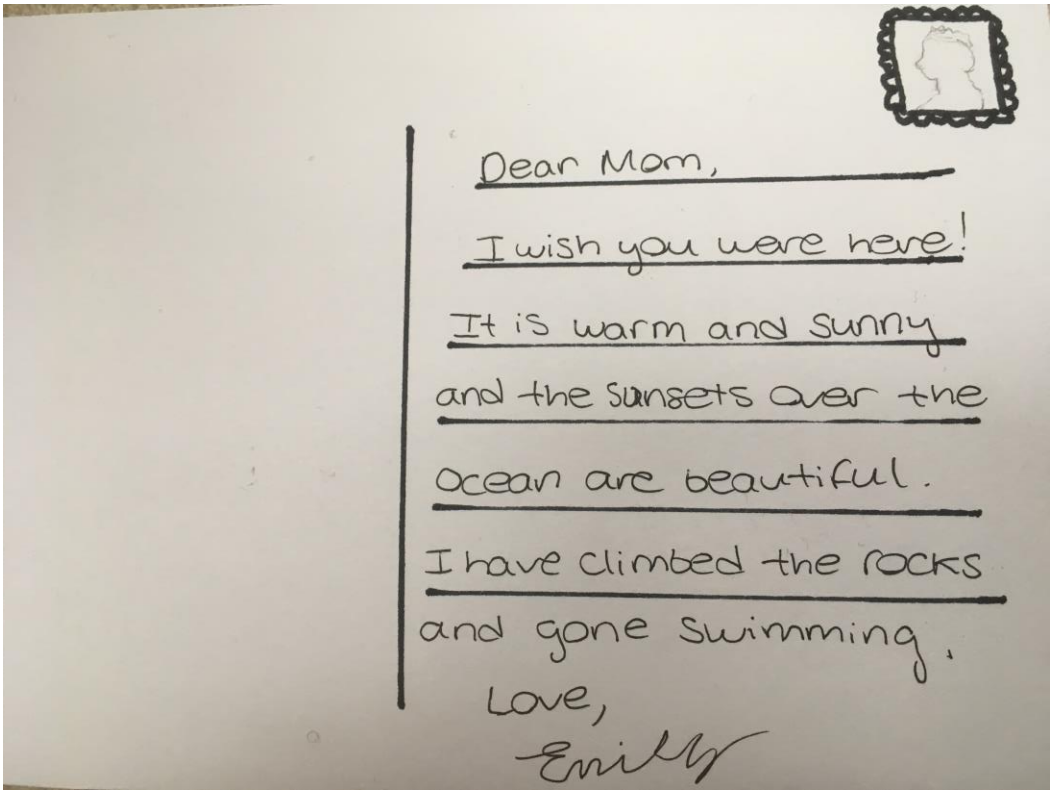
(a) A mail guard
b. The Queen
c. Steve from Minecraft

Appendix J: Collage example

Appendix K: Puzzle example



Appendix L: Postcard example



Appendix M: First student focus group timetable

School: Winton Primary School	Date: 26 March 2018	Students in group: 26 key stage 2

Time	**Activity**	**Objectives**	**Resources**
2 min	We introduce ourselves as university students visiting from America Share one thing about yourself and the best thing you have done in London	Introduction	PowerPoint
5 min	Ask students to write down what their favorite museum or place to visit is and what is the best thing about it	Icebreaker	Post-it notes
5 min	A few students will share their answers	Determine expectations of students	N/A
5 min	Ask students if they use tablets/phones and what they like to do on them, have them write down 2-3 of their favorite online activities.	Determine familiarity with digital technologies	Large sheet of paper, markers, Post-It note
10 min	A few students will share the activities they wrote down and talk about why they like them.	Determine why students like certain activities	N/A
10 min	Present different potential activities that the students could do in-gallery	Introduce the students to specific activities and gauge their reaction	PowerPoint
15 min	Ask students to pick their favorite and what made them choose the activity	Determine what draws students to specific activities	N/A
5 min	Feedback and finish	N/A	N/A

Outcomes:

- Find out about educational games and content students use in school
- Determine students' interests and what types of activities engage them

Represent different activities using storyboards/more primitive means.
We want to simulate:

- Photo Collage app
- Quiz app
- Guidance/Exploration app

Appendix N: Teacher focus group timetable

TPM teacher focus group
27 March 2018

Time	Activity	Objectives
17:15 - 17:30 (15 min)	Arrivals and refreshments	Introduction
17:30 - 17:35 (5 min)	Welcome and introductions ● Introduce ourselves and our project ● Ask teachers to introduce themselves (name, school, what they teach)	Building rapport with audience and adds context to teacher responses
17:35 - 17:40 (5 min)	Postal Museum ● Ask teachers if they have been to The Postal Museum before and how their experience was ● Ask if they teach related material in the classroom and how they would tie in a visit to The Postal Museum.	Find out how much teachers know about The Postal Museum.
17:40 - 17:45 (5 min)	Ask teachers if they have ever tried to integrate the games their students are playing in an educational way. Ask teachers if they are familiar with LearnPads.	Gauge teacher familiarity with LearnPads and what their students are playing.
17:45 - 18:05 (20 min)	Why digital learning? ● Have the teachers share their digital learning experiences and how it has influenced their teaching experience ● Ask teachers how digital learning should be used in the informal learning environment (museums) ● How should digital learning in museums tie back into curriculum	Assess teacher opinions towards digital learning and technology in the classroom and in museums.
18:05-18:15 (10 min)	Have teachers look at first LearnPad option: Structured quizzes/short answer Have teachers look at second LearnPad option: Creation based activity	Evaluate teacher opinions on different approaches to digital learning.

18:15 - 18:25 (10 min)	Ask for teacher feedback on activities	
18:25 - 18:45 (20 min)	Regroup and discuss: ● How should tablets be shared? ● Pre and post visit materials ● Privacy concerns?	
18:45 - 18:50 (5 min)	Discuss what would make teachers consider using tablets on their visit to The Postal Museum?	Determine the unique selling point of The Postal Museum with respect to LearnPads
18:50 - 18:55 (5 min)	AOB ● Is there anything we missed? ● Questions ● Thank you!	Make sure we did not miss anything

Objectives: What do we hope to get out of this focus group?

- Teacher opinions of the use of tablets in museum settings?
- Teacher evaluation of validity and effectiveness of content
- Gauge technology use in school settings
- Group dynamics and sharing
- Creative activities that appeal to Teachers
- Viability of providing additional content and information

Appendix O: Teacher focus group question outline

Welcome and introductions:

- Go around and share name, school, and what they teach

The Postal Museum:

- How many of you have been to The Postal Museum before?
    - How was your experience there?
- Do you cover topics relating to the postal system in your classroom?
    - How would you tie a visit to the museum into your curriculum?

Integrating games:

- What kind of digital or online games are your students interested in?
- Have you tried to implement these games into a classroom setting?
- Are any of you familiar with LearnPads?
    - What are your experiences with them?

Why digital learning:

- How has digital learning influenced your teaching experience?
- What has your experience with digital learning been like?
- What devices do you use in your classrooms?
- Are there perceptions around different types of devices as to whether they should be used for recreation or education?
- How do you believe digital learning and technology should be used in the museum environment?

After testing activities:

- What did you like/dislike about the quiz activity?
- What did you like/dislike about the collage activity?
- Which approach would be better for most students?
- What might be some unforeseen challenges associated with these activities?

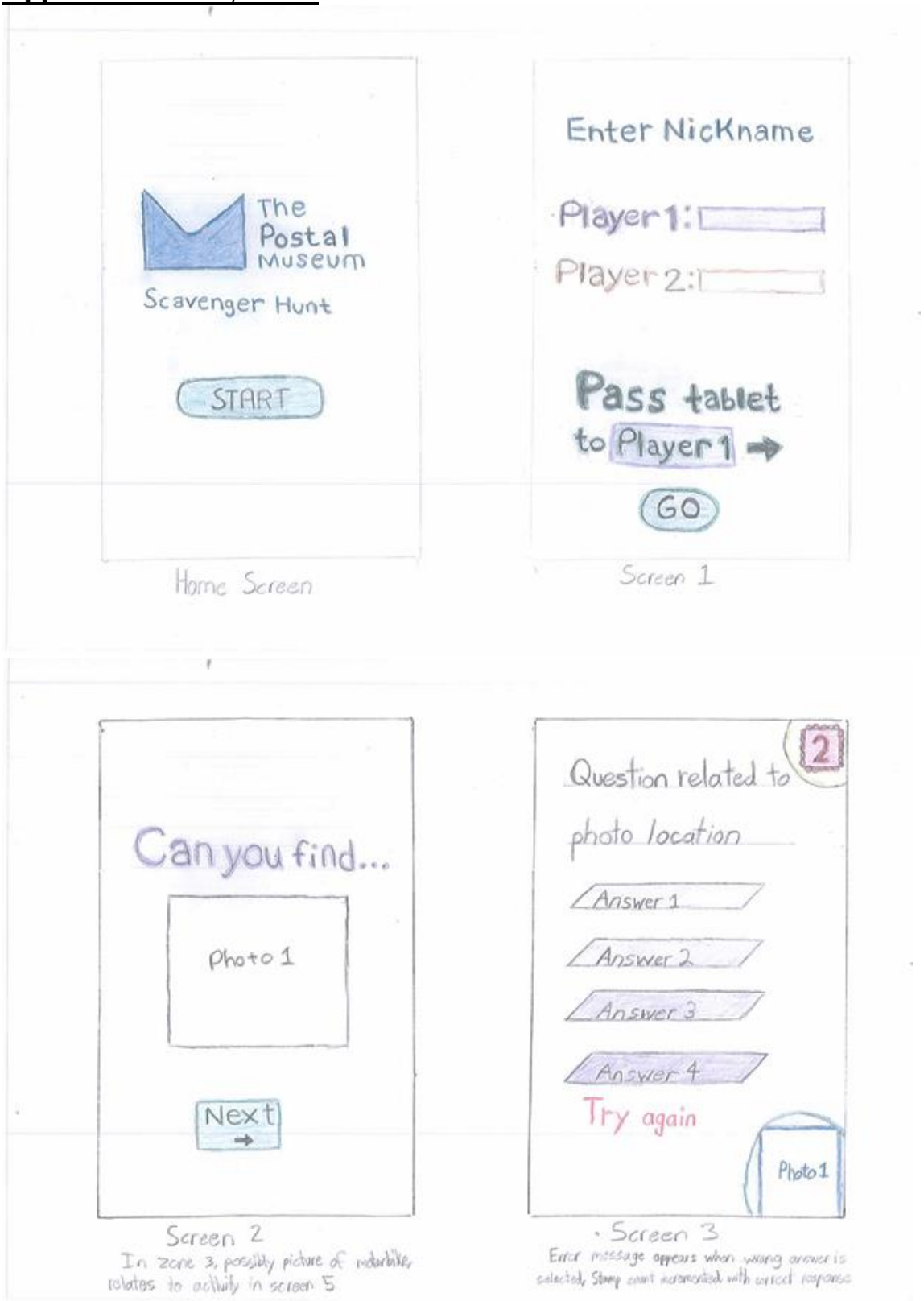
Misc.

- What are your thoughts on sharing tablets?
    - Optimal group size?
- Do you have any concerns about privacy or sensitive material?
- How does adult supervision influence a student's learning experience?
    - Would you consider it necessary in a museum setting?
- What types of post visit materials or activities would you like to receive?
    - Would you like the tablet activity to tie into post visit material?

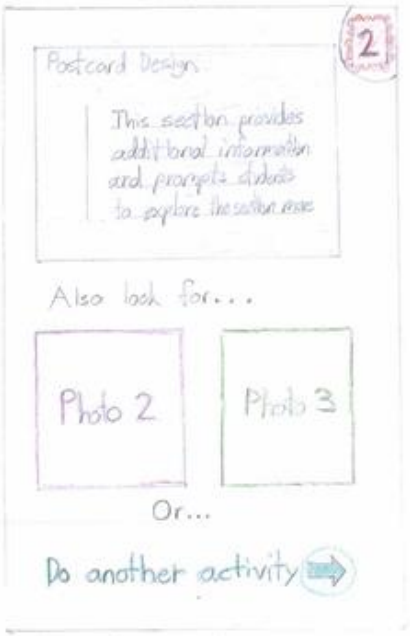
Selling point

- What about digital programs would make you want to come to The Postal Museum?

Appendix P: Storyboard



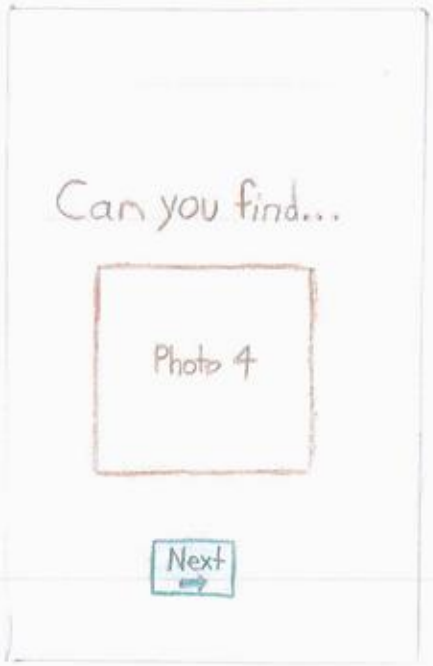
Screen 3 (expanded)
Background is dimmed, bubble transitions from bottom right to center when pressed



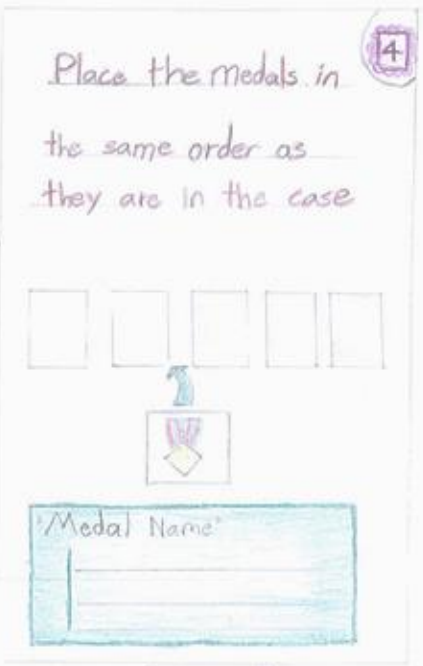
Screen 4

Screen 5
Second activity in first zone. When all correct answers are selected, screen advances

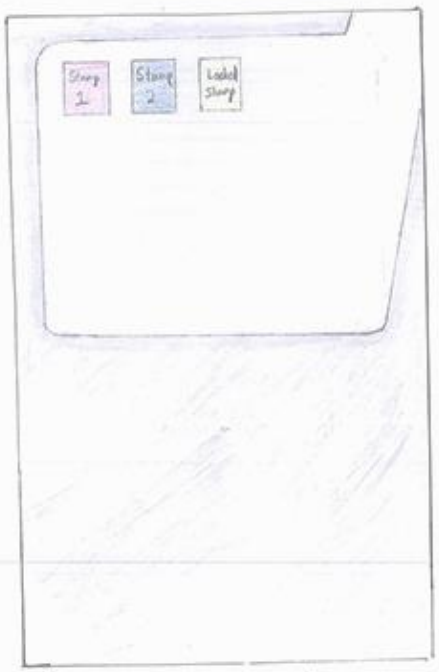
Screen 6
Lines of text appear at 2 second intervals. "Next" doesn't appear until the rest of the page does



