Improving Visitor Evaluation at the British Museum

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Abstract

The purpose of this project was to collaborate with the Interpretation Team at the British Museum to streamline the process of visitor evaluation. We reviewed best practices and technologies used in visitor evaluation by museums in general and the British Museum in particular. We developed an innovative toolkit for conducting visitor evaluation studies and visualizing the results in easy and intuitive ways. We used a temporary display room, Room 3, as the baseline for our approach. The team devised a README file to instruct the Museum staff and volunteers how to bridge the tools together. We recommend the British Museum use tools like Microsoft Excel and Visio and SurveyJS to obtain the necessary materials to gather, analyze, and visualize data using our prototype toolkit application.

Acknowledgments

We would like to recognize the individuals who have supported our team during the past seven weeks, especially due to the presence of the COVID-19 pandemic during the time of this project. Their guidance and advice were greatly appreciated throughout the remote implementation of our project.

We would first and foremost like to thank our sponsoring organization, the British Museum, for partnering with Worcester Polytechnic Institute and giving us the opportunity to work with them despite the unexpected circumstances. We would like to especially thank Stuart Frost, Head of Interpretation, for his guidance and dedication.

We would also like to thank one of our fellow WPI students, Revant Mahajan, for recommending key libraries that were used in development. His explanation of his own similarly focused work was of great use in designing our application.

Finally, we would like to acknowledge the faculty from Worcester Polytechnic Institute who advised us throughout this project from beginning to end. Thank you to Professors Dominic Golding and Suzanne LePage for their constant guidance and efforts to help us successfully implement this project. We are thankful for the work that they have done to make our project possible and to keep our project on the right path during the last seven weeks. Their continued support and dedication to advising not only our team but all of the London project groups during these challenging times helped make this process as seamless as possible.

Thank you.

Executive Summary

Museums are using visitor experience and audience studies to learn more about visitor interests and expectations so they can improve the entire visitor experience and enhance learning. The British Museum aims to better understand the impact that the Museum has on its visitors and to do so, it requires better and more practical tracking tools that would also allow them to analyze this data. For larger galleries and special exhibitions, the Museum typically hires outside consultants to conduct evaluations using best practices. Many other smaller evaluations are conducted in-house by staff, students, and volunteers. Due to a lack of resources and technology, most of these in-house evaluations use pen-and-paper methods to collect observational and exit survey data. These methods necessitate cumbersome and time-consuming data entry and analysis. Thus, the Museum is seeking an innovative digital tool to help streamline this process of data collection, analysis, and visualization. The goal of this project was to develop this tool. Our project had two objectives:

1. Review best practices and available technologies used in museum visitor evaluation
2. Develop and suggest an innovative toolkit for use in easily conducting visitor evaluation studies and visualizing the gathered data

We used an understanding of visitor evaluation and tracking techniques as well as software available across multiple platforms to complete these objectives.

We first sought information on visitor observation and tracking methods and potential software tools used by museums to analyze and visualize gathered data. Originally, we set out to conduct interviews with experts in the field of visitor studies to gather their insight on potential tools or ideas for innovative evaluation tools. However, given the circumstances of COVID-19, our research was limited to reviewing previous evaluation studies conducted by the British Museum and peer reviewed literature written by museum and visitor evaluation experts.

We identified multiple methods, including Bluetooth, GPS, LIDAR sensors, radio frequency identification (RFID), ultra-wideband (UWB), and ultrasound, as possible tools that the British Museum could use to track visitors. None of these tools would be a realistic option for the Museum, however, due to their lack of accessibility, cost, and difficulty to implement and maintain (Montanes, Rodriguez, & Prieto, 2013).

Once data is collected, there are many different options for visualizing visitor movement data depending on the desired analysis. One way visitor movements can be shown is through

having each visitor be represented by a different color when their path is tracked. This shows the complete movement of each visitor, nor the holding power of each object or area. Heat maps are another way visitor movement can be visualized. Heat maps are beneficial because they intuitively and concisely show the holding power of areas and objects. Another way to visualize tracking data is by using decay curves or other analytical graphs. Decay curves can show the dwell time of the visitors and how long they remained in the exhibit.

Following our review of best practices, we obtained information on the current protocols that the Museum staff and volunteers follow for their visitor evaluation studies. The most pressing issue with the Museum's current visitor evaluation system is that the pen-and-paper evaluation sheets must be completed by hand and then manually input into a system for data visualization. This method of visitor evaluation leads to several intermediate steps that are required for data to be gathered, processed, and then visually depicted for accurate understanding. Thus, we aimed for finding improved methods that would expedite transition between data entry and data visualization. To complete this task, we opted to focus on a small-scale example to create a foundation for developing and testing tools that could be used in a larger scale setting. Therefore, we targeted Room 3 as the baseline to develop and test the toolkit.

Using the gathered information from our research on the Museum's current practices, we developed a set of design criteria. We needed a toolkit that would be able to handle all aspects of visitor evaluation, including the gathering and analysis of data pertaining to interviews, observations, and visitor tracking. Most importantly, the Museum desired tools that would not only streamline the process of gathering and analyzing data, but also visualizing the data so that the entirety of the Museum staff would understand the information. To do so, we needed to find tools that were easily accessible to both our team and the Museum.

Due to the Museum's relatively low budget on software, we required tools that were inexpensive and/or readily available on almost all devices. In the case of the British Museum, the Microsoft Office Suite is available on all of their systems, which meshed well with our design criteria and solved the issue of both budget and availability for features such as designing floor plans. It was essential that we devised a toolkit that was not only easily manipulated, but that could be picked up and used by all Museum staff and volunteers.

Microsoft Visio was explored as a potential software for use in streamlining the process of gathering and visualizing tracking data. Visio provides a simplistic toolkit that can be used to

create floor plans in a short amount of time. The program uses a scaled measuring system to allow the user to make designs as accurate as possible. Visio's ease of use may be useful for the Museum, for it provides the Interpretation Team with a platform to design, create, and modify floor plans for its different galleries and exhibits. Although Visio has a function that allows data to be attributed to different objects in a floor plan, it does not provide an intuitive or visually exciting way of representing the data.

Microsoft Power Map was explored as a possibility for creating dynamic 3D maps that display data in an intuitive way over existing floor plans. This is because Power Map provides more insight than a 2D map and better visual representation of information. It allows for spatial and temporal data to be visible on custom maps created with images of floor plans. Ideally, this tool provides the Museum with an innovative and different way of presenting the information they seek with their tracking studies for their own analysis and evaluations.

Additionally, we explored another important aspect of visitor evaluation, which includes a better way of conducting exit interviews and surveys digitally. Multiple survey tools were considered and compared according to criteria discussed verbally on multiple occasions with Stuart Frost. We considered that the three best options are Survey Monkey, Survey Legend, and Survey Anyplace.

However, as we moved towards integrating spatial tracking with volunteer observations, we learned of SurveyJS. SurveyJS is an online tool that allows for surveys and forms to be added into a website or app by producing code that can be easily implemented into the backend code of the web application. It allows for:

- Different options of question formatting that can be edited at any point
- Offline collection of data if the application running the survey allows for it
- Unlimited responses that can be exported if the application allows for it
- No cost to the Museum

Most importantly, SurveyJS allowed us to potentially incorporate observations and surveys into a tracking application. Given these advantages, we selected this tool moving forward.

Development of the toolkit and a unifying application changed in scope multiple times throughout this project, eventually becoming a prototype for our toolkit application thanks to new information. In order to use the toolkit as a cohesive unit, it was designed as a static webpage that displays all the information and tools necessary for tracking.

The app was designed with modularity in mind, such that users can change the survey or floor plan within the tool with ease; all a user must do is move the proper files (*e.g.* image, coordinates, survey) into the same folder as the application, or into a file for storing said information. This way, users require no technical knowledge to be able to use the toolkit. The application is also able to upload the results of a tracking study to a spreadsheet at the user's request, preventing the need for manual entry of observations and exit interview results. As the app is only a prototype, it is restricted in some ways. For example, the tool is designed to upload one study at a time, *i.e.*, the user must create and insert new floor plans for every room they wish to study. Once the tools were assembled and operational, the team devised a README file (Appendix A) to instruct the Museum staff and volunteers on how to prepare and use the suggested tools for future evaluation studies. In addition to in-line commenting within the code itself, so as to improve readability and comprehension for future editors, the README document also provides information on how to utilize the application and its accompanying tools.

Authorship

Title	Primary Author	Secondary Author	Primary Editor	Secondary Editor
Abstract	All		PS	EJ
Acknowledgments	PS, EJ & KC			
Executive Summary	All		PS	EJ
Authorship	PS, EJ & KC			
Table of Contents	KC		PS	
Introduction	PS, EJ & KC		EJ & KC	PS
Background	All		All	
Section 2.1	EJ		ST	PS
Section 2.2	PS & ST		ST	PS
Section 2.3	All		ST	PS
Methodology	EJ	ST	All	
Section 3.1	PS		All	
Section 3.2	PS		All	
Section 3.3	ST	PS	All	
Findings	ST		All	
Section 4.1	EJ & KC		All	
Section 4.2	PS, ST & KC		All	
Conclusions and Recommendations	PS		All	

Aside from the writing and editing of this report, the team did a considerable amount of work to complete this project and provide the British Museum with useful and functional tools. Erinn researched the pros and cons of several tools used in the museum sector today. Karla and Parshon explored readily available tools from the Microsoft Office Suite like Excel and Visio. Once the tools were assembled, they were worked into a prototype web application that was mainly designed and developed by Sam. Karla aided in the prototype development by using SurveyJS to write and format the survey script and acquire the necessary code.

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Chapter 1: Introduction

Using visitor evaluation studies, museums improve the visitor experience and gain a better understanding of how galleries and exhibits convey information. Through observation, tracking, and surveys, museums gather data on visitors that they can use to generate powerful visuals that describe how visitors interact with the Museum's objects. Museums use a variety of methods to conduct visitor evaluations, ranging from the use of visitor tracking technology such as Bluetooth and GPS, to conducting pen-and-paper evaluations using face-to-face interviews and surveys. Using this data, museums seek to generate powerful visuals that display the collected data in an easily understandable and interesting way.

Currently, the British Museum uses two main methods of conducting visitor evaluations: consultant-led evaluations of large galleries and smaller in-house studies. While the large-scale evaluations provide the Museum with an easy method of gathering data and quickly receiving an analysis of that data, the in-house studies are much more tedious to perform. According to Stuart Frost, Head of Interpretation at the British Museum, the current pen and paper tracking methods in use at the Museum are not time-efficient and lead to difficulties in processing and visualizing the gathered data. Although the Interpretation Team works on a relatively small budget with limited resources, the Museum sought to improve its methods of visitor evaluation to obtain a better grasp of the visitor experience.

The goal of this project is to help the British Museum improve its methods of visitor evaluation. To accomplish this goal, we identified two objectives:

1. Review best practices and available technologies used in museum visitor evaluation
2. Develop and suggest an innovative toolkit for use in easily conducting visitor evaluation studies and visualizing the gathered data

To accomplish these objectives and our overall goal, we conducted research on current and best practices used at the British Museum and other museums, respectively. We also developed design criteria through discussions with Stuart Frost and by reviewing available software to develop and suggest an innovative toolkit. We then designed the toolkit using open-source software and proprietary software packages, including Microsoft Excel and Visio and SurveyJS. We compiled our observations and findings into a README file (Appendix A) that was provided to the Interpretation Team to further improve their methods of evaluating visitors.

Chapter 2: Background

In this chapter, we discuss the primary functions of museums and explore how museums have evolved to meet changing visitor needs and expectations. Museums continue to implement visitor evaluation studies to better understand visitor behaviors and preferences so they can improve the visitor experience.

2.1 The Functions and Evolutions of Museums

Over the centuries, museums developed from single room collections closed off to the general public, into major tourist attractions housing thousands of artifacts in large buildings. Although museums evolved dramatically in the last 150 years, the main purpose has remained the same: to enlighten people (Weil, 1999). The missions of individual museums range from research to social impact, but the primary underlying purpose is to inform and educate the public through their collections, research, exhibits, and programs. Every museum accomplishes its mission through different means, but the end result is the same; sharing the knowledge that has been carefully accumulated and curated.

Museums are shifting away from a collection-focused model towards a new model that better serves the public. Museums are working to make positive contributions to their visitor's quality of life and to enhance the community at large (Weil, 1999). Museums are now viewed as places of communal empowerment where visitors can experience the past to better understand the future. According to the International Council of Museums (2019), museums "work in active partnership with and for diverse communities to collect, preserve, research, interpret, exhibit, and enhance understandings of the world, aiming to contribute to human dignity and social justice, global equality, and planetary wellbeing." Museums are much more than a building, they are places of knowledge, learning, and appreciation. Each individual that visits the museum is impacted by the experience and the learning that takes place therein. Falk and Dierking (2018) suggest that "learning is an ongoing dialogue between the whole individual, and the physical and sociocultural world they are in" (p. 7). The three learning contexts of personal, sociocultural, and physical are not separable but instead add layers to the gradual process of not just learning, but understanding. Learning is more than cognitive development but entails also changes in awareness, attitudes, and skills (Falk and Dierking, 2018). Every aspect of the museum is deliberated to ensure that learning in all three contexts is achievable for every individual. The exhibits are designed to maximize

learning potential; and even the design of the museum buildings and galleries affects the learning experience. From the moment the visitor first lays eyes on the exterior of the museum, an impression and impact are made.

Museums are continuously evolving to better meet the needs and expectations of visitors. What used to be a silent building of white walls and polished stone is now becoming noisy, vibrant, engaging, and interactive. Museums like the Exploratorium in San Francisco and the Museums of Science and Industry in Chicago are changing the way visitor engagement is perceived and encouraged. Griffin (2008) states that museums have now become "engaging, educational and entrepreneurial organizations that are dedicated to building audiences and collections" (p. 46). The ways people learn are expanding, and new technologies allow for visitors to interact with exhibits in ways never before imagined (Griffin, 2008). Museums are continuously looking for ways to allow and encourage visitor engagement, be that through museum apps, audio guides, online exhibits, and even physically interacting with the exhibit itself.

To improve the visitor experience, museums need to be reflective of their exhibits, understand their audiences, and listen to their needs (Trofanenko & Segall, 2014). Improving visitor experience also depends on how the collection is managed as well as the research on the collection, as both contribute towards delivering a quality experience to the visitors (Griffin, 2008). Understanding and communicating with visitors is essential to the development of public programs that can make a museum successful. The goal of museums is to enlighten the public, and learning is more successful when the experience is memorable and enjoyable (Griffin, 2008).

