

DEVELOPING AN ARETFACT LIBRARY

Interactive Qualifying Project Report completed in partial fulfillment of the Bachelor of Science degree at Worcester Polytechnic Institute, Worcester, MA

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## **Abstract**

The London Transport Museum's Inspire program seeks to excite students about science, technology, engineering, and mathematics (STEM) through the incorporation of objects in engineering presentations. We have reviewed research in object-based learning, cataloging, and outreach programming, and have conducted interviews with museum staff and engineers. In response, we developed an artefact library of over ninety transportation objects and their backgrounds, and a training program designed to help engineers better engage students in STEM related discussions.

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## Executive Summary

In recent years, the need for workers in science, technology, engineering and mathematics (STEM) related disciplines in the United Kingdom has grown, but the numbers of trained individuals entering these fields has not increased with it. STEMNET, a national initiative to increase the number of STEM graduates, utilizes volunteer engineers to speak with students about the benefits of pursuing a career in STEM. Research conducted in the last twenty years has found that interactive learning works well for engaging students. As museums have shifted from traditional methods of exhibition to more engaging displays, the London Transport Museum (LTM) has been moving away from simply presenting to students, and now incorporates more interactive object-based programs. One program, Inspire, has over one hundred volunteer “engineering ambassadors,” but few objects for them to work with and no system for managing the items. The objects they sought were ones that could be used to present an engineering topic in an exciting way. The problem addressed by this project was the disconnection between resources in Transport for London (TfL): the ambassadors, who already have an audience in the schools, and the objects, which were available through various TfL contacts, needed to be brought together by an organized library of objects available for use by ambassadors. The creation of the library and training program was guided by four main objectives:

- To identify, obtain, and create detailed records for suitable engineering objects
- To create a storage system that safely contains objects and allows for items to be checked in and out
- To construct a database containing all object information that can be accessed online
- To create a training program that educates ambassadors about how to use the database and effectively incorporate objects into their volunteer work

The methods used for achieving these objectives included reviewing journal articles, conducting interviews, and attending workshops. We reviewed research into museums' work with interactive exhibits in order to understand the role and purpose of these institutions. We also reviewed work with object-based learning to understand the best techniques that could be used by the ambassadors when they try to engage the students during presentations by bringing a tangible representation of the abstract concepts that are being presented. We interviewed museum staff and engineers on object handling, labeling, and purposes. The first step in developing a functional artefact library was to obtain objects, and this was achieved through correspondence with a variety of contacts within TfL. Once the objects were accumulated, it was necessary to collect information about them for use by the ambassadors. This end was met through interviews with engineering ambassadors and museum staff, site visits to TfL offices and work places, and correspondence through e-newsletters and email. The information was then organized into fact sheets, and made accessible online to the ambassadors. The online database houses all the collection information. A storage system for the objects had to be devised; through consultations with museum staff, we determined and implemented the most feasible method of object storage using plastic bins and securely wrapping items.

We have found that objects need to be handled with care, and need to meet certain requirements to be used in schools. Those requirements limited what objects we were able to keep in the collection, and what restrictions had to be in place for handling. To best preserve the objects, a storage system that can safely contain objects both when traveling and not in use is essential. We've elected to use bubble wrapped boxes, bags, and carrying cases to ensure items are protected, and have dispersed items between three locations. All the object information needed to be collected in one easily navigated online database accessible to all ambassadors. A Wikispace was created at [www.artefactlibrary.wikispaces.com](http://www.artefactlibrary.wikispaces.com) to contain all object information, links to external content, and object-based learning information. The object-centered training session had to provide instructions on how to use the artefact library, and provide helpful information for ambassadors on using objects with students. We created a PowerPoint presentation and accompanying script to guide the facilitator in charge of the training, and a

number of handouts on accessing the library, using objects, and sample activities for ambassadors.

We recommend that the artefact library be kept up to date by obtaining more objects for the collection, and continuing maintenance on the database wiki. If possible, further improvements can be made to the artefact library by upgrading the bubble-wrapped object casings to more permanent foam cut-outs for objects to rest in. The evaluations created for the training session should be used to take in ambassador feedback, and the program should be adjusted accordingly to ambassador needs. We further recommend that an experienced engineering ambassador come to help with the training session, and speak with ambassadors about their experience to better prepare ambassadors for working with students. Finally, we recommend that the artefact library be publicized so that the ambassadors will be aware of this resource and how it can further their mission of promoting STEM.

## Introduction

Museums are constantly seeking new and innovative ways to engage the public and promote learning. This is achieved through educational exhibits, interactive displays, workshops and outreach programs. In the past, museums have primarily relied on visual presentations of artefacts, but in accordance with educational research conducted in the last twenty years, many museums are now shifting towards a more interactive learning model. Additionally, some museums are also seeking to interest students in science, technology, engineering, and mathematics (STEM) related subjects, as the national need for educated workers in STEM fields grows. While the need for engineers is high, the numbers of students going into engineering or science related fields are low. The term “engineer” is used in the U.K. to describe a variety of professions, from academically trained, highly specialized engineers to repairmen and train drivers. As part of this, engineering has acquired the stereotype of being a “dirty job” that carries little respect, and is not a highly desired career path. The London Transport Museum embraces the new hands-on approach to learning to combat the engineer stereotype and engage students in STEM topics through the use of objects in engineering presentations.

One outreach initiative that the London Transport Museum has undertaken is the Inspire program, which currently includes over one hundred Transport for London (TfL) staff who volunteer as ‘engineering ambassadors’ and visit secondary schools to talk with students about transport engineering. Previous research has shown that allowing students to handle pertinent objects during such programs is more effective in stimulating interest among students than are abstract talks alone, and the ambassadors hope to take greater advantage of these methods of object-based learning in the future. Currently, only a small portion of the engineering ambassadors take objects into schools with them, and the museum would like to extend this practice across the entire program.

The core problem of this project was a disconnection between the resources the London Transport Museum has to offer outreach programs and those that are currently being used. The museum had access to a small collection of objects but lacked a procedure for incorporating

them into school visits thoroughly and systematically. The program needed a broader collection of items, an organized storage and retrieval system for the items, and training for ambassadors on how to use these objects to facilitate discussion and learning.

The goal of this project was to create an artefact library of identified transport engineering tools and develop a training program on how to use the library for object-based learning. We had four main objectives: to identify and obtain transport engineering objects that expand and diversify the current collection; to create a storage system that will safely contain objects and allow for objects to be checked in and out; to construct a database that contains object history, storage location and other pertinent information; to create a training program that educates the ambassadors about how to use the database and effectively incorporate objects into their visits.

This project, in addition to its relation to the museum, also carries a broader social significance. Throughout the U.K., professions in STEM, especially engineering, have suffered from negative stereotypes and a consequent lack of interest amongst youth in these careers. To maintain its standing as a global leader, the U.K. needs to halt this trend and encourage students to consider these fields. Organizations, such as Transport for London, have sought to combat this trend by developing programs to engage youth in STEM topics. This project contributes to the efforts to encourage students to consider careers in STEM.

Reviewing research from academic journals, interviews with experts, and first-hand experience in museum settings were the main methods of information collection. We examined educational and engineering journals and museum resources in order to find information on object learning, handling and cataloging. We met with engineers and museum staff to gain understanding of what objects are needed and how to utilize them. Concurrently, we attended museum workshops to gain insight into what approaches are effective in student learning. These methods enabled our group to develop a system that allows all the ambassadors access to objects and information on how they are used in order to better facilitate learning during their visits.