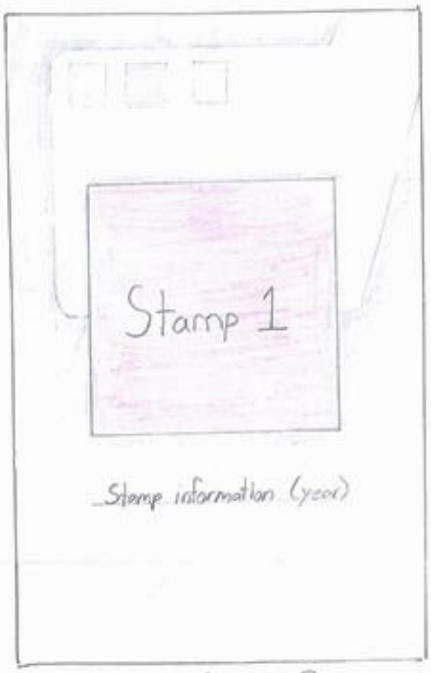
Screen 7
Repeat of screen 2, directs to same zone



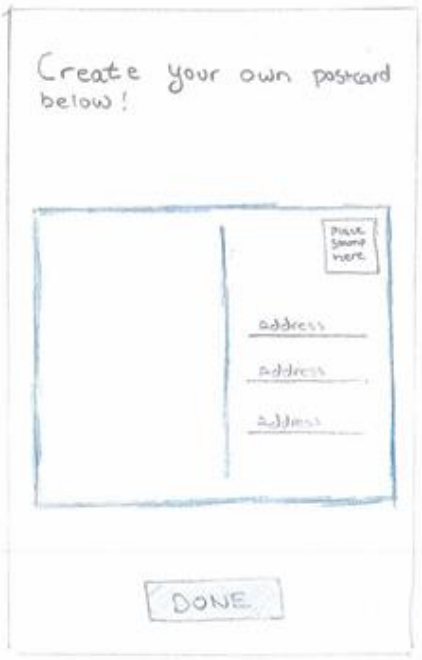
Screen 8
A variation of screen 3, used to ensure students found location, Medal name and information are displayed as medals appear



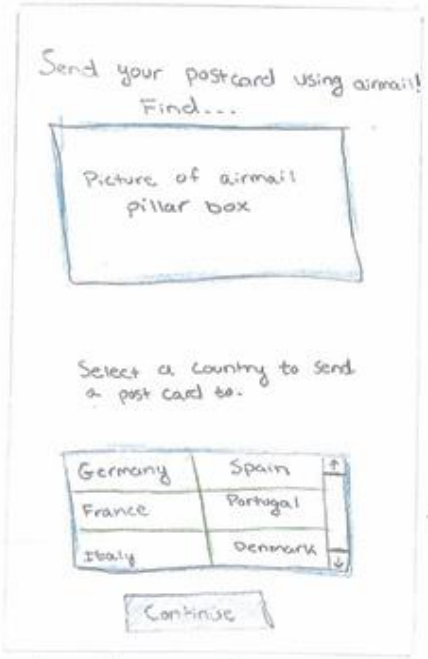
Stamp Screen 1
The stamp menu overlays on whatever screen students are currently on, dimming the background



Stamp Screen 2
Selecting a stamp enlarges it (possibly provides info), stamp menu is dismissed



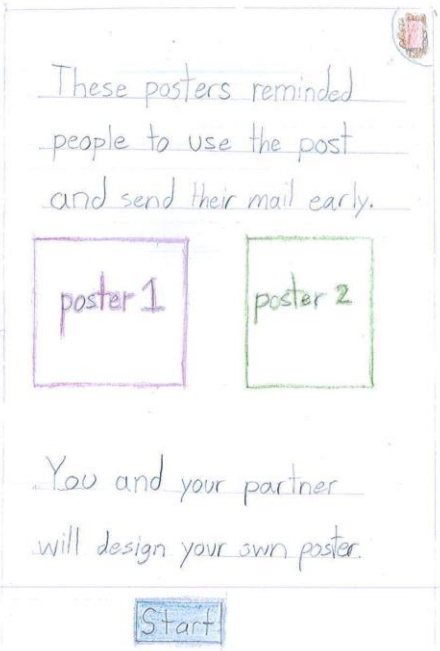
Airmail activity Screen 2: Students design a post card to send using air mail.



Airmail activity Screen 1: Used to direct students to exhibit an airmail. Students choose country which is also listed on airmail pillar box.

Airmail activity screen 3: Students get to visually see how airmail works.

Airmail activity screen 4: Students get to see the country where they sent their post card.



Poster Exercise 1

Poster Exercise 2

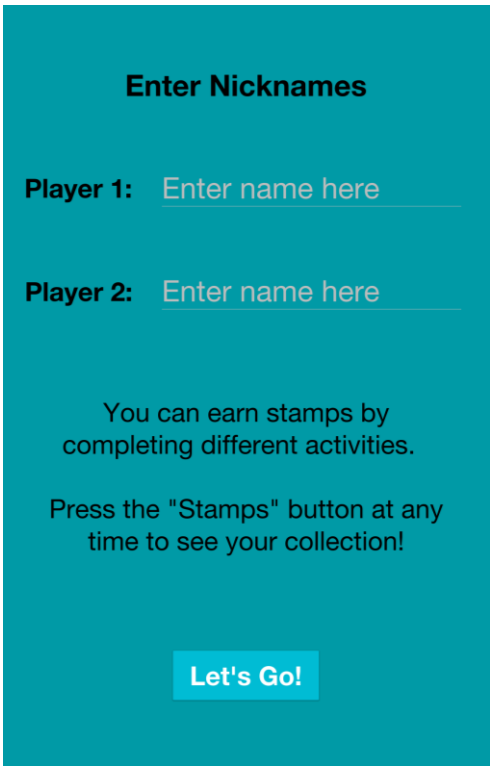
Jolly Reminder Screen 1
Used to further prompt students to engage with gallery outside tablet

Intermission Screen 1
clock counts down to 0, after "Next" appears & students can proceed

