Evaluating Digital Learning Resources for International Students at the British Museum

WPI

The British Museum

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Abstract

The British Museum designed a prototype digital learning tool intended for non-UK English learning students. Our goal was to evaluate the tool on its ability to engage and educate its users through surveys, teacher interviews, and student observation. We also compared the tool to digital resources from other museums in London. We ultimately recommended that the British Museum continue pilot tool research and development, and advised approaches by which the Museum could improve the tool.

Executive Summary

Educational systems have increasingly adopted technology as it has advanced over time. Museums have sought ways to improve their visitors' experiences by adapting interactive technology into their exhibits. By including technology in exhibits, museums appeal to a large group of digitally literate people, including student visitors who respond well to interactive learning environments. The British Museum is investigating how to enhance the visitor experience of a very specific audience—international student school groups. The British Museum administration believes that developing a digital tool intended for this group of students may improve the value of some museum exhibits. Our research team evaluated the museum's prototype tool for its effectiveness in enhancing the visitor experience of these international students.

Evaluating informal types of educational tools such as digital learning tools requires a deep understanding of general learning theory. Appealing to students' emotions may be a key component in reaching the international student visitors. Drago et al. (2014) describes an effort in the United Kingdom to teach materials related to the collections and missions of various institutions, such as the Tower of London and the Museum of London, to groups of students from multiple cultures. Drago's research shows that the highest rate of success comes when students form a personal connection to the material, as it helps them with the retention of information (Drago et al., 2014).

Although interactive activities take many forms, their principal goal is to engage learners during the learning process. In a study conducted on the use of mobile applications, researchers discovered that students using a mobile-based application performed better than students who used paper-based learning materials (Mikalef et al., 2012). This study showed that interactivity in digital tools such as mobile-based applications (as compared with more traditional, paper-based interaction) reinforces student learning in museums.

As digital learning technologies become increasingly accessible to the public, there is an increased demand around the world for cross-cultural programming. The British Museum is the fourth most popular museum in the world, with over six million visitors per year, most of whom are international visitors. These visitors primarily travel from other European nations and

currently make up over 40% of the annual visitors (British Museum, 2015). The British Museum recognizes the importance of integrating digital technology into its physical exhibits to ensure the continued engagement of young, international audiences.

This project evaluated the effectiveness of a pilot digital learning tool developed by the British Museum designed to educate and engage visiting international students. Our team focused on students who were at equivalent educational levels as British key stages three to five, 13 to 18 years of age. We then used the results of our evaluation to formulate recommendations that helped the organisation improve the tool and better understand its audience. To accomplish the overarching project goal, we executed the following set of objectives:

1. Determine the effect of English proficiency on how much information the pilot test subjects' retained
2. Determine the educational value of the digital learning tool
3. Assess the engagement and enjoyment of visitors using the digital learning tool
4. Evaluate the advantages and disadvantages of the use of similar resources in other museums

To relate English proficiency with students' educational experience with the digital tool, we collected basic information from English-learning, international students visiting the British Museum. We administered paper surveys to target audience groups after their visit (Appendices C and D). The staff at the British Museum also requested that we collect information on age, gender, and nationality, to guide their efforts in designing tools for international student visitors. Interviews with group leaders helped us understand the overall demographic data for the group and their opinions of the digital tool. The staff of the British Museum also requested that our team inform them of what teachers expected their students to gain from their experience at the museum to ensure the tool met these expectations in the future.

Our team sought to determine if the digital tool was effective at educating its users. For the tool to educate, it needed to facilitate the retention of information. We investigated whether tool users retained more information about the museum than non-users, and if the tool substantially assisted English language learning students in their visit. We collected data for this

component using two methods. The primary method we used to obtain quantitative data was the survey, which we administered to users and non-user groups. The first part of our survey consisted of demographical questions. Additional sections of the survey pertinent to education included questions about the museum and its exhibits. We designed these questions to evaluate memory. This data allowed for two important categories of comparisons: the first between survey results of individuals in user groups compared to the control groups, and the second between the users' survey scores and their English proficiency (Appendices C and D). The second technique we used in evaluating the digital learning tool on its educational capabilities was interviewing. This method provided critical information about the tool and its contents. We interviewed teachers about the tool to learn how, as educators, they felt it functions. We asked them about expectations for their visit to understand what they wanted the tool to accomplish. Additionally, we asked them how helpful they believed the tool was to their students, and how much it contributed to their goals for their students while visiting the museum.

In addition to evaluating the educational value of the digital learning tool, our team also investigated to what extent the tool could engage international student visitors and provide an enjoyable experience. Engagement is the intellectual investment of attention and curiosity into the matter at hand. Enjoyment, similarly, is the state of taking pleasure from an experience. The primary method for evaluating students' engagement and enjoyment during tool use was survey questions (Appendices C and D). Group observation was our qualitative secondary method. We conducted observation of student groups when groups used the digital tool, and when group leaders permitted us to do so. We based our observations on a set of pre-defined engagement and enjoyment criteria.

Our team also evaluated digital learning applications at similar institutions. We visited Tate Modern, the Museum of London, the Science Museum, and the National History Museum. We tested the digital interactive media of these museums to observe their functions and how such functions compare to the functions of the British Museum's prototype. This comparison was important because it allowed us to provide strong recommendations based on real examples.

With surveys, our team determined if there was a connection between respondents' self-ranked English proficiency and their scores on the survey. There were two unique groups, based on the type of experience the students received: the tool user group and the control group. We

found that the average English proficiency for users was 3.15 whereas the average English proficiency for the control group was 2.67. There was a limited amount of data available for the user group, including a lack of any data for level one English proficiency users. However, all level two, three, and four users averaged approximately the same score, regardless of English proficiency. Additionally, we collected basic demographic information, such as the age, home country, school program type, as well as other information relevant to our analysis, such as the length of the museum visit, and smartphone ownership. Survey data showed that students were primarily between 13 and 16 years old. Over 50% of participants came from France, while others came from Spain, Germany, Belgium, Austria, and South Korea. Approximately 57% of groups were part of an English learning program. Most groups planned to spend approximately an hour and a half in the museum. From the survey, we found that over 97% of the students owned smartphones with almost 97% of students with a smartphone using it for at least an hour each day (Appendix E).

We hypothesized that the digital learning tool designed by the staff at the British Museum significantly increased the information retention of users over non-users. In order to test this hypothesis, we carried out a number of analyses. We first compared survey scores on the education component of the survey between users and non-users. Second, we compared the frequency of visitation for featured exhibits between users and non-users to determine if users retained facts about featured exhibits more than non-users. Third, we compared the favourite exhibits of users and non-users to show whether the digital tool made featured exhibits more memorable than other exhibits. The user groups had a higher average performance than the non-user groups. Users had an average score that was 172% of the non-users' average score. Students who used the tool visited an average of 85% of exhibits listed, while non-users visited an average of 60% of the tool's featured exhibits. We also found that 55% of users answered with an exhibit featured on the tool when asked what their favourite exhibit was, while fewer than 25% of non-users answered with an exhibit featured on the tool. This data strongly supports that the tool had an effect on which exhibits participants remember.

We conducted an evaluation of whether the British Museum’s pilot learning tool engaged students and provided them with an enjoyable experience as they visited exhibits. In order to investigate whether or not the pilot learning tool engaged students, we looked for differences

between the behaviors of users and non-users. Observers who followed groups through exhibits noticed unique behavior from control and user groups. Students using the tool often appeared more directed and purposeful as they went from one exhibit to the next, while student groups without the tool sometimes appeared fragmented and uncertain.

When gathering population samples for participation in our study, we had to ensure that their participation was voluntary. While this practice was important in maintaining ethical conduct, it did present problems. With many groups having set schedules, guided tours, and limited time, it was difficult to convince a large group of students and teachers to participate in a potentially time-consuming study. We found that approximately 50% of the groups we approached agreed to participate in the study as either a control or experimental group. Although there are many groups that can use the tool, the British Museum's challenge is to promote and distribute the tool effectively.

While trying to collect data, we had difficulty finding appropriate groups. Many leaders said they would have considered using the tool if they had known about it before arriving at the museum. It would have replaced their own learning resources. Our first recommendation is to have the British Museum's website advertise the digital tool in the school group section, to ensure teachers know the tool exists. They may also then download it on their mobile devices before arriving. The second is to hang official posters or banners throughout the museum. Lastly, we recommend the museum establish a permanent station dedicated to this tool near the entrance, similar to the station dedicated to families. This would help school group leaders know that the British Museum sponsors the tool, and that the tool is free to use as a part of the group's museum visit.

Many students who found that their phones were incompatible with the British Museum's wireless internet network were unable to participate in tool testing. We recommend that the museum investigate its wireless connectivity and consider eliminating the sign-up page that requires visitors to fill in personal information. If the British Museum's wireless network did not require login, more students may be able to connect to the network without issue.

While the majority of students using the tool found the in-tool maps to be accessible and properly guide them to exhibits, we received informal feedback that the maps were less helpful than some would have preferred, most often due to display size issues. The British Museum

should consider providing a pop-up map feature where the device's entire screen displays the map, so it is as large as possible, or consider adding a more interactive guide feature where students select their current location, and the tool provides navigation. Students, through surveys, and teachers in their interviews said they would prefer to have additional exhibits added to the tool.

Our team visited museums in London to determine the advantages and disadvantages of using various types of digital tools. These institutions implemented interactive tools such as games, interactive displays, and mobile applications for student visitors. The most viable alternative to the current tool is distribution of tablets or smartphones with the program already loaded. The museum could establish a system to distribute the digital tool to school groups in this manner. This system would maintain the mobility of the tool, and preserve its original benefits. In summary, we recommend that the British Museum continue tool development. While we identified issues with its implementation, we also found that it was effective in engaging students and helping them learn about exhibits.

Chapter 1: Introduction

In a world with vast quantities of information available at the touch of a button, individuals are less dependent on institutions, such as museums, to fulfil their informal education needs. To keep visitors engaged, museums are trying to find ways to incorporate digital technologies into their existing exhibits, programs, and online resources.

The British Museum is experiencing a large increase in international visitors as well as visitors between the ages of 13 and 18. This age group is especially reliant on digital technologies (Trinder et al., 2008). As this generation has grown up around digital technology, and often depends on it for information, it is pertinent for the British Museum to include programs that use digital technologies to ensure these visitors' continued interest and engagement in exhibits.

The British Museum attempts to incorporate digital technologies into exhibits for both United Kingdom and international students. In a study examining a pilot digital learning tool, the use of a digital learning tool developed for UK students provided no increase in the retention of information from the students' visit, but slightly increased their engagement (Doll, 2012). In this study, Doll (2012) investigated a digital tool designed to accompany and interactive exhibit about the Hajj. The Hajj exhibit was a cross-cultural educational exhibit exploring the Muslim pilgrimage to Mecca. The study by Doll (2012) shows an increase in both educational value and engagement levels among students who interacted with the exhibit. However, in that study, the British Museum provided students with digital devices and preloaded applications. Due to logistical and financial constraints, the British Museum is now developing another digital learning tool to target international student visitors. This new digital tool operates on the visitor's smartphone instead of on devices provided by the museum. To determine the potential effectiveness of a cross-cultural educational smartphone tool for this audience, we evaluated the educational and engagement levels of visitors who used the British Museum's pilot digital learning tool.

Although the British Museum has digital tools and programs to supplement exhibits and enhance the visitor experience, it does not currently meet the needs of a large group of visitors with its educational resources: school groups from across Europe as a part of English learning

programs. As a result, the British Museum's new tool caters specifically to both the intellectual and language proficiency levels of English learning students. When considering the addition of a digital tool, the British Museum must ensure that its use does not distract users from exhibits. The tool must further enhance their experience by making it easier for them to engage with exhibits and retain their educational content. With successful implementation of this digital tool, the museum can attempt to meet the educational needs of international students between 13 and 18 years old.

We evaluated the effectiveness of the pilot digital learning tool developed by the British Museum designed to educate and engage visiting international students. Our research focused on students who are at equivalent educational levels as the UK key stages three to five. We collected data from visitors to determine how effective the digital tool is at educating and engaging international student visitors, and compared these results to factors such as English language proficiency, comfort with digital technology, and educational levels. We evaluated aspects of the tool developed by the British Museum based on our observation of digital tools at other museums and discussions with staff at those institutions. Using this information, we provided recommendations on how to further improve the tool's ability to enhance the user experience.

Chapter 2: Background/Literature Review

This literature review discusses background research in the fields of cross-cultural education and museum digital resource implementation. We first discuss cross-cultural education theory—the strategies behind teaching students about differences and embracing them. We then discuss how museum learning allows for new, unique learning approaches. We culminate with an integration of cross-cultural education and museum learning, a critical framework for our understanding of the British Museum's problem at hand.

2.1 Cross-Cultural Education Theory

Building and evaluating informal experiential education tools for international student visitors requires a deep understanding of general learning theory. According to Mastascusa et al. (2011), there are several learning methods that formulate general learning. The first, study-based learning, occurs when students focus on materials on their own time, often in a residential setting. Traditionally, in this method, students study for examinations they will take at educational institutions. The second traditional learning method, retrieval, is the conversion of memory-based learning into a more active learning method. With retrieval, students push themselves to practise accessing information for later informational synthesis. The third traditional learning method, which the authors call schema building, is learning based on situational practice, ensuring that students can appropriately handle the real-life aspects and applications of a concept (Mastascusa et al., 2011). The understanding of the theories behind informal learning serve as a foundation for the discussion of the dialogical model later, because references to dialogical learning must be contrasted with a basic understanding of memory-based and retrieval learning. Organizations working in all educational fields can benefit greatly from awareness of these core learning methods. In the 21st century, educators are moving towards more interactive approaches to teaching. These new approaches are often the amalgamation of traditional techniques and new technology, making the study of both critical.

Nakamura et al. (2002) analysed cross-cultural teaching models and wanted to investigate further into the “dialogical model” of executing visual learning for multiple cultures, and how that may make activities more effective. Dialogical learning is students' learning that centres on

conversations between students. They found that dialogical learning can ultimately provide a stronger learning environment than traditional environments where the material matches the culture of the student. The dialogical model, as described, facilitates students' discussions of this difference while concurrently promoting comprehension of the environment around them (Nakamura et al., 2002).

Within the realm of music education, Cain et al. (2013) suggest that learning environments designed to promote creativity and innovative thinking use theories that favour discovery-based methods rather than didactic instruction. Their study of this concept is critical in the understanding of cross-cultural education, because creating a personal meaning to an unfamiliar concept is an important part of learning under this theory. Cain et al. (2013) focused on music education, where focusing on unfamiliarity meant actively showcasing genres from around the world. The same technique can apply to any field, without a great quantity of effort (Cain et al., 2013). Moreover, Jovana & Olivera (2010) showed that such unfamiliarity is minimal in young people when they express themselves using creative and interactive means. According to the authors, museums are in a prime position to introduce such interactive methods that allow students to embrace unfamiliarity and learn from it. The intercultural dialogue that results allows students, international or not, to create personal meaning between the material and culture (Jovana & Olivera, 2010).