## **Background**

This section details the results of research into museum functions and programs, learning styles, object-based learning, and the London Transport Museum's Inspire program. We explored the role of museums in educating, and their transition from primarily using didactic learning to interactive object-based learning. The Inspire program is a product of the museum's shift towards object-based learning styles, and is the heart of this project.

## **Museum Overview**

Museums, though familiar to many, are so varied in focus and scope that they can be a challenge to accurately define. Museums are institutions that specialize on the collection, conservation, and exhibition of culturally significant objects and ephemera. They may concentrate on the heritage of almost any facet of human knowledge or experience and they vary tremendously in breadth and depth. A museum must be dually concerned with education as well as entertainment, for visitors must first be drawn into the museum before they can begin learning from the collections within (Macdonald, 1990). This duality of focus on entertainment and education can address both the interests and needs of the audience; success in both areas is of key importance to the success of an institution, and it poses unique challenges to finding the proper balance necessary for achieving the purpose of a museum.

## **Purpose and Goals of Museums**

Individual museums may have their own particular missions and goals, but many primarily concern themselves with teaching, which is typically achieved through the realization of subsidiary goals. These goals include the collection and preservation of materials, the creation of effective in-house exhibitions and outreach programs beyond the museum walls, and audience-appropriate interpretation of displayed objects. Our project deals most directly with the last two of these subsidiary goals, particularly with the development of educationally-valuable presentations and socially relevant interpretations in museum outreach activities.

Since the 1990s, many museums have undergone a transition in their understanding of what constitutes effective learning and how it can be achieved, though some museums have used modern approaches to learning since the 1970s. Museum exhibits used to be the primary method museums offered for learning opportunities, and exhibits have traditionally been designed primarily by curators with the purpose of providing factual information about an object in the museum collection for visitors to absorb largely on their own. In this traditional approach, the museum curator took the lead role in exhibit planning and educational staff played a supporting role (Czajkowski and Hill, 2008). The research of Eilean Hooper-Greenhill influenced museums to shift how they achieved their goal of educating the public away from relying only on the linear transmission of knowledge through written facts and towards the construction of knowledge through a more interactive museum experience (Fritsch, 2007). In light of this new philosophy of learning, educational staff has played an increasingly integral role in the way museums operate, and these educators work as a team with curators, designers, evaluators, and managers to develop exhibits as well as other learning resources that will encourage engaged rather than passive learning (Czajkowski and Hill, 2008). Actively engaging the public's interest in a subject has become a key focus of museum exhibits and programs.

Many museums have shifted their goals to reflect the need to engage their visitors in learning, and these goals include “contribut[ing] positively to social change and to widening access to collections,” (Galloway and Stanley, 2004). The first of these goals has been addressed by many museums by changing the context under which information is disseminated and the interpretations which are made available. Before the shift in focus to constructive learning, museums largely relied on a one-way style of information transmission to visitors that is analogous to a professor giving a lecture to students. In this model, the professor (or museum) was the authoritative expert on the topic and the students (or museum visitors) were expected to absorb the knowledge as it was presented and to accept the single perspective offered. In light of the research supporting constructivist learning, many museums have shifted towards learning through dialog inspired by museum objects and facilitated by museum educational staff. Under this new, more interactive model, many perspectives and interpretations were available to visitors, and the visitors themselves were engaged participants in the conversation rather than

being mere observers (Czajkowski and Hill, 2008). Additionally, the dialog that was provoked by this model broadened the view of an object and provided social perspective. By talking about an object, participants in the conversation gained the perspective to see an object in its larger cultural context rather than as a singular, isolated artefact. Also, by understanding the social context and impact of an object, visitors were more likely to be engaged in the conversation and the related learning because they could see more clearly how the object related to themselves. Implementation of learning through participation and dialog to achieve a broader social view has taken the form of interactive programs within the museum as well as participatory outreach programs that extend beyond the museum. These methods for learning were more in line with participatory dialog model than the traditional museum exhibit with accompanying placard of information that a visitor could read without truly being engaged. Museums, of course, still offered placards with their exhibits, as this method of teaching may have been ideal for some of their visitors who were already interested in the subject being presented. Interactive methods of teaching have been designed to be engaging to both visitors who are already interested in the topic and those who are not.

To achieve the second of Galloway and Stanley's goals, many museums have sought to extend learning beyond the museum itself. Two of the most common strategies were the development of museum websites so people can virtually visit the museum from a remote location and the creation of outreach programs. Outreach programs were inherently able to affect a broader range of people than a museum exhibit (West, 2013). Museums have long been associated with the elite, and have accordingly been faced with cultural barriers to wide-spread participation, particularly among young people (Galloway and Stanley, 2004). Outreach programs have helped to deconstruct the elitist view of museums by making museum content more accessible and widely available and, in many cases, tangible.

### **How Learning Goals are Met Through Museum Programs**

Many museums have implemented in-house learning programs and off-site outreach programs that help them achieve the two goals set forth by Galloway and Stanley. Here we investigate a few particular programs which have been notably successful for their respective



institutions. In order to engage an audience, a museum must first interest them in the surrounding knowledge; hands-on activities either in a museum or other setting are a key tool that museums use to accomplish this end. In 2009 the University College London (UCL) museums began an outreach program called *The Thing is...* (West, 2013). This program endeavored to provide thought-provoking discussions, interactions and engagement in a setting outside the museum using a single object rather than a collection to raise questions about societal issues. This purpose is consistent with both of the museum goals set forth by Galloway and Stanley (2004). In *The Thing is...*, museum educators went to schools or community venues with only a single object and they conversed with the participants rather than simply delivering information. The dialog in this program that was inspired by the singular object usually shifted to larger social issues connected with the object, while in discussions that focused on a collection of items, conversation tended to move only between the objects and not towards a broader cultural perspective. Also, the educational staff functioned in this program specifically as facilitators who not only guided the conversation and provided information, but also participated on the same level as the audience. By doing this, the educational staff succeeded in actively engaging the audience rather than merely talking at them. (West, 2013). In *The Thing is...*, the UCL museums, which specialize in topics including Egyptology, ethnography, geology, archeology, art, zoology, and the history of science, were able to widen the audience by taking their program to places where they could engage people who may not have visited the museum on their own. They engaged the audience with accessible rather than the traditional methods of presenting information. Additionally, by having the focus on a single object rather than a collection of items, the UCL museums facilitated conversation towards a larger cultural perspective that may not have been achieved through a traditional in-house museum exhibit.

The Detroit Institute of Art (DIA) was another institution that sought to achieve the goals set forth by Galloway and Stanley. In 2002 when the DIA was looking to restructure the museum, major consideration was given to the perspective of the visitor and the goal of providing a meaningful, engaging experience. Education department staff played key roles on an interdisciplinary team that created galleries with the visitor in mind. Object selection, stories, and interpretive strategies were the three focuses of the team. Like the UCL museums, DIA was

able to broaden the social scope of their collection by offering interpretations that would engage and interest visitors through the use of “interpretive educators.” The team that created the galleries “connect[ed] art to human experience, and encouraged staff to think about art in ways other than the traditional art historical frameworks,” (Czajkowski and Hill, 2008). With this in mind, museum staff members were able to present collections in ways that focused on creating a connection between art and the personal experience of every visitor, and thus they were able to broaden their target audience beyond strictly people with art backgrounds and widen access to the benefits of their collection.