Appendix Q: Student focus group prototype

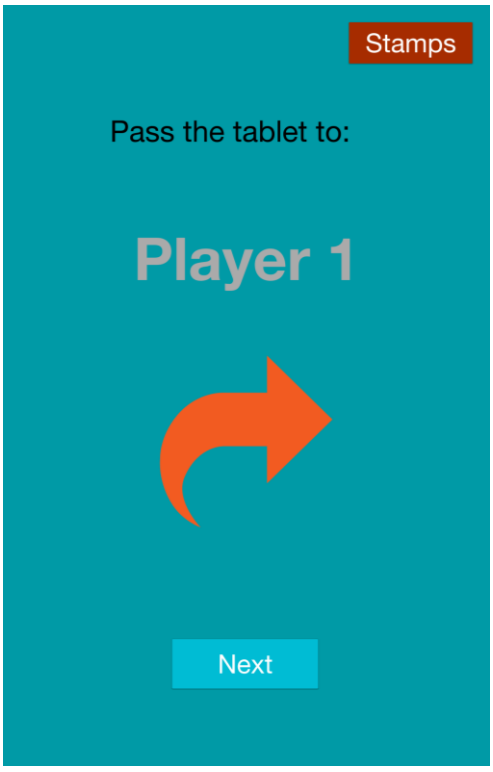
Home Screen

Enter Nickname

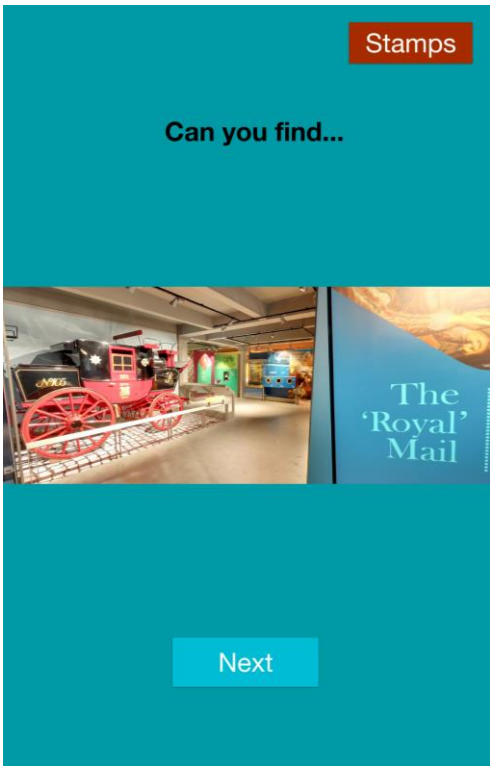


Postman Screen

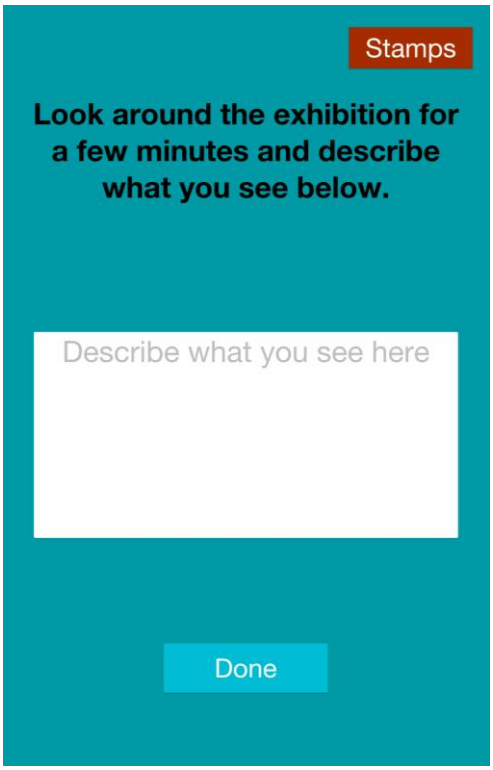
Pass the tablet 1



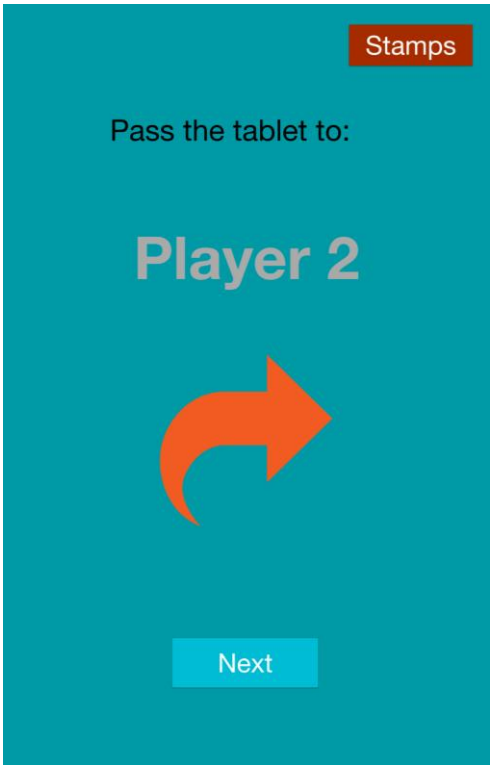
Find Zone 1



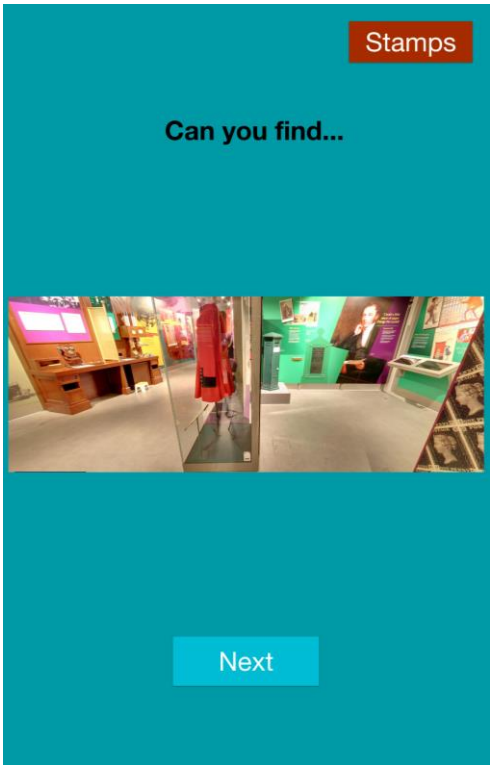
Describe Zone 1



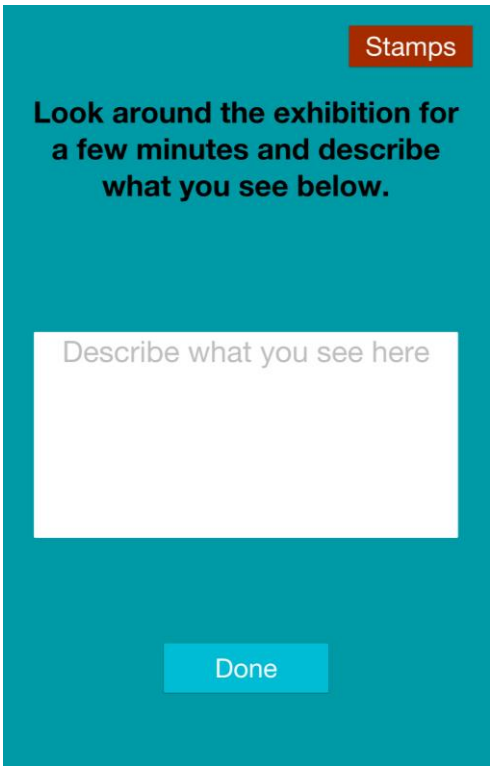
Pass the tablet 2



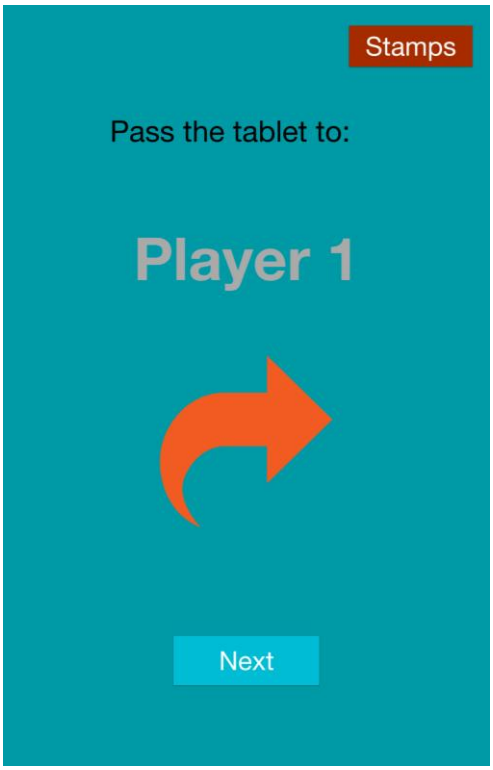
Find Zone 2



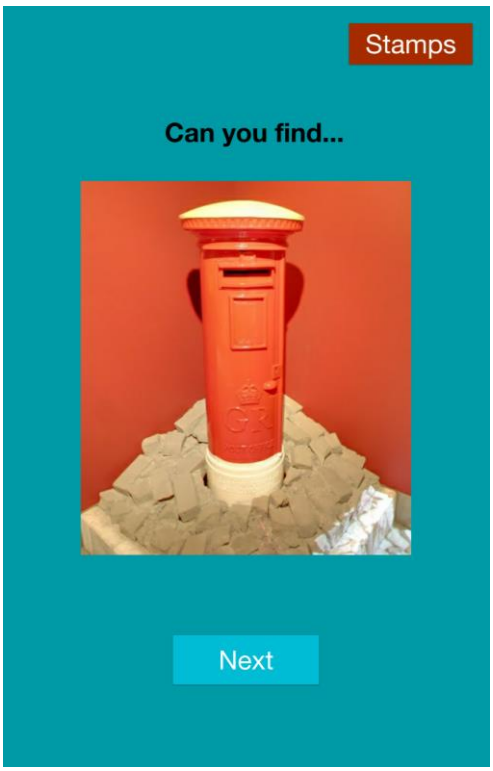
Describe Zone 2



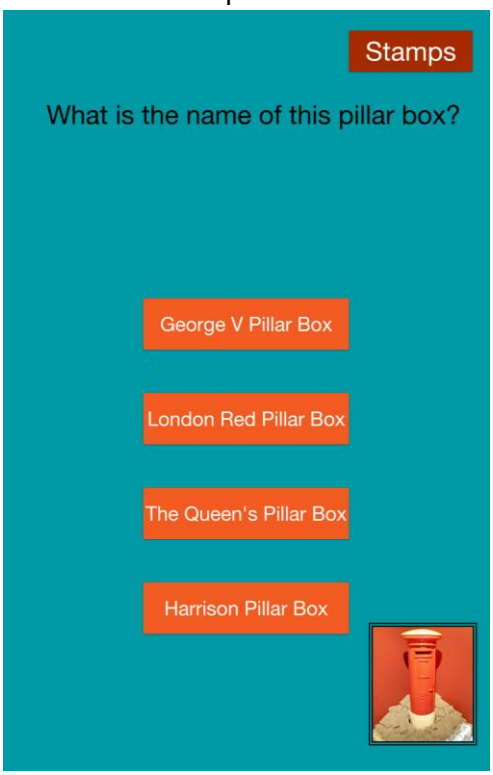
Pass the tablet 3



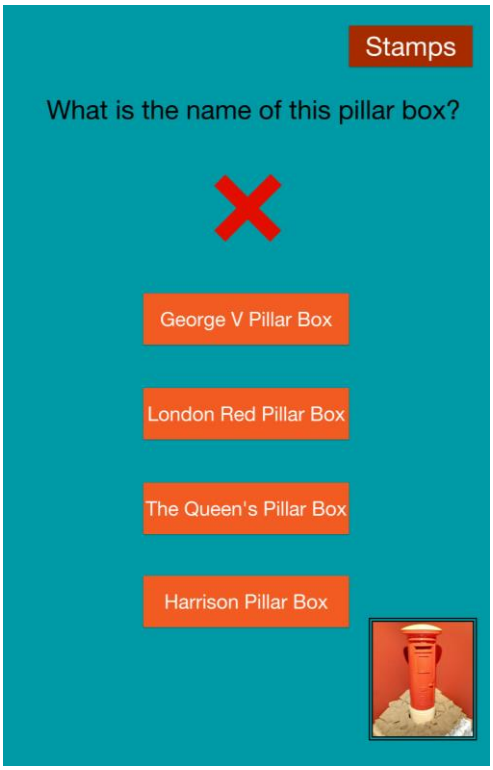
Find Pillar Box Zone 3



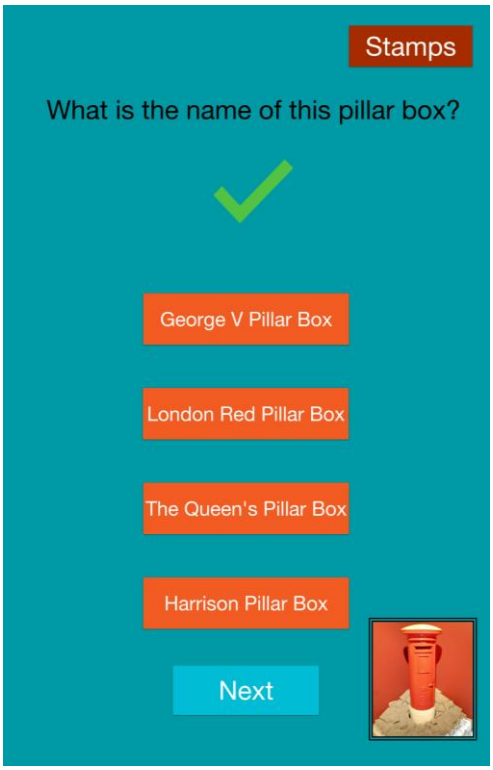
Pillar Box Multiple Choice



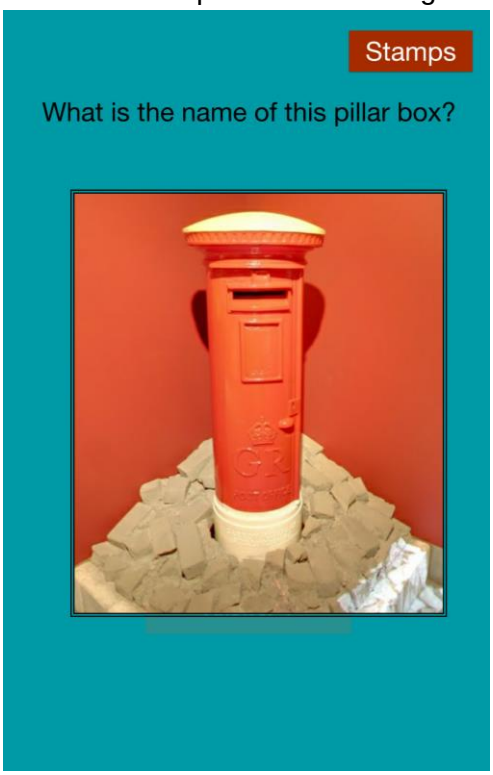
Pillar Box Multiple Choice: Incorrect



Pillar Box Multiple Choice: Correct



Pillar Box Multiple Choice: Enlarge Image



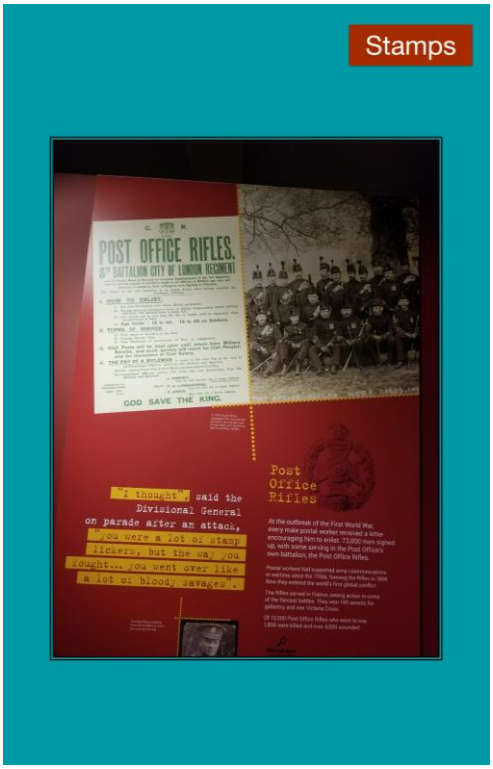
Find Post Office Rifles Zone 3

Post Office Rifles Multiple Choice

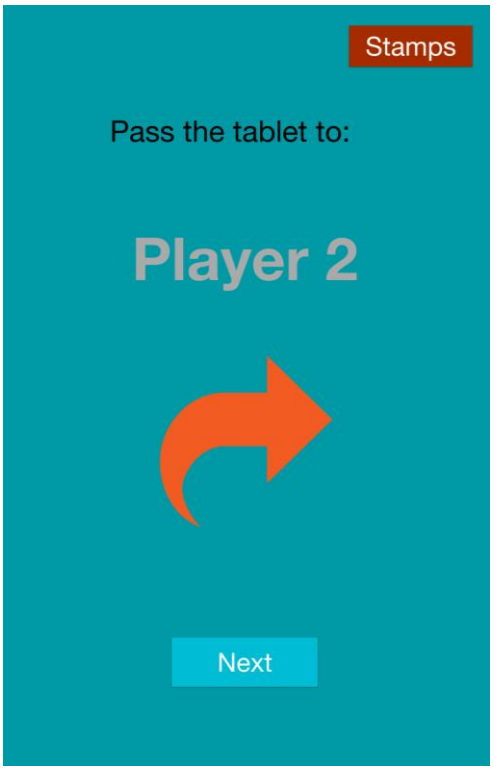
Post Office Rifles Multiple Choice: Incorrect

Post Office Rifles Multiple Choice: Correct

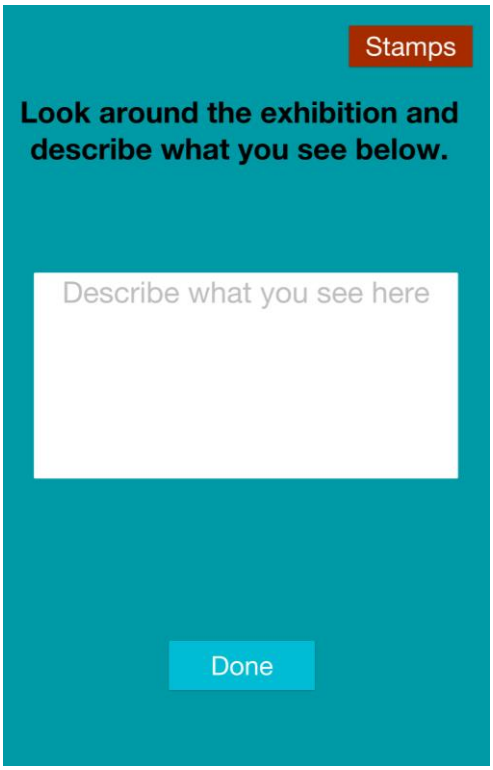
Post Office Rifles Multiple Choice: Enlarge Image



