

**Supplemental Materials for
Tower Bridge Team
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4/26/2022**

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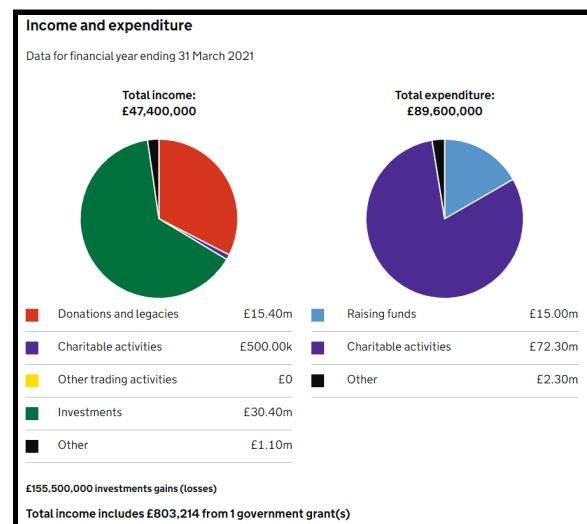
Supplemental Materials A: Tower Bridge and Bridge House Estates Description

Tower Bridge is a historical monument that was built by organizations dating back to the thirteenth century. This iconic structure has graced the London skyline since its completion in 1894 after eight years of construction. The bridge was implemented for the sole purpose of alleviating traffic congestion in London while continuing to allow the passage of ships to the Pool of London further up the Thames. An organization known as the Bridge House Estates executed the construction of the bridge (City of London, n.d.). Founded in 1282, the Bridge House Estates organization was initially created to protect and maintain the original London Bridge, which was constructed out of stone decades prior. In the modern era, Bridge House Estates is responsible for the maintenance of not only Tower Bridge, but also the Blackfriars Bridge, Southwark Bridge, and Millennium Bridges in London (City of London, n.d.). Bridges that are maintained by this organization are easily recognizable by their Bridge Mark, shown in Figure 1. Bridge House Estates runs a charitable arm known as the City Bridge Trust, a non-profit organization that donates approximately £25 million in revenue from bridge visitors (excluding the funds necessary for bridge maintenance) to over 600 organizations across London each year (City of London, City Bridge Trust, n.d.). About £6 million comes from admissions to Tower Bridge alone.



In addition to the construction of Tower Bridge, Bridge House Estates has built other bridges in the past such as the London Bridge twice (1831 and 1973) and most recently, to celebrate the new millennium, the Millennium Bridge in 2000. Every bridge built by Bridge House Estates has and will continue to be funded and maintained internally. Through exhibits such as those at Tower Bridge, Bridge House Estates and the City of London aim to educate the people of the United Kingdom and visitors from around the world on the rich history of these iconic structures.

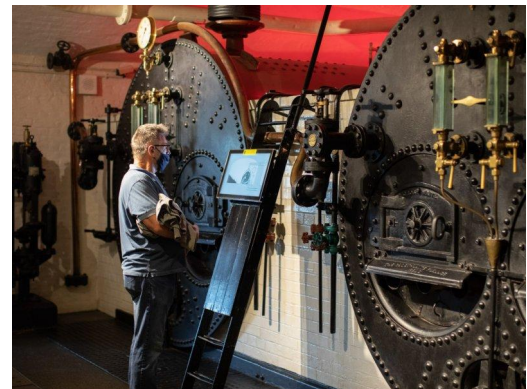
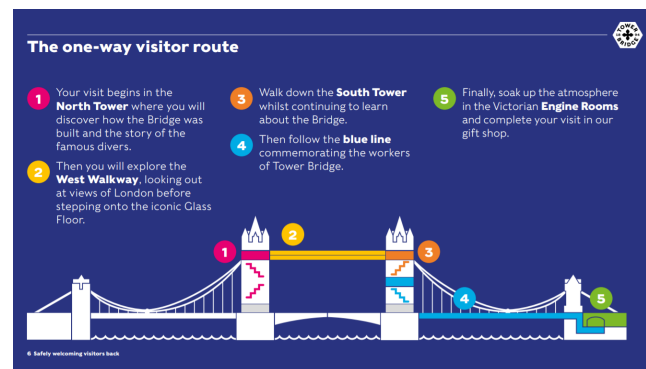
Bridge House Estates has 130 employees and one trustee – the City of London Corporation. Bridge House Estates uses its income to maintain and repair those bridges under its jurisdiction. Any extra funding is used to support the residents of London via the City Bridge Trust, mentioned above (Charity Commission for England and Wales, n.d.). As shown in Figure 2 below, for the financial year ending on 31 March 2021, Bridge House Estates received £47,400,000 in total income and had a total expenditure of £89,600,000. The organization has seen an increase in both income and spending since 2017 where its income was £34,100,000 and expenditures were