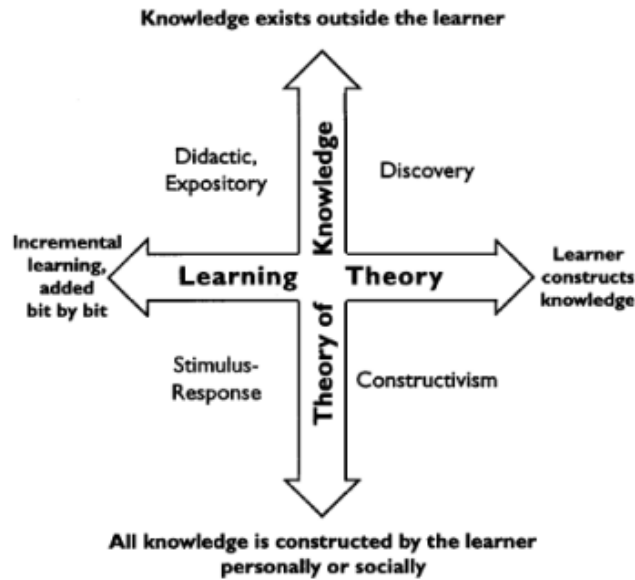
The Fort Worth Museum of Science and History, in collaboration with the National Science Foundation, has experienced exceptional educational success with two of its hands-on initiatives: Playful Invention and Exploration (PIE) and DesignIT Studios. In PIE, which focused on the use of technology for creative expression, students built tiny, programmable computers called “crickets.” These crickets, in combination with more familiar objects like hula hoops, were used to create a sound garden in the museum. Similarly, in the DesignIt Studio initiative, students used crickets and typical arts and crafts supplies for individual creative expression. Both programs involved the integration of technology with more familiar objects so that the new interpretation of technology is combined with a sense of familiarity for the students (Power & Robinson, 2005). This combined environment was intentionally created so that students will feel comfortable exploring science and technology on their own terms, thereby achieving genuine understanding of the topics in a deeper way than is allowed by traditional text-book learning. Hands-on learning initiatives such as these taken by the Fort Worth Science and History Museum have been considered one of the most effective methods for actively engaging students in the content of the museums themselves as well as inspiring and developing interest in science, technology, engineering, and mathematic (STEM) topics. Additionally, by presenting technology in a non-traditional way, the museums have expanded the audience to include students who may not have a technical background.

Each of the above institutions has employed various particular strategies for innovative museum activities and outreach programs that endeavor to broaden both the audience that was reached by the museum as well as the scope of the impact that museum learning had on that

audience. By reaching more people and connecting museum objects to relevant social issues, the above museums achieved the goals set forth by Galloway and Stanley (2004).

## Learning

Hein's categories of learning are created from his two interconnecting theories: the theory of knowledge and the theory of education (Hein 1998). Both theories are based on continuums with two extremes, that when brought together form the four domains of learning, as shown in Figure 1. The theory of knowledge is founded on the opposition between realism and idealism. Realism states that true knowledge is independent of the learner and that a specific reality exists and is not altered by the perceptions and ideas of people. Idealism is on the opposite end of the continuum and states that knowledge only exists in the minds of learners, and that reality is different for each individual, based upon what they construct in their minds. The theory of learning is based on the opposing concepts of active and passive learning. Passive learning is what is traditionally seen in school, with the learner absorbing the information in small pieces. There is only one conclusion that can be drawn from the information given, and thus only one real truth. Active learning is more of an interactive approach, where the learner can construct knowledge through their own investigation and experimentation (Hein, 1998).



**Figure 1: The Four Domains of Learning (Hein, 1998).**

Didactic, expository approaches to education are derived from a combination of realist ideas of knowledge and passive approaches to learning. Didactic approaches are typical of schools, where the instructor prepares the material, and later lectures the students. This style can imply that there is only one truth, and therefore only one explanation for the information being taught. Museums that use this form of education often have exhibits that follow a particular order and have a clear beginning and end point. The exhibits have labels and panels that inform the visitor of the specific learning objectives, and the subjects are arranged in ascending order of complexity. This is a common approach for museum education; however it is often criticized for not leaving any room for the learner’s own interpretation (Hein, 1998).

Discovery learning offers a type of hands-on approach and can often be seen in exhibits geared towards children. These types of exhibits focus attention more on the learner instead of the subject, and allow the learner to discover the meaning of an object through interaction. The theory behind this approach is if viewers are given the necessary tools, they will logically come to a desired outcome. As the subjects explore the objects, they themselves will change as they learn and come to conclusions that are predetermined by the teachers. Museums that utilize discovery learning will have hands-on exhibits with labels that ask questions rather than give

information. These questions will lead the visitor to accepted conclusions, and if these are not met, there will be a way to compare the theoretical and accepted conclusions. The exhibits are not typically arranged in a linear fashion, but rather allow learners to explore in a way that makes sense to them (Hein, 1998).

A constructivist approach also implies active learning, but the conclusions made by the learner are not necessarily an “accepted truth,” but rather what makes the most sense to the learner. Using the evidence at hand, the subject tries to decipher what they can, and creates their own meaning for the object. In order for this type of learning to be successful, two requirements need to be fulfilled. There must be active participation by the learner so that they can experiment and make conclusions about the concept that they are exploring. The second component is an understanding that the conclusions determined by the learner do not have to conform to any standard, but simply must make sense in the mind of the learner. Museums that focus on this type of constructivism typically rely on hands-on exhibits, where visitors can experiment and explore the various possibilities. Most exhibits will not have well-defined starting and ending points, but rather multiple entry points so the visitor can make their way through however they would like. There is some criticism of this approach from traditional educators, because learners are encouraged to use common sense to draw their own conclusions, and often these exhibits offer various points of view instead of a common truth. This can be problematic because often there is an accepted truth, and the learner’s conclusions can be considered wrong by society’s standards and empirical evidence, thus the learner will leave the exhibit misinformed.

Museums apply these types of learning to best cater to their purpose and own philosophy. For example, the Higgins Armory Museum in Worcester has many exhibits that are based upon object-based learning, and the museum has created its own approach to applying these learning styles in effective ways. The museum’s exhibit philosophy is, “Fun, engaging, exploratory: teaching with purpose, learning by accident” (DiRodi, personal communication, February 3, 2013). The museum allows the public to explore the exhibits of its choosing, and develop ideas and meanings for the objects using a combination of personal meaning-making and discovery learning. The Exhibition and Interpretation Philosophy, as shown in Appendix B,

also states that the objects should give the learner multiple points of access, which is a common trait for exhibits focusing on constructivism. The Armory has found through evaluation that a combination of both discovery learning and constructivism is most effective in fostering object-based learning, and has tailored their exhibits to enable these types of learning.

Evaluations are an integral part of the success of museum programs, and are used to determine what needs to change or remain the same in order for these programs to operate most effectively. Evaluations were categorized by Michael Scriven (1967) into two main groups, formative and summative. Formative evaluations involve assessments during the development of a particular program. The outcomes of the evaluation are used to change the program in an attempt to meet the desired goal, if still attainable. Summative evaluation is done after the completion of the program and is used to assess how successful the program was, based on comparison of the desired and actual outcome. A third type of evaluation used is front-end evaluation, which is done before the start of the program and is used to determine the desired outcome (Hein, 1998).