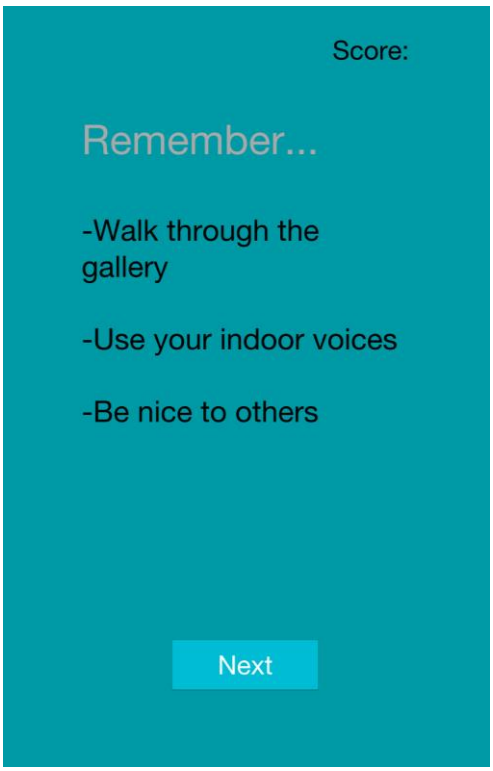
Pass the Tablet 4



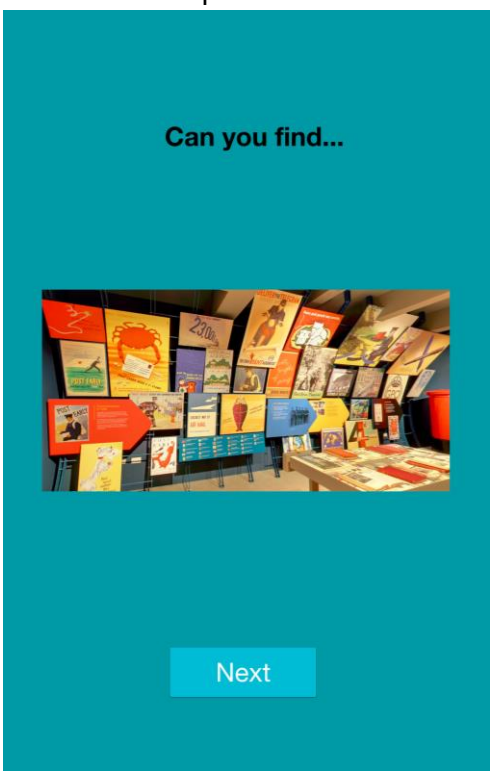
Describe Zone 3



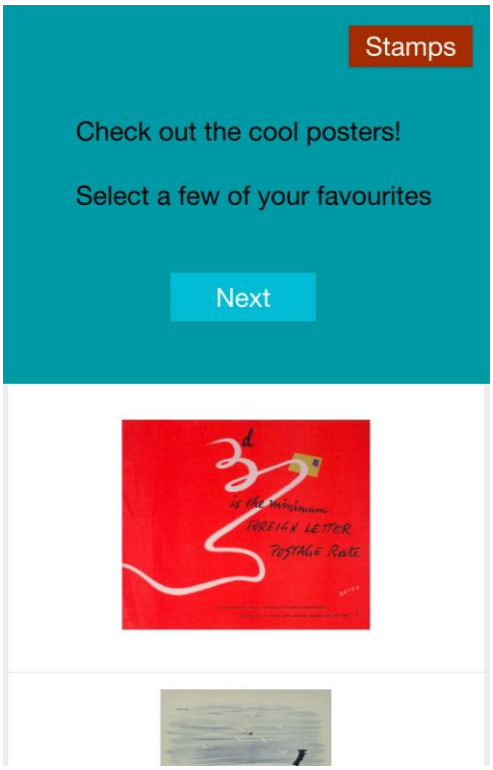
Reminder Screen



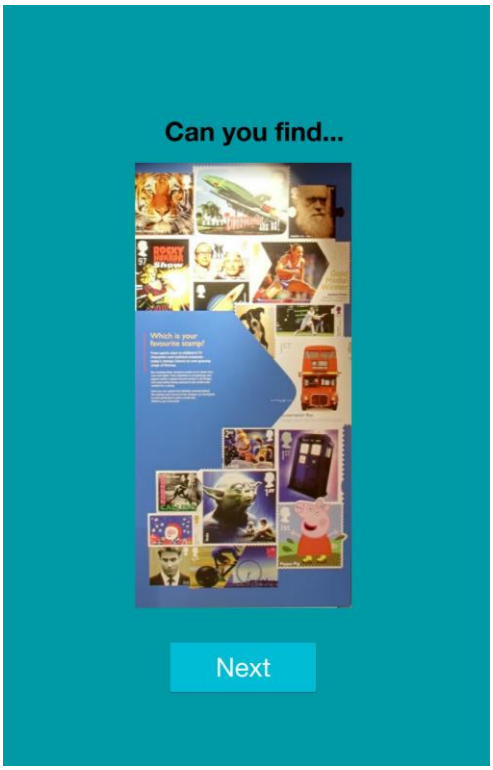
Picture Prompt 5



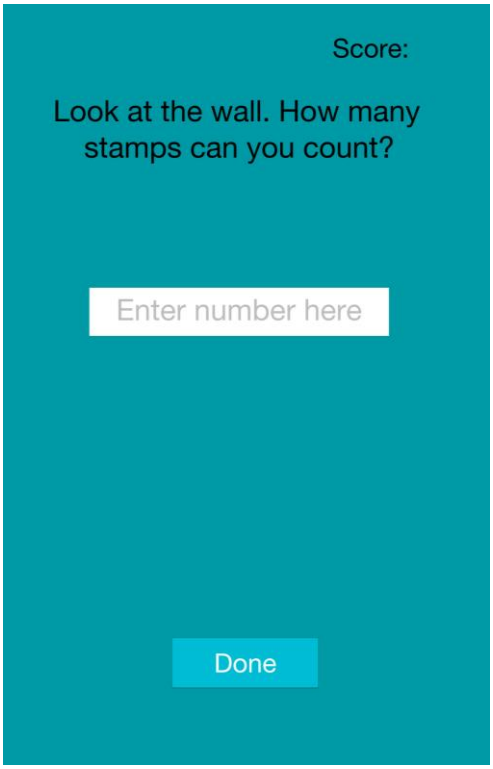
Poster Screen



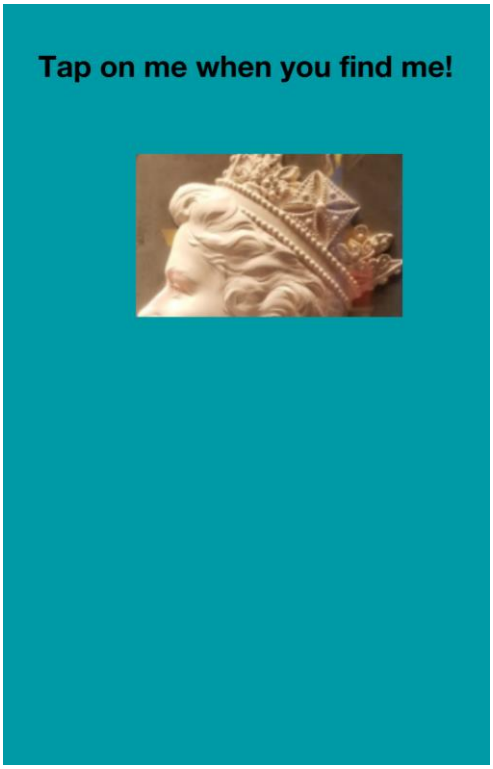
Picture Prompt 6



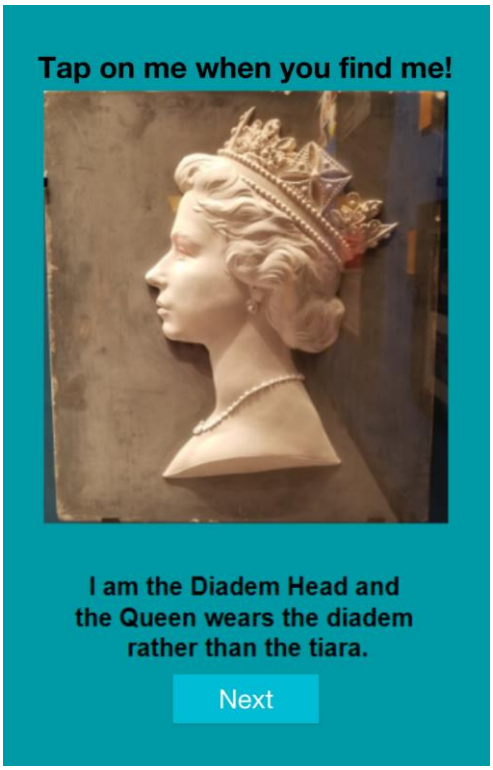
Counting Screen



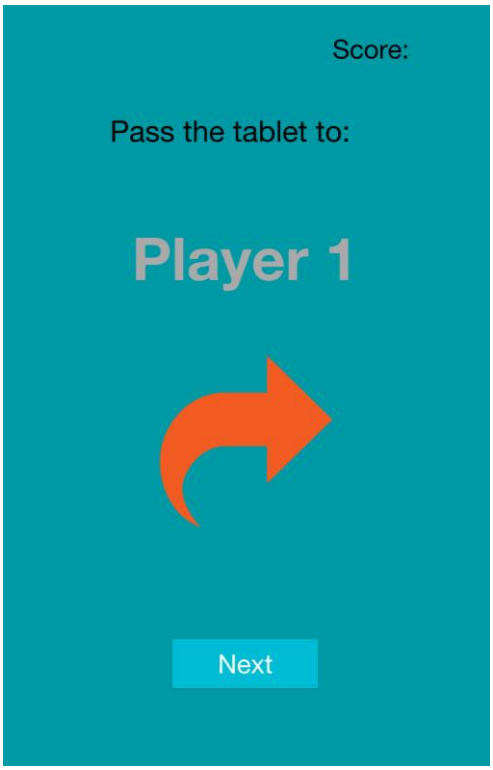
Mask Screen 1



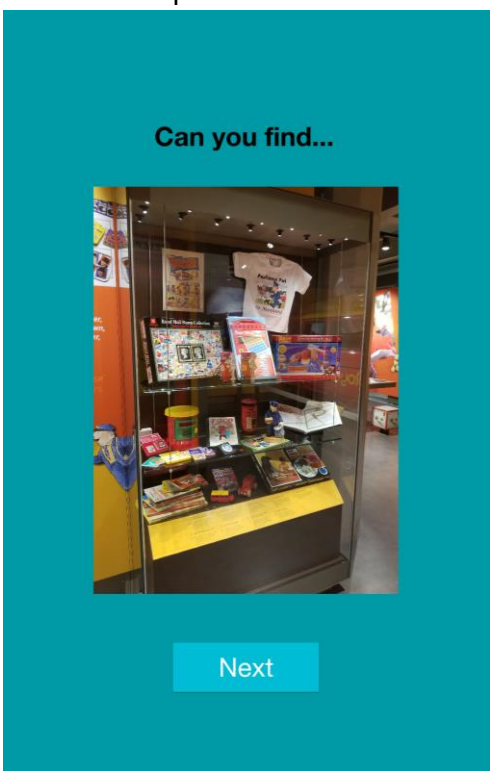
Mask Screen 2



Pass the Tablet 5



Picture Prompt 7

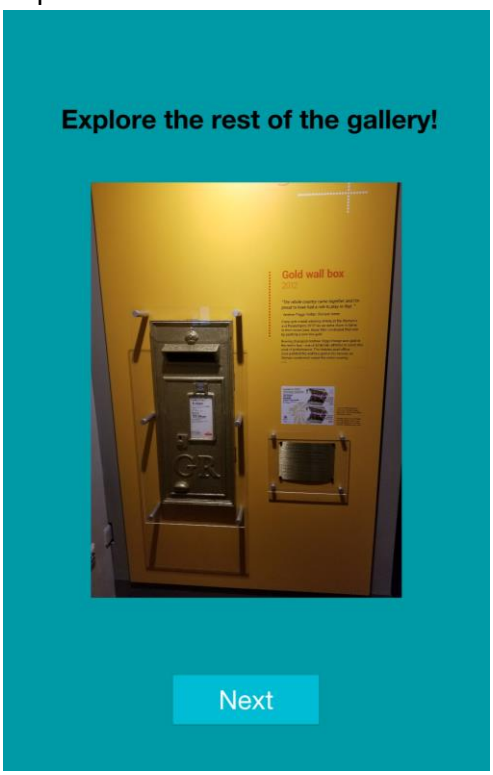


List Games

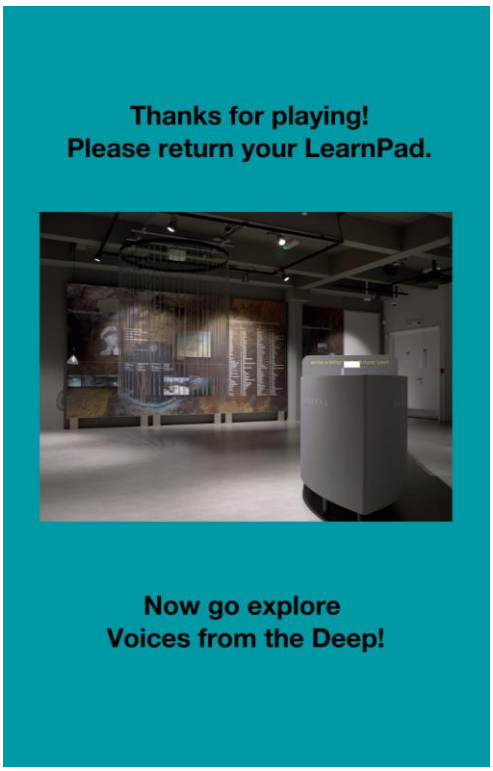
List Games: Enlarge Image

What other vehicles

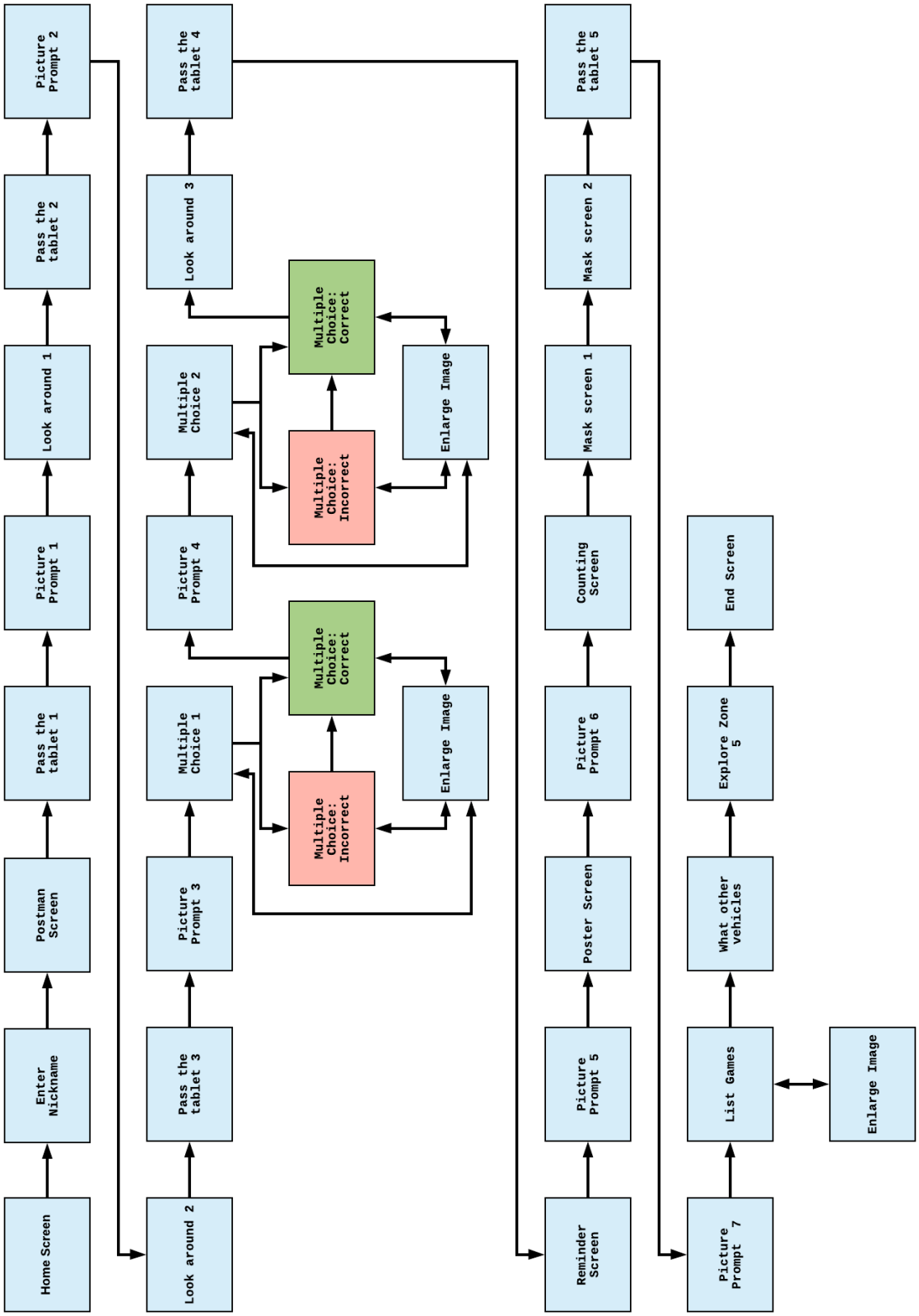
Explore Zone 5



End Screen



Appendix R: Student focus group prototype screen diagram



Appendix S: Second student focus group timetable

Time	Activity	Objectives	Resources
10.15 - 10.30	Arrival		
10.30- 11.30	Students tour Postal Museum galleries with WPI team	Students experience entire gallery Students complete LearnPad activity	LearnPads
11.55 - 13.30	Mail Rail & lunch intermission		
13.30 - 13.55	Feedback session (large group): ● Review what the students saw in the main gallery so that students don't confuse it with the Mail Rail ● Ask students to write down their favorite part of their visit ● Give students the opportunity to share their responses	Icebreaker Bridge the gap between the morning LearnPad session and the afternoon feedback session	Large sheets of paper pre cut to the size of the tables Markers
	● Ask students for feedback on specific aspects of the LearnPad application using screenshots	Evaluate the students' experience with the LearnPad activity Determine what specific features of the application students enjoyed	PowerPoint with screenshots of activities
13:55 - 14:30	Feedback session (small groups): ● Have students rank the activities within the LearnPad application	Determine which type of activity was the most engaging	Post-It notes and markers
	● Have students ask each other facilitated questions relating to their overall experience ● Students take turns asking a set of questions written on notecards to their small group	Gauge students' opinions of their visit Evaluate students' retention of The Postal Museum's content	Notecards with pre-written questions

Notecard Prompt Questions:

- What was your favourite part of the museum?
- What new things did you learn today?
- Tell us a story from the museum! Why do you remember it?
- What did you think The Postal Museum would be like?
- Did you see anything unexpected today?

Appendix T: Teacher and chaperone feedback survey

Winton Primary School Chaperone Survey

Please fill out these questions based on your time in the main gallery and the use of tablets. This is an anonymous survey being used by The Postal Museum to research tablet use with school groups.

1. **How engaged were the children during the gallery session?**
   1 = Student appears completely distracted and bored. 3 = Student appears busy with the activity but at a superficial level; there are few signs of real involvement and the student can be easily distracted. 5 = The student shows continuous and intense activity; they are concentrated, creative, energetic, and persistent nearly the entire time.
   Mark only one oval.

	1	2	3	4	5	
Very Disengaged	◯	◯	◯	◯	◯	Very Engaged

2. **How did students work in pairs?**
   Mark only one oval.