2.2 The Growth of Visitor Studies

Most systematic observation conducted in museums goes back to the 1990s, with relatively little before then (Yalowitz & Bronnenkant, 2009). The work that most consider being the first in the field was conducted in the 1930s. The original research conducted by William S. Robinson and Arthur W. Melton introduced the concept of evaluating visitors via psychology, their academic field of study, focusing on behavioral characteristics (Hein, 1998). In 1935, Melton conducted the first detailed study of timing and tracking visitors, opening up what is now a common form of visitor evaluation. Several of Melton's findings ring true today, such as the notions of the attracting power and holding power of exhibits, as well as the observation that most visitors spend minimal amounts of time in galleries or at specific exhibits (Hein, 1998). Melton and Robinson

demonstrated the value of visitor studies for improving the design of exhibits and galleries, but surprisingly little additional visitor research was conducted until the 1980s. Since the 1980s, however, visitor or audience research has become an integral part of museum operations. An enormous amount of research has been conducted on numerous aspects of visitors and their behaviors in museums, especially regarding how visitors interact with exhibits and how they travel throughout museums (Yalowitz & Bronnenkant, 2009). The field of visitor studies has shifted museums from an expert-centric view to a more visitor-centric view; museums are focusing on their visitors and how to provide the best experience for them, as opposed to dictating the flow and medium of information themselves. This can take the form of restructuring galleries, adding new educational programs, or creating interactive methods of learning.

2.2.1 Importance of Visitor Studies

Serrell (1997) suggests that "part of a museum practitioner's job is to encourage diverse populations in the activities of learning and discovery and to adapt their exhibitions to reach the largest possible audience" (p. 108). Without understanding how an audience will react to a particular exhibit, it is difficult for museum practitioners to know how effectively their exhibitions convey their intended message or information. Although early visitor studies initiatives, particularly those in the United States, were used to "measure the outputs of exhibitions and educational programs for funders and sponsors" (Hooper-Greenhill, 2007, p. 366), the field has since evolved. As Serrell (1997) notes, observing the behavior, understanding, and movement of visitors within exhibitions provides museum practitioners with useful data in their efforts to expand their reach to a larger audience (p. 108).

The information that museum practitioners learn through visitor studies allows them to identify and improve upon ineffective or confusing areas of exhibitions, gallery designs, and facilities such as the cafe and bathrooms. In doing so, museum practitioners are able to provide an exhibition design that better matches visitor expectations. As Sheng and Chen (2012) claim, visitor expectations are an important but neglected area of visitor studies (p. 53). Understanding visitor expectations is important to museums because gauging the expectations of those who come to see the museum prior to their time inside makes studying the visitor experience during a given visit simpler and more concise (p. 53). This is because visitor experience is not a static process, but rather one that changes as time progresses during a museum visit (Falk & Dierking, 2012).

The concept of an actively changing visitor experience means that museums should strive to keep visitors satisfied with constant improvements where and when possible. The information that visitor observation provides allows museum practitioners to do so by making exhibitions both more informative as well as more intellectually and physically accessible to future visitors. Hooper-Greenhill (2007) describes how knowing a visitor's level of understanding of an exhibition is useful to those who design the exhibitions, allowing them to better assist visitors in understanding the purpose and scope of an exhibition (p. 366). Satisfaction goes beyond the experience within the exhibitions themselves, for Sheng and Chen (2012) suggest that the visitor experience "usually includes visitors' opinions of functions (e.g., food and transportation), sensory stimulation (e.g., the attraction of buildings), and emotional description" (p. 53). As we observe the visitor experience within the entirety of the British Museum, it is important to understand that these concepts are key aspects of the visitor experience.

2.2.2 Understanding Visitor Motivations

Learning is a major reason why people visit museums. Museums provide the opportunity to learn something new by immersing oneself in the topic. Visitors are looking to sate their curiosity and many of them feel self-fulfillment from learning something new (Slater, 2007). However, people visit museums for far more reasons than merely to learn or experience something new. Museums are often used as an escape from everyday life. Leisure is a large part of people's lives and museums are becoming more popular as a source of relaxation. Many people use recreational time as a way to better understand themselves and the world, which is why many are choosing to visit museums. In America, museums rank as one of the most popular leisure experiences outside of the home (Falk & Dierking, 2018). People also visit museums to satisfy a personal or sociocultural need that can only be met through a museum experience (Falk & Dierking, 2012). Museums allow for family and friends to spend quality time together, as well as to experience and learn something new.

2.2.3 Visitor Demographics

Falk (2009) concluded that individuals who visit museums are typically "better educated, more affluent, and hold better-paying jobs than the average citizen" (p. 28). Adults between the ages of 25 and 44 account for nearly half of the total visitation at the Museum, and family groups

are a dominant demographic group within museums (Falk, 2009, p. 28; Sheng & Chen, 2012, p. 59). The role of family groups within museums is important, for Sheng and Chen (2012) emphasize that visitor expectations and motivation for visiting museums are based on family life cycles.

Falk and Dierking (2012) note that demographic composition may change over time and that museums must cater to the expectations and interests of a wide variety of ages, ethnicities, and generations (p. 189). Demographics analysis is useful, but due to its changing nature, it does not provide comprehensive insight into the overall visitor experience. Hooper-Greenhill (2007) suggests that "in order to understand the sense that visitors make in museums, it is not enough to observe what people do, and it is not enough to ask demographic questions" (p. 373). Instead, the focus should be placed on understanding how visitors frame their experience rather than improving methods of observation (p. 373). Falk (2009) agrees with this idea, stating that "variables like age, gender, race/ethnicity, and generation do tell us something about individuals but they tell virtually nothing about how these individuals might relate to museums" (p. 31).

2.2.4 Practices in Visitor Studies

Visitor evaluation is an evolving field. Most of the early visitor studies were summative evaluations (Korn, 1994). Summative evaluation is the process of collecting information after an exhibit is installed or a program has ended to assess performance against expectations and identify opportunities for improvement. As the field progressed, other forms of evaluation developed including both formative and front-end evaluation. These methods differ in the time of evaluation. Formative evaluation focuses on collecting information for the design process, whereas front-end evaluation collects information during planning and development. In the discussion below we focus on timing & tracking studies that are often used in summative evaluations (Korn, 1994).

The variables that are typically observed in tracking and timing studies "fall into four categories [see Table 1]: 1) stopping behaviors, 2) other behaviors, 3) observable demographic variables, and 4) situational variables" (Yalowitz & Bronnenkant, 2009, p. 49). Stopping behaviors that are typically recorded range from the time spent at a specific exhibit, to the time spent in a gallery or even the time spent in the museum as a whole. Since it is often difficult to measure learning associated with a particular exhibit or museum visit, researchers have often assumed that 'dwell times' are good surrogate measures of visitor engagement. The longer visitors stay at an exhibit, the more we assume they are engaged. In turn, the more visitors are engaged, the more we

assume they are learning (Lanir et al., 2016). Other behaviors of visitors (Table 1) refer to interactions with the museum and persons within it. Researchers often trace the paths that visitors take through a museum, to infer which exhibits are more attractive, to identify bottlenecks that impede visitor flow, and to identify improvements in wayfinding or signage. Social interactions with other visitors as well as museum staff or volunteers are also important factors. Conversations among and between group members have been used as indicators of the level of interest and engagement among visitors (Leinhardt, Knutson, & Crowley, 2003). Outside of visitor behavior, there are other variables to consider such as demographics. Demographics can provide potential insight to the actions of visitors and their behavior due to various factors such as age, culture or gender. When recording demographic information, it is important to factor the margin of error into any observations or conclusions made. When observing visitors, guesswork must be done to assume certain variables without interacting with the persons and thus altering their behavior. Context must always be taken into account, and in this case, it is described through situational variables. These are part of a very broad category composing of most anything that could affect visitors depending on the situation. Anything from levels of foot traffic to the month or day or even time of day can all affect visitor behavior. Other factors such as museum staff, facilities, or other experiences/programs available can also change the actions visitors take (Yalowitz & Bronnenkant, 2009).

Table 1: *Timing and tracking study variables*. Adapted from Yalowitz & Bronnenkant (2009, pp. 49-50)

Stopping Behavior	**Other Behaviors**
Total time in area	Visitor path
Total number of stops	Social interactions within the group
"Down time"/Non-exhibit related behaviors	Social interactions outside the group
Level of engagement scale for specifc elements	Social interactions with docents/volunteers
Time of a stop at a specific element	Use of hands-on/interactive elements
Observable Demographic Variables	**Situational Variables**
Estimated age	Levels of crowding
Gender	Month or season
Number of adults/children in the group	Time and day of week
Nationality/cultural influence	Presence of staff, carts, or other experiences

Yalowitz & Bronnenkant (2009) state that one of the leading researchers in the field during the early surge of visitor studies was Dr. Stephen Bitgood (p. 47). One of the more fundamental studies he conducted was on the simple interaction of what pedestrians will do at an intersection

based on their location. From this basic study in shopping malls, he determined that visitors utilize a cost-benefit analysis for their own behavior, meaning that as a general trend people will attempt to exert the least amount of energy, avoiding crossing through traffic patterns (Bitgood & Dukes, 2006). Utilizing simpler methods of tracking such as focusing on atomic decisions, as Bitgood has, allows for a broader scope to be utilized when analyzing data. Simply tracking visitor paths in a specific area can show unexpected revelations on how people behave in generally applicable scenarios such as tendencies to turn right when passing through a door or to exit a room at the first door encountered (Melton, 1935). Such trends could result in interesting patterns when applied to individual visitors and their interactions with tour groups.

Tracking Studies are often supplemented with visitor interviews. While visitor tracking can reveal much about visitor behavior, interviews allow researchers to solicit direct feedback from visitors and other related persons about their expectations and experiences. The only way to gather such insight is to speak directly to those involved and record their own thoughts. Interviews and direct feedback can come in various forms, such as speaking directly to a visitor one-on-one, asking a group of visitors questions, speaking to staff members in the area, or even less verbal methods such as asking visitors to record their thoughts on the location and experience in a diary (Griffin, 2004; Sheng & Chen, 2012).

Increasingly, visitor studies are using technology and software to analyze patterns and behavior. While software may prove more costly or time-consuming to set up, it can often ease data entry and analysis. Oftentimes, systems are put in place that are totally automated, allowing researchers to collect large amounts of data without having to manually track visitors. Multiple technologies are used to track visitors in the museum setting, including Bluetooth, infrared (IR), radio frequency identification (RFID), and ultra-wideband (UWB), all of which have their own advantages and disadvantages (Mygind & Bentsen, 2017). Even among these few technologies, the levels of accuracy, tracking capacity, and requirements for setup vary greatly. Achieving complete coverage in a museum with a technology such as Bluetooth can be difficult due to the number of sensors required, especially in larger museums where the exhibits themselves can interfere with signals. For technologies that require visitors to interact with or carry sensors on their person, other considerations must be taken into account such as the idea that “involving visitors by means of an electronic device might raise their awareness of being observed, causing self-consciousness about their own visiting behavior and, consequently, a change in what they

believe to be desirable" (Mygind & Bentsen, 2017). When comparing software and technologies to manual visitor tracking, it is often hard to determine if one is more effective or efficient than the other. Even when set up, all technological systems are limited by the technology powering them. In fact, the accuracy of many systems is easily achievable by manual methods, as the sensors can only be so precise when covering such a large area (Mygind & Bentsen, 2017). While these kinds of technologies offer many promising advantages for future tracking studies, direct observation with pencil and paper tracking remains the dominant approach in the field.

2.3 Visitor Tracking at the British Museum

Museums are using visitor experience and audience studies to learn more about visitor interests and expectations so they can improve the entire visitor experience and enhance learning. The British Museum aims to better understand the impact that the Museum has on its visitors and to do so, it requires better and more practical tracking tools that would also allow them to analyze this data. Currently, the British Museum uses pen and paper tracking to gather the majority of its information on the visitor experience. In larger galleries, the Museum opts for consultant-led evaluations due to their ability to quickly gather information and submit reports to the Museum staff for review. However, in smaller settings like exhibits, the Museum chooses to conduct in-house evaluations. Due to a lack of resources and updated technology, the Museum struggles to find data analysis and visualization tools to suit its needs for in-house evaluations.

The Museum is seeking an innovative data analysis and visualization digital tool for use in tracking how visitors move throughout the building, their usage of Museum facilities, and how visitors interact with the objects within its galleries. The aim is to understand the visitor experience in order to provide insight on how to best redisplay, redesign, and reevaluate the Museum over the next 20 years.

Chapter 3: Methodology

The goal of this project was to help the British Museum in improving its methods of visitor evaluation. To achieve this, we pinpointed the following objectives:

1. Review best practices and available technologies used in museum visitor evaluation
2. Develop and suggest an innovative toolkit for use in easily conducting visitor evaluation studies and visualizing the gathered data

We used an understanding of visitor evaluation and tracking techniques as well as software available across multiple platforms to complete these objectives. Figure 1 outlines the objective and the associated tasks needed to achieve that goal.