Ultimately, appealing to students' emotions may be a key component in reaching the cross-cultural student audience. Drago et al. (2014) describes an effort in the United Kingdom to teach material related to the collections and missions of various institutionsgroups of students from multiple cultures, including those with strong differences. Drago's research shows that the highest rate of success comes when students build on their existing knowledge and rely on familiar and known concepts, explore new information with confidence (Drago et al., 2014).

2.2 Learning and Museums

Museums have a long history of providing enjoyment, beauty, and education. Since museums transitioned from being exclusive organizations to open forums for the public in the 17th century, they have evolved into essential parts of our society (Alexander, 2008). In the early

19th century, museums focused on displaying government wealth acquired through colonization conquests. However, after the industrial era, museums became a centre for educating citizens (Hein, 1998). Today, museums try to reach their audiences by introducing new and improved interactive programs and technology. An increase in the number of museums has resulted in a shift in the way museums operate, as museums are increasingly competing with each other for the attention of their target audience. Museums are now focusing on ways to develop tools in order to engage their visitors, instead of relying solely on exhibit materials. Additionally, they are developing new ways to broaden the role of museums in society (Vicente et al., 2012).

Traditional approaches to learning, such as rote learning and memorization, have shifted towards hands-on methods based on constructivist learning theory. Constructivism focuses on active participation and a focus on creating personal meaning of the concept. Constructivism, in the case of museums, may provide a theoretical framework to help understand what kind of learning processes occur during museum visits. Museum environments offer an intimate involvement between the visitors and the objects, creating a change in the personal value of the experience in the minds of the visitors. To create a truly constructivist learning environment in which learning is voluntary and personalized, museums must develop exhibits that relate to visitors. Additionally, they must anticipate visitors' questions and interests to create successful exhibits (Jeffery-Clay, 1998). A constructivist museum may use several strategies to encourage learning. By adding interactive exhibits, where the interactive elements complement the content, museums can create a learning experience that is unique to the visitor (Simon, 2010). Complementary to the constructivist theory, the contextual model of learning integrates three main contexts: personal, socio-cultural, and physical (Falk et al., 2000). The visitor provides personal context, the exhibit provides the socio-cultural context of the visitor, and the museum provides the physical context. This model states that museums allow personally motivated free choice learning, which is informal and voluntary. Unlike a school environment, free-choice learning depends on the individual visitor’s interests (Falk et al., 2000). Understanding and implementing these learning theories is important for museums, since they must create learning tools that cater to their visitors and encourage learning.

Experiments in learning theory have begun to involve interactive activities over the past decade (Hein, 1998). Although interactive activities take many forms, the principal objective of

an interactive activity is to make the learner active during the learning process. Several different approaches can achieve this result, including allowing the learner to handle the artefact (Caulton, 1998). The British Museum, for example, offers handling sessions for school groups where students learn about several exhibits through handling activities where they get to interact with the artefact (British Museum, 2013). However, handling sessions are not identical to interactive exhibits. Interactive exhibits are more active and respond to the visitor's actions. These qualities reinforce learning in museums.

In a study conducted on the use of mobile applications, researchers evaluated sixty students between the ages of 15 and 16 after using a mobile-based learning resource at an art gallery. The educational mobile application included QR (quick response) codes and quiz software. The students in the study received a paper quiz as a control data. The goal of the study was to explore the effect of increasing levels of interactivity on learning performance. The results of the study indicated that the mobile-based student group had higher performance on the quiz than the paper-based group (Mikalef et al., 2012). This study shows that interactivity with digital tools such as mobile-based applications (as compared with more traditional, paper-based interaction) reinforces student learning in museums.

2.3 Digital Learning in Museum Contexts

To maintain relevance in the digital age, many museums are evolving by incorporating digital technology into existing exhibits. This is a necessity, as recent generations bring a new kind of student that is constantly connected to and raised with technology, often referred to in literature as "digital natives" (Gallardo-Echenique et al., 2015). For this reason, museums are turning to digital learning tools. The integration of these tools into museum environments is an attempt to engage the ever-growing population of digital learners (Gallardo-Echenique et al., 2015). Digital learning has great potential for maximizing factual absorption and excels at developing higher order critical thinking skills because digital tools encourage learning outside of direct memorization (Churches, 2011). The vast potential for differentiation is a hallmark feature of digital tools, resulting in numerous applications of the technology, including mobile applications, games, and webpage based tools (Becker et al., 2015).

As users become more competent with digital resources, educational institutions have sought to advance their techniques and technology to complement this growing digital literacy. Many implementations that museums previous thought to be too costly or impractical are now viable, since digital devices are in the pockets of so many. As a result, museums have a large selection of technologies to select for their own development. These include tablets, large displays, and smartphones. Large fixed displays are often the first option chosen by museums, as their nature is contiguous with existing methods of displaying information. These displays boast many benefits: they are highly customizable, easy to implement, and provide specific and engaging programs that can be both static and interactive. One example of a digital display is in the British Museum, in its Egyptian wing. In this wing is a hall of mummies, with various specimens of preserved humans and animals. Glass completely encases these exhibits, due to their fragility. To engage visitors despite this, the museum designed a large digital display and control panel that shows viewers a three-dimensional rendering of a mummy, and allows for virtual dissection and observation of the mummy from all angles (K. Bessette, personal observation, 14 March 2016). While this type of digital tool has many benefits, it is not without fault. Visitors without wireless internet access can immediately use these devices, but they have a dedicated purpose and are not easily customized post-installation. In addition, regular maintenance on this system is imperative—if the tool breaks, it breaks for all visitors. Museums avert this problem by using personal devices such as smartphones or tablets.

Smartphones are useful for digital learning tools, because they feature a balance between features and required configuration. Recent research shows that a staggering 80% of some age groups own and carry a smartphone, making them a great device for delivery of digital tools (Pew Research Center, 2015). These devices also boast many benefits, including high mobility, ability to function offline, a camera with QR code reading capability, and strong user familiarity. There are two methods for implementing a digital learning tool on this platform. Users can either download a mobile application, or view the tool with the browser. These functions are also available on most tablets, but phones are more prevalent than tablets. As a result, museums typically direct these functions at smartphones. The drawbacks for this "bring your own device" method are few, but significant. It requires that the digital tool operate on many different operating systems, and requires either a steady internet connection for the browser or bandwidth for downloading the app. Many museums appreciate the platform of smartphones and tablets,

seeking their mobility and versatility, yet they lack the necessary resources to provide the required connection. Many museums work around this issue by providing users with a prepared device.

Many museums provide audio tours using specifically programmed smartphones, MP3 players, and even tablets. This technology provides great potential for diversification in the application of digital devices. While some museums have used smartphones as their distributed device, the British Museum included, tablets are more common due to increased screen space and reduced risk of theft. This platform also boasts extreme portability, as it can function anywhere within a museum's building without depending on a reliable internet connection, since content is stored on the device itself. Digital learning resources built on tablet platforms can also take advantage of the built-in camera, graphics processing, and audio playback capabilities. These features allow for many methods of information delivery, including QR codes, interactive infographics, three-dimensional renderings, and auditory instruction (Lopez et al., 2008). However, Adam Rozan, Director for Audience Engagement of the Worcester Art Museum in Worcester, Massachusetts, believes the adoption of tablet computers has strong drawbacks. The Worcester Art Museum currently uses tablets to provide information at special kiosks, and while they add a new modern aspect to the museum, they have presented some difficulties. Rozan noted that the Worcester Art Museum often sees issues with the program, including keeping the devices consistently charged, as well as facing the high cost of replacement (A. Rozan, personal communication, 16 February 2016). The associated human resource requirement is also challenging. There are some drawbacks when implementing new and highly technical programs. When museums implement such devices in the correct setting with proper resources, they can be powerful learning tools.

In addition to the increase in available hardware, museums are also using a plethora of digital programs to provide increased accessibility to museum content. Applications on mobile devices, such as smartphones, tablets, and other smart handheld devices, are a particularly popular method of delivery. Applications are programs that are downloadable from online stores onto mobile devices. One such application developed by a technical department at the British Museum is Baron Ferdinand’s Challenge. This allows users, on their own devices, to play puzzles that correspond to the British Museum’s set of objects originally collected by Baron

Ferdinand Rothschild, a key collector and British Museum donator (British Museum, 2015). The quiz function in these applications provides an easy method for users to test retention and encourages user engagement through game-like motivation. The incorporation of challenge activities encourages the increase in uptake of information, as it engages critical thinking and creates neural connections (Becker et al., 2015). Games are especially effective for younger audiences. Many children lose focus while exclusively observing, but giving them a way to participate anchors their attention in the desired areas (Mikalef et al., 2012). Challenge and gaming elements are two strong components of the application. In addition, most applications have offline capability that allows for reliable usage and consistent engagement. A tool developed by the National Palace Museum in Japan is another example. The tool implements an interactive timeline for users to further their museum experience. The topics along the timeline expand to show more information and links to relevant, credible sources. This resource also allows users to learn more through content delivered from the National Palace Museum's internet databases (Chen et al., 2011). Users are able to access this information from their mobile devices and navigate the simple, yet expansive breadth of information that the tool makes available.

2.4 Digital Learning and Cross-Cultural Education at the British Museum

As digital learning technologies become increasingly accessible to the public, there is an increased demand from around the world for cross-cultural programming. The British Museum is the fourth most popular museum in the world, with over six million visitors per year, most of whom are international visitors. Figure 1 shows the breakdown of the British Museum's visitor population since 2011. These visitors primarily travel from other European nations and currently make up over 40% of the annual visitors (British Museum, 2015).

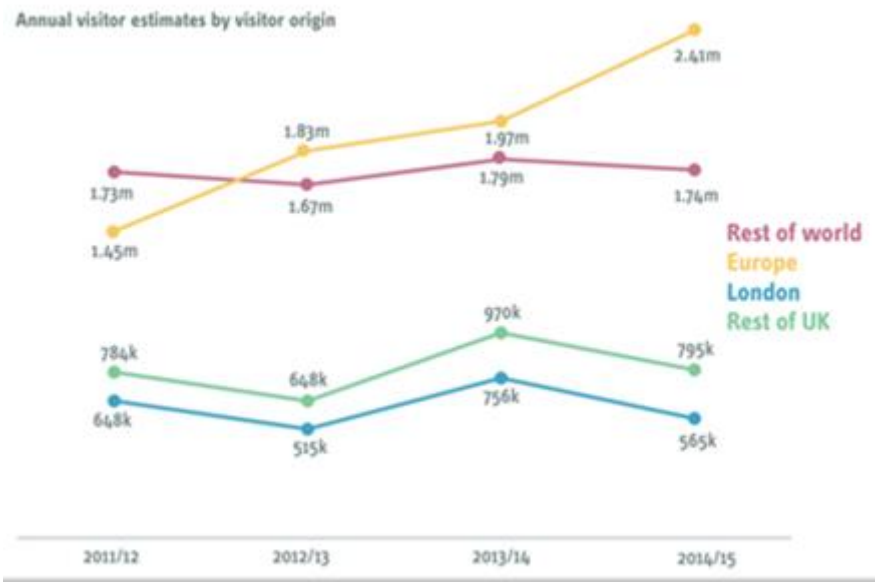


Figure 1: British Museum visitor distribution by region of origin from 2011-2015 (British Museum, 2015).

In addition to visitors who travel to the museum, its website and virtual museum receive another 24 million visitors each year (British Museum, 2013). This expanding international and digital demand requires the British Museum to develop stronger digital programs to satisfy its virtual audiences.

Without putting effort into incorporating digital learning techniques into its existing structure, the British Museum risks irrelevance, and other informal learning sources may replace the British Museum's exhibits and information. Visitors under the age of 18 currently make up over 15% of all European visitors to the museum. To ensure that this group continues to enjoy and remain engaged by the exhibits in the British Museum, the museum is developing digital technology to enhance the visitor experience at the museum (British Museum, 2013). In the 2010s, the British Museum began to take larger strides towards this goal by implementing digital learning tools into existing educational programs at the museum and studying the effectiveness of engaging and educating.

One such study at the British Museum focuses on the analysis of user engagement and knowledge absorption through student interactions with exhibits (Doll, 2012). The amount of time users spend in each exhibit and at each piece are a measure of engagement levels in the study. Interviews with the users consisting of questions about the exhibit content are a measure

of information absorption levels in the study. The study concludes that while the data did not prove that the users' knowledge retention is significantly different while using the tool, their engagement levels are much higher for the exhibits associated with the tool. However, this research has limitations and potential gaps as it analyses data provided by only one school tour group, which limits the variation in the students' backgrounds and capabilities that is necessary for conclusive findings (Doll, 2012).

There is a theory that the combination of cross-cultural education and digital technologies results in higher levels of youth engagement and information retention (Doll, 2012). The British Museum is attempting to make the visit more engaging for international, English learning students. However, the current program offered to international school trips is a self-guided tour of only six rooms. The program consists of a one-page printed document that, while appropriate for students under the age of twelve, is not challenging or engaging for older students visiting the museum (British Museum, 2012). However, the British Museum also offers another program that is more challenging, technologically driven, and engaging for its audience: The Samsung Digital Discovery Centre. The program allows visitors to interact digitally with pieces in the Centre using cameras and computers, which has made it one of the most popular areas of the museum for younger audiences. An example of the content offered in the centre is the workshop focusing on the Hajj, a Muslim pilgrimage to Mecca (British Museum, 2014). It encourages them to observe and investigate the impact of Hajj on pilgrims. Aesch (2012) evaluated this workshop's ability to educate students between the ages of twelve and sixteen on tours from Europe. Through surveying and interviewing students and teachers after interaction with the program, the study concluded that, in addition to an increase in engagement in most students, the centre increased information retention about the Hajj as well as the Islamic faith (Aesch, 2012). This research suggests that both cross-cultural education and digital technology in museum settings can be successful in engaging visitors.

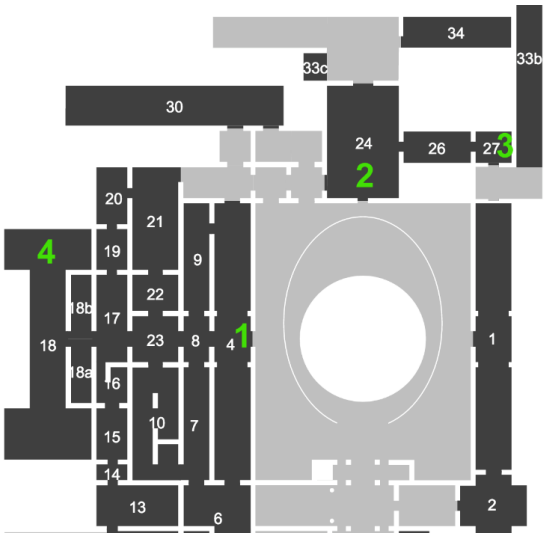
2.5 The British Museum's Prototype Tool

Staff members at the British Museum have built a prototype tool for international student visitors that runs on smartphones, tablets, and desktop computers in web browsers including Chrome, Safari, and Firefox. The British Museum built the tool with an authoring tool called

Elucidat, which provides a web-based interface for the development of such tools. Elucidat provided the British Museum with a simple workflow for the connection of various interactive modules together, so that students can pick exhibit modules in any order and at the pace of their experience in the museum. There are similar authoring tools such as Adobe Captivate and iTunes U but, as of early 2016, Elucidat's framework is one of the least platform-restrictive authoring tools (P. Mueller, personal observation, 15 March 2016). Content created with their framework runs on iOS devices, Android devices, Windows desktops, and Mac desktops. It is also most able to provide the British Museum with valuable features, since it targets interactive learning, as opposed to a broader form of interactive application development. These features include quizzing, drop zones, and module-based navigation to the featured exhibits.