	1	2	3	4	5	
Very Poorly	◯	◯	◯	◯	◯	Very Well

3. **How involved are you willing to be with this type of activity?**
   Mark only one oval.

	1	2	3	4	5	
Not Involved	◯	◯	◯	◯	◯	Very Involved

4. **How many times did students need help with the tablets?**
   Mark only one oval.

- ◯ 0
- ◯ 1
- ◯ 2
- ◯ 3
- ◯ 4+

5. **Did students complete the entire activity?**
   Mark only one oval.

- ◯ Yes
- ◯ No
- ◯ Other: _____

6. **Would you have preferred to NOT use tablets during this visit?**
Mark only one oval.

- ◯ Yes
- ◯ No
- ◯ Other: _____

7. **How did having tablets affect the students' visit?**

_____

_____

_____

_____

_____

8. **Are there any ways we can improve the gallery experience?**

_____

_____

_____

_____

_____

Appendix U: Museum of London interview findings

Museum: Museum of London
Interviewee: Ashley March, Rhiannon Looseley
Position: Digital Editor (Learning), Digital Learning Project Manager
Date: 14 March 2018

1. Role of tablets
    a. Use tablets to create material, as opposed to providing information
    b. Have supplemental sessions both before and after using the tablets
    c. Tablets have a wow factor still- presented as a surprise during the visit
    d. Teamwork is motivating

2. Features
    a. QR Codes
        i. MoL staff felt they were ugly and hard to use
        ii. Learnpads have a built-in QR reader that may make them easier to use
        iii. QR codes can be designed to fit in with gallery style
    b. iBeacons
        i. Delivers content when user is within a certain range
        ii. Postal Museum galleries are small, which will cause proximity issues

3. Activities
    a. Photo collages are a common activity on tablets
    b. Minecraft/activities children relate to
    c. Games designed to force students to fulfil roles/include everyone
    d. Impact of Empires- preloaded mind maps that students must fill in
    e. Activities must be able to facilitate post-visit conversation
        i. Post visit activity/lesson plan
    f. Making something based on your own experience avoids the content becoming dated

4. Concerns
    a. Someone needs to setup and maintain / Somewhat dependent on museum's IT department- potentially needs dedicated individual(s)
        i. One for content maintenance, one for physical tablet maintenance
        ii. It is easy to remotely synchronize lesson plans to LearnPads all at once
        iii. Using QR codes would allow students to download content themselves
    b. MOL cutting programs with tablets because of the amount of time and skills required to maintain/set them up
    c. Sensitive information (emails, photos of children) can be saved to the tablet and accessed later
        i. Photo permissions
        ii. Clear photos out after each session

        iii. Make sure personal info is wiped
    d. Difficult to successfully share activities with teachers via email
    e. MOL uses OneDrive
    f. Unless activities are designed for sharing, tablets may not be conducive to group work
        i. Activities must be adaptable to be shared or used individually
    g. British Museum uploads to Flickr/YouTube- MOL does not do this because of consent issues
        i. British museum offers opt out form

5. Apps used by MOL
    a. Puppet Pals HD Director's Pass
    b. Pic Collage
    c. Popplet
    d. DoInk
    e. TinType
    f. Tayasui Blocks
    g. Minecraft
    h. Curator
    i. Procreate
    j. Figure
    k. Pixlr
    l. PowerPoint

6. Feedback systems
    a. Leuven scale

7. Suggested Additional Contacts
    a. Alex Flowers V&A
    b. National Maritime Museum

Key Findings

- The Museum of London believes the role of tablets should be to create content rather than provide supplemental gallery material.

- The Museum of London saw benefit with providing supplemental sessions both before and after using the tablets.

- The Museum of London pointed out that tablets have a “wow factor” with students, and the tablets should be presented as a surprise during the visit.

- Many of the programs at the Museum of London use pre-existing apps that allow students to make collages, videos, comic strips, or mind maps.

- It is beneficial to have a dedicated member of staff to prepare and maintain tablets for programs and there is a skill and time commitment.

- Measures must be taken to ensure that sensitive personal information is handled properly.

Appendix V: Create a Great Fire animation observation findings

Museum: Museum of London
Program: Create a Great Fire animation (KS1 program)
Date: 27 March 2018

- The program began with the instructor establishing a base knowledge of what the Great Fire was.
- The instructor began the program by seating the students in rows on the floor in front of a slideshow and briefly lectured them on the Great Fire of London.
- The students were taught about the Great Fire of London prior to their museum visit.
- Students were separated into groups of six to participate in an object handling activity where the students would have to figure out what the object used to be used for.
- Students were then given tablets to complete the create a Great Fire animation activity.
- The program on the tablet utilized the application Puppet Pals HD to allow the students to create a short animation video.
- The iPads were distributed to groups of three students.
- The students were directed to share by a combination of the chaperones and the instructor.
- The instructor guided the students on how to use the application to make a short animation video through step-by-step instructions.
- All photos used in the video were preloaded onto the iPads.
- The instructor emails a link to the teacher to access all students' videos via a cloud sharing site after the session is complete.

Appendix W: British Museum interview findings

Museum: British Museum
Interviewee: Ed Lawless
Position: Education Manager: Samsung Digital Learning Programme
Date: 16 March 2018

- One interactive program the British Museum offers is Sutton Hoo, and this program focuses on gallery research.
- Sutton Hoo incorporates photographs, videos, and instructions throughout the program.
- Example instructions for this program are:
    - Find something that…
    - Can you describe what was this object was used for?
- The British Museum utilizes self-guided programs that incorporate digital technologies to guide the user.
- The British Museum outsourced many of their applications to a third-party developing company.
- The British Museum relies on the third-party company that developed the applications they use to maintain these products.
- The British Museum employs staff to physically maintain the Samsung devices used throughout the museum, and this staff member is trained to do trouble shooting for the devices.
- The British Museum looks to incorporate digital technologies into static gallery elements to avoid extra maintenance.
- The British Museum has done some in-house application development using Elucidat.
- The British Museum found that the Samsung devices they use to be reliable.
- After a session, a staff member deletes all pictures taken of users off the devices.
- The museum uses URL based photo sharing to distribute all post-visit material.
- All self-led sessions incorporating digital technologies have no method of recording data.
- The museum offers pre-visit material for allir sessions, and this material is posted on their website.
- The museum found it is more effective to distribute tablets to groups opposed to individually for younger audiences.

Appendix X: Decoding ancient Egyptian paintings observation findings

Museum: British Museum Samsung Discovery Center
Program: Decoding ancient Egyptian paintings (KS2 program)
Date: 16 March 2018

- The program facilitator started the program by setting expectations for behavior.
- Simple questions were used to gauge the group's baseline knowledge of the museum which allowed the facilitator to tailor the program to each school.
- It was evident that students had seen supplemental material relating to the subject before the visit and knew the answers to the baseline questions.
- When transitioning between activities children got distracted and were difficult to reign in quickly.
- Children talking amongst themselves seemed to be talking about the activity.
- Some children exhibited signs of disengagement by looking around and not paying attention to the program.
- The students got excited when the facilitator announced that phones were being handed out.
- Both activities in the program were completed in groups of three.
- Before giving the students phones, the facilitator reiterated behavior expectations.
- All students immediately leaned in and looked engaged in using the phone to complete the activity.
- Chaperones and teachers assisted each group and provided guidance during the activities.
- Students were given an ancient Egyptian artwork along with the phone and they were asked to decode what was in the picture.
- The facilitator gave very little instruction when handing out phones and the students were able to find what they needed on their own.
- Sharing seemed to go well, however there were some instances of students getting impatient when it was not their turn to use the tablet or they could not see the screen.
- Two students seemed more optimal for the phone-based activity because of its size.
- The questions asked on the phone application were multiple-choice and short answer and directly based on the picture.

- Engagement appeared to be at a steady four on the Leuven scale with a select few students at fives.
- After completing the activity students appeared to become restless.
- Students were steadily engaged for approximately 15 minutes and after that their level of interest fluctuated.
- At the end of the activity the facilitator had students put everything down to ensure she had their attention.
- There was a core group of engaged students, however the edges of the group were less engaged and went in and out of being focused.
- After the activity students were prompted with simple discussion questions relating to what they had learned.
- Students were less engaged when the tablets were not present and appeared to be at a two or three on the Leuven scale.
- Apps other than the one being used in the session were password protected.
- Photos of students were cleared between sessions to eliminate security risks.
- The second activity used tablets and the app Photolayers to place students in their ideal "afterlife"
- This activity required more instruction before the tablets were passed out.
- Students got excited again when it was announced that tablets were going to be used.
- Tablets were used over a table to minimize droppage; this also made it easier to centralize its location for sharing.
- Students often had difficulty agreeing on a background to photoshop themselves into.
- Student groups without direct adult supervision seemed less engaged.
- Different aspects of the activity resonated with different groups.

Appendix Y: Achievements of the Shang dynasty observation findings

Museum: British Museum

Program: Achievements of the Shang dynasty (KS2 program)

Date: 28 March 2018

- The program is designed for school groups and teachers can check out the tablets for an hour and a half.
- There are three versions of the digital in-gallery program and we were given the Achievements of the Shang Dynasty program specifically.
- Every tablet does not have the same version of the program, and this was a design decision to combat issues with overcrowding exhibits.
- The program was designed to be used by two partners.
- The program was designed with six challenges each focusing on a separate skill including look, compare, interpret, investigate, evaluate, and share.
- Each challenge in the program was composed of small activities, questions about gallery objects, and supplemental gallery information.
- After a challenge was completed, the program awarded the players an artifact.
- Some sample questions asked throughout the program are:
    - How many colors can you find in the exhibit?
    - How many handles can you find in the exhibit?
    - How many legs can you find in the exhibit?
- Upon completing the program, the players are presented with all the artifacts they collected throughout the program.
- This program does not incorporate any sort of post-visit material.
- The Achievements of the Shang Dynasty program was designed in-house using Elucidat.

Appendix Z: Field notes from The Postal Museum in-gallery observation

- Students tended to congregate in the entry point of the gallery (Zone one).
- Zone one contains a dense amount of material along with interactive exhibits
- Students often walked by exhibits with lots of texts and favored interactive activities
- Students appeared to be most interested in the activity of turning a picture of yourself into a stamp
- Students talked amongst themselves frequently during their in-gallery visit
- Students preferred to look at exhibits in groups rather than individually
- Some chaperones were very involved with their group of students while others took a less hands on approach.
- Students enjoyed the interactive exhibits where you got to write a letter
- Some students enjoyed the dress up activity where others completely skipped this
- Students frequently spent less than twenty seconds at each exhibit

Appendix AA: Head of School Islington Council interview transcript

School: Winton Primary School, Islington Council
Interviewee: Claire Brown
Position: Head of School
Date: 22 March 2018

- Claire's background is teaching mathematics and computing.
- Winton Primary decided to not use tablets at school because children use them so much at home. The school purchased a set of laptops instead.
- Claire wanted the students to focus on practicing more coding.
- Students at Winton Primary complete one hour of computing work a week and work two hours for other subjects.
- Students enjoy the computing work, and Claire did not receive any feedback from the student's stating otherwise.
- Claire suggested students see tablets as being for leisure and not for work.
- A few museums she visited with school groups are the Science Museum, the Natural History Museum, and the Tate Modern.
- The Science Museum utilizes screens and hands-on activities and focuses less on digital interfaces.
- Anything too educational will not hold student engagement. Students like instant gratification.
- Museums provide students with experience of what's out in the world, expand general knowledge, and how to behave in different environments.
- The most helpful pre-visit material is material that is accessible online on the museum's website.
- Post-material would be a bonus, liked the idea of emailing after the session.
- A museum visit should provide the students with an experience they can't get in the classroom.
- Independent student's will lead themselves to what interests them and require less supervision.
- Boys are more interested in competition-based games, while competition can have a negative impact on engagement in girls.

- Students tend to come into school at the same level of competency when it comes to digital technologies. This is often due to exposure to these devices at home.
- Boys are more likely to stick to the same game, while girls switch games more frequently (~ 15min).

Appendix AB: Student focus group findings

Concepts Students Liked:

- Finding an object and taking a picture
- Taking their own pictures and making a collage

Findings:

- When we presented our activities, they wanted to know more about the content they were based on
- Students were interested in having basic facts before their visit
- Students like being challenged to an extent- they talked about a difficult activity they did at the British museum
- Students liked all our activities almost equally
- Like to play on consoles- especially Nintendo Switch
- Would rather work with friends/in groups
- Students enjoy watching YouTubers
- Also use YouTube to research what they're playing
- Students have a wide range of attention spans
- Students would rather do activities on tablets as opposed to on paper
- Students vary in artistic abilities and activities should cater to all levels of ability
- Information should primarily be in the gallery and the tablet should supplement it

Content Ideas:

- Have students make their own games
- Scavenger hunt around the gallery
- Integrate fun facts in design
- Students want to create postcard using stock images
- Activity should make the students explore the museum more
- Want random order for gallery information

Appendix AC: Teacher focus group findings

Focus on pertinent key stages

- Teachers found that postal museum ties in mostly to key stage 1 curriculum
- Teachers are only interested in taking a school trip to a museum if it ties in with their key stage

Instant gratification

- Students like fast feedback and are more likely to continue with an activity if they can move through it quickly
- Levels shouldn't start as too challenging or students will give up
- Collecting things gives students a sense of accomplishment

Avatar creation/self-insert

- Students like projecting themselves into games
- Avatars offer the ability to creatively express yourself

Post visit material

- Something the student can take home- maybe even physical
- Email/Cloud Sharing is recommended way of sending material
- Post visit material shouldn't require further class time- the teacher has already dedicated a lesson to this material and does not have any additional time
- Privacy & legal concerns whenever students take pictures of themselves- content must be deleted in a responsible way
- Schools could potentially post material on their website or blog or twitter

Benefits of LearnPads

- QR capabilities + button
- Stylizing QR codes/embedding codes in pictures
- Screenshot button
- Wireless charging

Negatives of LearnPads

- Heavy for students to carry around the gallery

- Interface is not intuitive for first time users
- Difficult to make content for
- Teachers familiar with LearnPads said many features are buggy and don't always work

Implementation feedback

- Teachers liked the idea of incorporating Voices from the Deep- specifically using LearnPads for only a part of the gallery experience
- Content must link to real life to be valuable, however it can't be too immersive and take away from the museum experience
- Groups of 2 were preferred over larger groups
- Some teachers suggested the idea of having the chaperones be responsible for the LearnPads

Potentially useful applications:

- Seesaw
- PicCollage Kid
- Pop jam
- ChatterPix
- Purple Mash
- Yack It

Appendix AD: Second student focus group findings

Winton Primary

18 April 2018

Morning observation:

- Students spread out soon after arriving in the gallery
- Students appeared to be looking around and writing after being prompted to do so by the application
- Some students moved through the gallery as quickly as possible while others stopped frequently and went at a much slower pace
- Partners separated from each other easily
- Some pairs only interacted when the application prompted them to switch players
- A few students skipped some questions and just clicked the next button
- Pairs would often set the LearnPad down when engaging with interactives
- Students seemed to enjoy the find-it style activities, especially the more difficult ones with open-ended questions
- The basic structure of our application seemed to function well in the gallery environment
- Some students did not realize that the questions moved them through the gallery in order
- Students appeared to favor a number of interactives including:
    - The phone booth
    - The rotary phones
    - The pneumatic tubes
    - The plastic rods in Voices From the Deep