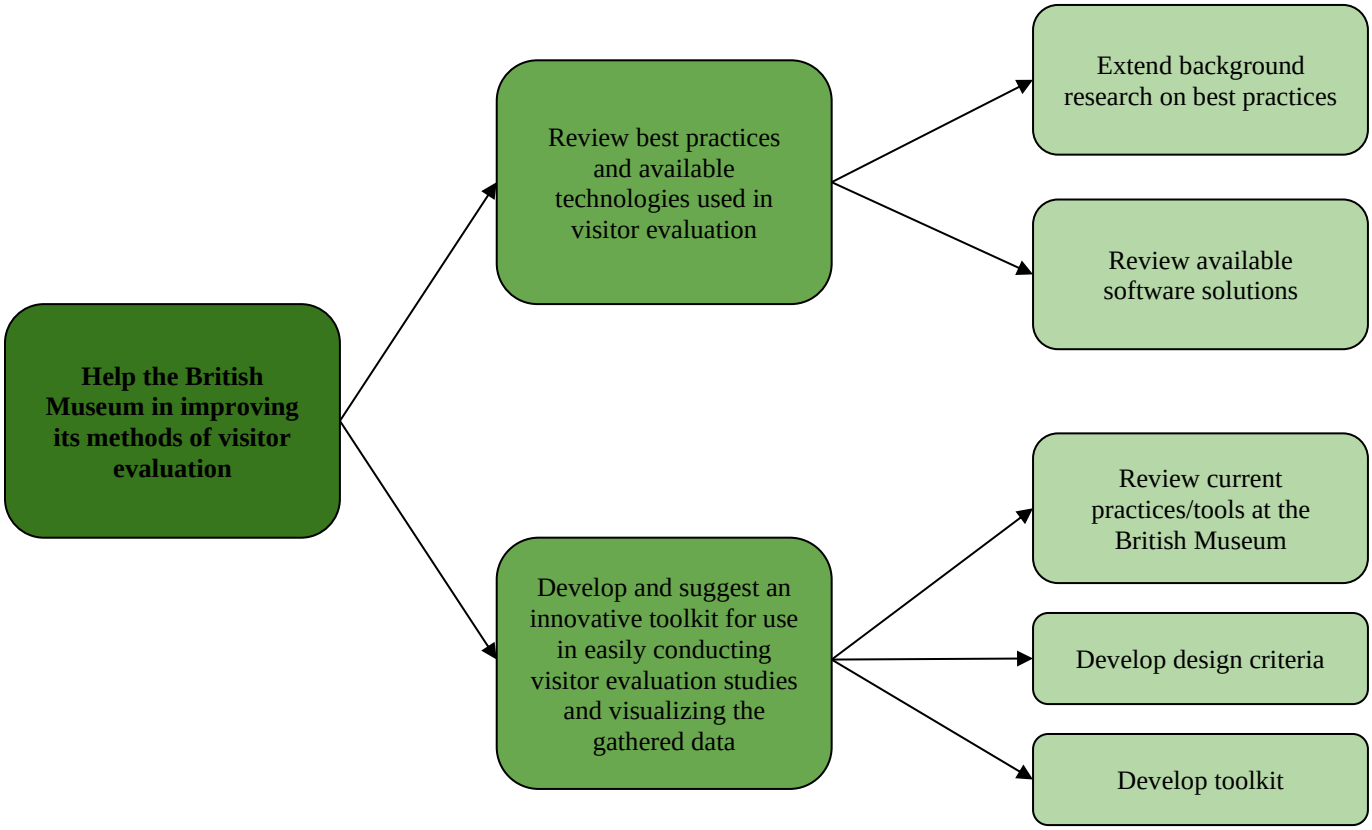

Figure 1. Project Goal and Objectives

3.1 The Effects of COVID-19 On Our Project Methodology

Due to circumstances presented by the COVID-19 pandemic during the implementation of this project's methodology, we did not conduct the project as initially intended. Initially, the plan

was to complete this project on-site in the British Museum. However, as a result of COVID-19, we conducted the entirety of this project remotely using services such as email and video calling through the application Zoom.

Without the ability to physically or virtually work within the British Museum and observe its visitor evaluation protocol, we based our analysis solely on literature review and consultation with our sponsor liaison, Stuart Frost. We researched tracking tools that are currently being used in the museum sector by reviewing literature through journals, museum studies, and databases. We compiled a list of potential tools, including the advantages and disadvantages of each, and evaluated them to determine if they would be a possibility for this project. Additionally, we were unable to pre-test our tools to see how the information would be gathered, recorded, and visualized in a live visitor evaluation study using our tools. Instead, we developed the tools using a set of design criteria based on previous visitor evaluation data gathered from the British Museum archives and the information gathered from our research of best practices in the museum sector.

Since we were not able to show the Museum staff and volunteers how the tools functioned and the necessary steps to begin their use, we created a "How-To" document to provide a step-by-step guide for preparing and using each of these tools for visitor evaluation studies. We also provided components of a unified toolkit that we aimed to develop if more time and resources were available to do so. We hope that these components may serve as a platform for a future team to further develop so that the Museum may have an innovative tool to serve its needs in the future.

3.2 Objective 1: Review Best Practices and Available Technologies Used in Museum Visitor Evaluation

Before we began the development of visitor evaluation tools, we first sought information on the current best practices that museums use for conducting visitor evaluation studies. This included information on visitor observation and tracking methods and potential software tools used by museums to analyze and visualize gathered data. Originally, we set out to conduct interviews with experts in the field of visitor studies to gather their insight on potential tools or ideas for innovative evaluation tools. However, given the circumstances of COVID-19, our research was limited to reviewing previous evaluation studies conducted by the British Museum and peer reviewed literature written by museum and visitor evaluation experts.

3.3 Objective 2: Develop and Suggest an Innovative Toolkit for Use in Easily Conducting Visitor Evaluation Studies and Visualizing the Gathered Data

Following our review of best practices, we then obtained information on the current protocols that the Museum staff and volunteers follow for their visitor evaluation studies. Through frequent discussions with Stuart Frost, we learned more about how the Museum observes, tracks, and surveys its visitors across more than 60 galleries. In addition, we gathered information on the tools that the Museum uses for visualizing data and other tools that are currently available for the staff to use.

Using the findings of our research on current and best practices at the British Museum and abroad respectively, in addition to key needs and information from discussions with Stuart Frost, we developed design criteria for any application or toolkit that would be developed. These design criteria focused on features to be incorporated, limitations of the British Museum's facilities, and other such factors that would affect the decisions that need to be made for development or selection of individual tools.

Based on the features identified in our design criteria, we researched different types of software for creating floor plans or conducting surveys. We obtained raw evaluation data from our sponsor to familiarize ourselves with how the data was collected and organized currently and to ensure that our selected tools would operate smoothly or could be modified to do so if need be.

Development of the toolkit underwent multiple scope adjustments over the course of this project. Originally, this project focused more heavily on the development of a fully functional application. Ideally, it would have acted as a single pane of glass solution — *i.e.*, a unified interface allowing for interaction with multiple different tools through a main application. After subsequent research however, we decided that the larger priority was to identify and understand a variety of data collection and data visualization tools. Near the end of the 7-week duration of this project, we learned from a fellow student about software libraries that could be used to streamline development and make it possible to assemble a working solution quickly. Thanks to this, we were able to create a working prototype of our overall toolkit application, with baseline functionalities that can be improved upon by future iterations.

Chapter 4: Findings

This chapter details the results of our research, as well as the selection of individual tools for our final goal. These pieces each serve their own purpose as part of an overall toolkit and were selected based on various features outlined in our design criteria or other qualities such as using tools that are innately compatible with each other.

4.1 Objective 1: Review Best Practices in Visitor Evaluation Used in the Museum Sector and Current Technologies Available

Prior to beginning the development of our proposed toolkit, we required additional background research on best practices regarding visitor evaluation in the museum sector at large. We gathered information on visitor evaluation studies from a variety of sources, including peer-reviewed literature, evaluation studies conducted by visitor evaluation experts, and information gathered by previous WPI teams who conducted studies within the museum sector. Expanding our research on best practices provided us with an understanding of the industry standard for conducting well-developed visitor evaluation studies and how to obtain and visualize important data.

4.1.1 Existing Tools and Best Practices

Existing tools that are currently used in museums were researched along with other tools that are used to track visitors. Multiple methods, including Bluetooth, GPS, LIDAR sensors, radio frequency identification (RFID), ultra-wideband (UWB), and ultrasound, were identified as possible tools that the British Museum could use to track visitors.

One major tool that is already widely used to track visitors in museums is Bluetooth. Bluetooth is inexpensive because no sensors need to be bought or installed. It accurately tracks people and can be used over both large and small tracking spaces. One study that used Bluetooth to track people in the London Zoo took time intervals of the visitors and was able to then create data visualizations of the path the visitor took along with heat maps of the dwell time of the visitors (Moussouri & Roussos, 2014). The ability of Bluetooth data to easily be converted to a visual platform would be ideal for the British Museums tracking studies. Bluetooth is also inexpensive, which is also something the Museum is looking for in a tracking tool. Although Bluetooth works well in some respects, many information technologies, Bluetooth included, are moving towards a

BYOD (Bring Your Own Device) approach (Moussouri & Roussos, 2014). Instead of the museum offering a device, visitors can download an app that tracks them throughout the museum. In our work with researching a possible way to streamline tracking visitors, this was an approach that the British Museum advised against because they do not want the visitors downloading an app to collect data. If visitors must download an app to collect data, there would likely be less participation because not everyone would be willing to download an app.

GPS is a very accessible and easy way to track people. Similar to Bluetooth, it can be added to a variety of devices for a low cost and can be accessed through a free app. GPS offers a lot of coverage, but it cannot be used indoors.

Another tracking tool that museums are using to track visitors are Light detection and ranging (LIDAR) sensors. LIDAR sensors use light to track distances and movement. In one study, a museum used LIDAR to detect the positions and body orientation of visitors in art galleries. They positioned the sensors on shoulder height poles in several places around the gallery. When the LIDAR sensed movement, it mapped the data on a two-dimensional image plane (Rashed et al., 2016). The LIDAR system is inexpensive (sensors can be as low as 19 dollars), but the data is hard to analyze once collected. This is because the data needs to be processed using multiple formulas that account for the accuracy of the data ("LIDAR," n.d.). For the purpose of our project, we did not look at placing sensors such as the LIDAR in galleries because the British Museum is not interested in purchasing and installing sensors (Rashed et al., 2016).

RFID can be used in complex indoor environments and it is inexpensive; a typical RFID sensor can cost as low as 29 dollars ("Atlas RFID Store," n.d.). However, RFID sensors need numerous infrastructure components, such as operating software, to be installed to support the RFID. In addition to installing components, the system needs to be regularly maintained.

UWB has a high accuracy, large coverage range, and is scalable. However, UWB is difficult to install because multiple sensors are needed on the ceiling of the room where data is being collected. UWB is also more expensive than the other tools that were researched, as it requires multiple sensors that are of higher cost, and they need to be recalibrated frequently (Curran et al., 2011).

Ultrasound sensors are another tracking tool that is inexpensive and priced similarly to RFID and LIDAR ("Ultrasonic Sensors," n.d.). Ultrasound has a large coverage area, but multiple sensors need to be installed and calibrated, and it is less accurate when tracking people than the

other tools available. All of these tools would not be a realistic possibility for the Museum to use due to their lack of accessibility and difficulty to implement and maintain (Montanes, Rodriguez, & Prieto, 2013). Table 2 presents all the tools that were researched along with their advantages and disadvantages.

Table 2. *Advantages and Disadvantages of Existing Tracking Tools*

Tool	**Advantages**	**Disadvantages**
Bluetooth	• Implemented in various devices (mobile phone, laptop, desktop, etc.) • Inexpensive* • Can be used over large and small tracking spaces	• Limited accuracy • BYOD to collect data
GPS	• Offers maximum coverage • Can be added to various devices • Inexpensive*	• Cannot be used indoors
LIDAR	• Inexpensive*	• Data is difficult to analyze • Multiple sensors need to be installed and maintained
RFID	• Can be used in complex indoor environments • Inexpensive*	• Multiple infrastructure components need to be installed and maintained
Ultrasound	• Inexpensive* • High system coverage area	• Complex Installation • Lower accuracy
UWB	• High accuracy • Large coverage range • Scalable	• Complex installation • Expensive* • Recalibration of sensors need to happen numerous times • Multiple sensors need to be installed and maintained

*The price varies depending on the features and capabilities of the tool

4.1.2 Visualizing Data

Once data is collected, it needs to be analyzed and visualized in a way that is easy to understand for the appropriate audience. There are many different options for visualizing visitor movement data depending on the desired analysis. One way visitor movements can be shown is through having each visitor be represented by a different color when their path is tracked. This shows the complete movement of each visitor, but it does not show when each visitor visited each area, nor the holding power of each object or area. There is open source software available that will compute this data and visualize it in this format. One such example of open source software, QGIS, has many different options for analyzing and visualizing data. In a study done on visualizing museum visitors' behavior, the path that an individual visitor took was shown in Figure 2 (Lanir et al., 2016). Notice how this portrays where the visitor went but does not indicate which exhibits were the most engaging.

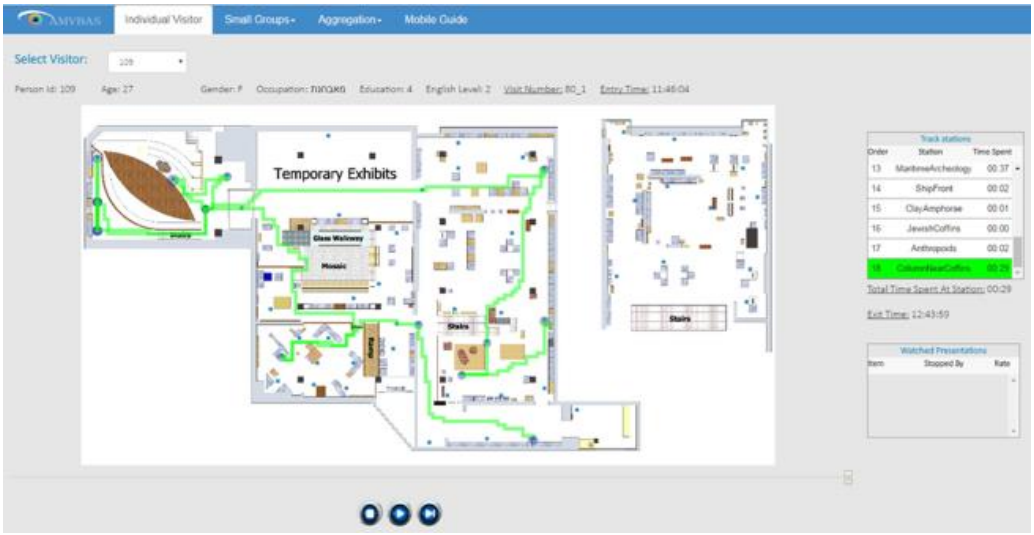

Figure 2. Trace Map of a Visitor in an Exhibit (Lanir et al., 2016)

Heat maps are another way visitor movement can be visualized. Heat maps are beneficial because they intuitively and concisely show the holding power of areas and objects. There are many different types of software available that can create heat maps for free depending on the features one is looking for. One study that visualized visitor flow in the British Museum used an open source software called DepthmapX from the University College London. DepthmapX is available through Github, a hosting site for code repositories. The DepthmapX software is shown in Figure 3, the warmer the color the more visitors visited that area. The red and orange areas represent a high visitor flow, while the green and blue areas represent a lower visitor flow (Moussouri & Roussos, 2014).