The British Museum's tool begins with an initial starting screen. This home screen presents users with six selection boxes, linking to the following modules: “The Museum,” “Your visit,” “Rosetta Stone,” “Easter Island statue,” “Mosaic serpent,” and “The Parthenon.” The first two modules provide information on museum basics and signage, while the remaining four lead users on a separate investigation into each piece.

The Learning and National Partnerships department selected the Rosetta Stone, the Easter Island statue, the double-headed serpent mosaic, and the Parthenon as the four exhibits in the tool.



As shown in Figure 2, each of the featured exhibits, denoted by green letters 1-4 in module order, is located on the ground floor of the museum. This positioning made them easy for students to access. According to Museum staff, the Rosetta Stone (Figure 3), the first exhibit featured, is one of the most visited exhibits in the museum.

Figure 2: Locations of the tool's featured exhibits on the ground floor of the museum

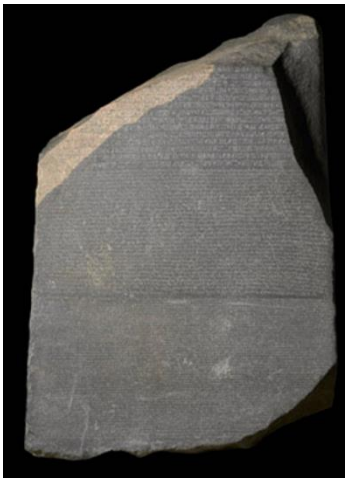


Figure 3: The Rosetta stone

The Easter Island statue (Figure 4) is less known than the Rosetta stone, but is equally as prominent, and also located on the ground floor of the museum. The staff selected this exhibit because it is easy to access, but often overlooked by student groups.

Figure 4: The Easter Island statue

The double-headed serpent mosaic (Figure 5) is located in the Mexico gallery, which is adjacent to the Enlightenment Gallery (Room 1), also near the Great Court. The staff selected this piece due to its easy access on the ground floor, but also because of its obscurity.

Figure 5: The double-headed serpent mosaic

The final piece featured in the prototype tool is the Parthenon (Figure 6). This piece is most similar to the Rosetta Stone, and is situated a few rooms away from the Rosetta Stone, away from the Great Court.

Figure 6: The Parthenon exhibit

The modules for each of these exhibits are accessible directly from the main menu of the tool, allowing students immediate access to all of the material once it has loaded in their browser. Each module begins with guidance for students to walk to the exhibit for that module. Figure 7, below, demonstrates what is displayed to lead a user to the Rosetta Stone.

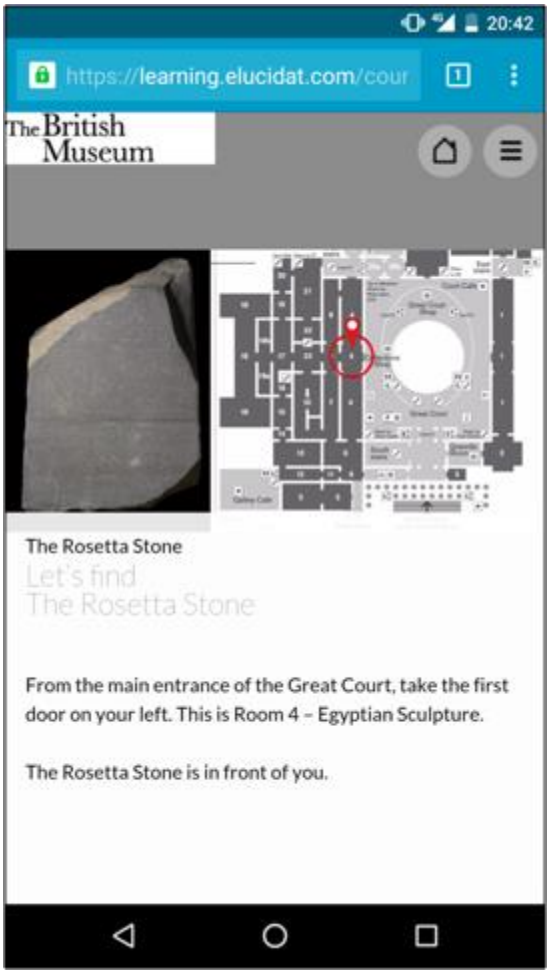


Figure 7: The navigation component of a digital learning module

The tool then asks a series of questions about the exhibit for that particular module. In our discussions with our British Museum liaisons, we found that the goal of these questions is to assist in the museum learning process and promote English language learning. The British Museum worked independently with an English learning expert to build the questions at an appropriate difficulty. For example, in the Rosetta Stone module, the tool asks students what languages were on the stone by providing a sorting game.

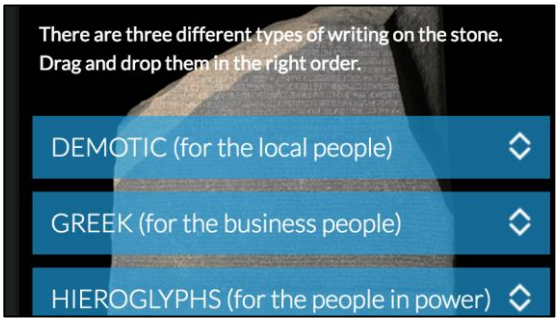


Figure 8: The tool's question for students

This sorting question ensures students' comprehension of the Rosetta stone's languages without requiring them to write complex English.

For the double-headed serpent mosaic, the tool asks the students about the colours of the serpent's body. The questions help students find critical information on the piece, while stimulating basic language learning topics such as colours, numbers, and verb tenses. When students answer these questions correctly, the tool totals their scores to a global score maintained across all of the modules. The current score is visible on the main screen, and the tool encourages students to compare their scores to their friends' scores.

2.6 Conclusion

The rise of technology presents a unique challenge and opportunity for museums. In order for these institutions to maintain their status as a standard of education, their traditional learning mechanisms must adapt to accommodate modern technology. With this increase in technology, the global community is more connected than ever. For this reason, museums must seize the opportunity to incorporate cross-cultural education into their mission, and use modern technology and its global youth outreach through the incorporation of digital learning tools to supplement physical exhibits.

Chapter 3: Methodology

Our team evaluated the effectiveness of a pilot digital learning tool developed by the British Museum designed to educate and engage visiting international students. We focused on students who were at equivalent educational levels as British key stages three to five, 13 to 18 years of age.

To accomplish the overarching project goal, we executed the following set of objectives. First, we collected information about our target audience in order to understand the relationships among subsets of this group. Second, we determined the educational value of the digital learning tool to see how the tool helped the students learn. Third, we assessed the engagement and enjoyment of visitors using the digital learning tool. Lastly, we evaluated the advantages and disadvantages of the use of similar resources in other museums in order to provide recommendations to the British Museum on how to develop the pilot tool further. We derived these objectives directly from the desires of the British Museum staff. The British Museum's staff was eager to learn about where these students were from—our first objective caters to this desire. They also wanted to ensure their tool was both educational and enjoyable. We evaluated those two characteristics in two independent objectives. Lastly, the museum's staff encouraged us to test tools at other museums and provide recommendations on how to improve their tool. Our final objective therefore evaluates other museums' tools. Each section that follows articulates the methodology for each objective, and Figure 9 presents an overview of our methodology for the project.

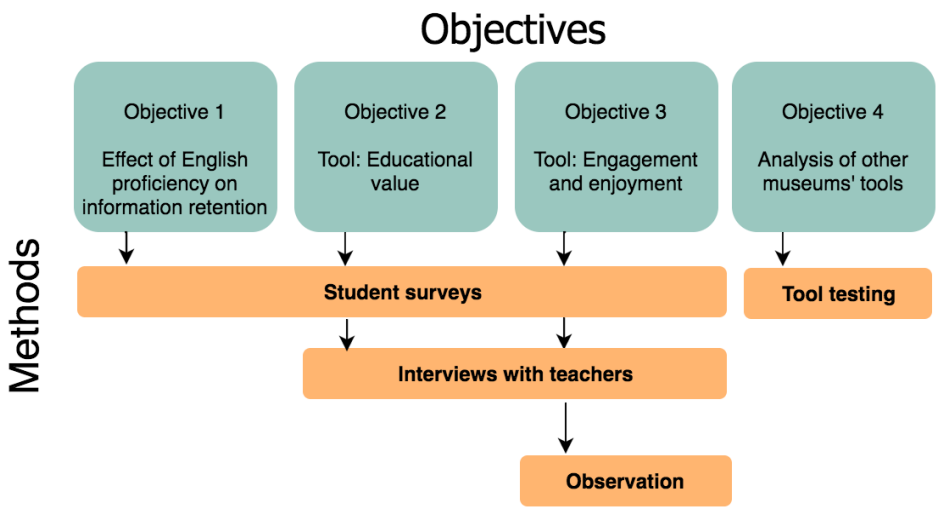


Figure 9: Project methodology flow chart. The flow chart shows the four principal objectives of our project and the methodologies associated with each. Interviews and surveys are the main mechanisms by which we collected data, with observation as a secondary mechanism for evaluating engagement and enjoyment.

3.1 Logistics

To accomplish our goal, we surveyed and observed international English-learning student groups between 13 and 18 years of age during their visit (Appendices B, C, and D). Additionally, we interviewed their teachers and group leaders. We placed a welcome station near the main entrance, with signage requesting in English, French, and Spanish that international school groups visit our table at the beginning of their tour from 28 March 2016 to 15 April 2016 from 10.00 to 16.00 (Figure 10).

Figure 10: Welcome station near the main entrance with signage

We assigned three team members to act as floating researchers. These floating researchers approached group leaders and asked if they would like to participate in the study, while the fourth group member stayed at the table. If the groups confirmed, we guided them to the table. The team member who remained at the table then explained the program to the group leader. This team member also obtained verbal consent to interact with the students. This was necessary as the students were unaccompanied by their primary guardians, and were minors, so we collected permission from the teachers acting as temporary guardians *in loco parentis*. If the leader declined to participate, we recorded this occurrence in the rejection log along with their reasoning. If we obtained permission, the floating researcher joined the group on their tour of the

museum to observe the students' interactions with pieces in different exhibits and interview the teacher. If the teacher allowed the students to interact with the tool while touring, the group became part of the user data. If the teacher agreed for them to be a part of the study, but would prefer the students do not use the tool, they were a part of the control data set. Figure 11 below shows this step by step process through which we obtain and utilize groups.

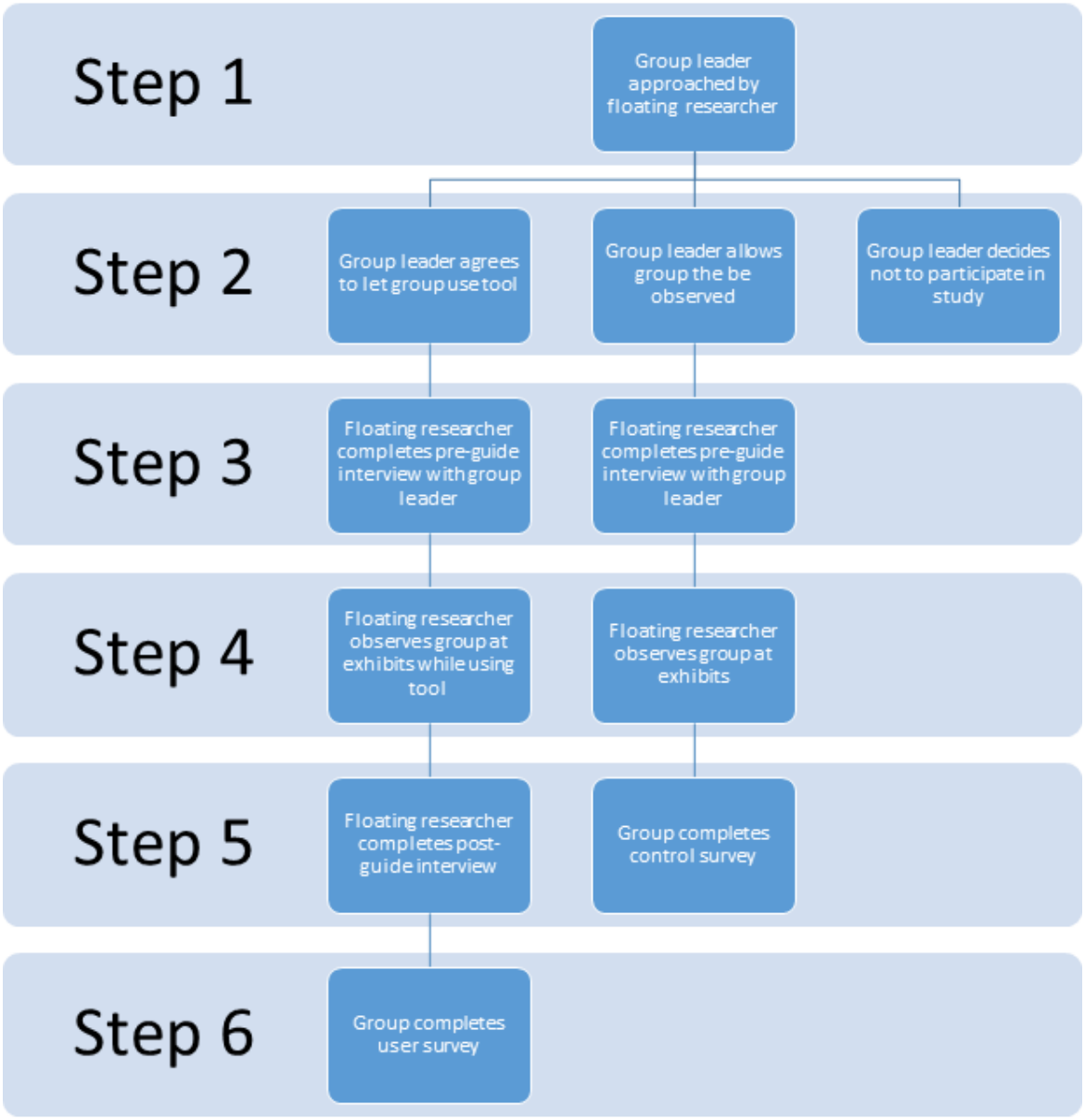


Figure 11: A flowchart explaining the procedure for the floating researcher

To organize data and ensure consistency across all data collection methods, we assigned a six-character ID to all groups that were part of our study. The first character referred to whether the group was a control or user group, with C representing the control group, and U representing the user group. The second character indicated the entrance through which the group entered, with N representing the north entrance and M representing the main entrance. The third character referred to the week of data collection (1, 2, or 3). The fourth character referred to the day of the week of the data's collection with M representing Monday, T representing Tuesday, W representing Wednesday, R representing Thursday, and F representing Friday. The fifth character referred to the group count for the day for that entrance, with the first group observed, surveyed, or interviewed represented by "1," the second group represented by "2," and so on. The sixth character in the codex applied only to the observation matrix, and referred to the exhibit piece where the observation took place with S representing the Double Headed Serpent, E representing the Easter Island Head, R representing the Rosetta stone, and P representing the Parthenon exhibit.