These types of evaluations can help shift the way museums develop exhibits, and have created a shift from typical school type learning, to a more hands-on and real world experience for the visitor. A survey done at the Natural History Museum in London showed that one of the things that visitors want the most from an exhibit is the ability to feel it come to life around them. They want to experience the subject and not just read about it or hear a lecture (Dean, 1996). Higgins Armory Museum accomplishes this real-life feeling through their various hands-on approaches, and then evaluates individual exhibits and programs to see what visitors like most. DiRodi (personal communication, February 2013) gave us the school tour evaluation form, which is given in house, and the educational program evaluation, which is given during the school outreach programs. Both forms ask the visitor about their experiences in each specific exhibit or show, and based on that feedback the museum has been able to create a more effective approach. The evaluations, seen in Appendix B, also ask about the tour itself, but focus mostly on the interactive programs because the museum is based upon the philosophy that visitors should learn through exploring and make their own meaning based on experiences they have in exhibits. The shift in focus from the typical didactic, lecture based learning to a more

hands-on approach is evident in the number of interactive exhibits in museums such as the Armory, and also in the evaluations, which primarily ask about those types of programs.

## Object-based Learning

With so many types of learning, museums face a challenge in educating visitors. How can a museum present and educate a wide audience of differing learning styles and speeds? Museums are limited to their collections and their own ingenuity. They have collections of art, artefacts, contraptions or tools. They have physical objects and knowledge of their origins, uses and purposes in historical or modern society. They have books and databases and staff members full of information. The challenge is how to convey all this information in such a way that visitors will be interested, engaged, and walk away with new understanding. Object-based learning can help to solve this challenge. While differences in proficiency at reading or mathematics can foster estrangement between higher and lower functioning students, objects are more versatile and intellectually accessible in that each person can look at an object and find something to learn (Durbin, 1990).

Object-based learning encompasses how a person's interaction with an object can prompt learning, rather than gleaning information from a book. For example, by reading a book, I can learn a great deal about apples. Photographs will show me that their protective skins come in a range of red, yellow and green colors. Words will describe to me that they have a core that contains seeds, and a stem from which they grew. However, holding an apple in my hand could tell me a great deal more. I can feel the weight of the apple in my hand, smell the fragrance, squeeze to understand the density, and bite to taste the sweetness. That's not to say that museums are allowing their visitors to touch, squeeze, and bite their collections, however an object can still tell a story or supplement existing knowledge (Leinhardt & Crowley, 2001).

A story is a powerful learning tool. Dr. Jeffrey Forgeng, the Paul S. Morgan Curator at Higgins Armory Museum (personal communication, January 2013), explained:

“Story is essential. As human beings, we're programmed to understand things as stories really well. We're programmed to listen to stories, to enjoy stories, to look for stories. And so that's a major part of what we try to do, is to create stories of various kinds...”

In response to this concept, each exhibit at the Higgin's Armory attempts to tell a story of some sort. In one alcove of the Great Hall lies an elaborate and decorative suit of armor surrounded by the tools with which helped to make the pieces of the suit. More than just a suit of armor, the set conveyed the time, effort, and skill to make such a fitted suit, as well as the wealth required to be able to afford such an item. More importantly, the display is designed to stimulate questions. Did someone use this suit of armor in tournaments? Was it designed for use or decoration? What did the suit represent in relation to the owner? Did the armor bring him prestige or flaunt his wealth? Each question could lead to more. Questions are key in object-learning. While an object can tell a story in itself, the real task is to interest the viewer in the object, and the story behind it.

In studying teacher development, Gregg and Leinhardt (2002) observed how objects could stimulate fundamental questions. After visiting a replica of a bombed bus from the Civil Rights era of American history, a student teacher was amazed by how real the bus seemed. This experience prompted questions about whether or not the bus was authentic, and even the realization that the exhibit was a replica did not negate the initial feelings the observation of the bus engendered. The sense of authenticity gained from holding an apple or walking beside a bombed bus is, in essence, object-based learning.

As Wehner and Sear (2009) aver "[o]bjects, potentially at least, invite an empathetic engagement with others' life worlds and experiences across time and space."

For a person to make a connection with an object, there needs to be some context or story behind it. These stories are what connect a person standing in front of an object to the understanding behind the object. This understanding of its purposes, uses, past and present implications in human life, and the resulting questions that come from such understanding is learning.

Humans learn by making connections between previous knowledge and connecting to something new. In terms of objects, we try to find the meaning behind them. The meaning itself can vary from person to person, and every person can find a meaning that resonates with them based on past experiences (Blume, 1969). Through our own walks through museums, we have noticed that visitors (as well as ourselves) tend to jump from exhibit to exhibit and rarely stop at



each one in turn. We naturally gravitate to items and displays that we find interesting, and that hold some meaning for each of us as individuals. This is why object-based learning is so important. While every visitor may find a different meaning or connection behind the same artefact, the important thing is that we find that connection. That connection and interest is what sparks questions and research into something we had not known before.

While a museum can create impressive and informative displays, it is up to the visitor to take the time to look at one (Fritsch, 2007). This is why museums are constantly seeking new ideas to interest visitors in their collections. They utilize interactive and object-based exhibits to allow for more visitors to find something that engages them so they might continue to learn.

Learning can be greatly enhanced by the use of objects. A learner can develop skills in identifying, planning, discussing, hypothesizing, experimenting; can expand on knowledge of social or historical context of items, the physical effects of time, or symbolism in items (Durbin, 1990). The challenge to overcome when utilizing object-based learning is continued interest in an object. Museums combat this challenge by making displays more appealing and attention grabbing. Research shows that objects which are particularly beautiful, famous, large, shocking, or have great nostalgic value garner a lot of attention. Isolating objects and highlighting moral, social, or ethical issues also make objects more appealing (Teixeira, 2009). An object that looks odd or out of place, but has a very mundane purpose that a person can relate to would be an ideal object to use in learning. Everyday items have been effectively used to transition a discussion from objects to the context beyond them.

## **Specific examples in Object-Based Learning**

This section contains examples of object-based learning in the classroom to better emphasize the positive qualities detailed in the previous section.

### **Presentation**

Depending on the time and day of a visit to Higgins Armory, there are several presentations and shows available. The Arms and Armor presentation is one of the extras the

museum has to offer. It is led by a staff member and delves into first the history of Mr. Higgins and then into the museum collections and history. Questions were asked throughout the presentation, ranging from “How much would you think this cost?” to “Can anyone tell me what this is?” Volunteers were also regularly called for, even if their only job on stage was to hold something. More than actively engaging the audience with questions and holding props, the presenter also brought her own excitement into the show. “My personal favorite...” and “I really like...” were used to emphasize certain weapons or suits of armor and create a connection between the presenter, the objects, and the audience.

## Questioning

Laurel Thatcher Ulrich, a Professor of Early American History at Harvard University, is a strong supporter of using objects to direct discussion and learning in classrooms. She gives an example of bringing a quilt into her classroom. The students can initially interest themselves in the pattern, the color, the degree of fade or use, or imperfections. However, much more can be taken from the quilt than just its singular qualities or history. A quilt can begin a discussion on cotton, and the implications of slavery. What of the technological advances in fabric printing? How did fabric play a role in industrial labor? What does the quilt say about the “cult of domesticity” or the role of women in society? Ulrich noted that bringing the quilt into the classroom not only allowed for the basis of discussion topics but allowed students to connect with generations past through a simple object (Ulrich, 2003).

## Mystery Objects

Mystery objects are usually odd looking items that serve a very mundane purpose. In a secondary classroom, one teacher used mystery objects to “enhance product analysis” in students. Small groups of students were given mystery items with the purpose of understanding what they were used for. Students were encouraged to look, draw, touch, and brainstorm possible functions of the object, no matter how ridiculous or unlikely they were. When using similar techniques for a class assignment in product analysis, the teacher found the work of the

students to have been greatly improved over prior work in terms of detail, skill and understanding. Additionally, it was noted that the students were enthusiastic about both the object-based activity and their work after (Stables, 1996).