£50,000,000 (Charity Commission for England and Wales, n.d.). Most of the Bridge House Estates' income comes from investments and donations. The charity gives grants to organizations that help children, the elderly, people with disabilities, people of certain races or ethnicities, and other various groups of people. It helps with education, healthcare, disabilities, poverty, the environment, housing, and many other causes (Charity Commission for England and Wales, n.d.).





The experience of visiting Tower Bridge offers a wide variety of ways to explore the historic British landmark. Tower Bridge also has an efficient system to give guests a wonderful experience while remaining safe, especially during the current COVID-19 situation in the United Kingdom. Upon arriving at Tower Bridge, visitors enter an outdoor queue where they wait with their prepaid tickets (Tower Bridge, n.d.). Tower Bridge offers many experiences for all types of people to enjoy. Tours include guided tours from Tower Bridge tour guides, which can be offered with British Sign Language specialists, group tours for large parties, and behind-the-scenes tours that show parts of the bridge that are not usually open to the public. Families can also enjoy activities such as exploring the Family Trail, drawing challenges, special family tours, and more. Tower Bridge can even be booked for larger events including weddings, corporate events, and more (Tower Bridge, n.d.).

Figure 3 is a graphic detailing the full tour through Tower Bridge. The tour starts as visitors walk up the stairs into the North Tower, which displays an exhibit containing photographs dating back to the grand opening of the bridge in 1904. The exhibit also shows footage of Victorian London during the construction of Tower Bridge (Museums London, n.d.). The museum also takes visitors on a journey through the building of the bridge, with exhibits including interesting facts about how the bridge was built and the stories behind the people who built the bridge. Diver's gear, nameplates of workers, design blueprints, how-to manuals, and more are on display for visitors to explore (Tower Bridge, n.d.). From there, guests walk out of the North Tower onto the high-level enclosed West Walkway, where visitors can take in beautiful views of other parts of London from forty-two meters up, including City Hall, St. Paul's Cathedral, the Shard, and the Gherkin. Once across the walkway visitors come to the South Tower, which, similar to the North Tower, educates about the history of the Tower Bridge through old photographs and memorabilia. Visitors then exit the South Tower and walk across the blue line, which commemorates those who constructed the Tower Bridge back in the 20th century (Museums London, n.d.). The tour then ends in the engine rooms, which shows how the Tower Bridge operated before moving from steam engines to electric engines (see Figure 4). The tour finishes in the Tower Bridge gift shop.



Overall, COVID-19 has impacted the visitor experience significantly at Tower Bridge. While the pandemic has soured the bridge’s short-term outlook, it remains a world-recognized landmark. Through new and innovative approaches, such as the potential bring-your-own-device system to be explored in this project, the bridge can remain a fixture of the London skyline, beloved by both Londoners and tourists alike.

Supplemental Material B: Audience Segmentation

Audience Segment	Characteristics	Motivations
Expression 	<ul style="list-style-type: none"> ● Highly culturally motivated/active ● Enthusiastic ● Creative ● Wide range of cultural interests ● Enjoy arts in active manner 	<ul style="list-style-type: none"> ● Broad spectrum of artforms ● motivated/engaged by all artforms ● Feature learning, community, and nature
Perspective 	<ul style="list-style-type: none"> ● Traditional over contemporary art/exhibits ● Interests are sparked through literature, history, natural world ● Self-sufficient ● Driven by own agenda 	<ul style="list-style-type: none"> ● Traditional, historical aspects of life ● Cultural venues focused on learning ● Libraries, Museums
Entertainment 	<ul style="list-style-type: none"> ● Socially motivated ● Low engagement levels ● Attend blockbuster events 	<ul style="list-style-type: none"> ● Popular events of art/culture ● Carnivals, concerts, movie premieres
Stimulation 	<ul style="list-style-type: none"> ● “Live for the moment” ● Engage in out-of-the-ordinary things ● independently-minded 	<ul style="list-style-type: none"> ● Non-mainstream events ● Street art, music festivals, street performers