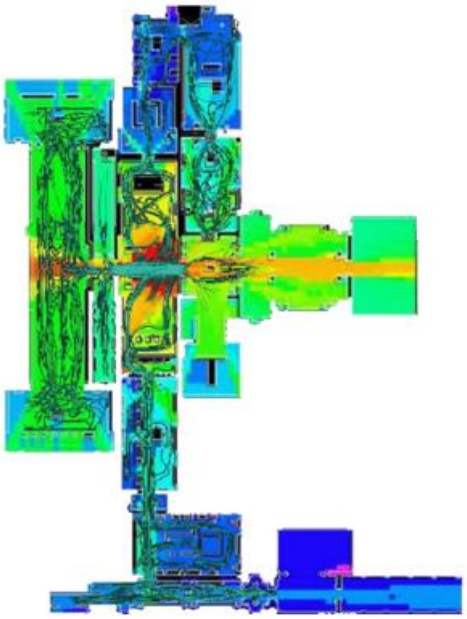

Figure 3. Heat Map of Visitor Flow in the British Museum (Moussouri & Roussos, 2014)

Another way to visualize tracking data is by using decay curves, or other analytical graphs. Decay curves can show the dwell time of the visitors and how long they remained in the exhibit. These types of graphs can directly compare exhibits, the longer the dwell time is, the higher the holding power is for that exhibit. One previous IQP used a decay curve to show the dwell time of the visitors in various exhibits in the Museum of New Zealand Te Papa Tongarewa. The generated decay curve is shown in Figure 4 (Harrington et al., 2017). In this decay curve, the exhibits were directly compared to each other, the Squid in 3-D exhibit had the longest dwell time, but the number of visitors that visited that exhibit is lower than the other exhibits. Ideally exhibits should have a high volume of visitors and a long dwell time, this shows the success of the exhibit.

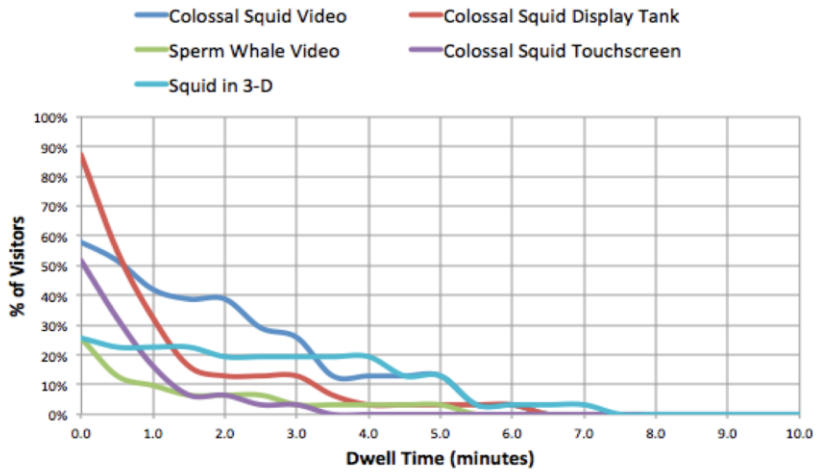

Figure 4. Decay Curve of Dwell Time (Harringtonr et al., 2017)

4.1.3 Survey Tools

Multiple stand-alone survey tools were considered and compared in Table 3 according to criteria discussed verbally on multiple occasions with Stuart Frost. Across the Museum, a WiFi connection is unreliable, and therefore we needed to consider survey providers that allowed for offline data collection. Two online-only options were also considered as a reference and as potential options if the internet connection throughout the Museum were to change in the future. We included both free tools and priced options to provide the Museum with an array of options. We also considered what tools the Museum already has available and the tools that would better meet their demand.

Table 3. *Comparison of Survey Tools*

Tool	**Mode**	**Cost**	**Questions**	**Answers**	**Export Data**	**Comments**
Survey Monkey	Offline through the app and online	Limited free version	Only 10 questions with free version	100 responses	Exporting data unavailable with free version	Museum already has an account
Survey Anyplace	Offline through the app and online (web app)	Starting at $33 monthly	Unlimited	400 monthly responses	CSV, Excel, PDF	
Google Forms	Online only	Free	Unlimited	Unlimited	Automatic collection in Google Spreadsheets	
Survey Planet	Online only	Limited free version	Unlimited	Unlimited	Only Pro can export to Excel	Pro starting at $20 monthly
Survey Legend	Online and offline versions	Limited free version	Unlimited	Unlimited	Only Pro can export data	Pro starting at $15 monthly

Table 3 summarizes a variety of independent survey tool options available to the British Museum, and how the tools partially their needs. These tools are great for the collection of data but do not allow for the unification of a single toolkit or web application. However, as we moved

towards integrating spatial tracking with volunteer observations, we learned of SurveyJS from a fellow classmate. SurveyJS is an online tool that allows for surveys and forms to be added into a website or app by producing code that can be easily implemented into the backend code of the web application. It allows for:

- Different options of question formatting that can be edited at any point
- Offline collection of data if the application running the survey allows for it
- Unlimited responses that can be exported if the application allows for it
- No cost to the Museum

  Given this, we considered the four best options of survey tools to be:
- Survey Monkey given that the Museum already owns an account
- Survey Legend since the Pro version is of a lower cost than most other options
- Survey Anyplace since it works on an app format that can be downloaded into any tablet regardless of the operating system.
- SurveyJS since it allowed us to potentially incorporate observations and surveys into a tracking application

  Given these advantages of SurveyJS, we selected this tool moving forward. This selection was made in accordance with what resources the Museum had available at the time of this study.

4.2 Objective 2: Develop and Suggest an Innovative Toolkit for Use in Easily Conducting Visitor Evaluation Studies and Visualizing the Gathered Data

The process of visitor evaluation involves a wide range of practices, including observation, visitor tracking, and surveying in addition to visualizing the data gathered. According to Stuart Frost, the Interpretation Team at the Museum currently uses a pen-and-paper method for visitor tracking and surveys, and this targets mainly individual visitors and small family groups. The evaluation protocols used by the British Museum vary based on the area, gallery, or type of exhibition that is being studied, for different methods are used in large galleries and smaller exhibits, respectively. For larger galleries and special exhibitions, the Museum typically hires outside consultants to conduct evaluations using best practices. Many other smaller evaluations are conducted in-house by staff, students, and volunteers. Due to a lack of resources and technology, most of these in-house evaluations use pen-and-paper methods to collect observational and exit survey data. These methods necessitate cumbersome and time-consuming data entry and

analysis. Although the paper-based tracking system is easily comprehensible by all staff members and volunteers, the outdated system is especially inefficient for a museum as popular and large as the British Museum. As noted by Stuart Frost, the vast amount of paper used for conducting the tracking studies and surveys results in overwhelming stacks that must be manually analyzed and sorted page-by-page by members of the Interpretation Team staff. Within its current tracking procedures, we identified two areas of interest that would be of substantial help to the Museum's visitor evaluation protocol: streamlining the interview process and technologically improving the process of analyzing and visualizing evaluation data.

4.2.1 Improving the Process of Gathering, Recording, and Analyzing Data

The most pressing issue with the Museum's current visitor evaluation system is that the pen-and-paper evaluation sheets must be completed by hand and then manually input into a system for data analysis and visualization. This method of visitor evaluation leads to several intermediate steps that are required for data to be gathered, processed, and then visually depicted for accurate understanding. Thus, we aimed for finding improved methods that would expedite transition between data entry, analysis, and visualization. To complete this task, we opted to focus on a small-scale example to create a foundation for developing and testing tools that could be used in a larger scale setting. Therefore, in conjunction with Stuart Frost's recommendation, we targeted Room 3 (Figure 5) as the baseline for the toolkit, for it was a relatively small space with readily available information for designing the desired tools.

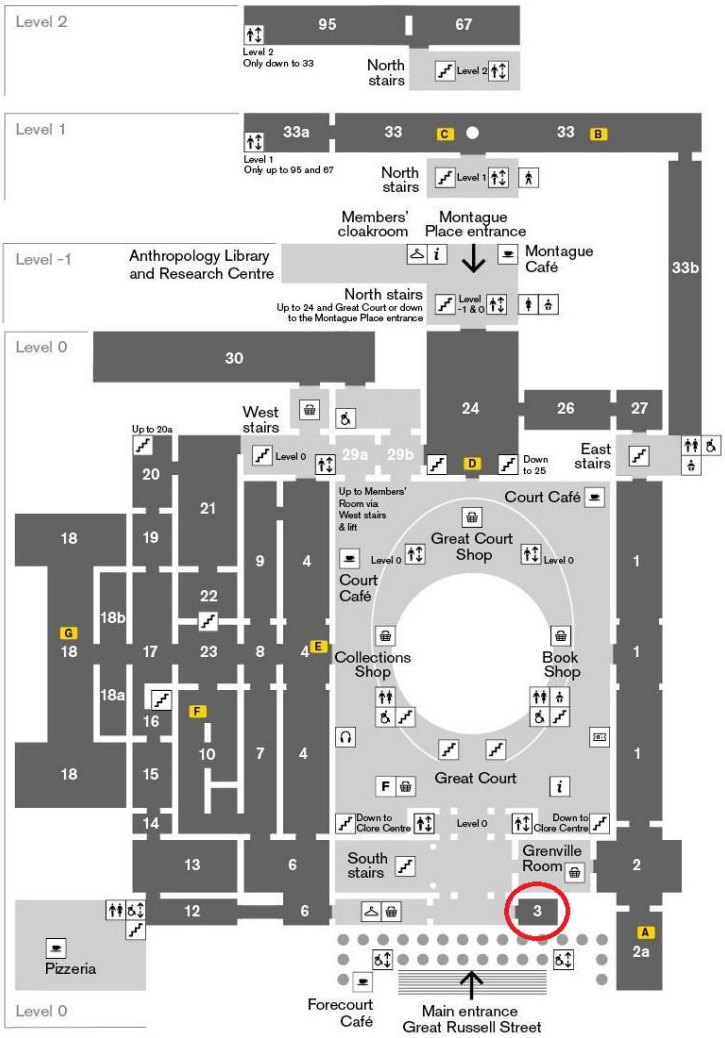

Figure 5. Room 3 Location on Level 0 of the British Museum

We sought to improve upon the pen-and-paper method of data collection by creating a simplified, electronic observational sheet that would expedite the collection of data and eliminate the additional work of transferring handwritten data to an electronic platform for data analysis.

Through our discussions with our Stuart Frost, we gathered information on how the British Museum currently handles the process of interviewing and surveying visitors to gather data on their experience. This process varies mainly due to the size of the gallery or the exhibit that the visitor evaluation study is being conducted in. In cases where the study is taking place in a large gallery or new exhibit, the surveying process is conducted mainly by large evaluation companies who develop the survey tools and protocols with the Museum staff. The Museum often works with Morris Hargreaves McIntyre and survey management specialists like Snap Surveys to create, record, and analyze the survey data so that it may be reviewed by the Museum. For the past eight

years, Morris Hargreaves McIntyre has worked with the British Museum to conduct evaluations of their exhibits, and in doing so they improved the Museum's understanding of how their visitors interact with the exhibits ("Grayson Perry: Culture Segments in Action," n.d.). Through Snap Surveys, the Museum has access to services that help create, analyze, and provide feedback on surveys in addition to generating multi-language surveys ("About Snap Surveys: Management Team," 2020). These services provide the Museum with a relatively streamlined and effective way of gathering data on large galleries, but they are not the method of choice for conducting smaller, in-house evaluations.

In cases where the evaluation study is taking place in a smaller gallery or room, however, there is room for improvement in the Museum's evaluation process. In a smaller setting like Room 3, the Museum Interpretation Team collects visitor feedback primarily in two ways: self-completed surveys at a kiosk and face-to-face interviews with visitors. In both cases, the Museum has a list of standard questions that it uses in all evaluations, but there is an additional set of questions that pertains to the contents of the room or gallery where the study is taking place. The kiosk, which typically consists of an iPad with integrated survey questions, serves as a way for visitors to give quick feedback and answer the general questions that the Museum would like answers to for every study. Table 4 below contains the five questions that the kiosk has at every show that is held in Room 3.

Table 4. *Standard iPad Survey Questions Used for Every Show in Room 3*

1. Please enter three words that you feel best describe this display.
2. How clear was the overall theme, narrative, or message of this display? (0-5)
3. On a scale on 0-5 to what extent do you feel you learned something new as a result of visiting **name of show** (0 = lowest, 5 = highest)?
4. On a scale of 0-5 how innovative and experimental did you feel this display was?
5. How satisfied are you with this display overall? (Excellent, Good, Fair, OK, Poor, Very Poor)

The face-to-face interviews supplement the standard set of questions with additional, more detailed questions regarding the current exhibit. Despite this, both sets of data from these methods are gathered separately and therefore must be individually entered into a spreadsheet before the information can be analyzed. This is where the process is largely ineffective, and a system where the data can be gathered and processed simultaneously would be ideal for the Museum.

4.2.2 Toolkit Design Criteria

Using the gathered information from our research on the Museum's current practices, we developed a set of design criteria. We needed a toolkit that would be able to handle all aspects of visitor evaluation, including the gathering and analysis of data pertaining to interviews, observations, and visitor tracking. Most importantly, the Museum desired tools that would not only streamline the process of gathering and analyzing data, but also visualizing the data so that the entirety of the Museum staff would understand the information. To do so, we needed to find tools that were easily accessible to both our team and the Museum.

Due to the Museum's relatively low budget on software, we required tools that were inexpensive and/or readily available on almost all devices. In the case of the British Museum, the Microsoft Office Suite is available on all of their systems, which meshed well with our design criteria and solved the issue of both budget and availability for features such as designing floor plans. It was essential that we devised a toolkit that was not only easily manipulated, but that could be picked up and used by all Museum staff and volunteers. Devising a set of design criteria allowed us to develop an easy-to-use set of innovative and effective tools that met the needs and concerns of the British Museum. A summary of our design criteria is displayed in Table 5 below.

Table 5. *Toolkit Design Criteria*

Goals	Constraints
Track visitor movement and dwell times	Lack of budget, minimize costs
Create custom floor plans efficiently	Lack of portable technology (e.g., tablets)
Utilize existing resources where possible	Poor network connection in the Museum
Streamline visualization of data	External software verification
Improve accessibility and intuitiveness	Inability to test in the field

4.2.3 Microsoft Visio

Microsoft Visio was explored as a potential software for use in streamlining the process of gathering and visualizing tracking data. Visio provides a simplistic toolkit that can be used to create floor plans in a short amount of time. The program uses a scaled measuring system to allow the user to make designs as accurate as possible. Visio's ease of use may be useful for the Museum,

for it provides the Interpretation Team with a platform to design, create, and modify floor plans for its different galleries and exhibits.