A similar mystery object technique is implemented during object handling sessions at the Horniman Museum in London. After being handed an item with no prior context on its origin or nature, an ‘ultimate question sheet’ can be used to gain as much information on the object as possible. These questions span from what the physical features of the object are, how it might have been made, what it might have been used for, the value of the object, the history behind the object, or if the object has an aesthetic purpose. By asking these questions, one can conclude more about the object than may have been previously thought by simply looking at it. After making initial guesses as to what the answers to these questions might be, a sheet containing detailed information on the object is obtained and findings from handling the object are compared to facts on the sheet. Most times, this questioning brings the viewer much closer to understanding the object than prior to asking these detailed questions.

### **Interacting with Students**

The London Transport Museum has the Inspire program, an outreach program aimed at getting secondary school students interested in STEM topics. Engineers working for Transport for London visit schools and talk about their experiences as engineers in efforts to excite students about careers in the sciences. One of the ambassadors, Ian Rawlings, has begun to incorporate objects into his presentations, and has found that to be extremely helpful in engaging the students and giving them an illustration of engineering concepts in real life. In the opening of the presentation, he asks the students questions to stimulate them right away, and get them to start thinking about why the object is important. He asks students what they think the object is used for, and then leads them to discover the solution on their own based on follow up questions and prompts. Rawlings also makes a lot of personal connections between the objects and what the students see in everyday life. This approach makes it easier for students to relate to objects that they might have otherwise thought were irrelevant to their life and uninteresting (personal communication, March 2013).

## Outreach Programming

The staff members at the Science Museum in London are experts in the area of outreach programming. Danger High Voltage, Material World, and The Supercool Show are just a few of the programs they hold for secondary students. They've collected multiple reports and surveys to better understand what students, teachers, and parents enjoy seeing from these programs, all freely available on their website (Appendix C). They have found that the programs work well when props or objects the school is unlikely to have are available, students are able to participate in fun and varied activities, and topics are carefully chosen to interest students while complying with school curriculum.

## Object Care

In any collection of objects, proper care is necessary to ensure that objects maintain their condition over time. Several environmental factors as well as the nature of the materials in the objects can contribute to object damage. Objects that have inorganic materials, such as metals, tend to be more durable over time than organic materials, which tend to deteriorate. Exposure to light can fade color and change the appearance of an object. Fluctuations in temperature make materials expand and contract, causing cracks over time. Humidity is a particular problem because it can lead to mold in organic materials and corrosion in inorganic materials. The resulting damage can alter both the appearance and structural integrity of an object. While these environmental factors and the damage they can cause are a concern in object conservation, the majority of object damage is caused by people handling the object (Horniman Museum Training Session Materials).

## Handling

According to the curatorial staff at the Horniman Museum, damage from handling can be either chemical, which results from contact between the object and skin, or physical, which results from careless handling. The salts, oils, and acids that are found on hands can be very

corrosive to materials. In addition to the chemical threats posed by handling an object, the object is also at risk of severe structural damage should it be dropped or mishandled.

Proper handling practices are vital to extending the life of an object in a handling collection. People who work with objects should wash their hands prior to handling to reduce the amount of perspiration and dirt that an object is exposed to. Hands should also be washed after handling an object because the object may carry harmful substances from its natural environment or germs from the hands of others who have previously touched it. For some objects, especially those with polished or porous surfaces or those that have dirt or grease on them, wearing gloves during handling is an advisable practice.

The manner in which an object is handled is vital to its preservation. When objects are being handled, both the person who is touching the objects as well as the people around him or her should be calm and careful with their movements. Objects should always be picked up gently with two hands to avoid dropping it, and if possible, an object should be handled over a table or desk. Objects should always be supported by the heaviest part and minimal stress should be put on thin or fragile sections. Examining the structure and condition of an object prior to picking it up can reduce the danger of damage. (Horniman Museum Training Session).

## **Labeling**

Objects must be labeled in some manner so that the physical artefact can be linked with the information that is known about it, but if done improperly, labeling can also damage the object. Methods for labeling an object vary greatly depending on the type of object, but for most, writing the label on the object itself is best because with this method, the object and the label that identifies it cannot be accidentally separated and this method can be carried out in ways that do not permanently alter or damage the object. To carry out this technique, a Paraloid base coat is applied with a brush to an area of the object that will not detract from the object's appearance if marked. Paraloid is an acrylic polymer resin that is favored for conservation work because it does not yellow over time, it holds up to the strain of handling, and it can be easily removed without damaging an object. Once the base coat is dry, a unique identification number is written on top of the Paraloid using a thin fountain pen dipped in white ink. When the ink is

dry, another coat of Paraloid is applied and let to dry. Should the label ever need to be removed, a cotton swab dipped in acetone would take off the Paraloid and leave a clean, unmarked surface (Collections Trust).

## **LTM Inspire Engineering Program**

The London Transport Museum strives to engage visitors with more than just its exhibits, and frequently hosts events that are aimed at increasing and maintaining the public's interest in transport related history and science. One of the most successful and highly endorsed programs that London Transport Museum has to offer is Inspire, which is a STEM program for secondary students. The goal is to encourage young people to pursue career paths in the fields of science, technology, engineering and mathematics. Through efforts to arouse interest in these areas, STEM programs aim to increase the number of students who decide to go into these fields, and subsequently increase the number of highly trained minds that will help to advance technology in society. Students throughout the United Kingdom currently face a severe lack of interest in these areas, possibly stemming from a misinterpretation of what engineering careers involve. London Transport Museum is one of the groups that consider the effort to change this miscommunication important for the future success of both itself and the economy as a whole, and specifically gears its Inspire program towards transport engineering. This focus on transport engineering demonstrates to students that this field is an interesting and important one to enter, while they might have not previously considered a career in this field due to lack of knowledge on what these occupations actually entail. This program aims to inspire these students to get formal schooling in these areas, so that there will hopefully be a greater number of trained scientists and engineers to work for the transport system in the future.

## **The Importance of STEM**

STEM represents a variety of efforts made towards promoting the importance of careers in the fields of science, technology, engineering, and mathematics, and the need for an economy having more graduates with degrees in the STEM areas. According to recent publications, many

nations have neglected the importance of these technological fields, and increasing efforts should be made in guiding youth towards these careers (Carnevale, Smith, & Melton, 2011). The knowledge base that expands from STEM education, including critical thinking, programming, complex problem solving, troubleshooting, and analysis among other skill sets, is extremely crucial in many of today's industries and professions. STEM workers "design our bridges, invent our medicines and our phones, and create the architecture of our buildings and our Internet," (Carnevale et al., 2011) amongst other things. Without people who have the proper expertise in these areas, advances in technology would plateau.

Careers in STEM fields make a vital contribution to the success of the United Kingdom's economy. Over six million people throughout the U.K. are employed in engineering-based sectors, and it has become increasingly important that the government focus its goals for the economy on these STEM related fields in order to maintain standings as one of the largest economies in the world (Brown et al., 2011). However, the U.K. is currently lacking the workforce that it needs to have this economic growth, and these "skills shortages and gaps have a detrimental effect on the development of economic sectors and limit the U.K.'s ability to innovate and grow," (Brown et al., 2011). STEM programs aim to bridge this gap, and encourage youth to enter the fields that will lead to the future success of the U.K.