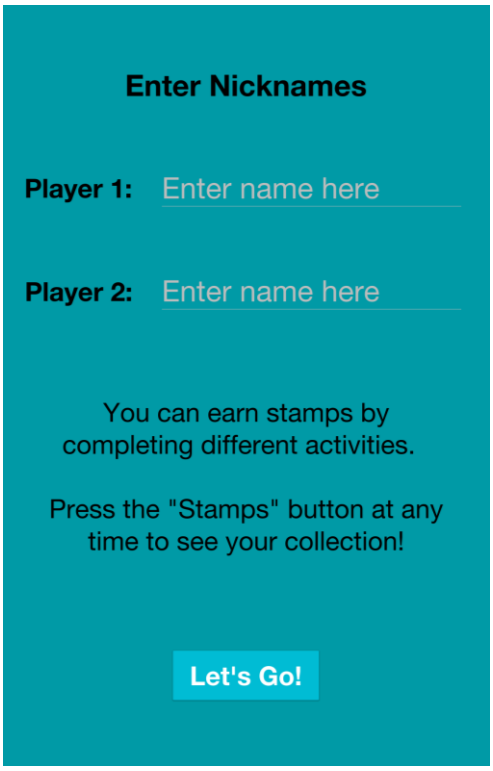
Afternoon feedback session:

- The question with the hidden image of the Queen Elizabeth II stamp carving received a highly positive reaction
- Students didn't like the "select vehicles" question because they perceived it as patronizing due to the simple nature of the answer choices
- Students enjoyed describing things
- Mail rail was the most memorable part of the students' day, however students did remember specific facts from the morning gallery session