Supplemental Materials C: Platforms

Smartify was founded in 2017 in the UK, and is already an established platform with an active audience of over 2.5 million users (MuseumNext, 2021). While specializing in audio and visual museum tours, Smartify also has tools to promote e-commerce within a museum's souvenir store (MuseumNext, 2021). Smartify also can help with the curation and development of a guided tour (shown in Figure 9), and provide continued maintenance and updates on a digital tour throughout its useful life. Smartify also provides a user-friendly interface for museum staff to access and edit the experience without any prior coding or IT experience.



However, Smartify may be limited in terms of customization. It has proven to be effective at providing audio and visual guided tours of museums, but examples of other forms of interpretation are limited. For example, Smartify supported an augmented reality experience at the National Galleries of Scotland, but this is the only example of this form of interpretation (Smartify CIC, 2022). If features beyond audio and visual tours are desired, ample communication with Smartify will be necessary to ensure it can support such features.

As an alternative, a self-developed, proprietary application can provide much more flexibility. This application would not need to fit within the Smartify framework, and could reasonably support any feature that mobile devices are capable of. Still, developing a standalone application would take much longer and cost more than using Smartify. Maintenance would also need to be handled by professionals unless an interface was developed that allowed museum staff to alter the application without coding or IT experience.

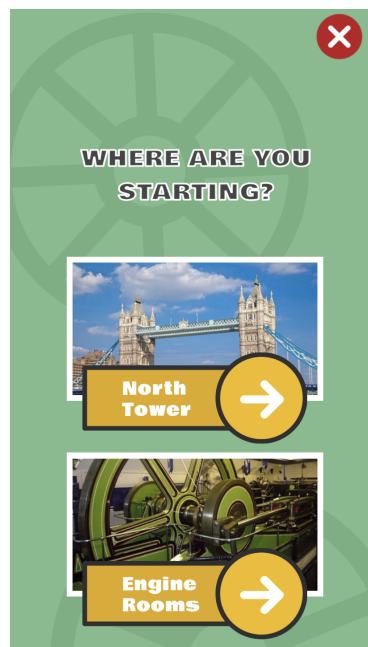
Supplemental Material D: Tower Bridge Family Trail App Features



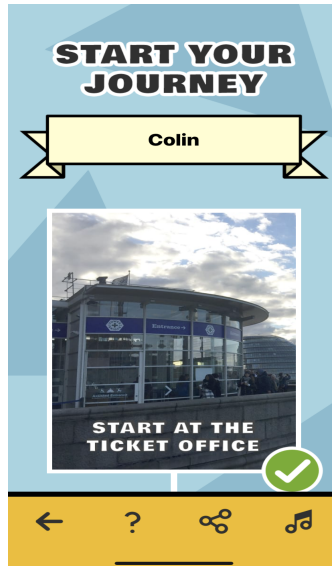
The Tower Bridge Family Trail app was introduced for Apple and Android users for people to explore the Tower Bridge through a guided tour for the entire family to enjoy. The app allows users to choose which part of the exhibition to begin at (either North Tower or Engine Rooms) and follow the directions given by the app to explore the Tower Bridge. This tour includes various stopping points where users are prompted to interact with the exhibition's features in various ways. This includes searching for the displayed diver, using your mobile device as a wrench to tighten bolts on the engine, and providing interesting facts for guests to enjoy, among many other features. Many of the games and features are geared towards engaging young children, however the app can be used by people of all ages. See the series of figures below to see what the app has to offer.