## **Inspire**

The Inspire program led by London Transport Museum and Transport for London helps to work towards the goals set forth for STEM based programs. Through this program, London Transport Museum has had the opportunity to engage young minds in the excitement and importance of transport related science and engineering fields. The intention of this program is to encourage students to pursue STEM fields in the future, and keep the number of highly trained individuals at a stable or increasing level, in order to promote the advancement of transport engineering in our society. So far, the Inspire program has reached over four hundred students between the ages of nine and thirteen (Johnson, 2012). During the course of the program, students are engaged in a series of activities that are meant to simulate different types

of challenges that engineers might face on the job in order to demonstrate to children the practical applications of engineering in everyday life, as well as the creativity and excitement that go with STEM careers. One activity that is held for students at the Inspire program is the challenge of safely delivering eggs from one location to another by building their own miniature rail track. Through this activity, students get the chance to solve problems using critical thinking, and find more efficient ways towards accomplishing the task, something that engineers do on a daily basis. Students interact with transport engineers who hope to excite them about STEM topics and encourage further coursework in these academic areas. Students are given the chance to ask these engineers about tasks they might face while on the job, different projects they've worked on, and other aspects of the daily life of an engineer. This is an important opportunity for the students involved in the program as it allows them to get a first-hand account of what it is like to be an engineer, and helps to give them a better idea as to what their future might be like if they decided to pursue a career in one of these areas. The engineers are often a part of a larger Engineering Ambassador program that Transport for London operates with help from the museum. These ambassadors are also a part of a separate entity known as STEMNET, which is a nationwide program that aims to encourage interest in STEM fields. The Engineering Ambassador program's objective is to train engineers and other people working in the STEM fields in the art of engaging and exciting students about STEM careers. Aside from volunteering to lead programs such as Inspire, these ambassadors also go out to local schools to talk about their careers, lead engineering activities, deliver presentations and answer questions on their respective fields (Johnson, 2012). To date, over one hundred professionals have been trained as ambassadors on how to present effectively and elicit excitement from their audiences.

## Artefact Library

Our project incorporates the use of objects from an artefact library into the presentations that TfL engineering ambassadors give to secondary school students. Artefacts that are used on a daily basis by transport engineers have been cataloged in order to properly utilize and source them to the engineering ambassadors. We were responsible for making decisions as to how to



organize the items within the catalog, whether it is by alphabetical order, what type of engineering each item is integrated with, or some other means of organization. Through conversations with curators at both LTM and external locations such as Worcester Historical Museum, we were able to view these institutions' organizational methods and the information that they deemed important for the organization of their own collections. It is also important for us to include as much relevant information about each artefact as possible, in order for ambassadors to gain a more complete grasp on the items that they will be bringing into schools. Some of the information from the created training session is included in the artefact database as well, such as what important connections can be made between the artefacts and current devices and technology, the relevance of these items in London's transport system, and miscellaneous facts about the objects that will make them more interesting and engaging to the audience. This catalog and training session for the ambassadors will tie together our research on learning to its importance within our project's goal of establishing and implementing a successful artefact library.

## Methodology

The goal of this project was to supplement the existing Inspire program at the London Transport Museum with an artefact library and corresponding training program. The artefact library was designed to be used by Transport for London ambassadors for work with secondary students, whom are the target audience for science, technology, engineering, and mathematics (STEM) related initiatives. Between the ages of eleven and fourteen, secondary students are able to choose what fields of study they want to take to complete their General Certificate of Secondary Education (GCSE) at sixteen. This artefact library is a tool for ambassadors to help encourage secondary students into exploring STEM related concepts before choosing their GCSE subjects.

The project contained four main objectives.

- To identify, obtain, and create detailed records for suitable engineering objects
- To create a storage system that safely contains objects and allows for items to be checked in and out
- To construct a database containing all object information that can be accessed online
- To create a training program that educates ambassadors about how to use the database and effectively incorporate objects into their volunteer work

Each section below provides an overview of the methods and tasks used to achieve the objectives. Figure 2 indicates a schedule of tasks.

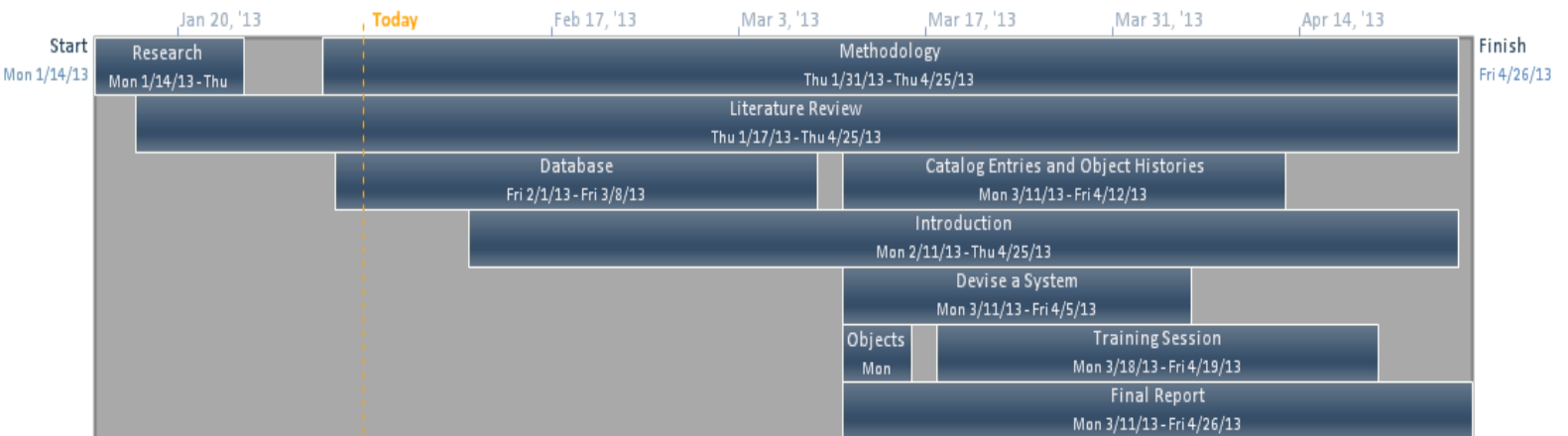


Figure 2. Project Schedule

## **Objective 1: Identify, source, and create a detailed record for objects that are suitable for using in schools for object-based learning programs.**

The central focus of this project is on transport engineering objects, and all subsequent objectives depended on the existence of an artefact collection that was carefully developed and catalogued such that engineering ambassadors could use it as a tool when teaching engineering concepts. One of the engineering ambassadors, Ian Rawlings, had already begun a small collection that he used during his presentations. Rawlings, one of the custodians of the collection we developed, gave us thirty nine objects to form the foundation of the collection. These objects were selected to be in the collection because they meet a number of criteria.

When considering an object for potential addition to the collection, the group had to critically consider many aspects of the object. One was size: objects in this collection must be easily transportable by an engineer into classrooms at schools around London, and thus only small objects were considered. Second, object availability was assessed because over time, the objects will need to be replaced. Due to frequent handling, the objects will essentially be slowly destroyed. The objects will be exposed to the moisture, salts, and acids that are found on human hands, and each of these can contribute to corrosion in metals. Also, some objects, particularly those related to signaling, have delicate parts like contacts and wires. We anticipate that over time, these more fragile parts will break due to being handled by students. As such, only common and widely available objects are suitable, as the individual items will need to be replaced over time due to wear. Safety was another key consideration for selecting objects to be taken into a classroom. Secondary students may be handling the objects during the visits, so any item that contains hazardous materials or sharp points or edges was unacceptable. The objects in the collection should represent all aspects of transport in London, including track, computing, electrical, civil, train, bicycle, and signal engineering. In order to equip the engineering ambassadors with the most complete resource possible for exploring a wide variety of engineering concepts. The final criterion that our group considered when selecting objects to add to the collection was the educational value of an object. The story behind each object will be utilized by the engineering ambassadors as a teaching tool and a way to connect the object

with the lives of the students. The engineering ambassadors will be presenting to secondary school students, so the concepts that can be taught with the objects should be interesting to the students and relevant to the curriculum, though neither too basic nor too complex. If an object met each of these criteria, it was considered for inclusion into the engineering ambassador artefact library.