We subjected all groups to the same methods of data acquisition: interviewing, observation, and surveying. The floating researcher conducted interviews of teachers to determine their perceptions of how well the tool improved students' experiences. The interviews also obtained demographic data, goals of their visit, suggestions, and other information (Appendix A). While we conducted teacher interviews, another team member observed students and their interactions with exhibits featured in the digital learning tool, if teachers permitted us to do so. We used both control and user groups to determine if there were differences in the level of engagement and learning for the two groups. We used a standardized observation matrix to record behaviors, as described in the section for Objective 3 (Appendix B). We also administered surveys to both user and control groups. The first few questions of the survey aimed to collect demographic data and mobile device usage information. The second half of the survey was a brief quiz designed to ascertain data on the effectiveness of the tool's educational components, and gather students' opinions on the tool (Appendices C and D).

When we arrived at the British Museum, our liaison provided us with the latest version of the tool built from the Elucidat framework. We first explored it using our smartphone browsers. Our liaison then provided us with Elucidat login credentials for making changes. The version

provided had styling issues and logistic bugs. We fixed these issues before we began data collection.

On many pages, for example, the theme and colours were inconsistent. The colour contrast between background images and text was extremely limited, making text barely visible (Figure 12).

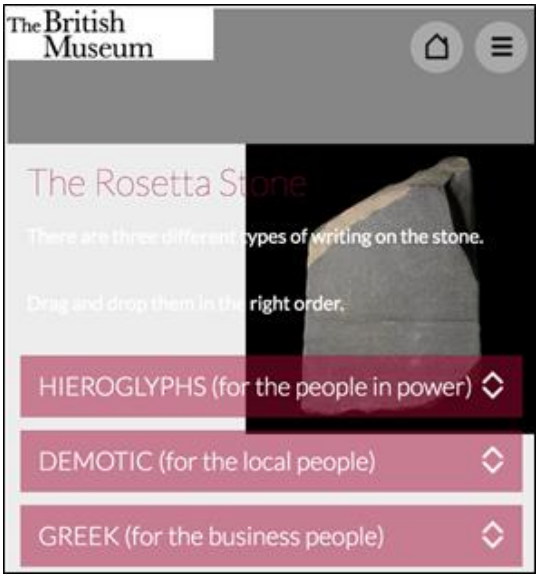


Figure 12: A page containing readability and colour errors in the initial version of the tool

Using Cascading Style Sheets (CSS) code available for modification through the Elucidat framework, we were able to change the colour structure, streamline the colours behind the British Museum logo, and ensure readability.

Figure 13: The first Rosetta Stone question screen after CSS restructure

As seen in Figure 13 above, after modification, the tool matched the British Museum's desire for a blue-based colour scheme, readable text, and professional logo styling. We also found further issues in other modules. In the module where students match Museum map icons to various services including lift, cloakroom, and café, only three of the six icons for the quiz were visible.

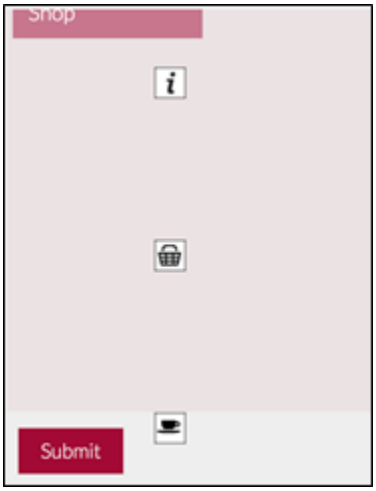


Figure 14: Erroneous page where only three of six drop zones are displayed

We fixed this issue by adjusting the *n*th*-item* selectors in the CSS code, which controlled what height and width parameters affect each drop zone icon, depending on its index in the grid.

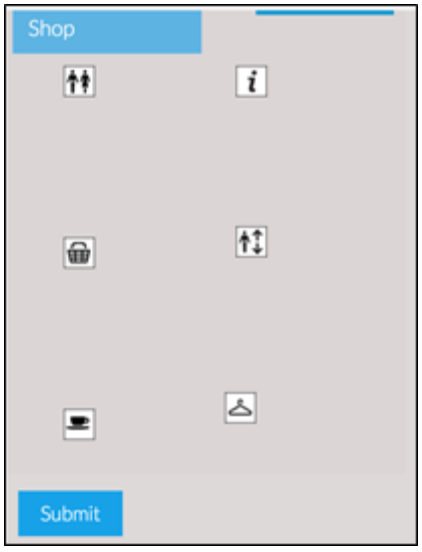


Figure 15: The adjusted game module with all drop zones displayed

By fixing this game module to ensure it was operable on all screen sizes, we made significant progress towards bringing the tool to a state where it was ready for participants from school groups to use.

The final set of issues we found with the tool was related to navigation and scoring. We found first that the tool did not log the score a student should have received for visiting the Parthenon exhibit correctly. Second, the Easter Island statue module was not clickable when viewed on smartphones. We fixed these logistic issues concurrently with the styling challenges, and came out with a more professional, ready to use tool prototype.

In addition to the data we collected in association with our four objectives (described below), our liaisons at the British Museum requested specific data in addition to our objectives. We collected those data through our surveys and present the data in Appendix E.

3.2 Objective 1: Determine the effect of English proficiency on how much information the pilot test subjects' retained

For objective one, we collected data on students' English proficiency and compared those data with survey scores from English-learning, international students visiting the British Museum between the ages of 13 and 18. We administered surveys in paper form, with similar English complexity to the language in the digital tool, to the target audience groups after their visit. Collecting this data showed how the British Museum could better tailor the tool for this audience. We used Pearson's correlation and the associated p-value to determine if the relationships between the students' English proficiency and survey scores were significant. We also collected data on smartphone usage from the target audience. Based on this data, we made recommendations on the feasibility of student personal device use in the museum (Appendices C and D).

3.3 Objective 2: Determine the educational value of the digital learning tool

Our team sought to determine if the digital tool is effective at educating its users. In our research, we considered education to be the degree to which visitors retain information from the exhibits they visit. For the tool to accomplish this objective, it must have the capacity to facilitate retention by its users. This included determining if users retain more information about the museum than the control group, and if the tool substantially assists English language learning students. Educational evaluation is critical to the overall goal of the project, as British Museum staff is designing their tool to help international students learn more about the museum in their brief visits. Educational value is thus a key aspect of the tool's functionality.

Museum staff, with the digital prototype, is targeting English learning, international student visitors between the ages of 13 and 18 (British Museum, 2013). We evaluated the tool on its ability to educate this kind of student using quantitative criteria. The tool must effectively provide instructions and act as a successful medium to assist in English learning while students are exploring the museum. To evaluate these criteria, we tested the tool by comparing users to control groups. This group did not use the digital learning tool during their visit to the museum.

The use of a control group provided a statistical contrast for our data, allowing us to demonstrate whether the tool truly educated users.

We collected the desired data using two methods. The primary method we used to obtain quantitative data was the survey, which we administered to users and non-user groups (Appendices C and D). While the first part of our survey consisted of demographic data acquisition, the section of the survey pertinent to this objective included questions about the museum and its exhibits. The surveys utilized open text-box questions to evaluate active recall. We designed the questions to provide data that could demonstrate a difference between users and non-users, having a correct and incorrect set of answers that we could compare. This design focused on information available to anyone in the museum, so both users and non-users had the opportunity to gain the knowledge they would need to answer the questions correctly. However, the questions also directly related to material in the digital tool. For example, one of the exhibits featured in the tool was a mosaic serpent. Every module of the digital tool came with a brief explanation of the exhibit, a map, and questions that challenge museum knowledge and English language learning. The tool specifically noted the country of origin for the exhibit, Mexico. This fact was readily available to all museum visitors, considering information posted at the exhibits. However, since the digital tool highlighted this in particular, we expected tool users to have a higher success rate in recalling this information. Following this logic, survey question eight asked the country of origin of the mosaic serpent. In addition, our survey also asked if the visitor went to the exhibit in the question. This question served to compare whether the tool affected the set of exhibits that students chose to visit. If the tool is effective, it should increase the number of students that saw the exhibits featured in the tool. To make sure we encouraged accurate responses, we included a grayscale image of the exhibit with the corresponding question. This ensured that even if students did not recognize the exact names of exhibits, they could still have a chance at answering questions. Questions six through nine followed the same format to provide data for comparative analysis (Appendices C and D).

This data allowed for two important categories of comparisons: the first between survey results of individuals in user groups compared to the control groups, and the second between the users' survey scores and their English proficiency. In order to standardize the survey grading, we designed a grading rubric for grading surveys. This rubric provided a point value and range of

accepted answers (Appendix F). At grading time, a group member read responses to a blind group member to prevent grading bias. The blind group member was not aware whether the response originated from a user group or a control group. Each survey response received its own entry in our spreadsheet. Given that a major component of our research was to determine the tool's effectiveness in user learning, we compared averages to determine whether there was a significant difference between the scores of students in user groups and control groups. Another key component to the educational value of the digital tool is its ability to assist in English language learning. We assessed this ability by comparing individuals' scores on the survey to their perceived English language proficiency (Appendices C and D). We examined these patterns to provide information on the tool's effectiveness.

We also used question five on our survey to create another layer of comparative analysis. Question five asked students about their favorite exhibit, and was unique given that we did not have predefined correct answers (Appendices C and D). Though this data may seem subjective, we designed this question to show whether the tool significantly affected recall of information by its users. We expected that an effective tool would result in a higher frequency of students selecting exhibits from the tool as their favorite. There was a possibility that this question would not provide usable data, however. If all control groups stated their favorite exhibits were ones featured in the tool, there would not be a difference between groups. However, if control groups infrequently listed exhibits used in the tool, then we could conclude that the tool increased exhibit notability.

While surveys are an efficient way of gathering objective information, we also gathered subjective data to provide an additional analytical angle. The second technique used in evaluating the digital learning tool on its educational capabilities was interviewing. This method provided qualitative, critical information about the tool and its contents. We interviewed teachers about the tool to learn how, as educators, they felt it functions. We questioned them on goals for their visit, how helpful they believed the tool to be to their students, and how much it contributed to their original goals in visiting the museum (Appendices A and E). We consider teachers to be an extremely valuable source of information as they have prior experience with the students, and provide an educated perspective to the data. We also asked teachers to use the tool so they could provide a full disclosure of their opinions of the tool. Their perceptions and advice greatly

influenced the way we interpreted our data. With teachers' perceptions providing a lens through which to view the data, we can examine trends, outliers, and variance with more perspective than solely numerical data.

3.4 Objective 3: Assess the engagement and enjoyment of visitors using the digital learning tool

In addition to evaluating the educational value of the digital learning tool, our team also investigated to what extent the tool could engage international student visitors and provide an enjoyable experience. We identified engagement and enjoyment as two critical metrics to evaluate this tool's effectiveness. Engagement, in our project, is the intellectual investment of attention and curiosity into the matter at hand. Enjoyment, similarly, occurs when students are pleased with their experience. Quantitative survey data and qualitative observation data were the two methods we used to assess these metrics. We also collected quantitative observation data, but qualitative observation data was ultimately far more informative.

The relevant survey questions for this objective were survey questions 13 through 16. Survey question 13 asked students to self-report, on a Likert scale, how much they enjoyed the game. Survey questions 14 and 15 asked students how helpful the game was in finding exhibits and learning new things, and survey question 16 asked students to indicate how easy the game was to use. Each question also asked that students provide reasons for their ratings. We expected these survey questions to inform students' engagement and enjoyment, because a student that feels the tool was worthwhile would indicate that it was helpful (Appendices C and D). Additionally, an engaging tool cannot be too easy for students to complete—engagement includes challenge (Underhill, 2012).

Execution of our observation began with approaching the group, as described in Section 3.1, methodology logistics. In addition to asking group leaders whether their students would use the digital tool, we also asked them whether they would allow us to observe their group at the exhibits on which the tool focuses. Once at one of the tool's target exhibits, the team member began an observation session using the observation matrix (Appendix B). The observation matrix featured two categories with two levels of observation: engagement and disengagement, and enjoyment, and displeasure. A member of our team using the matrix with a student group was

responsible for scoring the group using a scale with a predefined threshold of 50% for a particular activity. For example, in the engagement category, we observed closeness to items, time spent, and engaged conversation. Table 1 defines these characteristics.

Table 1: Observation metric definitions

Metric	Definition
Close to item	Less than two meters away from the piece while observing
Long time spent at item	At least 15 seconds standing by the piece
Engaged conversation	Demonstrable intellectual curiosity: discussions with instructor or other students about in-app material

For each observation metric, we took the environment into consideration. For example, due to group size, some groups could not fit around an exhibit. We considered student effort here, and considered students who attempted to reach an exhibit close (even if they were two or more meters away).

We filled the checkboxes for each of these observations if 50% or more of the students in the group exhibited that behavior. We created standardized measurements for each category by assigning an "occurrence level" with values of zero to three. We assigned a level of zero if, at no point, 50% of students were showing any behavior for that category. We assigned a level of one if we only observed one event of the category in at least 50% of the group, and so on for levels two and three. We also recorded the duration of observations. Additionally, the observation matrix included a section for additional comments of noteworthy interactions at exhibits or in the Great Court.

3.5 Objective 4: Evaluate the advantages and disadvantages of the use of similar resources in other museums

Our team identified, examined, and evaluated tools at other museums for this objective. We reviewed the digital tools at other museums in the London region to understand how they work and how they compare to the tool developed by British Museum staff. Although the tool developed by the British Museum is for English learning students, the other museums we visited

have yet to develop tools for this target group. We based our examination of other museums' tools on how easy they were to use, how they enhanced the visitor experience, how they were advertised, and how they were integrated into exhibits. For consistency of evaluation, all of our team members visited the museums and evaluated the tools together.

By the recommendation of one of our British Museum liaisons, Emilia McKenzie, and our own research, we evaluated tools at the following institutions:

- The Science Museum
- The Museum of London
- Tate Modern
- The Natural History Museum

We used the assessment rubric specified by Appendix G to collect data at each of these institutions. As educated visitors using the technology first hand, we were able to observe which tools work best to enhance the visitor experience. Additionally, we analysed the tool's ease of use since our target audience for this research was international school groups. We completed the rubric for each of the museums during our visit for comparing the tools and summarizing their key features. We then compared these features to those offered by the British Museum's digital tool and provided the British Museum with recommendations for future changes to make to their pilot program.