Appendix AE: Final Prototype

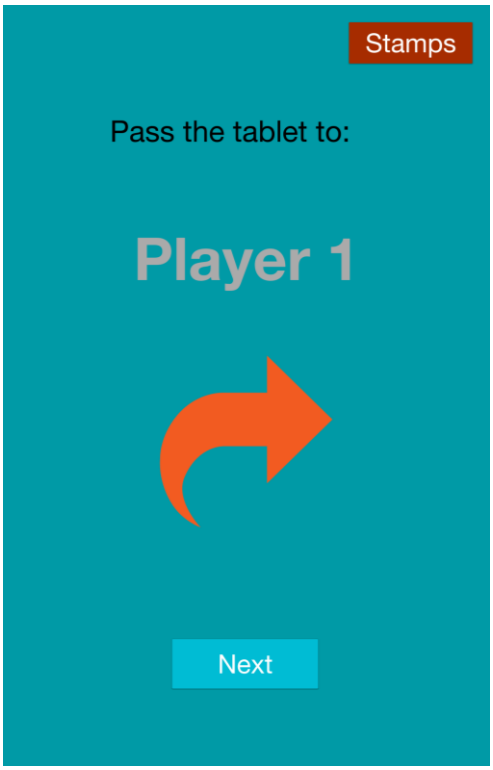
Home Screen

Enter Nickname

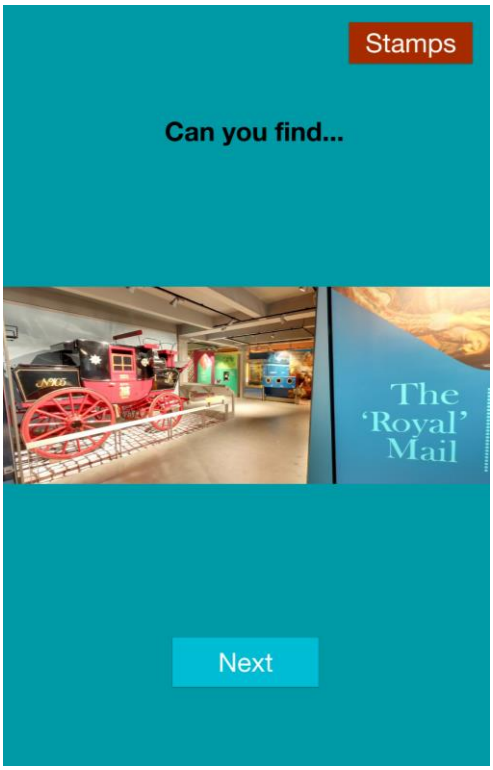


Postman Screen

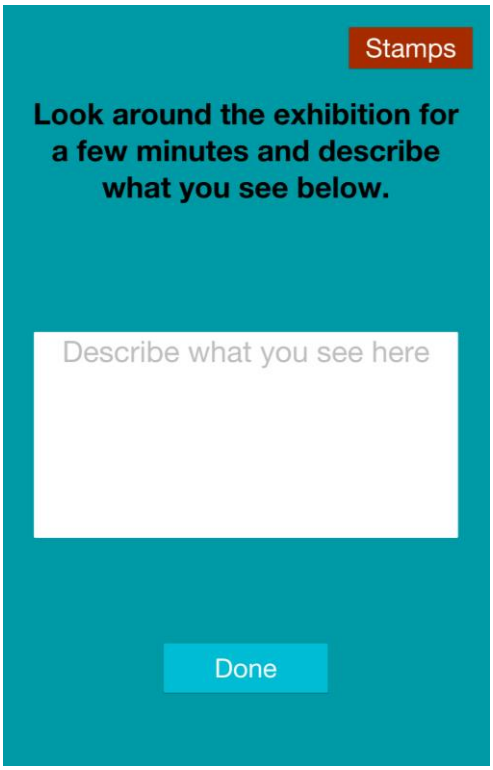
Pass the tablet 1



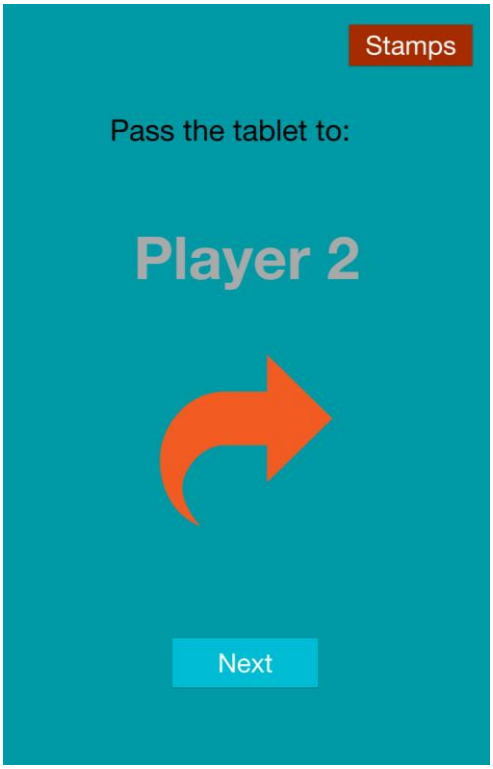
Find Zone 1



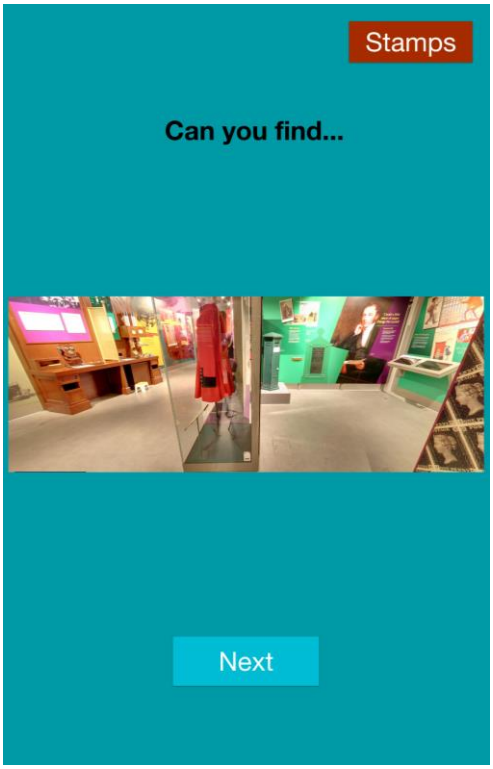
Describe Zone 1



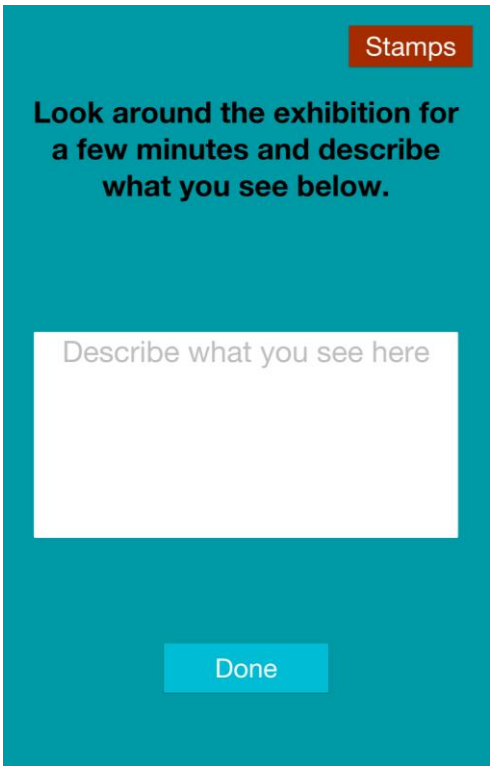
Pass the tablet 2



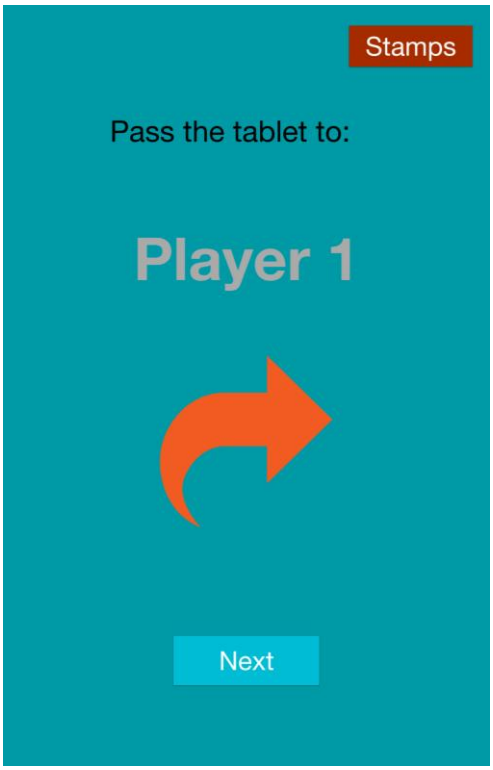
Find Zone 2



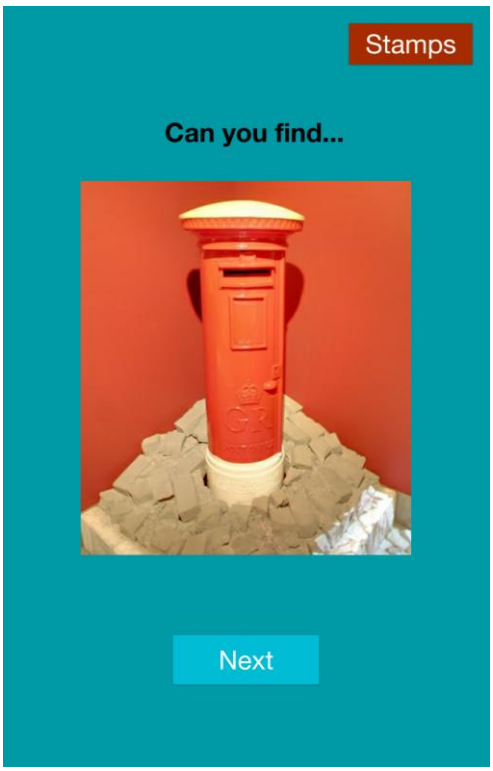
Describe Zone 2



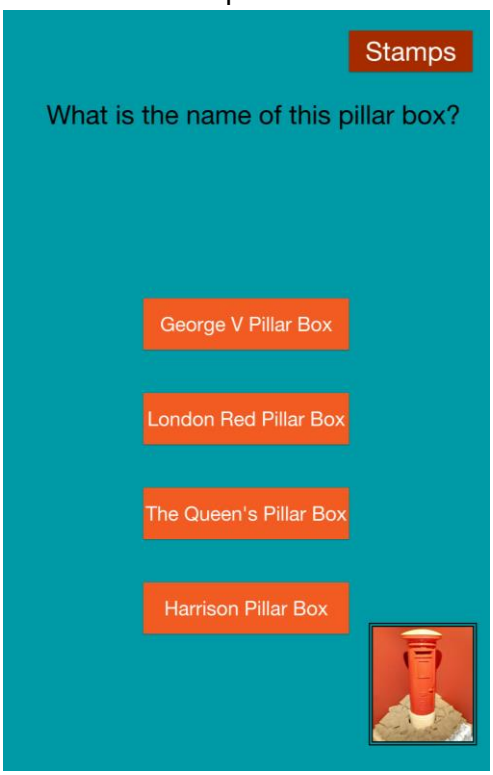
Pass the tablet 3



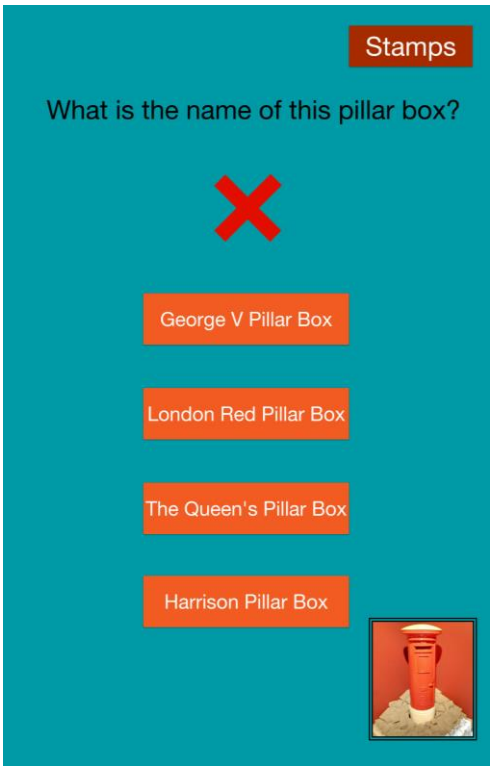
Find Pillar Box Zone 3



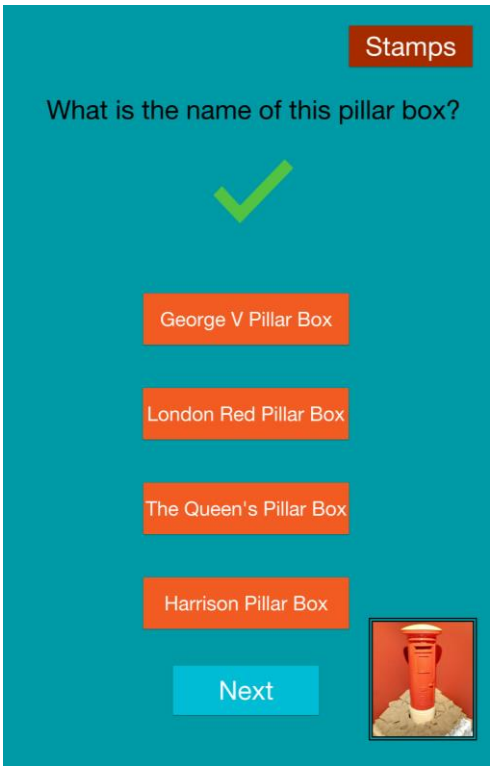
Pillar Box Multiple Choice



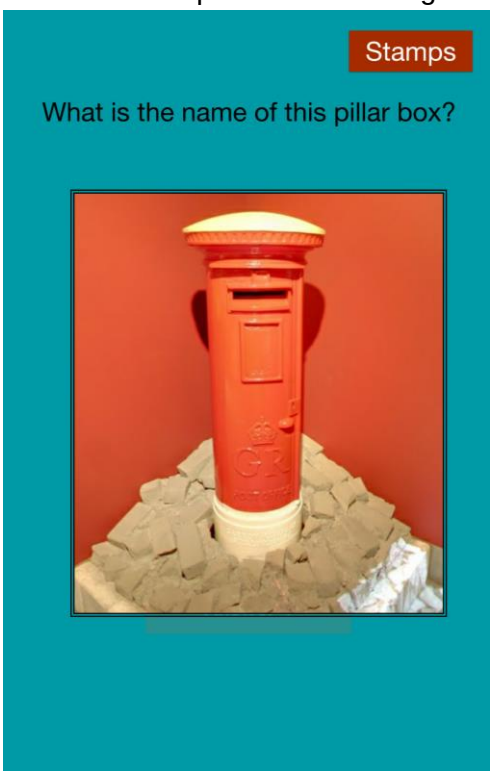
Pillar Box Multiple Choice: Incorrect



Pillar Box Multiple Choice: Correct



Pillar Box Multiple Choice: Enlarge Image



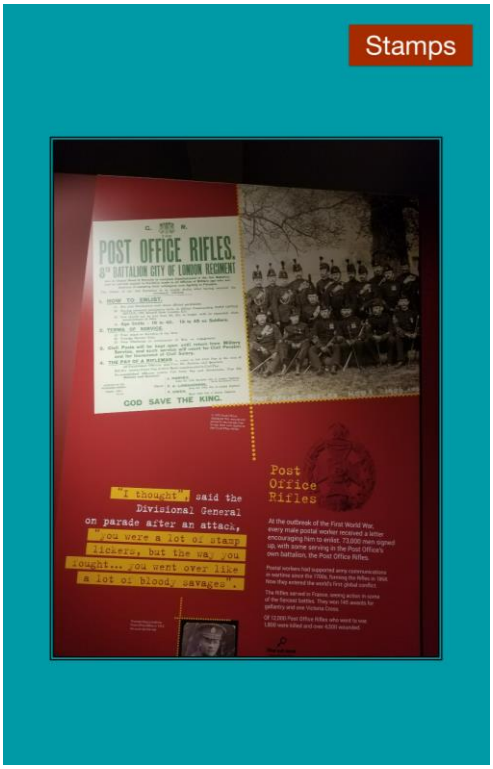
Find Post Office Rifles Zone 3

Post Office Rifles Multiple Choice

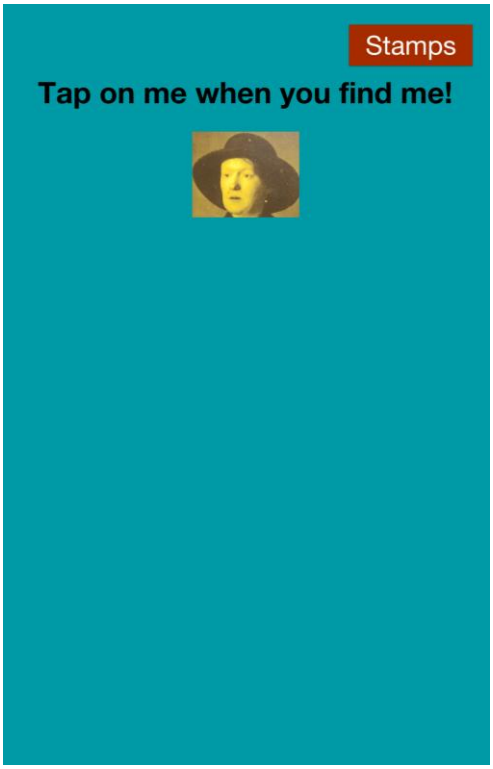
Post Office Rifles Multiple Choice: Incorrect

Post Office Rifles Multiple Choice: Correct

Post Office Rifles Multiple Choice: Enlarge Image

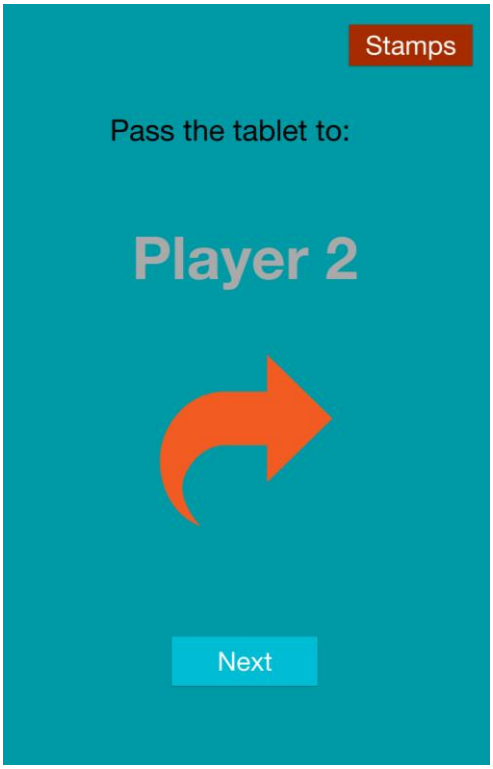


Woman in post 1



Woman in post 2

Pass the Tablet 4



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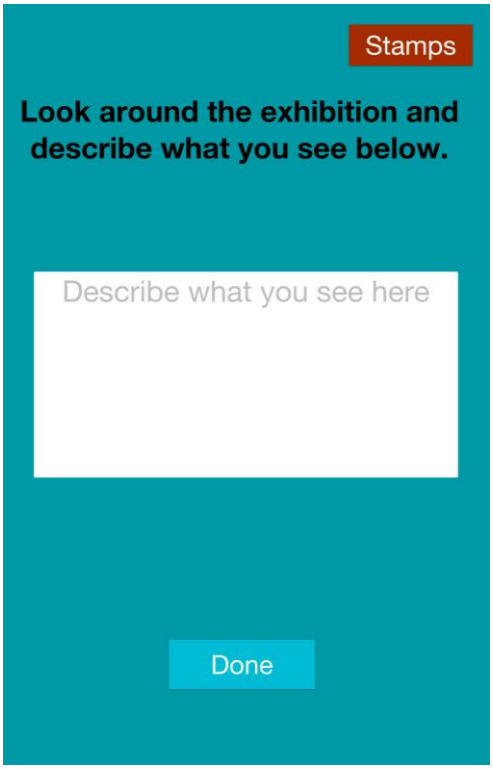
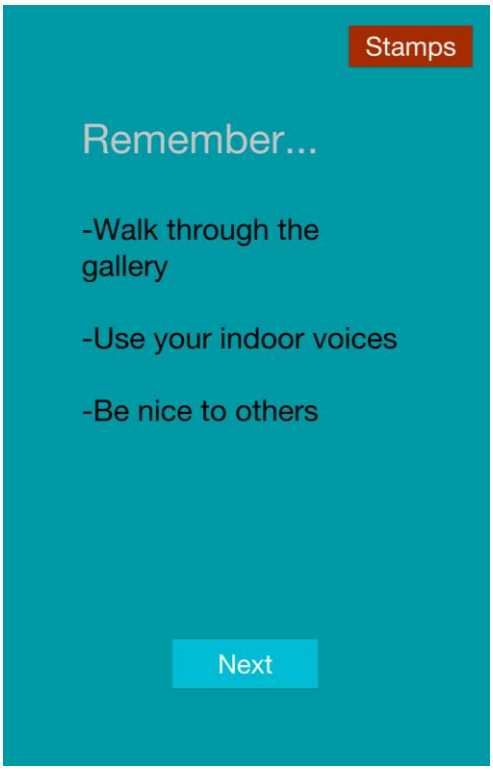


Reminder Screen



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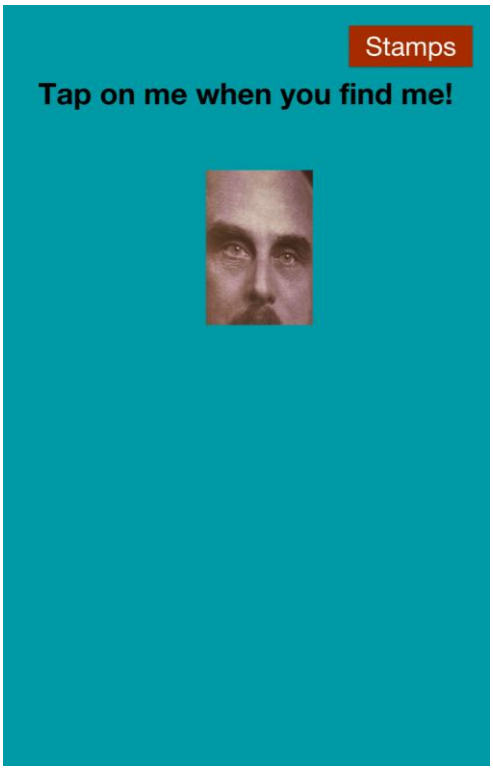
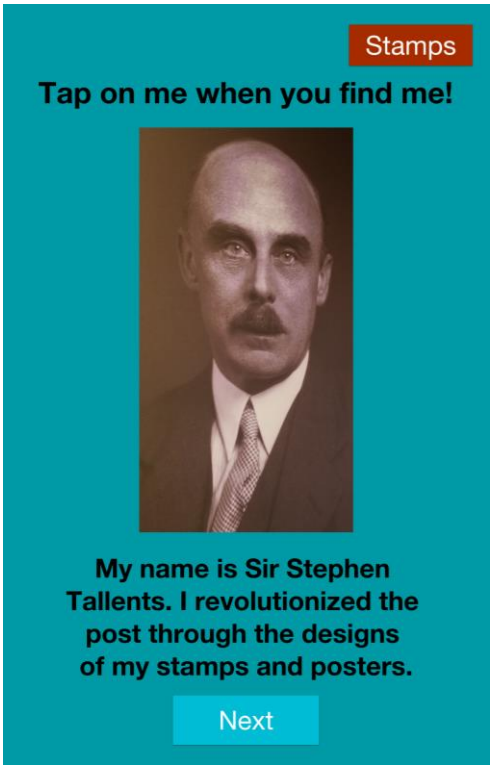
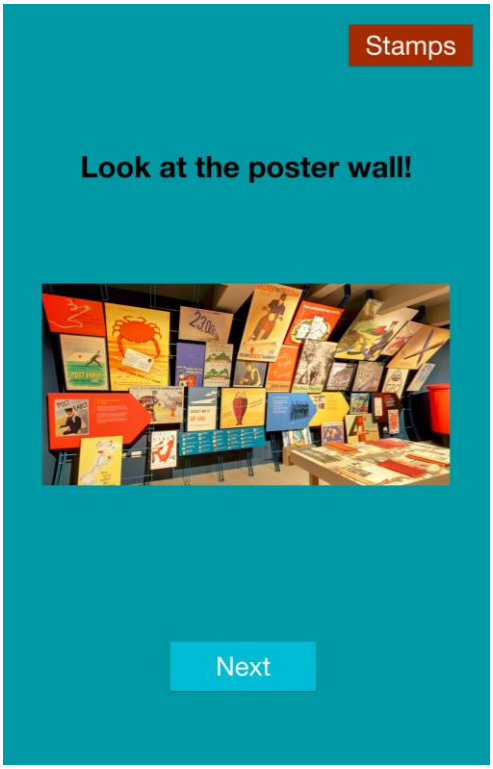


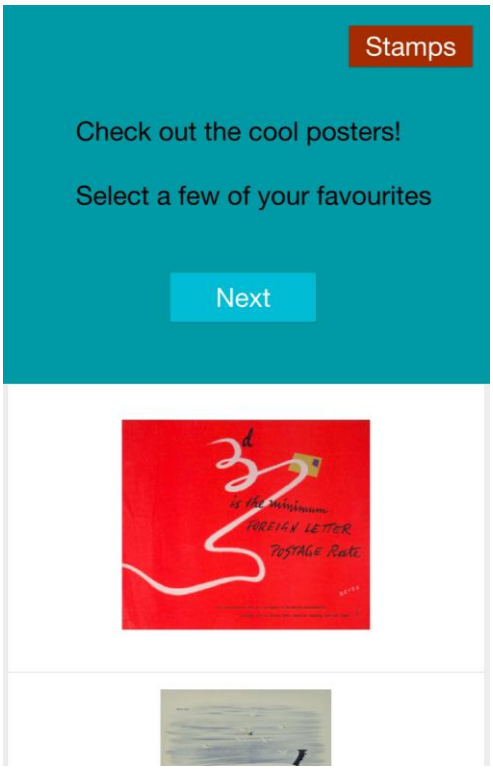
Tallents 2



Find Posters Zone 4



Choose Favorite Posters



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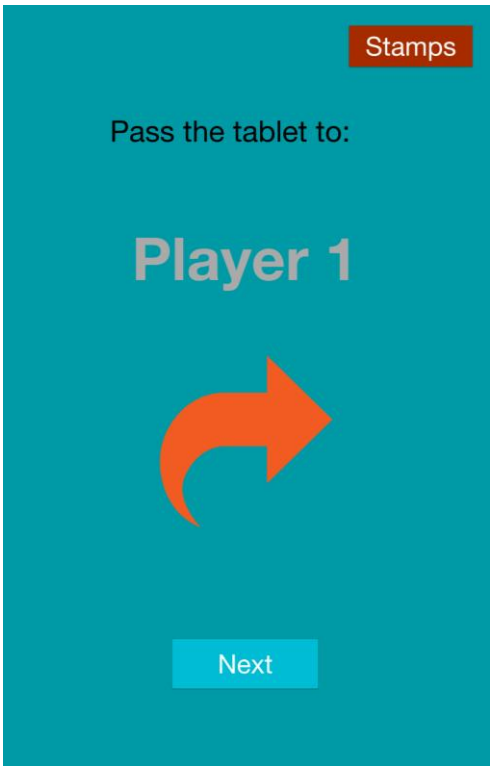
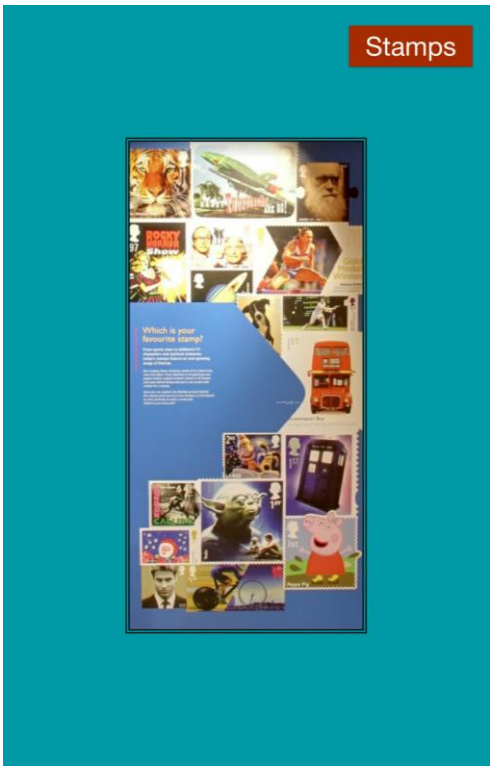