Although Visio has a function that allows data to be attributed to different objects in a floor plan, it does not provide an intuitive or visually exciting way of representing the data. The data remains as simply numerical or textual data. Therefore, Visio serves well as a tool for Museum staff or volunteers to efficiently make floor plan designs for areas that they are evaluating. However, Visio does not provide the necessary tools for making significant improvements to the Museum's data visualization protocols.

4.2.4 Power Map for Microsoft Excel

We considered many options to create dynamic floor plans for the Museum that could represent different sets of information that are of interest to this organization. Ultimately, due to potential software accessibility issues and the need for cheap and readily available easy to use options, we opted for an option that the Museum already had available as part of the Microsoft Office Suite subscription, as described in the design criteria.

Microsoft Power Map was explored as a possibility for creating dynamic 3D maps that display data in an intuitive way over existing floor plans. This is because Power Map provides more insight than a 2D map and better visual representation of information. It allows for spatial and temporal data to be visible on custom maps created with images of floor plans. Ideally, this tool provides the Museum with an innovative and different way of presenting the information they seek with their tracking studies for their own analysis and evaluations. It could portray information such as the time spent by a visitor in front of different displays and the popularity of each case or wall display in the form of heat maps, columns, or bubbles in 3D.

Using Room 3 as a trial, we obtained an image of the gallery's floor plan from previous reports provided by Stuart Frost. In order to use Power Map, we identified the coordinates of each display within the given floor map. To do this, we used Microsoft Paint, an accessible graphics editor included in all versions of Microsoft Windows. We chose this tool to pinpoint coordinates due to its advantage of locating pixel coordinates in an efficient way and the accuracy of its measurement translation when scaled. Once the coordinates were precisely identified by placing the cursor on top of each object, they were manually inputted in an Excel worksheet and labeled appropriately.

Standard protocols for creating a custom map were followed as instructed in Microsoft's Support webpage (Get started with Power Map. (n.d.)) and a step-by-step manual is attached for reference. Once the map was created, a layer with the XY coordinates was added to the floor plan image and the accuracy of the locations given by the worksheet coordinates was adjusted to match the pixel location of the objects within the map. Initially, this program appeared promising, but its capabilities proved difficult to explore given that there exists very limited information regarding how it works.

4.2.5 Assembling the Toolkit

Combined with our research on individual tools, we considered how to join these tools together and intuitively utilize the entire kit to conduct visitor tracking and evaluation studies. In order to use the toolkit as a cohesive unit, it was designed as a static webpage that displays all the information and tools necessary for tracking. Figure 6 below shows the application's screen when entering observational data.

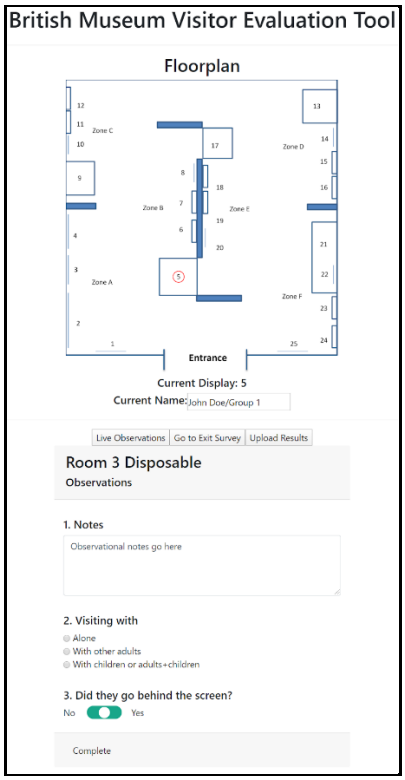

Figure 6. Application Screen When Recording Observations

The app was designed with modularity in mind, such that users can change the survey or floor plan within the tool with ease; all a user must do is move the proper files (e.g. image,

coordinates, survey) into the same folder as the application, or into a file for storing said information. This way, users require no technical knowledge to be able to use the toolkit. The application is also able to upload the results of a tracking study to a spreadsheet at the user's request, preventing the need for manual entry of observations and exit interview results. As the app is only a prototype, it is restricted in some ways. For example, the tool is designed to upload one study at a time, i.e., the user must connect to the network and upload the results after each group or visitor they track, up through and including the exit survey. In addition to in-line commenting within the code itself, so as to improve readability and comprehension for future editors, the README document (Appendix A) also provides information on how to utilize the application and its accompanying tools. The general process of using the toolkit is summarized in the README as follows:

First a floor plan must be made using software such as Microsoft Visio and saved in an image file format (e.g. PNG, JPEG, etc.). To make this process easier, the team created a Visio template that can be modified for each individual study. This floor plan must have display numbers marked for each display that is to be tracked. After the image is saved, it must be opened in a photo manipulation software such as Microsoft Paint. The user will then record the pixel size of the image into the configuration file, as well as the pixel coordinates of each individual display number. The coordinates must have the headers "display", "x", and "y" in order to be read by the program. These coordinates should be saved as a CSV file from any spreadsheet program, and then placed along with the floor plan image into the same folder as the webpage (i.e. the Github repository). Both the names of these files should also be recorded in the configuration file.

Following creation of a floor plan image and corresponding coordinates, the user must then create the survey they wish to use. If the user wishes to change the survey in the application, they may copy the survey JSON from the configuration file into the JSON editor of the SurveyJS creator site. They may then change whatever aspects they like and recopy the JSON data back to the configuration file. To make a new survey, simply use the SurveyJS creator.

Once all information is copied into the configuration file and into the directory, the user can connect to the app through a network connection and begin utilizing the app either online or offline. The user can freely switch between live observations and exit surveys, with a responsive floor plan to track where visitors are. All observations are automatically tagged with the current name and an accurate timestamp upon creation. Whenever the user is ready to upload, they can

send all of their collected data to an online spreadsheet at the press of a button, where it will be automatically processed and inserted into organized sheets. Figure 7 below shows what the application looks like after completing an exit survey.

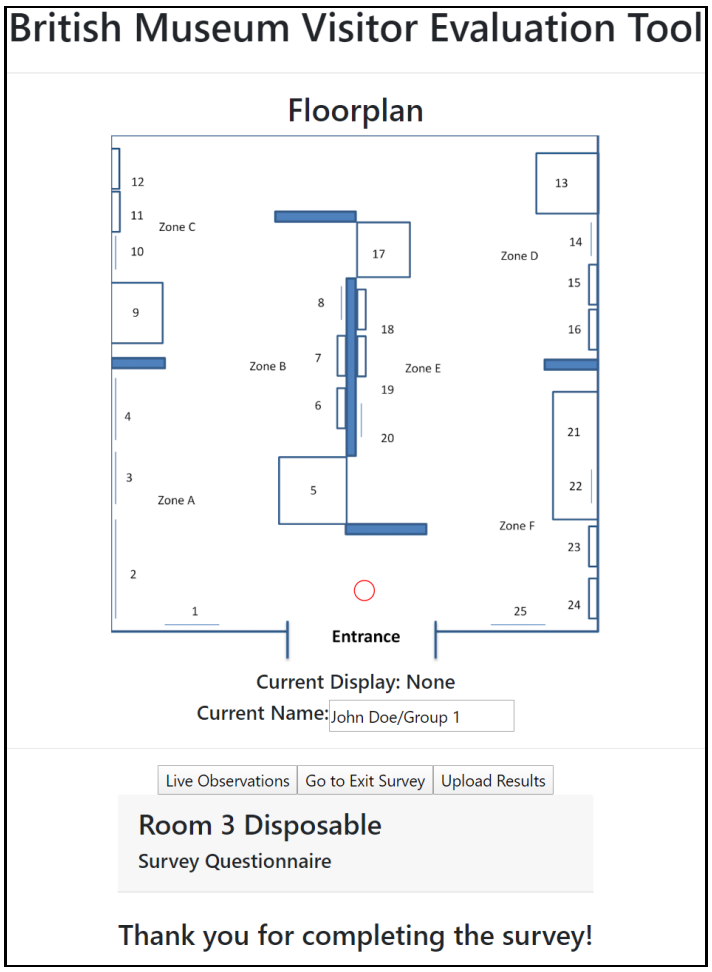

Figure 7. Application Screen Upon Completing Exit Survey

Chapter 5: Conclusions and Recommendations

The goal of our project was to help the British Museum in improving its methods of visitor evaluation. We developed a toolkit to be used for conducting future evaluation studies using open-source software and other proprietary software packages, including Microsoft Excel and Visio and SurveyJS. Our toolkit provides the British Museum with an immediate and innovative solution that streamlines the visitor evaluation process and eliminates the need for antiquated pen-and-paper evaluation methods. The toolkit also serves as a valuable baseline for future teams who may aim to further improve the Museum's evaluation methods.

Although we successfully provided these tools to the Museum, we must address the limitations in our research and development. Due to circumstances presented by the COVID-19 pandemic during the implementation of this project's methodology, we were unable to conduct the project on-site at the British Museum as initially intended. Therefore, we conducted the entirety of this project remotely using services such as email and video calling through the application Zoom. Our research was limited to reviewing previous evaluation studies conducted by the British Museum and peer reviewed literature written by museum and visitor evaluation experts. Given the circumstances, we were unable to contact other museums and evaluation experts to gather additional information on visitor evaluation protocols. Additionally, we were unable to pre-test our toolkit to aid in the developmental process.

Since we were unable to pre-test our toolkit, we recommend that the Museum test the toolkit with a variety of visitors in a variety of situations. By testing the toolkit in different exhibits and galleries, the Museum can identify potential issues and improvements that may be necessary for future use. We recommend that the Museum work with a future WPI team to make these potential improvements and refine and polish the toolkit further based on feedback from users. A future WPI team will be able to use our toolkit as a baseline for making additional improvements to the Museum's evaluation methods.

Despite the limitations, we provided the British Museum with a functional toolkit along with a README file (Appendix A) that described the necessary steps for using each individual tool. The Museum now has an improved method of gathering information from its visitors. We are honored to have had the opportunity to assist the British Museum in conducting its research and improving its evaluation methods, and to further its goal of educating the public in the most effective and meaningful ways.

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Appendix A: Evaluation Toolkit README

Improving Visitor Evaluation at the British Museum

Evaluation Toolkit README

By
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This README file was created in order to provide the Interpretation Team staff and volunteers at the British Museum with gathering the necessary materials from the recommended tools to use in our prototype web application. Steps for inputting, saving, and submitting data into the web application are detailed for each tool in the toolkit.

Table of Contents

General Summary

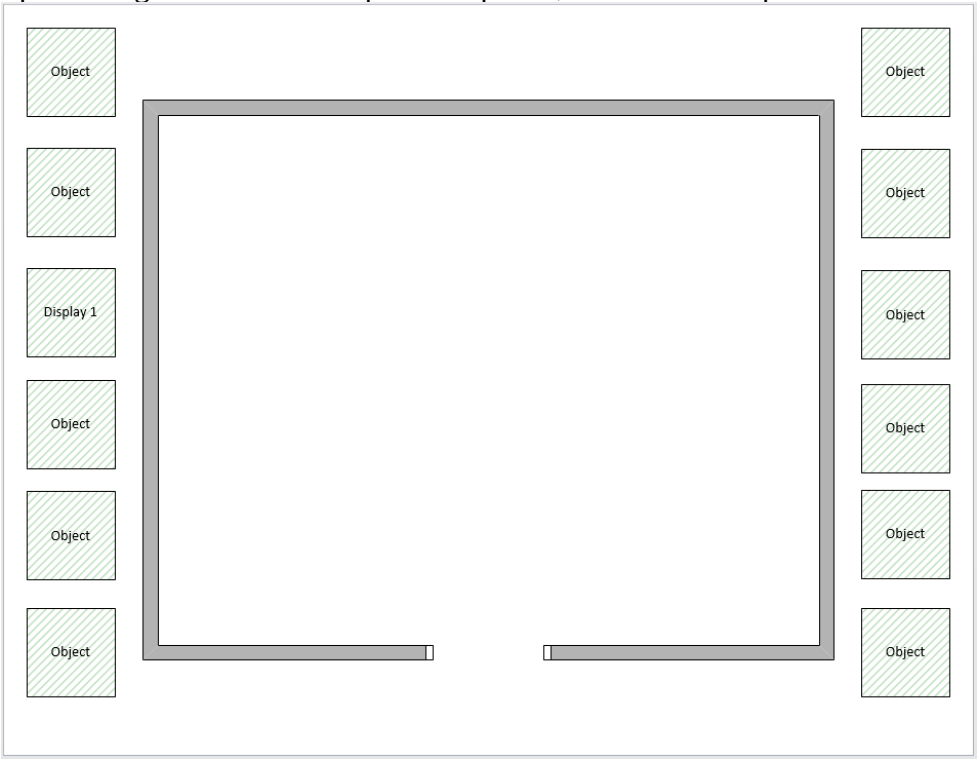
First a floor plan must be made using software such as Microsoft Visio and saved in an image file format (e.g. PNG, JPEG, etc). This floor plan must have display numbers marked. After the image is saved, it must be opened in a photo manipulation software such as Microsoft Paint. The user will then record the pixel size of the image into the configuration file, as well as the pixel coordinates of each individual display number. The coordinates must have the headers “display”, “x”, and “y” in order to be read by the program. These coordinates should be saved as a CSV file from any spreadsheet program, and then placed along with the floor plan image into the same folder as the webpage (i.e. the Github repository). Both the names of these files should also be recorded in the configuration file.

Following creation of a floor plan image and corresponding coordinates, the user must then create the survey they wish to use. If the user wishes to change the survey in the application, they may copy the survey JSON from the configuration file into the JSON editor of the SurveyJS creator site. They may then change whatever aspects they like and recopy the JSON data back to the configuration file. To make a new survey, simply use the creator.

Once all information is copied into the configuration file and into the directory, the user can connect to the app through a network connection and begin utilizing the app either online or offline. The user can freely switch between live observations and exit surveys, with a responsive floor plan to track where visitors are. All observations are automatically tagged with the current name and an accurate timestamp upon creation. Whenever the user is ready to upload, they can send all of their collected data to an online spreadsheet at the press of a button, where it will be automatically processed and inserted into organized sheets.