Chapter 4: Results

Our group applied different aspects of our methodology outlined in the previous section in order to complete each of our objectives. The application of our methodology produced the following results.

4.1 Objective 1: Determine the effect of English proficiency on how much information the pilot test subjects' retained

The first objective of our research is to determine if the pilot test subjects' English proficiency influenced their ability to recall information from the exhibits at the British Museum and the digital learning tool designed by the museum's staff. Our primary investigation in the first objective was to determine if there was a connection between the respondents' self-ranked English proficiency and their survey scores. There were two unique groups, based on the experience the students received: the tool user group and the control group (Appendices A, C, and D).

For our research, we needed to consider that participants have varying levels of understanding of the English language. We asked students to self-report their comfort with the English language as part of their survey (Appendices C and D). We collected data from 143 surveys, with 27 user surveys and 116 non-user surveys.

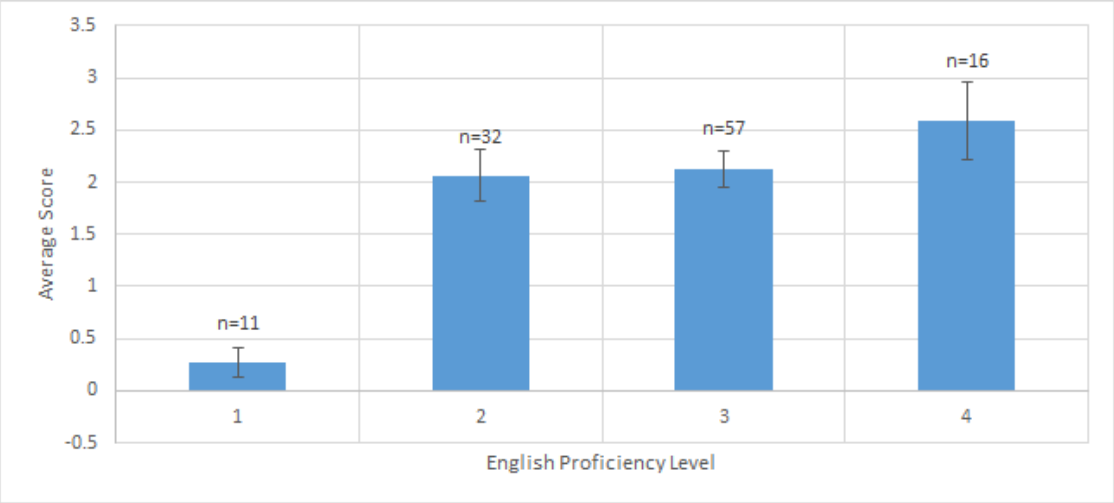


Figure 16: A bar graph showing the relationship between survey scores and English proficiency for all non-users. Error bars show standard error and numbers over bars indicate the related sample size.

Figure 16 shows the relationship between students' self-reported English proficiency and their scores on the survey, for control groups. The proficiency ratings and scores were significantly related (Pearson's correlation=0.355, p=0.000092). The average English proficiency for non-users was 2.67 and a standard deviation of 0.832.

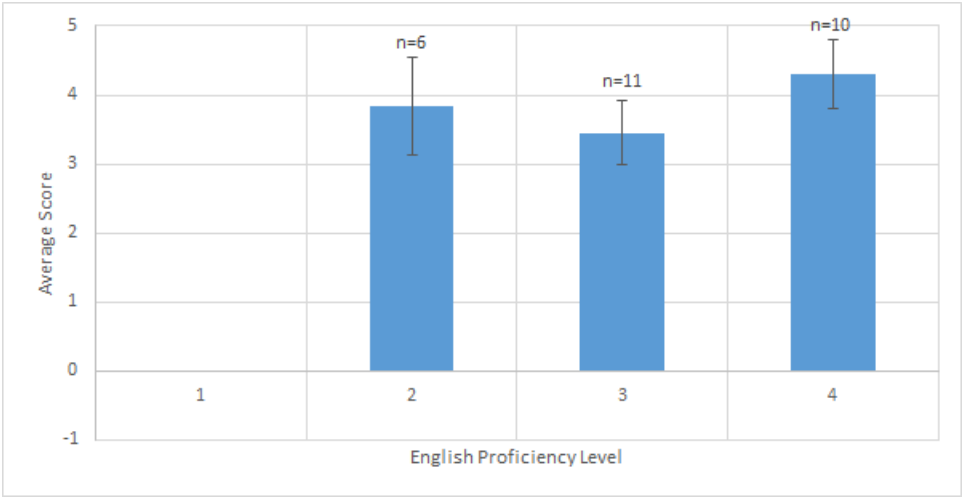


Figure 17: A bar graph showing the relationship between survey scores and English proficiency for all users. Error bars show standard error and numbers over bars indicate the related sample size.

Figure 17 shows the relationship between students' self-reported English proficiency and their scores on the survey, for tool-user groups. The proficiency ratings and scores were not significantly related (Pearson's correlation=0.1447, p=0.4715). There was also a limited amount of data available for this audience, including a lack of any data for level one English proficiency users. However, all level two, three, and four users averaged approximately the same score as each other, regardless of English proficiency. The average English proficiency for users was 3.15 with a standard deviation of 0.770.

4.2 Objective 2: Determine the educational value of the digital learning tool

For our second objective, we hypothesized that the digital learning tool designed by the British Museum significantly increased the information retention of user over non-user visitors. In order to test this hypothesis, we carried out a number of analyses. The first analysis we performed was comparing frequency of visitation for featured exhibits between users and non-users. Second, we compared the survey results of users and non-users. This comparison would show if users retained facts about featured exhibits more than non-users. Third, we compared user and non-user answers to question number 5, which asked their favourite exhibit (Appendices C and D). We designed this question to show whether the digital tool made featured exhibits more memorable than other exhibits. We reasoned that students who used the tool would likely recall an exhibit featured in the tool more frequently than non-user students. In this analysis, we compared the frequency of which individuals responded with a featured exhibit to the number of individuals who responded with an exhibit not featured.

In using surveys, we did not control for factors such as English proficiency or age. One reason we did not control for these factors is that when taking samples it is necessary for the process to be voluntary and random. We cannot discriminate which groups to take data from, as long as they were from the target audience. We are using these surveys as a method to test whether tool users have an experience that is more educational that that of non-users (Appendices C and D). We administered these surveys to 143 individuals, with 116 of them being control and 27 being users.

We first tested our hypothesis using survey questions six through nine (Appendices C and D), comparing responses from user and control groups. These questions asked both whether the student visited each featured exhibit and a related question designed to test their memory of the exhibit. Based on a grading rubric, we assigned points to correct answers to provide the survey with a final score (Appendices C, D, and F). Additionally, we tallied the number of featured exhibits attended. We compiled these data into a spreadsheet where we organized survey results according to group code. We performed two separate analyses on the data for questions six through nine. One analysis was to determine whether the tool influenced which exhibits users visited. The second was determining if the tool affected their ability to answer questions about those exhibits. For both analyses, we used mean, standard deviation, standard error, and other statistics to evaluate the data.

Questions six through nine asked which of the featured exhibits the subjects attended. By comparing which exhibits featured in the digital tool users and non-users visited, we determined whether the digital tool affected which exhibits users visited. We show this analysis in Figure 18.

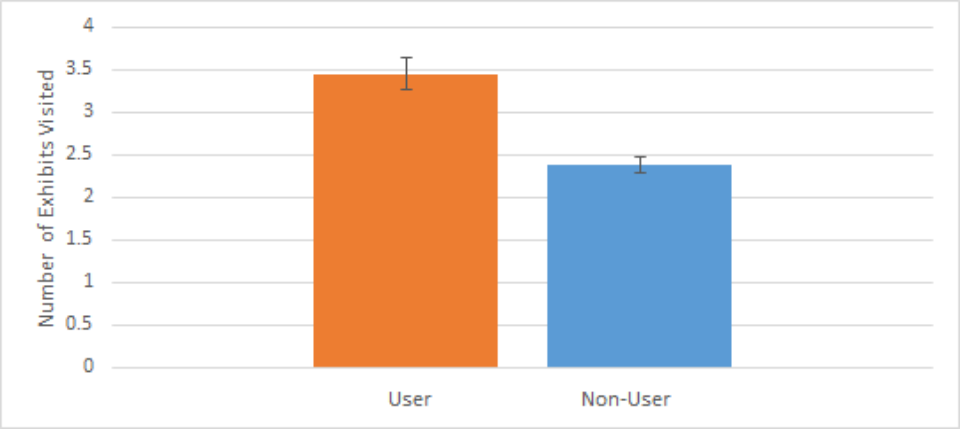


Figure 18: Statistical analysis for number of featured exhibits visited by user and non-user groups. Error bars show standard error and numbers over bars indicate the related sample size.

Figure 18 shows that the average number of featured exhibits visited for user groups was more than one higher than non-users. Out of 116 control surveys and 27 user surveys, the user group had an average of 3.4 (SD=0.97), and the non-users had an average of 2.4 (SD=0.98). A t-test showed that the two means were significantly different (t=-5.15, df=39, p=0.00000039).

Questions six through nine also asked students an information retention question about each of the exhibits featured in the digital tool (Appendices C and D). We evaluated the survey responses using a grading rubric that assigned specific point values for correct responses (Appendix F). We analyzed and compared these scores in Figure 19.

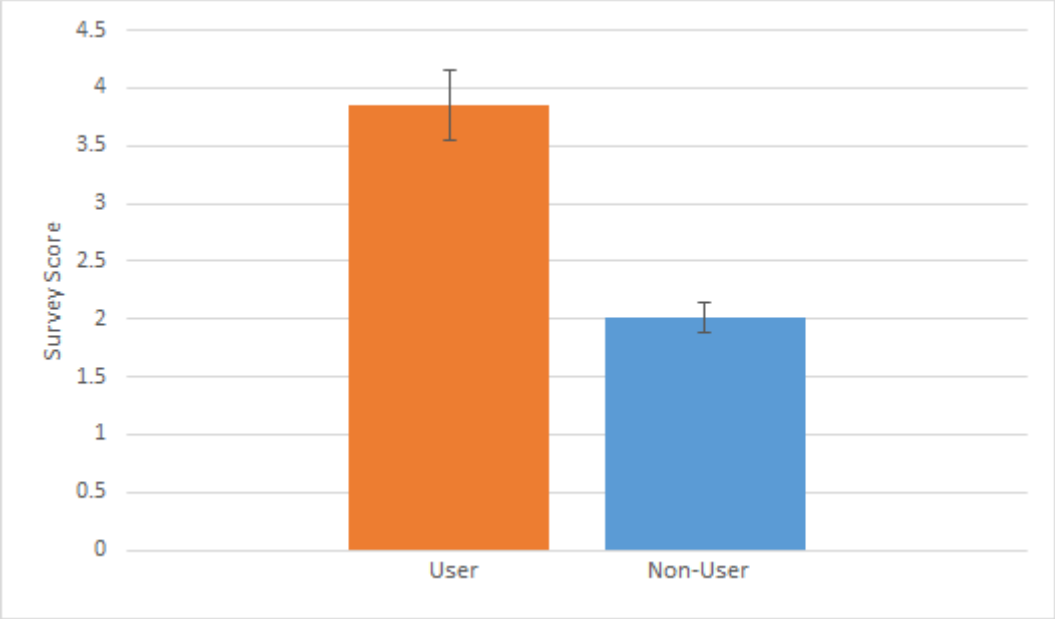


Figure 19: Statistical analysis for survey scores from user and non-user groups. Error bars show standard error and numbers over bars indicate the related sample size.

Figure 19 shows that the average survey score for user groups was more than non-users. Out of 116 control surveys and 27 user surveys, the user group had an average of 3.9 (SD=1.6), and the non-users had an average of 2.0 (SD=1.4). A t-test showed that the two means were significantly different (t=-5.51, df=37, p=0.0000029). This data includes all responses from individuals who did not visit all of the exhibits. It is important for us to show the data in this manner, as it represents the educational effect of the tool on students' experiences. Educational capacity of the tool is partially how well it taught students, but also how easily it led students to exhibits. This analysis sought to compare the result of those factors, combined.

The difference in scores between users and non-users could be due to the fact that tool users visited more featured exhibits than non-users (Figure 18), rather than due to a difference in information retention caused by the use of the tool. To remove the confounding factor of exhibit

visitation differences, we standardized test scores by dividing them by the number of exhibits each respondent visited and compared these standardized scores between user and non-user groups. This analysis, unlike the previous, considers that individuals who did not see an exhibit may be unlikely able to answer a question about that exhibit correctly. Figure 20 shows the results of this analysis.

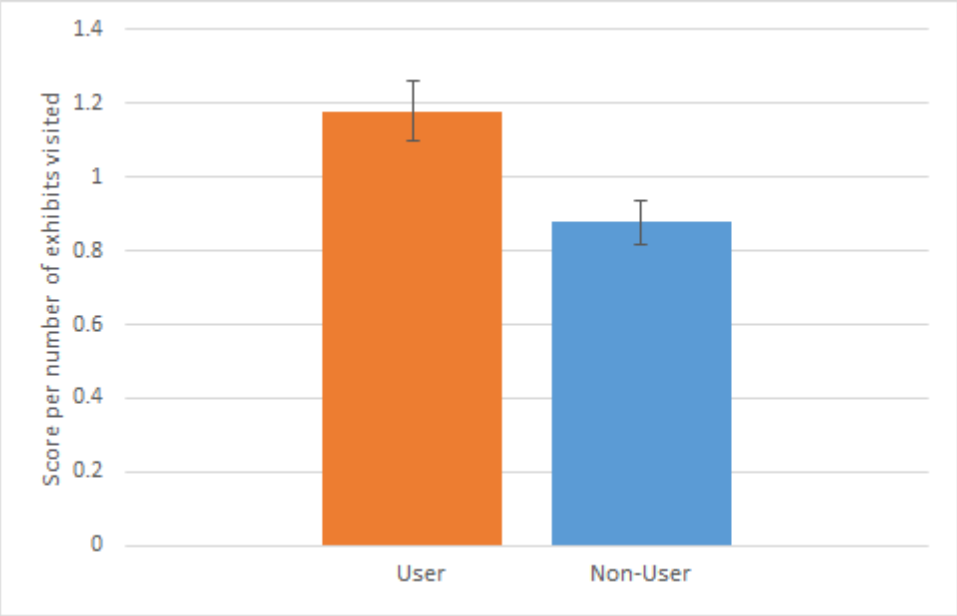


Figure 20: Mean survey scores related to exhibit visitation for user and non-user groups. Error bars show standard error and numbers over bars indicate the related sample size.

Figure 20 shows that the average score per number of featured exhibits visited for user groups than non-users. Out of 116 control surveys and 27 user surveys, the user group had an average of 1.2 (SD=0.43), and the non-users had an average of 0.88 (SD=0.66). A t-test showed that the two means were significantly different (t=-2.91, df=58, p=0.0026).