After meeting with Rawlings to acquire the objects, we obtained a contact list of Transport for London (TfL) engineers from our sponsor liaison, Elizabeth Poulter. We emailed the engineers to ask if they had any objects they would be willing to donate to our collection. Many engineers at the various TfL locations have excess retired engineering tools and other objects in their offices which were ideal to add to the ambassador library. We had great success in procuring more objects using this method of emailing engineers and asking for donations. Throughout the seven weeks, we acquired around fifty additional objects for the collection.

For each object, a detailed record of information had to be compiled from various resources. The object donor was the primary source of information on an object's purpose, use, and connecting stories. Oftentimes, the donor's knowledge of an object was incomplete, and further research into an object's history needed to be done. Using an object's official name, manufacturing company, or visible ID number, we found information about it online. Objects occasionally came without any identifying numbers, in which case we emailed engineering ambassadors in that field area to ask for further information. More often than not, we were invited out to work sites to learn more about an object, or to see it in use. For objects with minimal to no background information, we utilized an email newsletter method. An email was sent to all engineering ambassadors asking them if they were "up to the challenge," and challenged them to identify mystery objects. This method was very successful, and we received multiple answering replies for each object with either object information, or an official name to use for further online research. Whenever we met with an ambassador to gather information about an object, we conducted informal interviews. During these discussions, we drew on the questions laid out in the interview script (Appendix D). All the information gathered on an object was organized into a single fact sheet for ambassadors' use.

Ideally, all sectors of transport engineering should be appropriately represented in the collection. Through personal communications with Rawlings and our own research into the origins of the objects we already had, we determined that the collection had a strong representation of the track and signaling sectors and a weak representation of cable car or bus transportation. We determined that although cable cars are different from other track vehicles, the track items that were already in the collection could adequately be used to demonstrate many of the same engineering principles that would have been demonstrated by items from a cable car. The engineering concepts that could be demonstrated by items from a bus, however, are unique in transport engineering. We have pursued several contacts in the bus sector in an attempt to find disused objects from a bus that we could add to our collection. We contacted both engineers in Transport for London as well as independent junkyards that might have had a retired bus. Unfortunately, none of these initial leads were successful. Items from a bus such as the steering wheel or the push-to-stop button mechanism would have been ideal to add to the collection.

## **Objective 2: Devise a system where the objects can be stored and accessed from a range of sites across London by engineering ambassadors.**

A system to store the objects is essential for the artefact library, and will need to be easily accessible to the engineering ambassadors in order to create an effective program. The system is computerized, and contains information of the specific location of the artefacts in question, as these objects will be housed at several different locations across London. The system is specific enough to identify not only the physical location in the city, but also what box in the storage facility the object can be found. Appendix D contains some important questions that needed to be answered in order to develop this system.

We have answered the questions found in Appendix D through interviews conducted with our sponsor liaison and the engineers involved with the project, as well as other museums. Through discussions with our sponsor liaison, Elizabeth Poulter, we have learned what means are available to house the objects across the city and what buildings will be used. The objects

will be stored at two TfL locations, Albany House and Buckingham Palace Road, and the London Transport Museum. These three locations will be under the supervision of our sponsor liaison, and two leading engineering ambassadors Rawlings and Rowan Joachim, as they are the representatives of the collection at each of the locations. We have visited both Rawlings and Joachim at their offices to see what space they have available to store the objects. Through online research on the materials and manufacturing companies, and our discussions with Rawlings, we have found that no object in the collection needs to be stored under special conditions. Therefore, no objects will need to be housed separately, and no modifications will need to be made to the facilities in order to accommodate these objects.

We have conducted interviews with Dr. Jeffrey Forgeng and Kim DiRodi at Higgins Armory Museum (personal communication, February 2013) in order to gain a better understanding of how they catalog items in storage. Forgeng explained how the items stored are organized and what kind of system is used to access these items. We also learned how each object is identified with the system and found that some sort of barcode or identification number is assigned to each item, which can then be searched on a database to show both information on the object and its location in the facility. The system used by this organization also has a check-in/check-out method so staff members can know at a specific time if an object is currently in use. This will be essential for our project, as the engineers will need to know before arriving on site if the object in question can be found at the facility. The complexity of this system is a potential problem for the project, as it will become increasingly difficult as more ambassadors are actively removing and returning objects at different times and locations. Rawlings and Joachim confirmed during our meeting that it is feasible for them to keep a record on the database of the object's current whereabouts, which will alleviate this problem.

We have also had the opportunity to collect ideas on labeling objects from Robert Excel, an archivist at the London Transport Museum. He has given us information on the proper techniques to label objects in a collection, and from there we have developed our own system of identifying the objects. We have created five main categories, with an optional sixth category if we are able to obtain any parts from a bus. The objects have been separated into the categories

based on their functions and properties, and each object in the category has been given a number based on the order that they have been received. Following the labeling technique given to us by Excel and using the supplies he gave us, a base coat of Paraloid was applied to a clean surface of the object, and then the identification number was written on it with a fountain pen. This identification system has been incorporated into the database and will help to keep an organized record of each object.

Using this information, we have developed our own system for the artefact library that has the capability of locating the objects, and also determining whether they are currently in their specified location or are on site with an engineer. The objects have been labeled as described, and after speaking with Rawlings and Joachim, we found which locations each of the objects will be stored in.

### **Objective 3: Create a database for objects that can be accessed online.**

When storing and repeatedly accessing a large quantity of items regularly over a period of years, it is important to have an effective and easy to use cataloging system in place to avoid confusion, disorganization, and misplaced items. This process of cataloging has become essential for the smooth operation of many museums, including London Transport Museum (LTM). When creating the artefact library for LTM and its engineering ambassadors, it was essential for us to focus on properly recording and presenting information on each item, as well as finding a backbone for our database that would be both simple to use and easy to navigate. Some of the main questions that stem from this objective are listed in Appendix D, and were used in subsequent interviews.

From these questions, we discovered some of the basic information that would need to be acquired for the artefact library, including what our sponsors intend for the aesthetics of the online database, which organizational methods are optimal for the database, and what specific features the site should have. Through speaking with our sponsor and the ambassadors who began this collection of artefacts, we were able to find out the basic expectations, both functionally and visually, for the database itself. They suggested that the database be easy to use

and structured in a way that is both simple and informative, with few requirements for the actual aesthetics of the database as long as it met the functionality requirements. We also met with curators at other museums, including the Worcester Historical Museum and the Higgin's Armory, who were able to show us how they organize their own collections in an efficient way. While the programs used at these museums are expensive and structured to keep track of thousands of items, we were still able to gather important insight from these databases for our own system, including the need of a search function, ease of access for all users, and what types of information should be used.