A screenshot of a mobile application interface. At the top right is a red circular button with a white 'X'. The main heading is 'ENTER YOUR TEAM NAME' in bold, black, uppercase letters. Below the heading is a light green rectangular text input field with a blue cursor. Underneath the input field are two buttons: a blue 'SKIP' button and an orange 'OK' button. At the bottom of the screen is a virtual keyboard with grey keys and a dark grey background. The keyboard includes letters, numbers, a spacebar, and a return key.

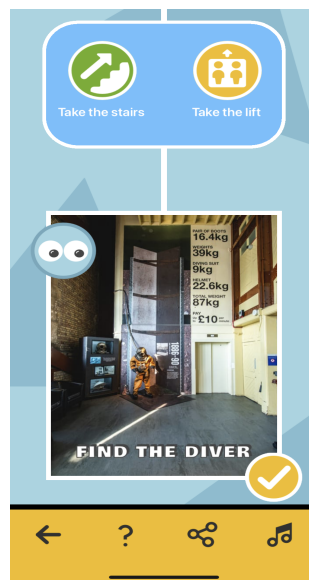
1. Enter your team name to begin the exhibition.



2. Choose your starting point at the Bridge.



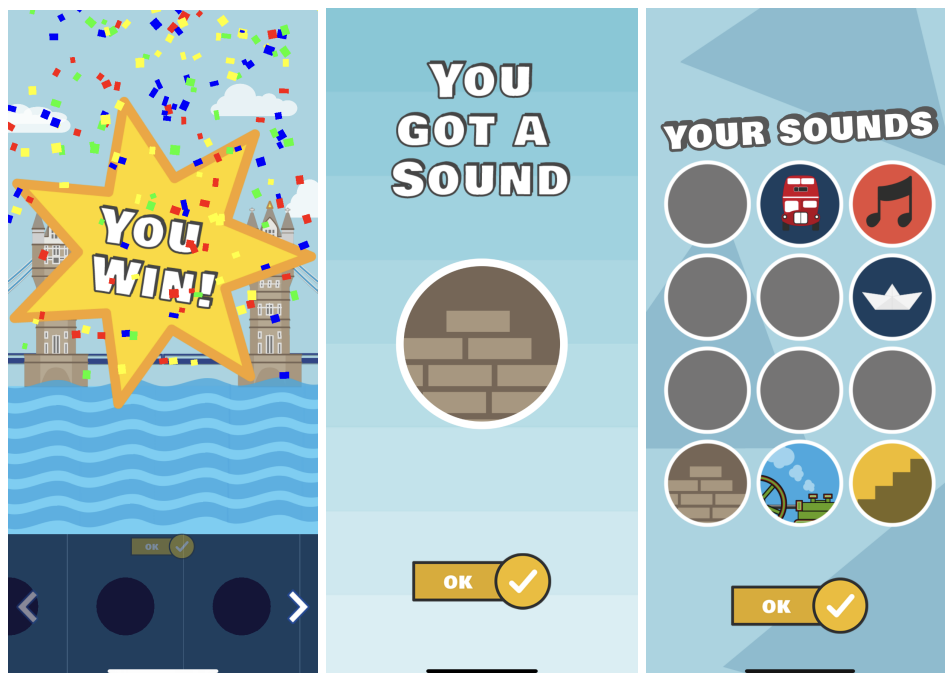
3. Follow the directions to the ticket office and other various stops along the tour.



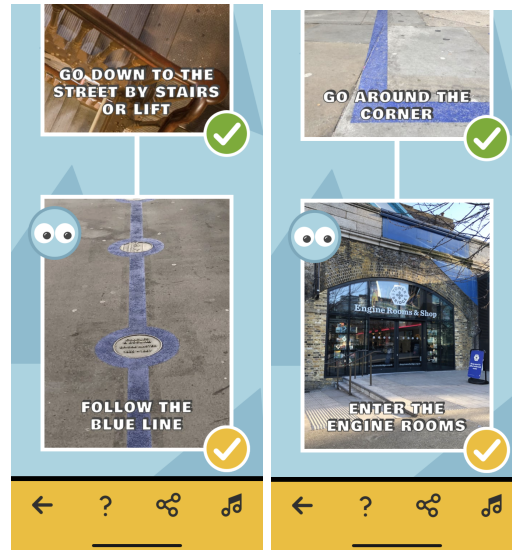
4. Find the diver, among other features, throughout the exhibition.