We measured the tool's effectiveness lastly through question five on our survey (Appendices C and D). This question asked participants of their favourite exhibit. If the tool made the featured exhibits more memorable, students who used the tool would be more likely to name an exhibit featured in the tool than non-users. We measured this data by assigning a point to all the answers to question five that were exhibits featured in the tool. This means that every individual who answered the question with an exhibit in the tool has a score of one, and every

individual who did not has a score of zero. We also eliminated all individuals who answered that they visited none of the featured exhibits. We eliminated this data on the basis that you cannot recall an exhibit that you did not visit, and to use data from these individuals would have misconstrued the intent of the question. Figure 21 shows the percent of users and non-users that visited featured exhibits that responded to question five with a featured exhibit.

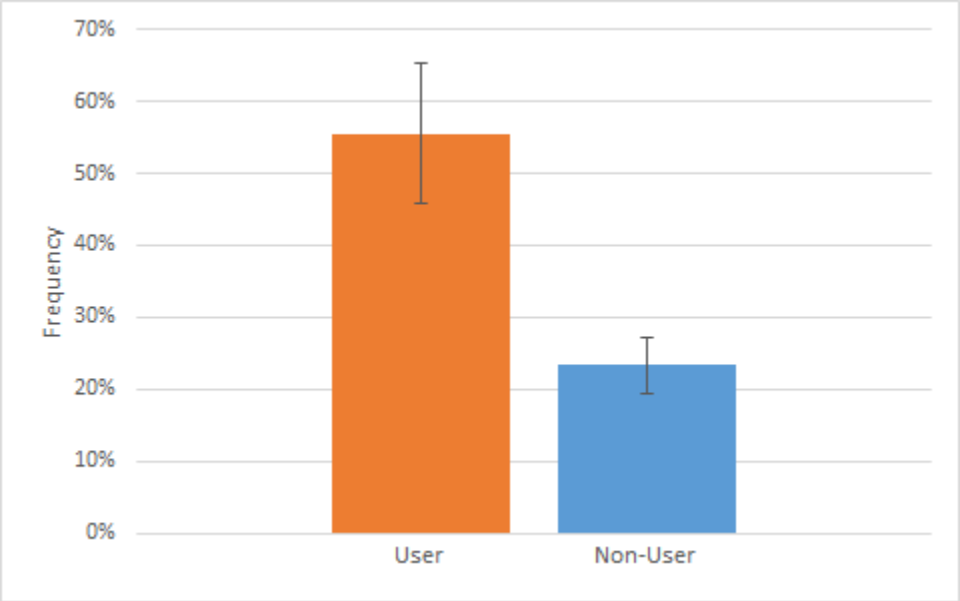


Figure 21: Percentage of users and non-users who answered question five with an exhibit featured in the tool. Error bars show standard error and numbers over bars indicate the related sample size.

As seen in Figure 21, the number of individuals in user groups who answered with a featured exhibit is more than double that of those in non-user groups. We saw that 116 non-users had a percentage of 23.27%. With 55.56% of the 27 individuals in user groups answering with a featured exhibit, this data strongly supports that the tool has an effect on which exhibits individuals recall.

4.3 Objective 3: Assess the engagement and enjoyment of visitors using the digital learning tool

The third objective of our research, as described in our methodology, was an evaluation of whether the British Museum's prototype learning tool engages students and provides them with an enjoyable experience as they peruse exhibits. Both survey data and qualitative observation data contributed to our results in this section.

Survey data for this objective originated from questions 12 through 15 on the user version. A total of 28 students answered these questions. Question 12 requested students rate how much they enjoyed the tool on a Likert scale ranging from one (not fun) to five (very fun). The average for this question was 4.4, with a standard deviation of 0.9. Question 13 requested students rate how helpful the game was in finding exhibits on a Likert scale ranging from one (not helpful) to five (very helpful). The average for this question was 4.0, with a standard deviation of 1.0. The average for this question was 4.3, with a standard deviation of 0.6. Further survey questions, 14 and 15, asked tool users how helpful the tool was in their learning, and how easy the tool was to use. These questions had average response values of 4.1 and 4.2, respectively, and standard deviations of 0.8 and 1.0 (Appendices C and D).

Survey data was augmented with qualitative observation data for this objective. In total, we collected data from 29 observation events from the four focus exhibits in the museum: the Rosetta Stone, the double-headed serpent mosaic, the Parthenon, and the Easter Island statue. One observation event corresponded to a single group at a single exhibit. Out of 29 observation events, 10 were of groups that did not use the tool, known thus far as control groups. The remaining 16 observation events were of student groups using the tool (Appendix E). .

Our reporting of observation results begins with how lengths of time spent at exhibits differed between control groups and tool user groups. We observed 11 groups at the Rosetta Stone exhibit, five of which were control groups, and six that were user groups. For control groups, the average time spent at the Rosetta Stone was 5.4 minutes, with a standard deviation of 3.2. For user groups, the average time spent at the Rosetta Stone was four minutes, with a standard deviation of 3.2. We observed eight groups at the Parthenon exhibit—four control groups and four user groups. The average time spent at the Parthenon exhibit for control groups

was five minutes and the average time spent at the Parthenon exhibit for user groups was six minutes, with standard deviations of 2.2 and 5.0, respectively.

Observers who followed groups through exhibits noticed unique behavior from both kinds of control and user groups. Control groups with large numbers of students often only had engaged students in an inner ring that surrounded the guide, and students on the outside were often playing games on their phones or having private, independent conversations. This was also a function of group size, since one group leader with a large group of students cannot easily communicate with students, or maintain face-to-face contact with the majority at once. Tool user groups had a different dynamic. Even in cases where the group of tool users was large (8 or larger), students actively used their phones and tried to figure out answers to the questions posed by the tool prototype. For a group of eight students from Germany in particular, known by internal identifier UN2R3, the observer recognized such active use from glancing at students' phones while at the Rosetta Stone. Every phone that connected to the Museum's wireless network was showing the tool, and students were regularly switching between looking at the languages on the stone and the tool's sorting question (pictured in Figure 8).

Unfortunately, wireless internet issues caused a rapid decrease in engagement within a group, due to group fragmentation and loss of focus. Common observer comments for these are in Appendix H. In a group of three students from France (group UM2M2) using the tool, one student was only able to connect to the British Museum's wireless internet network in the Enlightenment Gallery (Room 1), and the connection failed when the student reached the Mexico gallery. The student with the malfunctioning device was demonstratively disappointed by being unable to participate, and was entirely disengaged while he attempted to fix the problem. When the group proceeded to Room 24, the location of the Easter Island statue, the student's device functioned correctly again, and the student's focus immediately returned to answering questions through the digital tool. We saw similar behavior when there were students completely without smartphones in a group—we observed at least one case where a student without a smartphone fell to the back of the group as students with map guidance proceeded to the next exhibit.

The tool had further effects in student interaction with exhibits. When control students approached a display case without a learning resource, their focus in the exhibit space began on the exhibit, but deviated from the exhibit as the length of time spent at the exhibit passed their

attention span. This phenomenon was evident through fidgeting that gradually increased among students as each minute spent at the exhibit passed, or through side conversations between students after the first two minutes with a piece. At the Parthenon exhibit, for a group of 18 students from France (matrix identifier CM2R1), we observed 70% of students fidgeting, at the worst point, during the period of the observation event. When the tool was present, in every observed user group, we found that students approached exhibits with the explicit intention of answering the tool's posed questions, and were always eager to move on as soon as they finished.

4.4 Objective 4: Evaluate the advantages and disadvantages of the use of similar resources in other museums

Our team collected data from the four museums described in the Methodology chapter using an assessment rubric. This assessment rubric (Appendix I) helped us collect information about digital tools at these other museums and examine the advantages and disadvantages of using various types of digital tools. These institutions implemented interactive tools such as games, interactive displays, and mobile applications for student visitors.

Our team first evaluated examples of digital technology in the Atmosphere exhibit of the Science Museum. An example of digital technology in the exhibit was a game station that allowed multiple visitors to play games simultaneously. The game station used a touch screen interface that allowed the user to choose from multiple games and compete against each other. Each game focused on a separate part of the atmosphere. The games were simple and focused more on the challenge than the information itself.

Another example of digital technology in the Atmosphere exhibit was a touchscreen station that provided users with information on multiple topics (Figure 22). Users could press on different informational boxes to view detailed explanations on those topics. This tool was not very interactive, as it displayed information in plain text with no graphics to enhance the presentation of information. We observed most visitors go to these touchscreen stations and use them for a minute or two before moving on.

Figure 22: Touchscreen stations in the Atmosphere exhibit at the Science Museum

Finally, our team visited the Who Am I exhibit. It was comprised of large screens set into large structures (Figure 23). Each of these structures allowed visitors to explore the science behind characteristics that make them human, such as personality, intelligence, and language. This exhibit was one of the most interactive exhibits we visited at any institution, because each piece was interactive and used fixed display screens and activities such as games and quizzes. The exhibit was appealing to use, because it gave users options on how to learn. Games, short quizzes, videos, and questionnaires were all available. Since each structure in the room took no longer than two minutes to complete, visitors were able to visit each of these interactive pieces in a short amount of time. Visitors of all age groups used these interactive displays extensively.

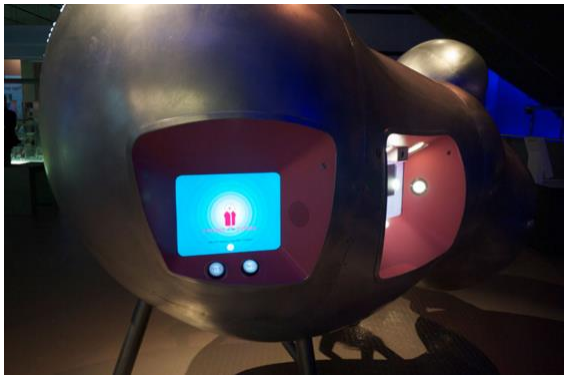


Figure 23: Touchscreen quiz in the Who Am I exhibit at the Science Museum

Another example of digital technology our team evaluated were the interactive fixed displays at the Museum of London (Figure 24). These displays provided visitors with

information on the associated exhibit. Some exhibits had touchscreen interfaces that allowed the visitors to browse through maps, especially in rooms showcasing old Roman artifacts. In addition to interactive fixed displays, museum kiosks attached to some exhibits helped visitors understand why the artifacts were important. These kiosks also tested visitors' knowledge of these artifacts on the spot. Computer kiosks were also present at the museum, with a keyboard and a mouse available for children to use on a table. We did not observe a single individual use these at any point, since they were slow to load new pages and their purpose was unclear.

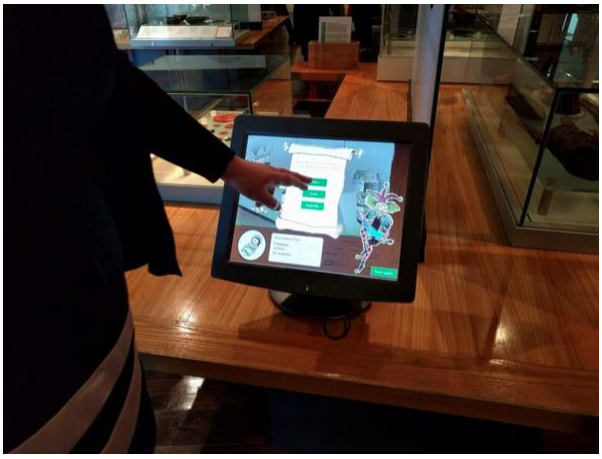


Figure 24: Interactive fixed displays at the Museum of London

The Museum of London also provided QR codes in many of their exhibits (Figure 25). These codes give the visitors the option to download more information regarding the particular object or the entire exhibit, directly to their smartphones. One QR code, for example, provided audio of a first-hand account of someone living during a period in the 20th century. Another QR code brought up more informational text for visitors to read regarding the exhibit. This form of display only attracts visitors who are already interested in the exhibit, since it is not interactive, or engaging.

Figure 25: Example of QR codes at the Museum of London

Staff at the information desk at Tate Modern informed us that the Clore Learning Centre at Tate Modern does not currently have any digital tools that they regular distribute to students visiting the museum. The museum has a smartphone application available for visitors to download for museum map guidance, but it is not designed for students in particular. The museum also has paper materials that the learning department staff hands out to school groups that pre-register at the learning centre. Digital displays around the museum are limited to videos about various artists, with a maximum of one video per artist, and no further information available.

The Darwin exhibit at the Natural History Museum offers visitors a card when they enter the exhibit that they can scan at multiple stations. When users insert this card into such stations, the station displays information relevant to that section of the exhibit. This information is stored in the card, and the users can view all the information after their visit to learn more about the topics they chose.

Chapter 5: Discussion and Recommendations

While performing our study of the effectiveness of the British Museum's pilot digital learning tool, we aimed to follow proper scientific protocol. When gathering population samples for participation in our study, we had to ensure that participation was voluntary. While this practice was important in maintaining ethical conduct, it did present problems. With many groups having set schedules, guided tours, and limited time, it was difficult to convince a large group of students and teachers to participate in potentially time-consuming research. Our team sought to investigate the number of groups that participated in our study, and why they participated in more detail. We began tracking how many groups accepted and rejected our offer to participate on 6 April. We found that approximately 50% of the 34 groups we questioned responded favorably to participating in the study. Of these, only 16 of the groups returned to fill out surveys (Appendix H). The primary reasons that groups declined participation in the study were a lack of time, and that they did not speak any English. This information helps to explain why we experienced less participation than we expected. The data does show, though, that there is sufficient group traffic in the museum to warrant the use of the tool and its continued development. From data analysis and general observation, we saw that many groups visit the British Museum who could potentially use the tool. However, though there are many groups that could take advantage of the digital tool, the British Museum's principal challenge is promoting and distributing the tool effectively.

British Museum staff tasked us with evaluating how effective the pilot tool was in engaging and educating students, and evaluating students' response. Unfortunately, it was difficult to find appropriate groups. With multiple entrances, the groups' busy schedules, and leaders' keeping track of many students, it was difficult to find groups that fit our age range and were from outside the UK. Group leaders also needed to agree to be part of the study. Many leaders said they would have considered using the tool if they had known about it before arriving at the museum. Due to the informal setup of approaching the group leaders during their visits with our current method, many group leaders were reluctant to cooperate. We recommend that the British Museum's staff adopt a formal system for approaching group leaders. The following three strategies may assist in creating a formal and potentially more successful plan. First, the staff should consider advertising the digital tool and providing a link for teachers to the tool in

the school group section of the website, so that teachers know about the tool before arriving. Second, the British Museum's staff should consider posting official posters or banners throughout the museum. Existing family activities already have advertisements, and this would increase overall awareness of the tool as groups visit. Third, the staff should consider a more permanent and professional table, similar to the Families desk and the Audio Guide desk. Group leaders would be more likely to view the British Museum's tool as official with such a change.