Microsoft Visio

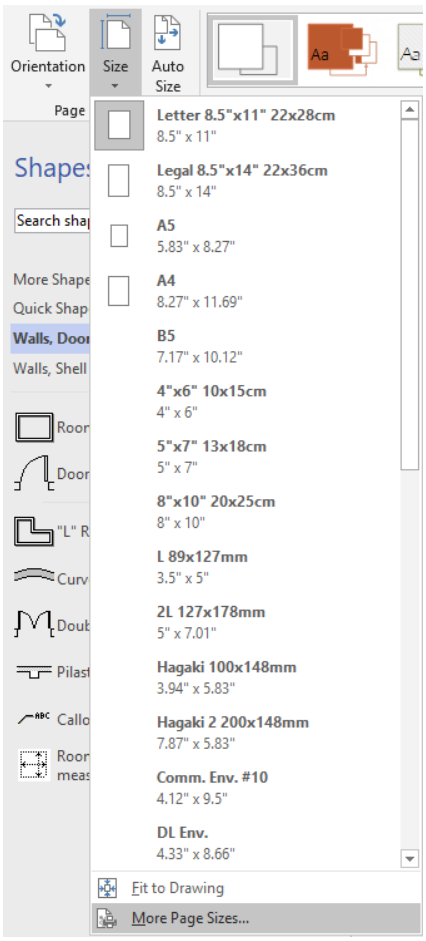
The provided template has a basic outline for a room with the most pertinent objects already selected and ready for use immediately. The template can be modified and then saved as a for all future floor plan designs. Once the template is opened, a default floor plan will be on the canvas.



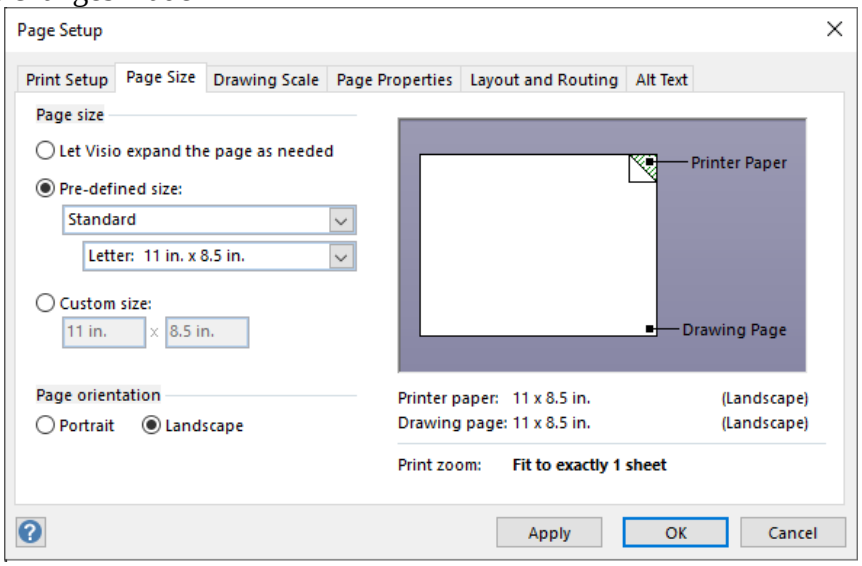
To increase the size of the canvas, use the following steps:

1. On the top toolbar, click on the “Design” tab

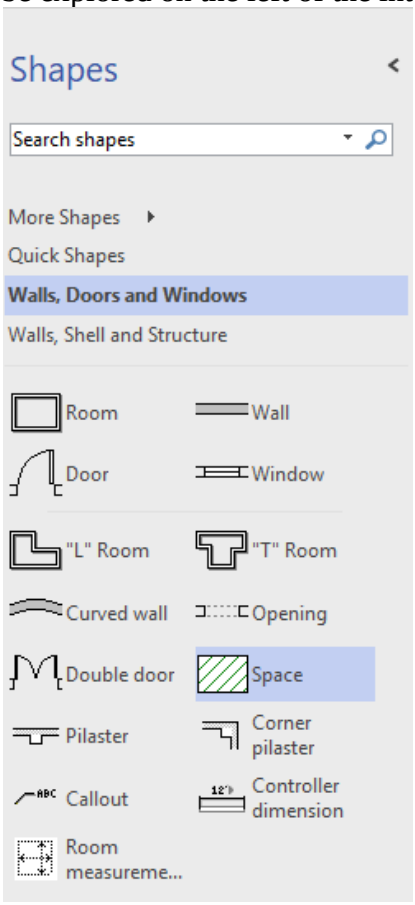
2. On the top left under the “Page Setup” bar, click on the “Size” button. When the menu opens, click on “More Page Sizes” at the bottom of the list.



3. A window will pop up with several options, including pre-defined sizes and the option to manually size the canvas. Click “Apply” to see how the size changes, then click “OK” to confirm the changes made



The available shape options can be explored on the left of the interface.

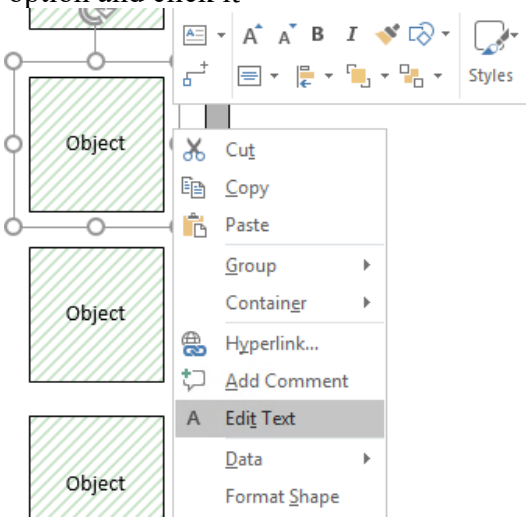


To add an object, simply click-and-drag the object onto the canvas. Objects can be placed over each other to connect them and form unified structures, indicated by the “glue to geometry” note

The easiest and most common shape to use to represent an object in the museum is the “space” shape. For ease of use,“space” objects have already been placed on the template, and they can be resized, relabeled, or copied. Below is a zoomed-in image of a space object that is on the template.

The “Object” labels on these objects can be edited using the following steps:

1. Right-click the object to open the editing options
2. Highlight the “edit text” option and click it

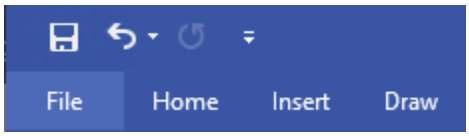


3. The label will turn grey, and it now can be modified to whatever text is necessary

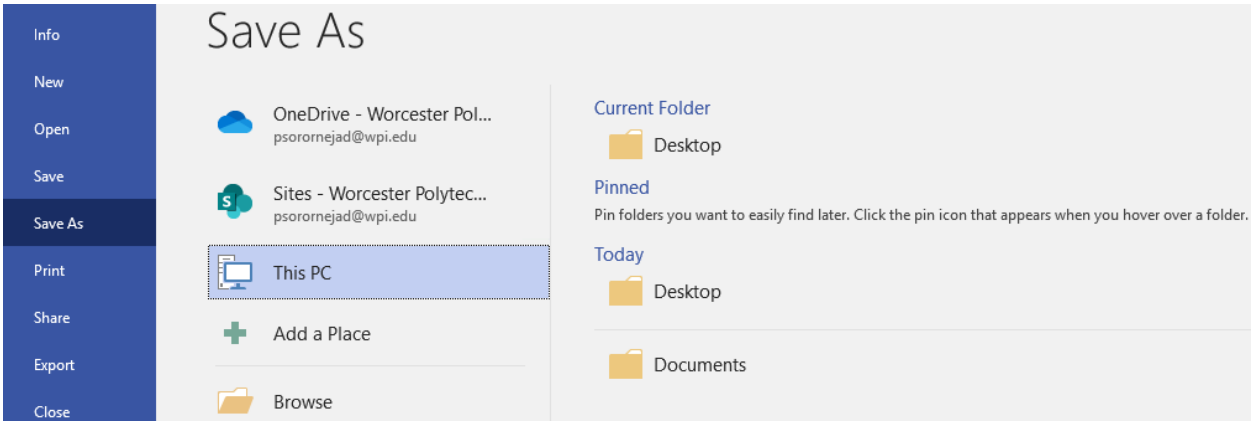
4. Click on a space away from the object to save the new label

Once the floor plan is complete, the file must be saved properly for us in the following steps. To do so, follow the steps below:

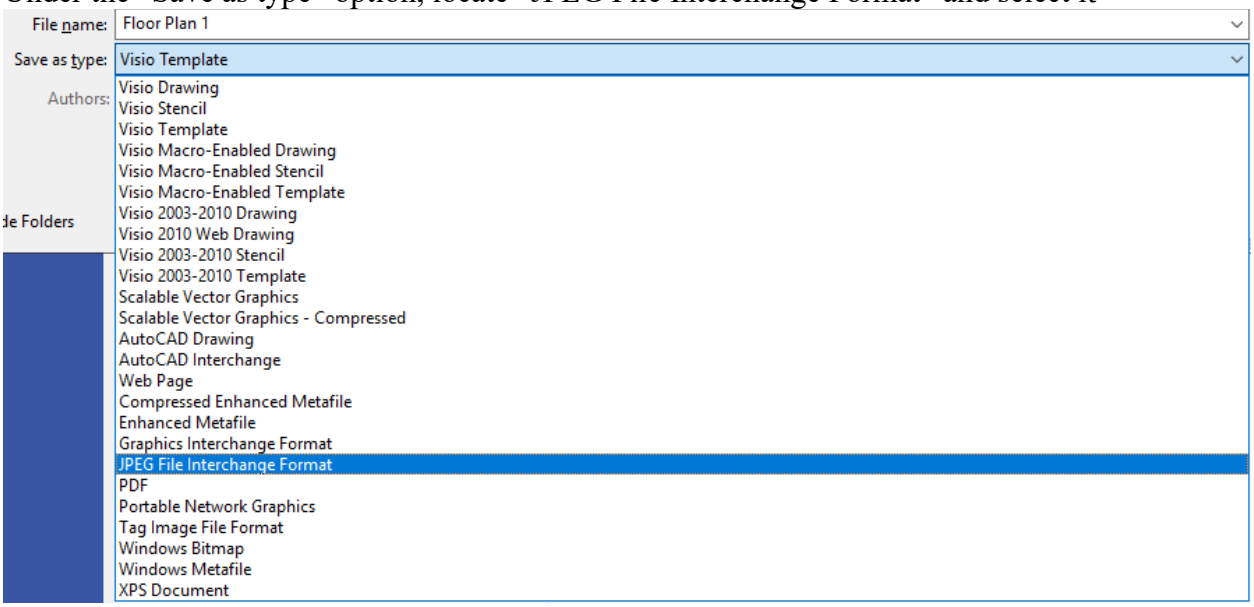
1. On the top toolbar, click on the “File” tab



2. Click on the “Save As” option, and choose/browse for an appropriate location to save the file



3. Once the location is selected, a window will pop up to save the file. Name the file appropriately
4. Under the “Save as type” option, locate “JPEG File Interchange Format” and select it

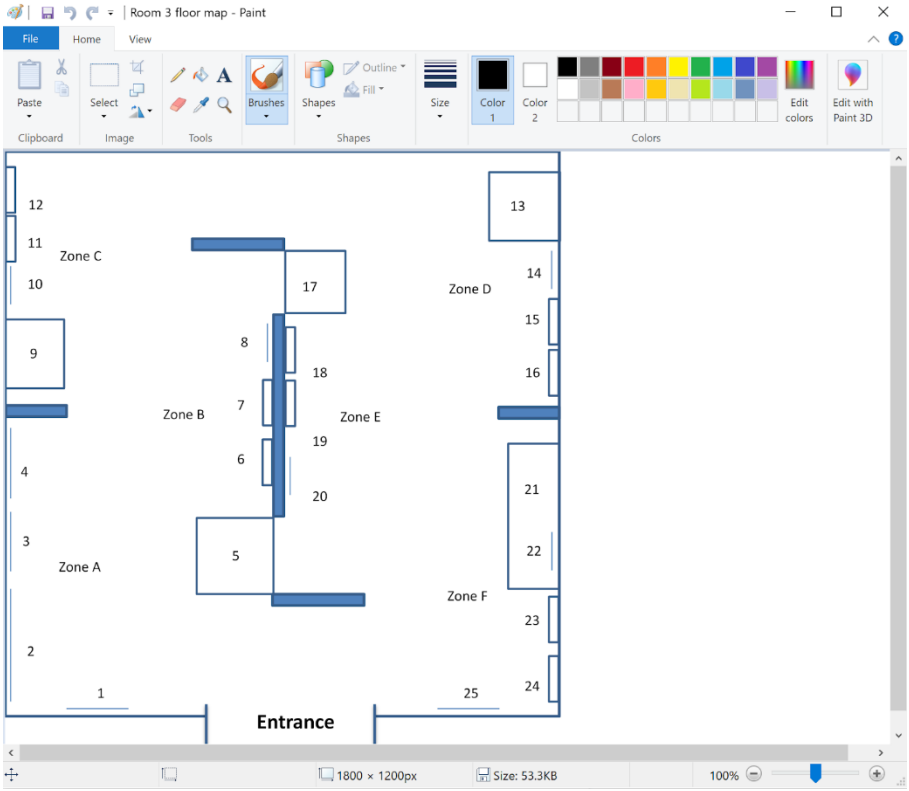


5. Click the “Save” button, and now the file is properly saved for the following steps

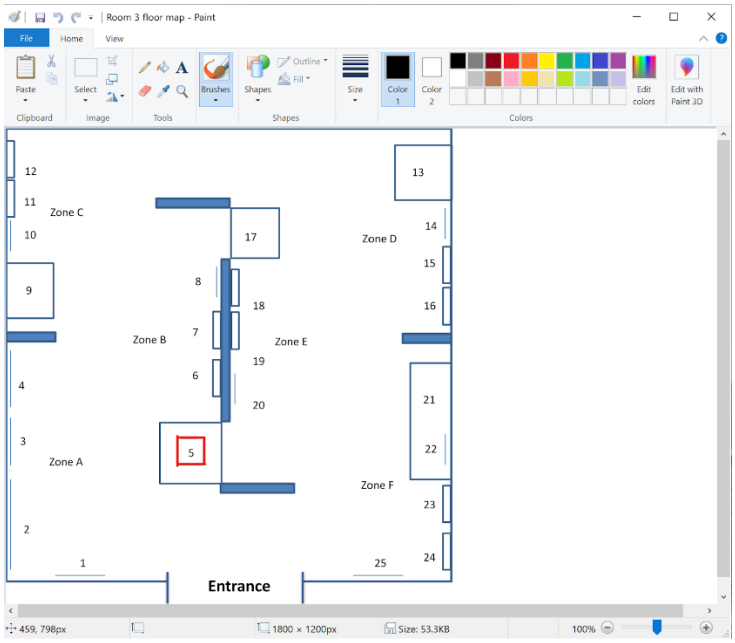
Microsoft Paint

Once Microsoft Paint has been launched, the file containing the image of the floor plan created through Visio must be opened through it.