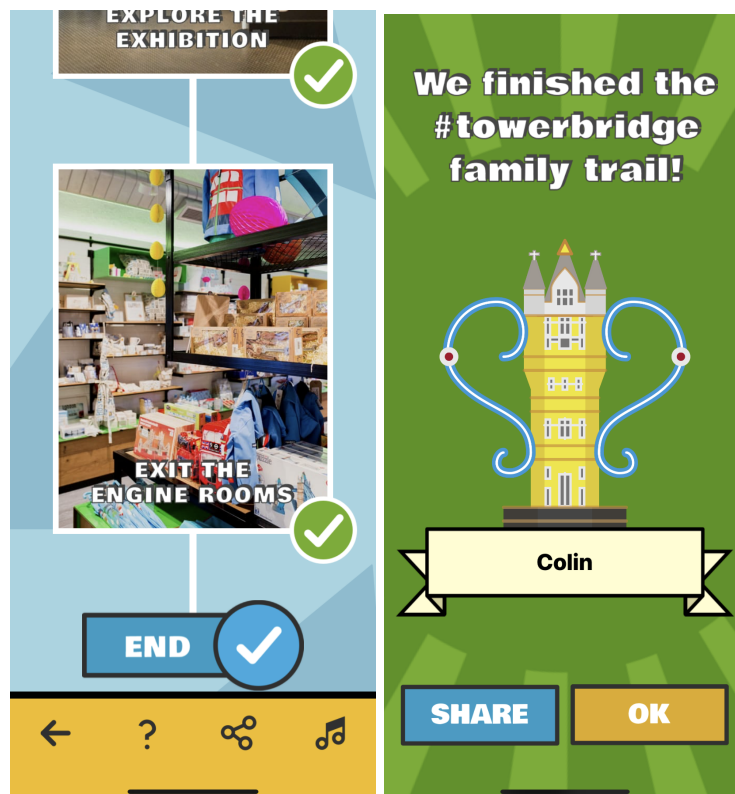
5. Explore interesting features of Tower Bridge (such as the walkways). Play games and learn new facts along the way!



6. After completing each game, earn sounds until you collect them all! These are earned all throughout the experience.



7. Continue following the directions to make your way to the last stop of the tour.



8. End your experience and share on social media!

Supplemental Materials E: Student Testing Questions

Below are the goals and questions our team established prior to our student testing sessions. After each tour, students were debriefed in an informal manner and were asked some or all of the questions below. The defined goals included App interactivity, app navigation and structure, Entertainment Value, Application Completeness, Sensory Features, and Future Recommendations and Suggestions.

Testing Goals:

- App interactivity - what features worked well and what did not.
 - What features did you think were the most interactive?
 - We envisioned the sliding walkway panoramas to be the most interactive. Do you agree or disagree with this?
 - Which did you prefer - the slider panorama view or the side-by-side view?
 - If you didn't think this was the most interactive part, what could be improved?
- App navigation and effectiveness of current app structure
 - Did you like the structure? Were there any times you felt confused or lost based on the provided directions?
 - If so, which sections were most confusing?
- App Entertainment - Did users enjoy using the application?
 - What features in the application did you find the most entertaining?
 - Was your visit to Tower Bridge enhanced by the use of the application?
- Application Completeness - Did the app do everything it set out to do
 - Were there any spots where you found yourself searching for even more information?
 - Did we include the correct content for our target audience (those who are interested in engineering and technology)?
- Sensory Features add an additional layer of immersion to an exhibition past the educational content.
 - There were various sensory notes added to the application, such as imagining the smell of the boiler room or touching one of the structural rivets. Did these enhance your experience in those rooms?
 - Were there any spots that you think sensory details could be provoked, such as touch, sight, hearing, smell, etc?
- Future Recommendations and Suggestions
 - Were there any stations or features you would remove from the application?
 - Do you have any ideas for other features, interactives, animations, videos, audio, etc. that could be added?