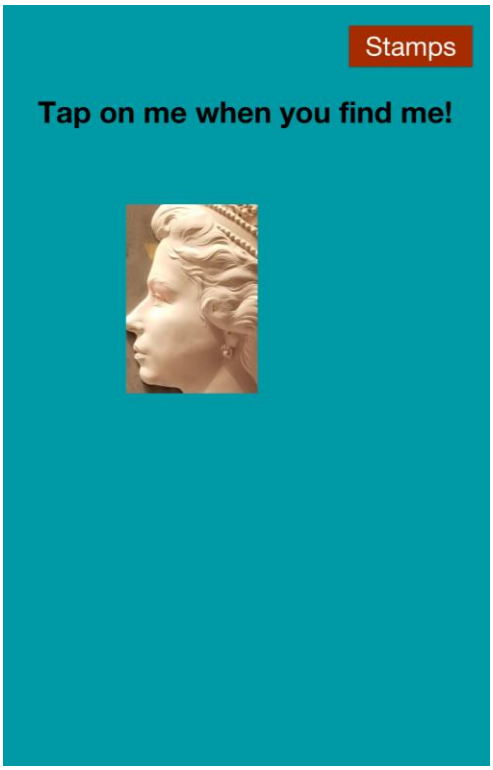
Find Stamps Zone 4

Count Number of Stamp

Count Number of Stamp: Enlarge Image

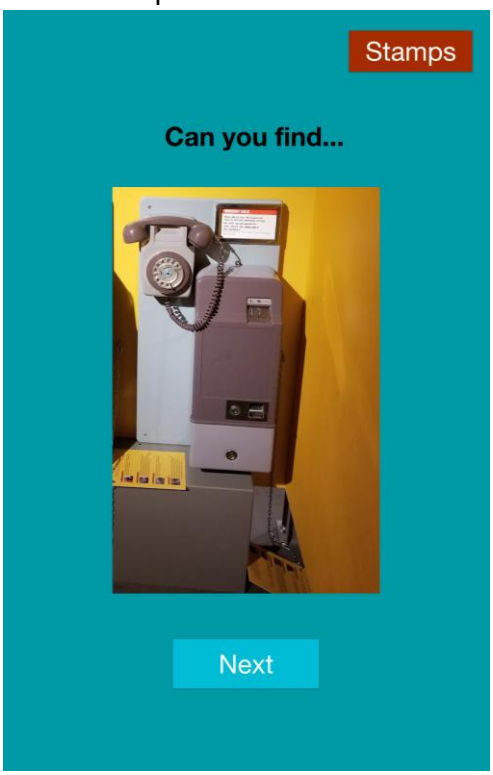


Queen Elizabeth II 1

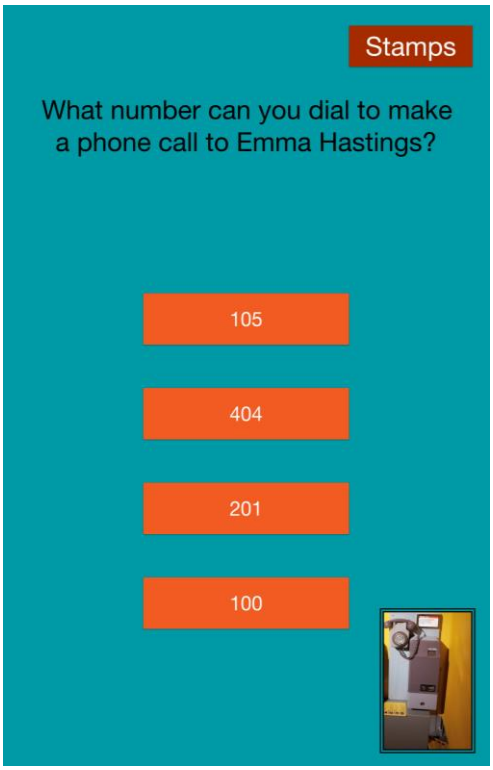


Queen Elizabeth II 2

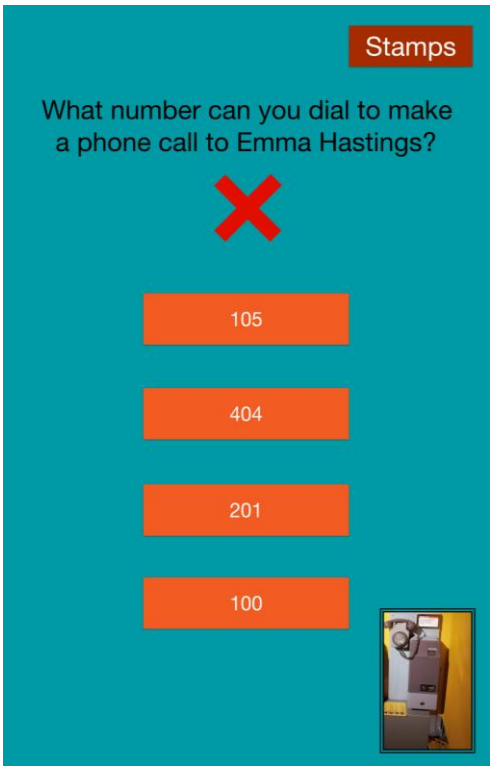
Find Telephone Zone 5



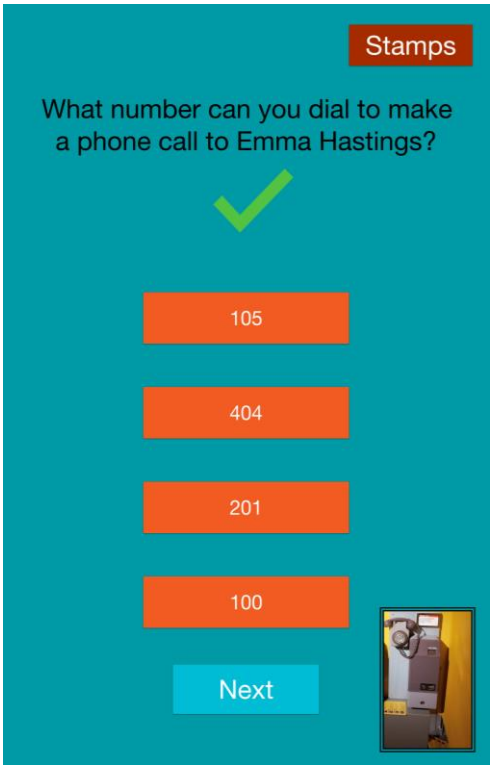
Telephone Multiple Choice



Telephone Multiple Choice: Incorrect

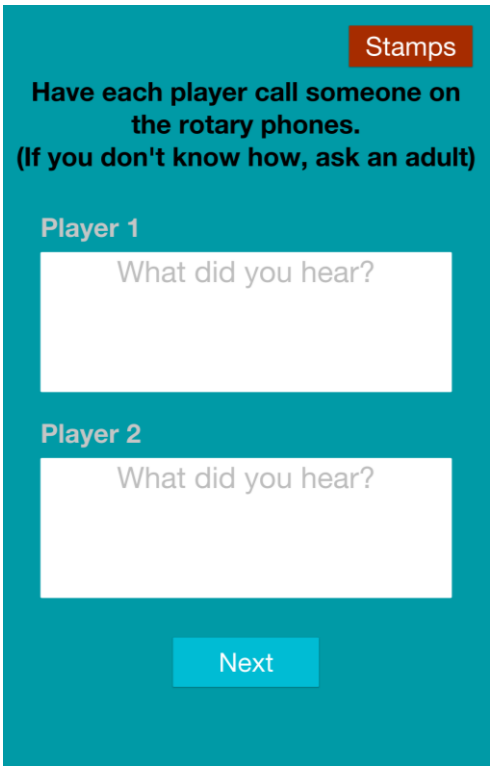


Telephone Multiple Choice: Correct

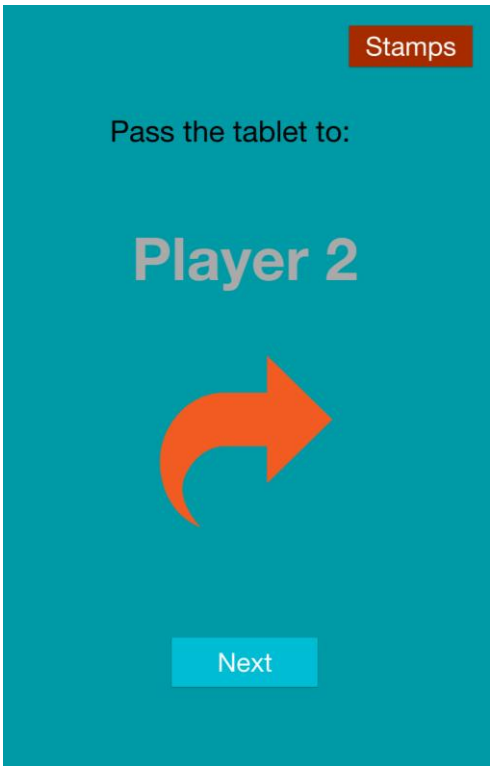


Telephone Multiple Choice: Enlarge Image

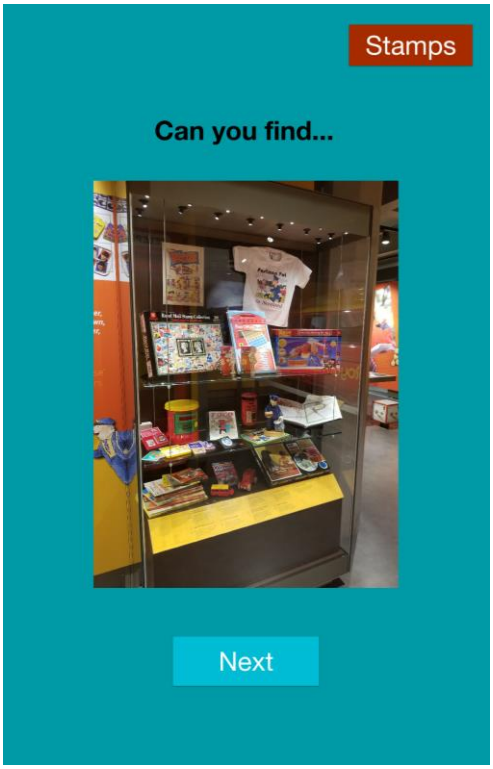
Rotary Phone Call



Pass the tablet 6



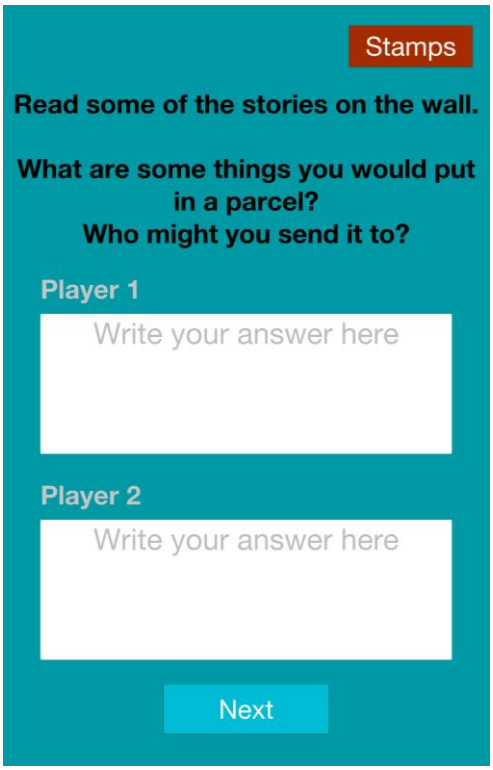
Find Games Zone 5



List Favorite Games

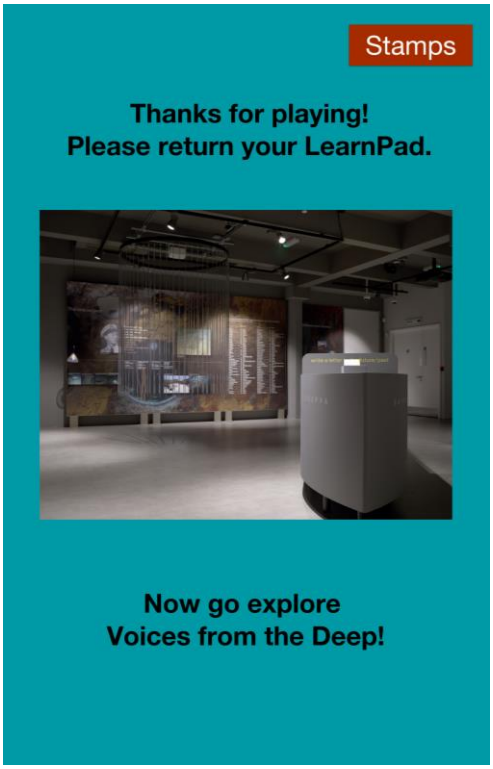
Find Parcel Zone 5

Parcel Question

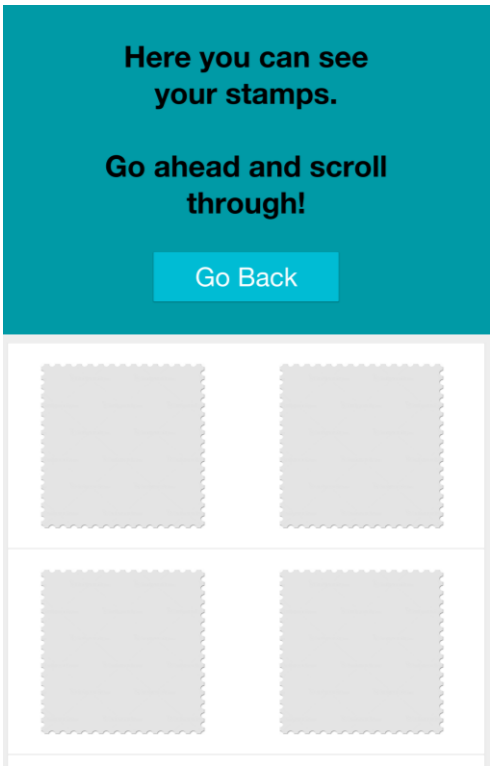


Explore Zone 5

Explore Voices from the Deep



Stamp Collection



Appendix AF: Final Prototype Screen Diagram