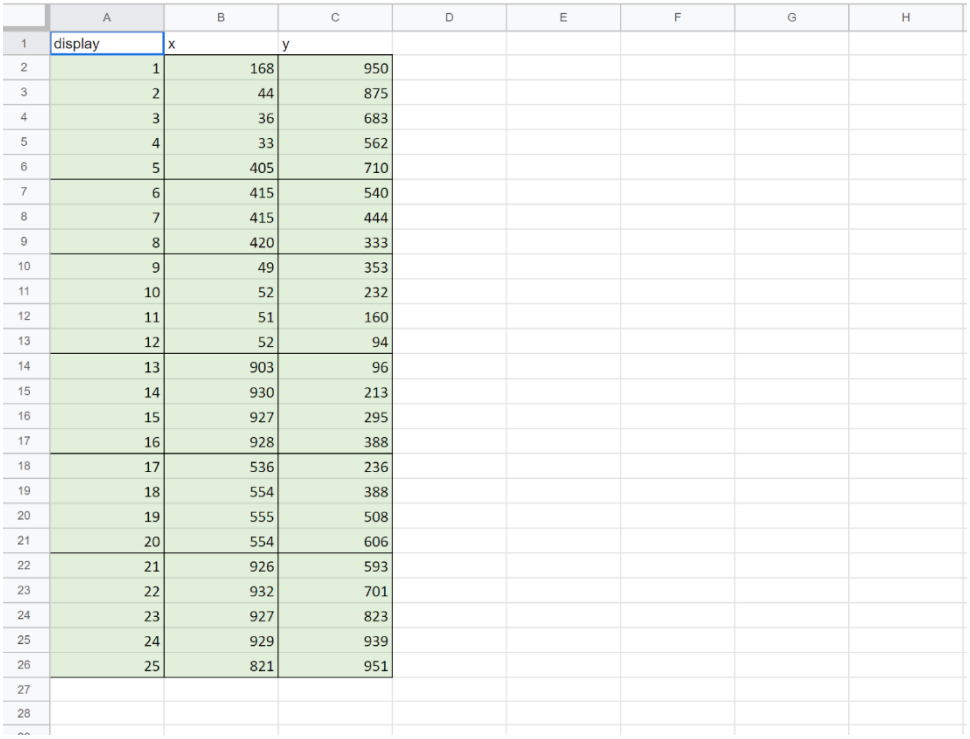
1. Floor plan was imported through clicking on File and then Open and selecting the floor plan image file



2. By hovering the cursor over the desired number, the XY coordinates in pixels (px) will be displayed on the lower left corner of the window



3. The XY coordinates must be manually inputted into a Microsoft Excel document or a Google Spreadsheets document with the following headers: display, x, y, in order for the program to read the data



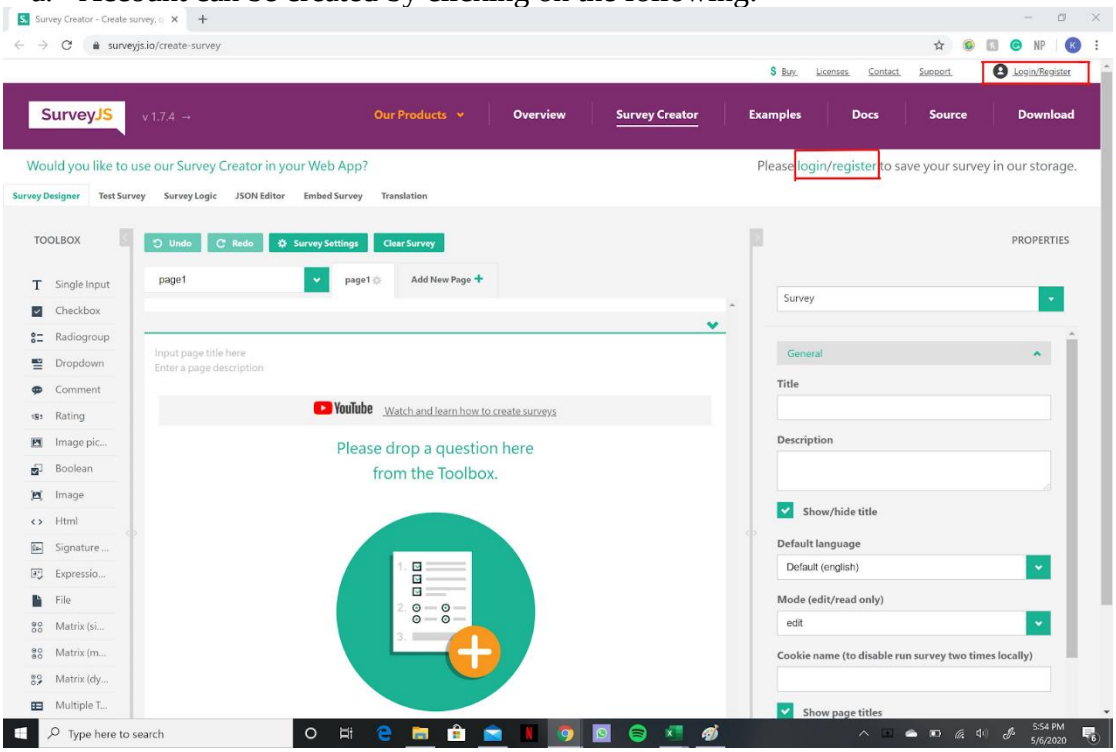
	A	B	C	D	E	F	G	H
1	display	x	y					
2	1	168	950					
3	2	44	875					
4	3	36	683					
5	4	33	562					
6	5	405	710					
7	6	415	540					
8	7	415	444					
9	8	420	333					
10	9	49	353					
11	10	52	232					
12	11	51	160					
13	12	52	94					
14	13	903	96					
15	14	930	213					
16	15	927	295					
17	16	928	388					
18	17	536	236					
19	18	554	388					
20	19	555	508					
21	20	554	606					
22	21	926	593					
23	22	932	701					
24	23	927	823					
25	24	929	939					
26	25	821	951					
27								
28								

4. Once completed, the file containing the coordinates must be saved as or exported as a CSV file (comma-separated value)

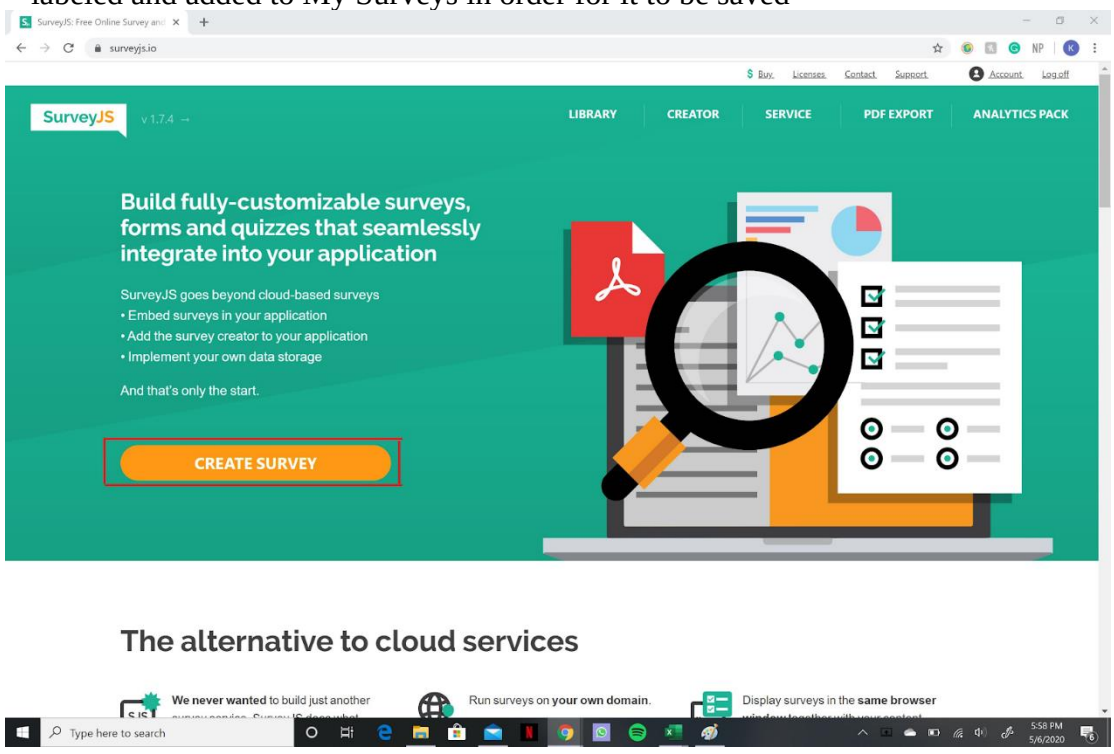
SurveyJS

Webpage can be accessed by clicking on the following link: https://surveyjs.io/create-survey

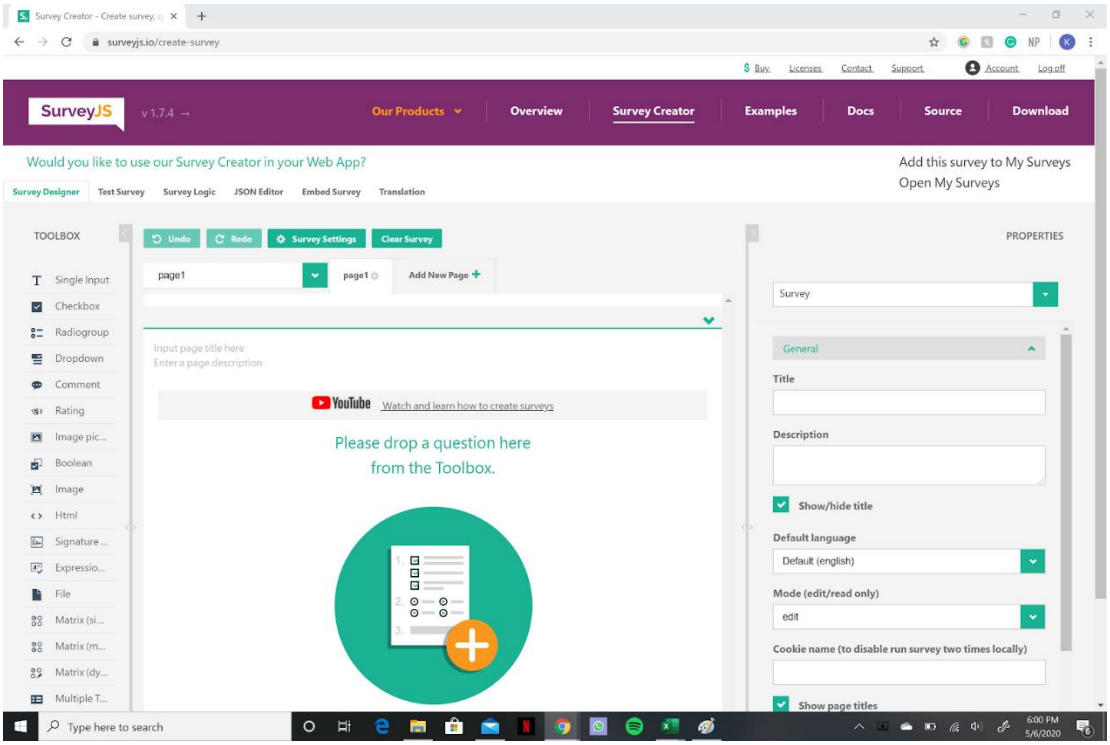
1. An account must be set up in order to save surveys, but is not necessary to create/modify
   a. Account can be created by clicking on the following:



2. Once the account has been set up, click on Create Survey. Each new survey should be labeled and added to My Surveys in order for it to be saved



3. The column on the left side of the window labeled Toolbox offers the different types of formatting that are available for each question within a survey. For a question to be created, the desired format should be selected by clicking on it on the left or by dragging it from the Toolbox

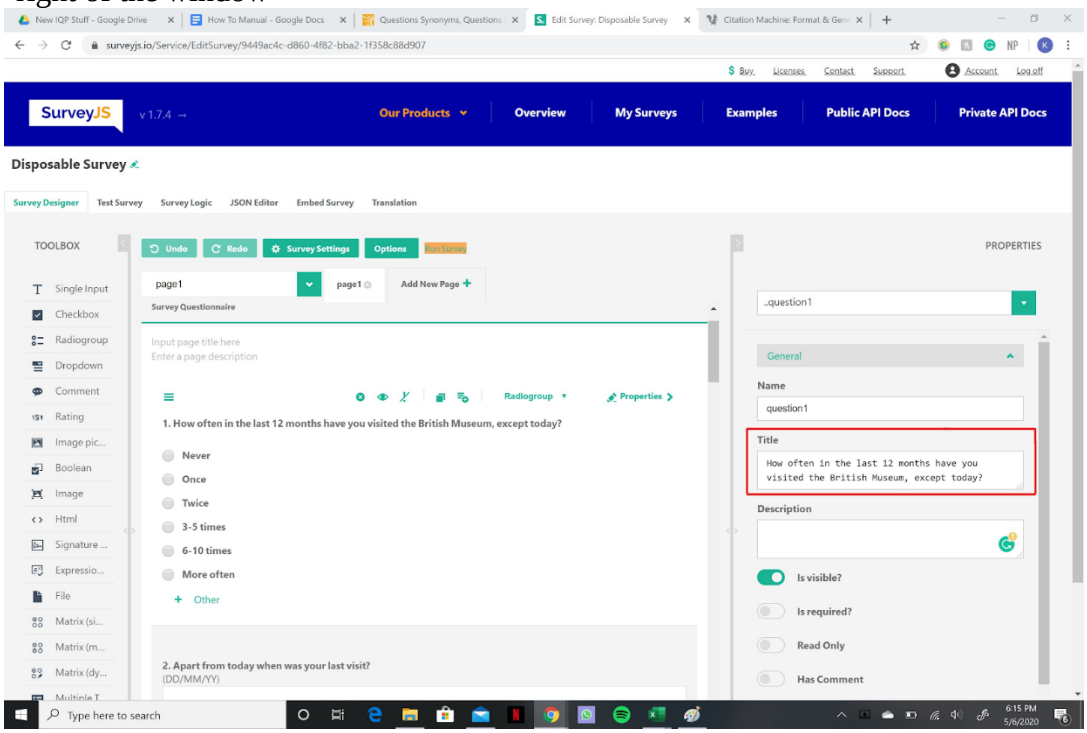


As a reference, the question formats used in the Disposable Survey Questionnaire were as follows:

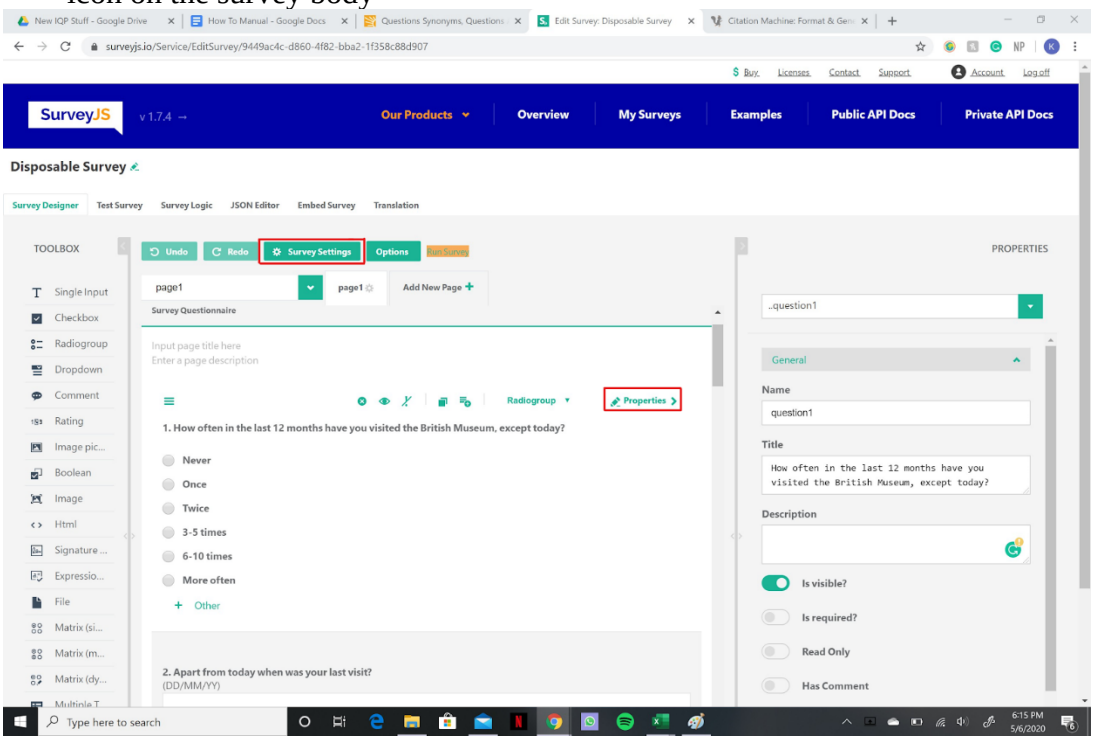
- Single input: for short answers such as name/date/email
- Checkbox: for multiple choice questions with more than one potential answers
- Radiogroup: for multiple choice questions with only one potential answer
- Comment: for longer written answers than the Single input option such as opinions/suggestions
- Rating: for rating on a customizable scale
- Boolean: for yes/no questions or questions with only two options that could lead to further interrogation depending on the answer

For a full list of descriptions of each question format and examples of each refer to: https://surveyjs.io/Examples/Library/?id=questiontype-text&platform=jQuery&theme=modern

4. Type in or insert the question in the Title box on the Question Properties column at the right of the window



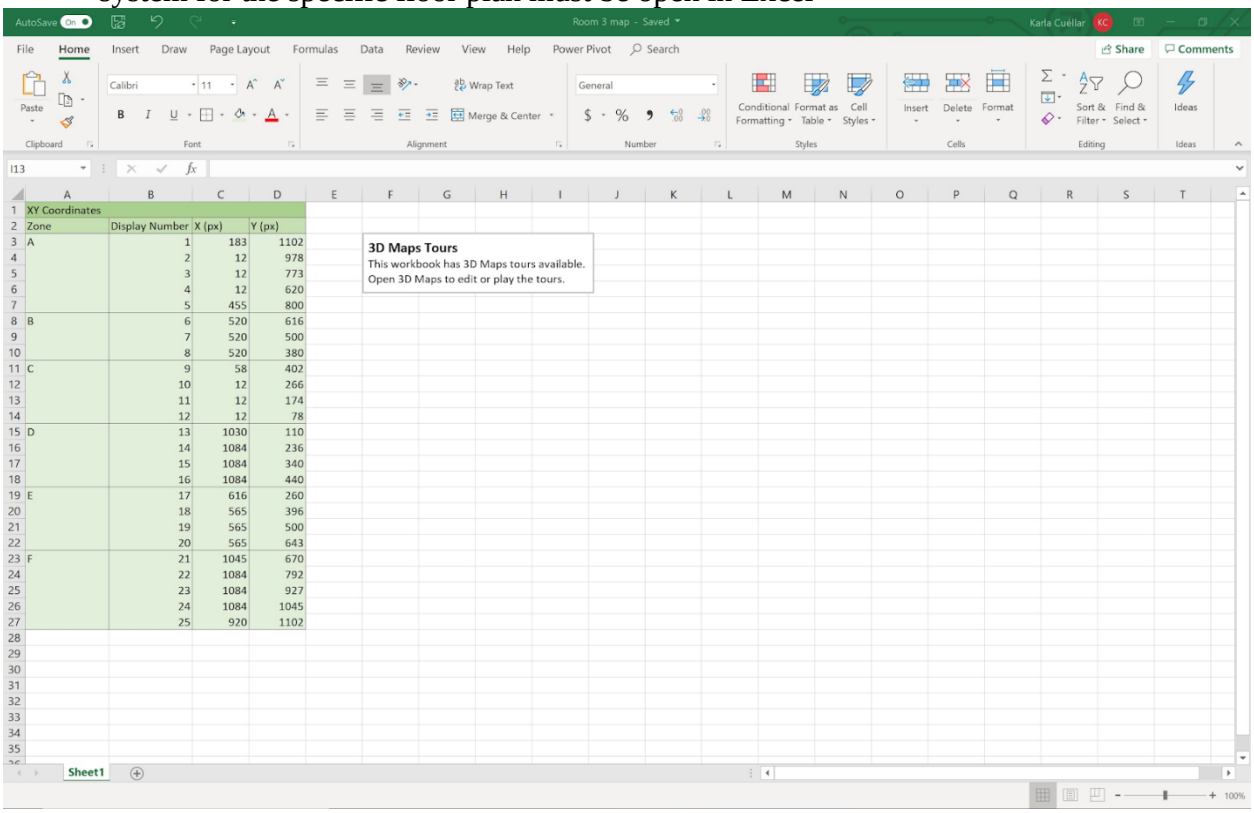
a. Each question can be edited at any time by clicking on Survey Settings or the pencil icon on the survey body



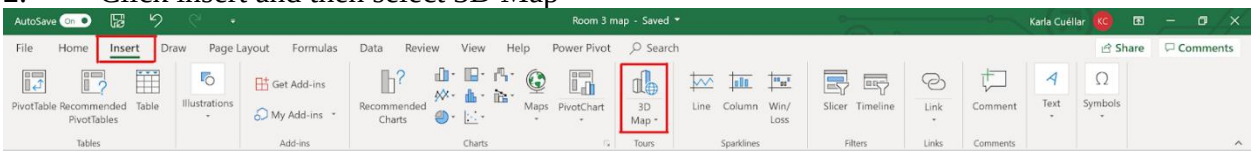
Power Map Through Microsoft Excel

Standard protocols for creating a custom map can be followed as instructed in the Microsoft Support webpage (Get started with Power Map. (n.d.)). This tool potentially will allow for the data collected to be displayed in an innovative way with further exploration. Within this manual, basic instructions for custom map creation as a template for Room 3 are described.

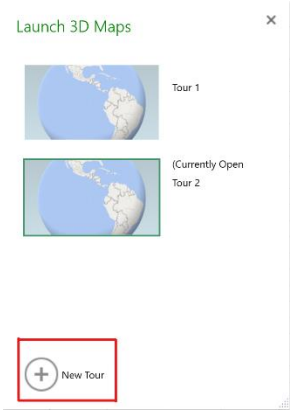
1. The workbook created specifically to display the tracking data that contains the coordinate system for the specific floor plan must be open in Excel



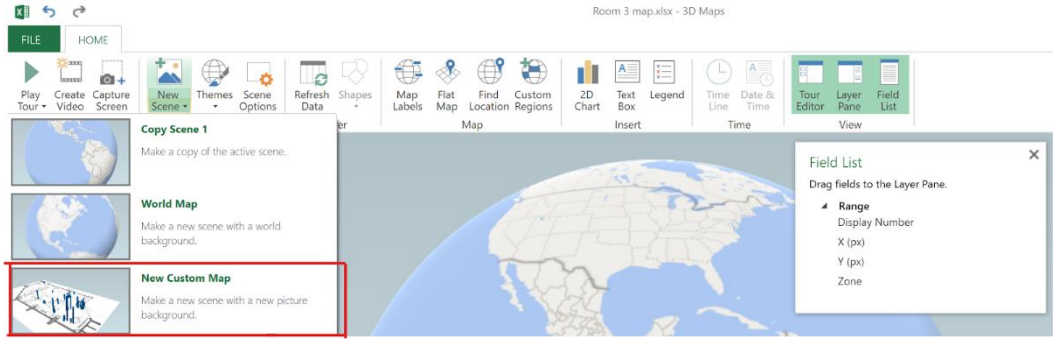
2. Click insert and then select 3D Map



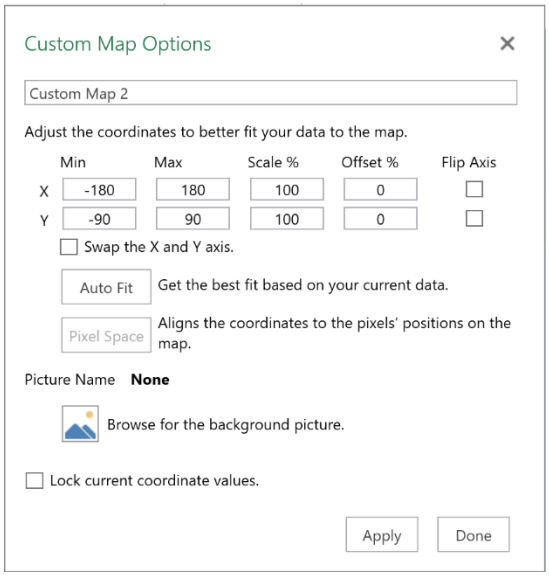
3. In Power Map click New Tour



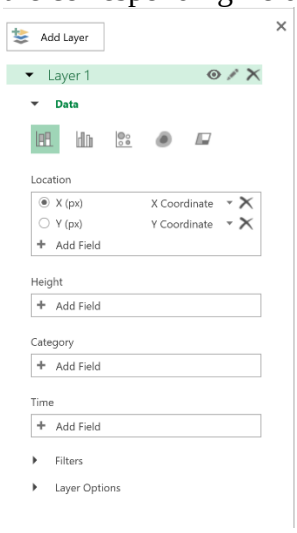
4. Click New Scene and select New Custom Map



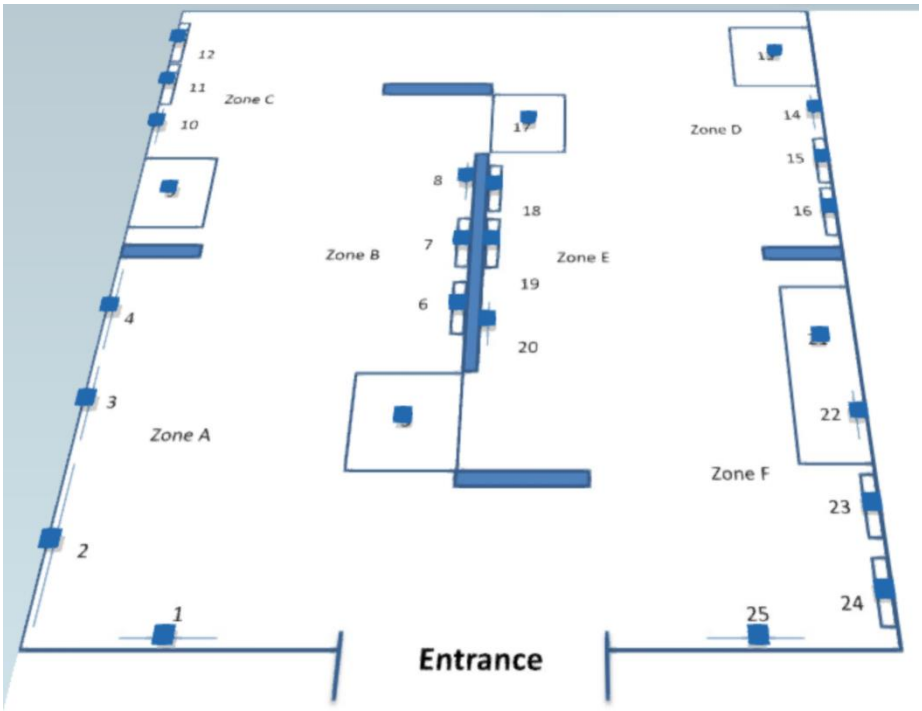
5. In the Custom Map Options window, browse for the background picture and select the floor plan.
   a. If the coordinates are in pixels, select Pixel Space
   b. Otherwise, select Auto Fit to obtain the most accurate fit and click the Lock current coordinate values box



6. Once the selections are made, add the desired data in the Layer pane and select visualization preferences and adjust the corresponding fields



7. A completed floor plan map including marked locations of each display and case in Room 3 will look as follows:



8. Once the map is created, a layer with the XY coordinates must be added to the floor plan image and the accuracy of the locations given by the worksheet coordinates has to be adjusted to match the pixel location of the objects within the map.