Increasing awareness of the tool and marketing its value is critical in encouraging tool use, but tool distribution is also important in turning interest into actual use. The current distribution method, providing a short electronic hyperlink to students, had both benefits and shortcomings. Given an internet connection, the link was the only additional piece of information students needed to access the tool—nothing else was required. Unfortunately, distribution via link is more time consuming than we expected, and many students did not enter it into their phones correctly the first time, due to the capital letters and lack of a traditional ".com" domain. To limit this difficulty in the future, the British Museum should investigate other distribution methods that may be easier for students to take advantage of, such as a download through popular application stores, including Apple's App Store and Google's Play Store, or even a QR (quick response) code that students could scan with their phones. Additionally, if the British Museum's prototype tool had a memorable name, students may be able to search the name through a search engine and reach the tool faster than through a defined distribution method.

Students with phones incompatible of connecting to the British Museum's wireless internet network were unable to participate in tool testing. Older Android phones without updated software were often the culprit, because they did not support the required log-in procedure. This log-in method, often referred to as a "captive portal", requires students to use a web-browser to log-in. Students were often unaware of the need to proceed through the captive portal, and became frustrated when they discovered that their phones would not connect directly to the network. We recommend that the museum further investigate wireless internet connectivity in the museum. If the British Museum's wireless network did not require login, more students may be able to connect to the network without issue, and feel more ready to use the tool with their friends.

In evaluating the British Museum's pilot digital learning tool, we tested if the tool affected which exhibits the users visited. We asked users and non-users on their survey if they visited the exhibits featured in the digital learning tool (Appendices C and D). If users did visit the exhibits featured in the digital tool more frequently than non-users, it would provide evidence that the digital tool did affect which exhibits the users visited. If the tool does affect which exhibits users visit in the desired way, it shows that the tool is effectively promoting the exhibits featured in the tool, and providing adequate guidance for users to find such exhibits. In its current state, this result would mean that users would be more likely to see these four exhibits over other exhibits in the museum. However, a goal for future tool versions is to feature every major exhibit. As a result, we can apply the successful guidance and interest in exhibits generated by the tool to all exhibits. Our results showed that the tool did in fact have a considerable impact on students seeing exhibits. As seen in Figure 18, there was a significant difference in the average number of exhibits visited by user and non-user groups. The number of featured exhibits the user groups visited was 42% higher than non-user groups. This leads us to the conclusion that the tool did have an effect on which exhibits the subjects visited.

While the majority of students using our tool found the in-tool maps to be accessible and properly guide them to exhibits near the Great Court, we received informal feedback that the maps were unhelpful to some. The tool prevents students from zooming into maps, or orienting the maps differently. Students that enter the museum through the Montague Place entrance, for example, may not have recognized that they were in the back of the museum instead of the front. The symmetry of the Great Court contributes to this confusion. Students would benefit from multiple available map orientations in the tool. The Museum should consider providing multiple map options in the tool, or consider adding a more interactive guidance feature where students select their current location, and the tool provides a direct route.

Determining the enjoyment and engagement value of the British Museum's tool, Objective 3, was another critical component of tool evaluation. We used questions 12 through 15 on the survey to ask users' opinions of the tool. This provided a baseline for what users thought about the tool's function and accessibility, in addition to how enjoyable they felt it was to use (Appendices C and D). From those results, we saw that users generally rated the tool above average in every question, with answers almost exclusively being three or higher on the scale of

one to five. Additionally, we examined the difference in time spent at exhibits between users and non-users. Control groups spent more time at exhibits than user groups, on average. In user groups, the students likely spent less time at exhibits because they proceeded to the next exhibit as soon as they answered questions on the tool. On the contrary, in control groups led by teachers, students had less authority to pick where to move within the museum. We also noticed a difference in students' behavior at the exhibits. We found that tool users had increased motivation to learn about what was in front of them. Students using the tool appeared to have intrinsic motivation to answer questions on the tool correctly and thus seek out information with greater diligence. We also noted that users seem to have more focus on single pieces, as opposed to the entire room of objects. Such strong focus on single exhibits in galleries may have more abstract educational consequences—students may be less likely to capitalize on their own interests in that environment. The British Museum needs to investigate this further. We ultimately believe the tool helps focus users' attention, engage them in exhibits, and provide them with a more enjoyable experience.

The British Museum's digital learning tool currently highlights four of the museum's most popular attractions: the Easter Island statue, the Parthenon gallery, the Rosetta Stone, and the double-headed serpent mosaic. However, teachers in interviews said they would prefer to have additional exhibits added to the tool, with a potentially different presentation. The most commonly requested galleries for addition were the Assyrian gallery, the Egyptian death and afterlife gallery, and the Africa gallery (Appendix E). The digital learning tool currently takes users to exhibits that are all in separate galleries. Several teachers said they would prefer if the tool encouraged users to spend more time in the individual galleries and had modules for galleries rather than individual pieces (Appendix E). This would potentially increase the students' ability to engage with the pieces, as it would require fewer breaks between observations than the current model. Teachers also requested that, if possible, the tool created flow between exhibits, having adjacent exhibits be in sequence in the tool, so that students could travel between exhibits easily with the tool.

Students who used the tool may also benefit from additional in-application foreign language assistance. Students who lacked comfortable English proficiency, in some cases, found that it was unclear how to use the British Museum's tool. Although the tool exists to support

English learning, students may benefit from instructions in their native language when they first open the tool. This may also help students begin using the tool more quickly, as the guidance would ease the transition between students' native language and English.

We also believe British Museum staff could improve the tool's capacity to foster discussion among users. As previously mentioned, while this tool does effectively bring students to exhibits and engage them, it does not always encourage discussion of material among peers. The goal for this tool is to be completely effective in educating and engaging its users. Further discussion and collaboration is the next step. We recommend that the British Museum integrate features into the tool that are more likely to cause students to engage with one another. For example, the tool could pose a question at the end of each module that does not require an answer, but suggests an abstract concept. The tool could then display a prompt requesting students discuss this question with their peers. This format is a simple example of how the tool could promote discussion. Other examples are games or questions that require multiple users to answer, puzzles that may require users to talk about solutions, or scavenger hunts that promote competition. We strongly suggest that the learning team implement some form of discussion promotion in further versions of the tool, based on these examples.

The educational value of the tool was the comparison of the number of exhibits the students visited and the score the students received on their survey when asked to recall facts from the exhibits highlighted in the tool (Appendices C and D). This comparison showed that the average users did in fact visit more exhibits featured in the tool and recall more information than the average non-users. This result demonstrates that this tool is potentially an educational aid.

Question five on our post visit survey asked the subject's favorite exhibit (Appendices C and D). We designed this question to determine whether the tool made exhibits more memorable to visitors who used the tool. In comparing the results from this survey question, we saw a 143% increase between the number of users who answered with an exhibit featured in the tool over non-users. This difference is a significant increase in recall. We see this data as supporting evidence that the tool affects which exhibits are more memorable to visitors. However, with such a strong relationship between the two variables, we believe there should be further research into the tool's effect on exhibit memorability. A more detailed test involving control and user groups

that visit all four exhibits could accomplish this inquiry. We ultimately believe the tool does have a strong effect on user experience, and the museum staff should investigate this project further.

The English proficiency of students was critical for our analysis, because the British Museum's tool aims to assist with English learning. We investigated the relationship between English proficiency and information retention using the post-visit survey. We related their self-evaluated English proficiency to their score on post-visit survey questions six through nine, as seen in Figures 16 and 17 (Appendices C and D). It is worth noting that students who did not understand the questions typically left that portion of the survey blank rather than guessing an incorrect answer. In addition, many group leaders provided assistance with translating the questions for the students who were less comfortable with English. We found that in both tool user groups and non-user groups, individuals who rated themselves higher in English proficiency scored higher on the survey. However, more research is needed–there were no tool users who rated themselves as a one for English proficiency. This shows there may be a relationship between English proficiency and information retention. To check for consistency, we also examined whether there was a significant difference in English proficiency between user and non user groups. Figures 16 and 17 show that there was only a small difference in English proficiency between them.

The digital learning tool depends on the support of the group leaders. To ensure their support, museum staff want to understand the teachers' expectations for the visit to the British Museum and their suggestions on how to improve the tool. Data collected from the teacher interviews showed that most teachers are expecting their students to gain English language experience while visiting the museum (Appendix E). Teachers also expressed a desire for the museum to provide a digital device instead of having students use phones, because some students used other applications once they opened their phones instead of the digital tool. Group leaders also explained that having some form of language assistance on the tool in the students' first languages would be helpful for those with very low English proficiency (Appendix E). However, teachers said the tool is potentially very useful for students, and with improvements, would encourage their students to use it on future trips to the British Museum.

While we do believe the tool contributes greatly to the British Museum's offerings, it is also important for the museum to be aware of potential alternatives to the current system. Our

examinations of digital tools at the Science Museum, the Museum of London, Tate Modern, and the Natural History Museum led to various unique insights. The game stations at the Science Museum or the interactive fixed displays at the Museum of London would not work for the British Museum because they were either too focused on the game or not at all interactive. The staff at the British Museum is trying to educate and engage students, so they require a tool that is informative as well as interactive. Additionally, staff at the British Museum could apply digital tool techniques such as the ones used in the Who Am I exhibit at the Science Museum, the QR codes at the Museum of London, or the scan cards in the Darwin exhibit at the Natural History Museum. The most viable alternative to the current tool is distribution of tablets or smartphones with the program already loaded. The museum already has the infrastructure for this system, as they distribute smartphone audio guides for a fee. The museum could establish a similar system to distribute the new digital tool to school groups. This system would maintain the mobility of the tool, and preserve its original functionality, but would require a large device investment, potentially leading to a fee passed on to groups. This payment could prove to be a deterrent, and is counter to the department's goal of providing for international student visitors in groups. We ultimately advise that the Learning and National Partnerships department continue developing the current system.

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Appendix A: Interview Questions for Teachers

Before Guide

1. What country are you from?
2. What school/programme are you from (Private, state, English learning, etc)?
3. What age are your students?
4. Can you estimate the English proficiency of your students?
5. Which entrance did you come through (North, Main)?
6. What are your plans at the Museum today, and how much time do you plan to spend here?
7. Did you bring any assignment materials with you today? Did you make them yourself or get them from the British Museum website?
8. What do you want your students to gain from the experience?

After Guide

1. Did you use the tool?
2. Did this tool assist in their English learning experience at the British Museum?
3. Did you perceive this tool as a useful teaching device?
4. Did you perceive the tool as a distraction?
5. What other content would you like to see implemented?
6. What are some ways this tool could be improved?

Appendix B: Observation Matrix

Group (circle one): **Control [or] User**	**Country:**	**Location:**
Time started: ___/___ ___:___	**Time ended: ___:___**	**Number of individuals observed:**

Level of occurrence	**Definition**
0	Less than 50% of the observed students exhibiting all of the associated activities
1	50% or more of the observed students exhibiting 1 of the associated activities
2	50% or more of the observed students exhibiting 2 of the associated activities
3	50% or more of the observed students exhibiting all of the associated activities

Indicators		**Comments/Observations**	**Level of occurrence**
Engagement			
• Close to item (less than 2 meters away from the piece while observing) • Long time spent at item (at least 15 seconds standing by the piece) • Engaged conversation (Positive engagement behavior near piece)	❑ ❑ ❑ ❑		
Disengagement	❑		
• Far from item (more than 2 meters away from piece while observing) • Short time spent at item (less than 15 seconds standing by piece) • Disengaged conversation (closed discussion away from piece)	❑ ❑ ❑		
Enjoyment	❑		
• Smiling • Taking a picture • Pointing	❑ ❑ ❑		
Displeasure	❑		
• Frown • Fidgeting • Looking at map, brochure, etc.	❑ ❑ ❑		

Other observations:

Appendix C: User Survey

The British Museum

Date: _____ Country of Origin: _____ Age: _____ Reason for Visit _____

1. How comfortable are you with the English language?

Not comfortable Moderately comfortable Comfortable Very comfortable

2. Do you own a smartphone (iPhone, Android device, Windows Phone)?

Yes No

3. If yes, phone manufacturer and model:

4. On average, how many hours per day do you use your phone?

0-1 hours 1-2 hours 2-3 hours 3+ hours

5. Which exhibit was your favorite? Why?

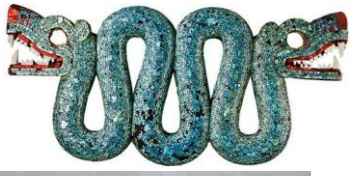
6. Did you visit the Rosetta stone? Yes No

If yes, how many types of writing are on the Rosetta Stone? If you can, please name them:

7. Did you visit the Easter Island Statue? Yes No

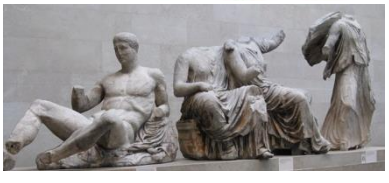
What is one thing you learned about the Easter Island Statue?

8. Did you visit the Double Headed Serpent? Yes No



What country does the Double Headed Serpent come from?

9. Did you visit the Parthenon? Yes No



What country is the Parthenon located in? What kind of building is it?

10. Did you use the digital game?

Yes No

11. What was your score on the digital game?

12. On a scale of 1 to 5, how much did you enjoy using the game and why?

Not fun 1------2------3------4------5 *Very fun*

13. On a scale of 1 to 5, how helpful was the game for finding exhibits in galleries and why?

Not helpful 1------2------3------4------5 *Very helpful*

14. On a scale of 1 to 5, how helpful was the game for learning new things and why?

Not helpful 1------2------3------4------5 *Very helpful*

15. On a scale of 1 to 5, how easy was the game to use and why?

Hard 1------2------3------4------5 *Easy*

16. If you could change anything about this game, what would you change?

17. Would you use a game like this again? Would you recommend using this game to a friend?

18. Do you like using your own phone in the museum? Did you have any issues with the wifi? Would you prefer to be given a device by the museum?

Appendix D: Control Survey

The British Museum

Date: _____ Country of Origin: _____ Age: _____ Reason for Visit _____

1. How comfortable are you with the English language?

Not comfortable Moderately comfortable Comfortable Very comfortable

2. Do you own a smartphone (iPhone, Android device, Windows Phone)?

Yes No

3. If yes, phone manufacturer and model:

4. On average, how many hours per day do you use your phone?

0-1 hours 1-2 hours 2-3 hours 3+ hours

5. Which exhibit was your favorite? Why?

6. Did you visit the Rosetta stone? Yes No

If yes, how many types of writing are on the Rosetta Stone? If you can, please name them:

7. Did you visit the Easter Island Statue? Yes No

What is one thing you learned about the Easter Island Statue?

8. Did you visit the Double Headed Serpent? Yes No

What country does the Double Headed Serpent come from?

9. Did you visit the Parthenon? Yes No

What country is the Parthenon located in? What kind of building is it?

Appendix E: Data collected for the British Museum

Table 2: Group leaders' responses to being a part of study with a sample size of 33.

Group leaders' response	***Percent***
Agreed to be in study	51.52%
Declined to be in study	48.48%

Table 3: Group leaders' choice of which part of study to participate in with a sample size of 33.

Group leaders' response	***Percent***
User	48.15%
Control	51.85%

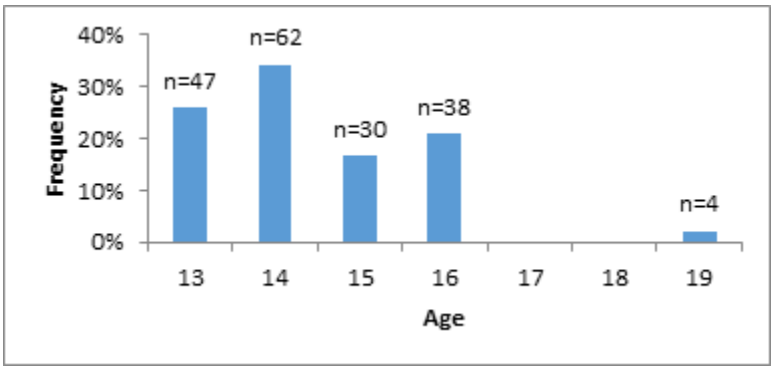


Figure 26: A distribution of students participating in the study by age

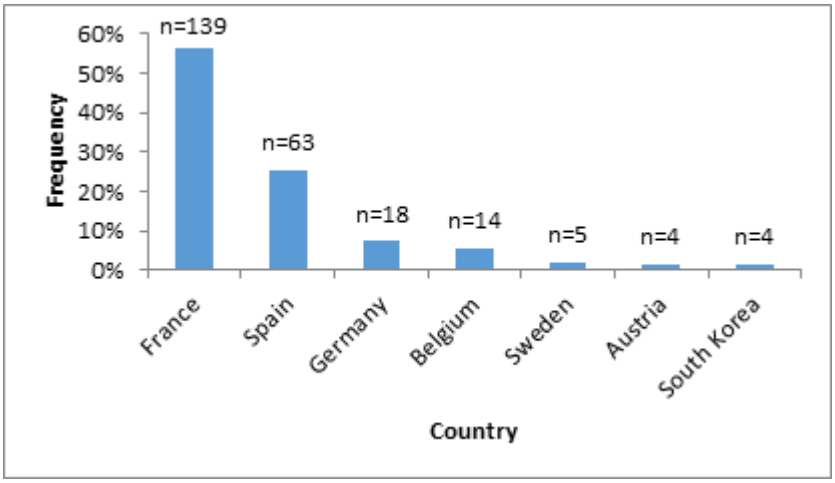


Figure 27: A distribution of students participating in the study by home country

Table 4: A table of the entrance used by group leaders while visiting the British Museum with a sample size of 33.

Entrance used	***Percent***
Main Entrance	61.90%
North Entrance	38.10%

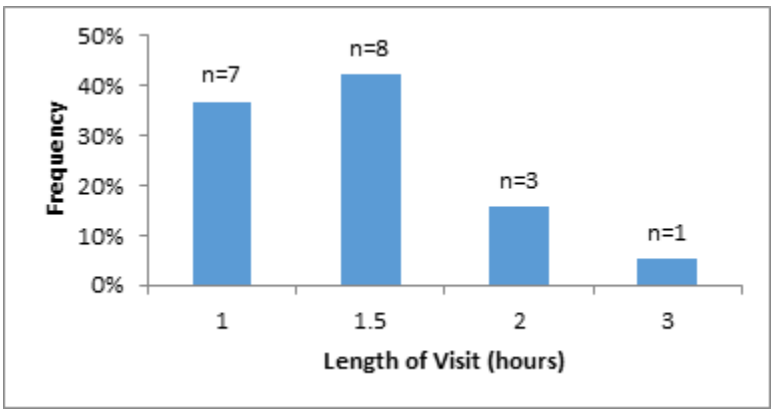


Figure 28: Frequency distribution of length of student visits in the British Museum

Table 5: A distribution of smartphone ownership for students involved in the study with a sample size of 143.

Smartphone ownership	*Percent*
Owns a smartphone	98.60%
Doesn't own a smartphone	1.40%

Table 6: A distribution of smartphone usage in students involved in the study with a sample size of 143.

Smartphone ownership	*Percent*
0-1 hours/day	7.09%
1-2 hours/day	29.79%
2-3 hours/day	29.08%
3+ hours/day	34.04%

Table 7: A table illustrating the group leaders' expectations for the museum with a sample size of 18.

Expectations of visit	*Percent*
English Language	50%
Culture	39%
Other	11%

Table 8: A table illustrating the group leaders' opinions about the digital tool relating to its usefulness and ability to distract students with a sample size of 3.

Opinions expressed by group leaders	*Percent*
Potentially useful	100%
Currently useful	67%
Distracting on personal devices	33%

Table 9: A table illustrating the group leaders' suggestions on how to improve the tool with a sample size of 3.

Suggestions of group leaders	***Percent***
Include native language assistance	100%
Include more exhibits	67%
Include more exhibits for each gallery featured	33%

Appendix F: Survey Grading Rubric

Survey Question #	**Point assignment**	**Criteria**
6	2 Available	1 for Three Types of Writing: 1 for Demotic, Greek and Hieroglyphics
7	1 Available	1 for One correct fact about statue
8	1 Available	1 for Mexico
9	2 Available	1 for Greece 1 for temple, place of worship, and other synonyms for temple

Appendix G: Museum observation matrix

Museum: Science Museum Game	***Response***	***Comments***
Advertising		
Were there signs for the application in the museum?		
Were they informative?		
Was it advertised outside the museum?		
Enhancing the visitor experience		
What kind of device was the application used on?		
Was the application meant for a single user?		
Did the application take a long time to use?		
Ease of use		
Were there instructions on how to use the application?		
Was there staff available to help explain the application?		
How easy was it to navigate through the application?		
Integration		
Are museum workers aware of this application?		
What other types of technology is the museum using?		
Does the application cover exhibits in the whole museum?		
Features		
Was it a game?		
Was it informational?		
Was it mostly text?		

Appendix H: Raw observation data

Group Code	Exhibit	Engagement Count	Disengagement Count	Enjoyment Count	Displeasure Count	Country	Start Time	End Time	Length	Student count
CM1W1R	Rosetta Stone	3	0	2	0	Belgium	13:15	13:18	3	14
CM2M1P	Parthenon	2	1	1	3	France	10:11	10:16	5	11
CM2M1R	Rosetta Stone	2	1	1	2	France	10:08	10:10	2	11
CM2R1P	Parthenon	0	2	1	1	France	10:28	10:30	2	18
CM2R1R	Rosetta Stone	0	2	0	2	France	10:13	10:18	5	18
CN1F1P	Parthenon	2	1	1	1	France	10:36	10:42	6	22
CN1F1R	Rosetta Stone	2	0	1	1	France	10:28	10:35	7	22
CN1W1S	Serpent	1	2	1	0	Spain	13:58	14:15	17	15
CN2R2P	Parthenon	2	1	1	1	France	10:30	10:37	7	21
CN2R2R	Rosetta Stone	1	2	2	1	France	10:37	10:47	10	21
GN2M3E	Easter Island statue	3	1	2	0	Spain	10:50	10:57	7	23
GN2M3P	Parthenon	2	1	2	1	Spain	10:59	11:05	6	21
GN2M3R	Rosetta Stone	2	1	1	0	Spain	11:09	11:13	4	22

UM1R2R	Rosetta Stone	2	0	1	0	South Korea	13:50	13:57	7	4
UM2M1R	Rosetta Stone	0	0	1	1	France	10:38	10:39	1	3
UM2M2E	Easter Island statue	2	0	1	0	France	10:51	10:54	3	3
UM2M2P	Parthenon	2	0	1	1	France	10:41	10:44	3	3
UM2M2S	Serpent	1	0	2	0	France	10:49	10:50	1	3
UM2R6P	Parthenon	2	0	0	0	Austria	14:05	14:06	1	2
UM2R6R	Rosetta Stone	2	0	1	0	Austria	13:51	13:53	2	2
UM2R6S	Serpent	2	0	0	0	Austria	13:59	14:00	1	2
UM2W1S	Serpent	3	0	1	0	Spain	10:58	11:01	3	2
UM2W2R	Rosetta Stone	1	0	2	1	France	14:05	14:07	2	0
UN1F1P	Parthenon	3	0	1	2	Germany	11:01	11:13	12	8
UN1F1R	Rosetta Stone	2	0	1	2	Germany	11:15	11:35	20	8
UN2R2E	Easter Island statue	1	1	2	1	Germany	11:11	11:16	5	7
UN2R3P	Parthenon	1	1	2	1	Germany	11:19	11:27	8	7

UN2R3R	Rosetta Stone	1	2	1	1	Germany	11:31	11:39	8	7

Noteworthy comments:

UM2M2E: All students involved in app at statue, statue was not too busy. Encouraged connections amongst students when students show others' their own device and ask questions

UM2M2E: One student without a phone was the sole individual fidgeting of all the students

CM2R1P: Group was centered in the middle of the gallery but did not approach exhibits, until near the end, when the part of the gallery featured in the tool was approached

UM2M1R: Students did not answer any questions about the Rosetta Stone in tool; no student in the group understood the questions

UM1R2R: After a wireless internet failure entering the room, one student caused the rest of the group to lose focus and play with phone settings more than tool

Appendix I: Museum observation matrix results

Museum: **Science Museum Game**	***Response***	***Comments***
Advertising		
Were there signs for the application in the museum?	No	It was a part of the exhibit
Were they informative?	No	
Was it advertised outside the museum?	No	
Enhancing the visitor experience		
What kind of device was the application used on?	Fixed display	
Was the application meant for a single user?	No	Users could compete against each other
Did the application take a long time to use?	No	But the user to spend more time playing smaller games
Ease of use		
Were there instructions on how to use the application?	No	
Was there staff available to help explain the application?	No	
How easy was it to navigate through the application?	Easy	
Integration		
Are museum workers aware of this application?	Yes	
What other types of technology is the museum using?	Fixed touch screen displays	
Does the application cover exhibits in the whole museum?	Only the atmosphere exhibit	
Features		
Was it a game?	Yes	
Was it informational?	No	
Was it mostly text?	No	

Museum: Science Museum Touchscreen Station	*Response*	*Comments*
Advertising		
Were there signs for the application in the museum?	No	It was a part of the exhibit
Were they informative?	Yes	
Was it advertised outside the museum?	No	
Enhancing the visitor experience		
What kind of device was the application used on?	Touchscreen Fixed display	
Was the application meant for a single user?	Yes	
Did the application take a long time to use?	If the user wanted to	
Ease of use		
Were there instructions on how to use the application?	No	
Was there staff available to help explain the application?	No	
How easy was it to navigate through the application?	Easy	
Integration		
Are museum workers aware of this application?	Yes	
What other types of technology is the museum using?	Fixed displays	
Does the application cover exhibits in the whole museum?	No	
Features		
Was it a game?	No	
Was it informational?	Yes	
Was it mostly text?	Yes	It was all words

Museum: Science Museum 'Who Am I' exhibit	*Response*	*Comments*
Advertising		
Were there signs for the application in the museum?	No	It was an exhibit
Were they informative?	Yes	
Was it advertised outside the museum?	No	It was an exhibit
Enhancing the visitor experience		
What kind of device was the application used on?	Fixed displays	
Was the application meant for a single user?	Yes	
Did the application take a long time to use?	Yes	Took some time to get through all the stations
Ease of use		
Were there instructions on how to use the application?	Yes	Incorporated into the application
Was there staff available to help explain the application?	No	
How easy was it to navigate through the application?	Easy	Application explains each step as you go along
Integration		
Are museum workers aware of this application?	Yes	
What other types of technology is the museum using?	Fixed touch screen displays	
Does the application cover exhibits in the whole museum?	No	
Features		
Was it a game?	Yes	
Was it informational?	Yes	Learned a lot about yourself
Was it mostly text?	No	

Museum: Museum of London fixed displays/kiosks	*Response*	*Comments*
Advertising		
Were there signs for the application in the museum?	No	
Were they informative?	No	
Was it advertised outside the museum?	No	
Enhancing the visitor experience		
What kind of device was the application used on?	Fixed touchscreen displays and kiosks	
Was the application meant for a single user?	Yes	
Did the application take a long time to use?	Yes	Kiosks were very slow and sometimes didn't load
Ease of use		
Were there instructions on how to use the application?	No	
Was there staff available to help explain the application?	No	
How easy was it to navigate through the application?	Easy	Easy to understand, hard to use because of how slow it was
Integration		
Are museum workers aware of this application?	Yes	
What other types of technology is the museum using?	Fixed touch screen displays	
Does the application cover exhibits in the whole museum?	Yes	These displays were a part of multiple exhibits
Features		
Was it a game?	No	
Was it informational?	Yes	
Was it mostly text?	No	Included maps and quizzes

Museum: Museum of London QR codes	*Response*	*Comments*
Advertising		
Were there signs for the application in the museum?	No	
Were they informative?	Just the QR codes	
Was it advertised outside the museum?	No	
Enhancing the visitor experience		
What kind of device was the application used on?	Smartphones, tablets	
Was the application meant for a single user?	Yes	
Did the application take a long time to use?	No	
Ease of use		
Were there instructions on how to use the application?	No	
Was there staff available to help explain the application?	No	
How easy was it to navigate through the application?	Easy	
Integration		
Are museum workers aware of this application?	Yes	
What other types of technology is the museum using?	QR codes	
Does the application cover exhibits in the whole museum?	Yes	
Features		
Was it a game?	No	
Was it informational?	Yes	
Was it mostly text?	No	Included audio

Museum: Tate Modern app	*Response*	*Comments*
Advertising		
Were there signs for the application in the museum?	No	
Were they informative?	No	
Was it advertised outside the museum?	No	
Enhancing the visitor experience		
What kind of device was the application used on?	Smartphones, tablets	
Was the application meant for a single user?	Yes	
Did the application take a long time to use?	Yes	Didn't seem to work
Ease of use		
Were there instructions on how to use the application?	Yes	
Was there staff available to help explain the application?	No	
How easy was it to navigate through the application?	Not easy	Because it didn't work
Integration		
Are museum workers aware of this application?	Yes	
What other types of technology is the museum using?	Fixed touch screen displays	
Does the application cover exhibits in the whole museum?	Yes	
Features		
Was it a game?	No	
Was it informational?	Yes	
Was it mostly text?	No	

Museum: Natural History Museum Darwin exhibit	*Response*	*Comments*
Advertising		
Were there signs for the application in the museum?	No	
Were they informative?	No	
Was it advertised outside the museum?	No	
Enhancing the visitor experience		
What kind of device was the application used on?	Touch screen displays	
Was the application meant for a single user?	Yes	
Did the application take a long time to use?	Average (30 minutes)	Didn't take too long to get through the entire exhibit
Ease of use		
Were there instructions on how to use the application?	Paper instructions	
Was there staff available to help explain the application?	Yes	
How easy was it to navigate through the application?	Not very easy	Took a little while to understand at first
Integration		
Are museum workers aware of this application?	Yes	
What other types of technology is the museum using?	Touch screen displays	
Does the application cover exhibits in the whole museum?	No	Only the Darwin exhibit
Features		
Was it a game?	No	
Was it informational?	Yes	
Was it mostly text?	No	Lots of videos