After compiling these requirements for our database, we began research on different programs that might be suitable for this purpose. Through exclusion of expensive programs and database limitations, we narrowed our choices for the database down to either an Excel based document, a program through Microsoft Access, or our own site at Wikispaces.com. We presented these options to our sponsor, and she approved of each of the database methods, allowing us to make the final choice in program. Due to the complicated user interface of Microsoft Access and the lack of control over the aesthetics of a large excel sheet, we made the decision to create our artefact library through Wikispaces. This site has a number of features that will be valuable to the success of our artefact database, including the capability to make multiple pages for the list of items and a page on how to teach with objects. This site also allows us to attach documents to each page, so that we can upload the information for each item in a separate file, therefore minimizing clutter in the database. With this feature, ambassadors will not have to download detailed information for every item if they only require information on a specific object, which would be the case if we had used an Excel document. A search function is also present on Wikispaces, and can be used by giving each page a number of tags that would make the page easier to search for. Another feature of this site is its ability to grant certain levels of editing capabilities to specific users. This would allow our main custodians of the objects to go into the database and change it when needed or easily add a new item into the system, while other ambassadors would be able to view the database without having permissions to edit its content.



Though a part of our project is to train engineering ambassadors on the use of these items, it will be necessary for the catalog entries to be informative and pertinent to what types of information an ambassador may need on the object during school visits. In order to complete each database entry, we have included a fact sheet and high quality photographs for each object, as well as other information that our sponsors and the ambassadors have deemed to be important. This additional information includes the location of the item, who to contact if an ambassador wants to use a certain object, and the identification number of each object. Each fact sheet can be printed out by ambassadors whenever they might need it. Another essential detail in the success of our database is to assess how well it is working once it has been established. The online database has been shown to the three custodians of the artefact library, who have all given it positive feedback. For future evaluation, a survey should be given to ambassadors after they have interacted with the site to see what they believe should be added or changed to allow for ongoing improvements to the system.

#### **Objective 4: Develop an 'Object-based learning' training session for ambassadors about using the Artefact library.**

Once a collection of suitable items and the artefact library was established, the final objective of this project was to create a training session that would instruct current and future engineering ambassadors on using the artefact library in their school visits. As noted previously, the museum has a small collection of objects that are used in the Inspire outreach program, but very few of the engineering ambassadors use the collection extensively. The training program will help prepare ambassadors by providing object-based activities and presentation skills to use in conjunction with the artefact library.

We've supplemented the research done in the literature review with first hand observations of activities with young people and a training session for engineers working with students.

## Inspire Day

Inspire Day is an all-day event sponsored by the London Transport Museum. Its goals are to eliminate the stereotype surrounding engineers in the United Kingdom, and to encourage students to think about pursuing a career in a STEM related field. During this day, students are brought on tours of the Museum Depot in Acton, tasked to solve several engineering “problems”, and given the chance to speak with TfL engineers.

We observed Inspire Day to understand how adults can effectively interact with children. The best method, from our observations, was to ask young people questions. Rawlings brought an object to speak with students about. He didn’t give away what the item was, but encouraged students to ask questions to try to figure it out. Allowing the students to ask questions and guess about the object’s uses proved to be very stimulating for them.

## Training Session

We also observed a training session for engineering ambassadors. The training session included topics on how to initially interact with students and keep their attention. As well as observing the content of the training session, we also observed how the program was organized and how it kept the attention of those partaking in it.

## Object Handling

We attended an object handling session sponsored by the Horniman Museum in London, which also had some content on how to observe and analyze an object using questions. The content we found useful can be found in the Background.

Based on the information learned from these training sessions, we have put together what we believe to be important for a training session on object-based learning and using the artefact library. The program should have a PowerPoint presentation, a script or guide for the presenter, helpful handouts for the attendees, and an evaluation at the closing.

The PowerPoint presentation must include the basic outline of the training program, but acts more as a guide rather than the training vehicle itself. The training should be as interactive as possible, with a lot of input from the attendees and activities to keep them interested.

The script, or guide, should detail what activities to be done with the attendees, what to say at each point of the PowerPoint, and how much time should be devoted to each task.

The handouts should have information on how to access the online artefact library, and any other resources they might need. The information should be limited to a page, and contain only the most pertinent information necessary so attendees are not deterred from reading it by too much text.

The closing evaluation should be short (take one to three minutes to fill out), and should contain questions on whether attendees found the training session to be helpful, what they enjoyed, and what they think could be improved upon.

After an initial outline of activities was created, we met with Poulter, who developed the previous ambassador training, and she advised us on improvements that could be made. Using the questions detailed in Appendix D, we spent time analyzing our work and discussing what could be changed. All of the suggestions made were taken into account when editing. The final training PowerPoint (with presenter's script), the handouts developed, and the closing evaluation are shown in Appendices H, I, and J respectively.

## Findings and Conclusions

This section details the findings and conclusions drawn from methods described in Methodology.

### Objects

Ian Rawlings, a Transport for London (TfL) employee and Inspire engineering ambassador, collected and used objects in his presentations in order to engage the students since before we began this project. His collection of thirty-nine objects was passed along to our group to form the basis of the artefact library. Before the collection could be widely used by engineering ambassadors, it needed to be expanded. The expanded collection of objects was one of the main products of this project, and the decisions we made about which objects to add to the collection were influenced by several factors.

One was the storage space we had to work with. Those managing the collection currently are Rawlings, Rowan Joachim, and Elizabeth Poulter. Rawlings and Joachim are both engineering ambassadors, and Poulter is the Inspire Officer working with the program. The collection will be distributed between the offices of these three custodians, so the storage space available at each location factored into our decisions about what objects to include in the collection. The three locations are the London Transport Museum, the Buckingham Palace Road Transport for London (TfL) office, and the Albany House TfL office at 55 Broadway. Although the people who are currently acting as custodians will not maintain the role forever, the storage locations will remain the same in the future.

When considering an object for potential addition to the collection, the group critically examined many aspects of the object. One such aspect was size: objects in this collection must be able to be easily transported by an engineer into classrooms at schools around London, and thus only small objects are suitable. Additionally, we found that the space at the three office locations where the collection will be stored is very limited. We decided that objects in this collection must be both compact in size and light in weight.

The collection we produced was intended to be a hands-on collection, meaning that the objects will be handled by people who have not been trained in proper object handling techniques. We found through discussions with curatorial staff and through our own research on object care that the vast majority of damage to museum objects comes from being moved and touched by humans, and the degradation of an object is accelerated when the object is handled frequently. The conditions to which objects will be subjected during frequent handling affected the decisions we made when adding to the collection.

Due to this finding, we decided that object availability needed to be assessed. The objects will need to be replaced over time due to handling by non-professionals. As such, we decided that only common and widely available objects are suitable.

An intended outcome of this project was to deliver a collection of objects that ambassadors can bring with them to school visits, and thus special consideration was given to student safety around the objects. We found through talking with ambassadors that certain materials, shapes, and textures could potentially be threats to student wellbeing. Our group's decisions about which objects to include in the final collection were influenced by these safety considerations. We concluded that any item that contains hazardous materials, such as lead, or that has sharp points or edges is unacceptable for the purpose of this collection.

Engineering covers an extremely broad range of fields, and even transport engineering is not a single profession. We found through our conversations with ambassadors that they seek to introduce students to the varied nature of engineering, which has suffered from the stereotype of being a narrow or unexciting career. Ambassadors needed objects from all sectors of transport in order to show the breadth of engineering, and this demand was another factor that influenced the criteria we used when selecting objects.

We decided that objects must represent all aspects of transport in London, including track, computing, electrical, civil, train, bike, and signal engineering. The purpose of this standard is to equip the engineering ambassadors with the most complete resource possible that will enable them to explore a wide variety of engineering concepts with students.

Finally, the goal of bringing objects into schools was to engage students on a deeper level and to interest them in engineering. As we learned both through conversations with

ambassadors as well as through our own first-hand experiences, secondary school students can be a challenging population to reach intellectually. We observed that when Rawlings used a hands-on activity during the Inspire day program, students were significantly more interested in the topic he was teaching than at other times throughout the day when engineering topics were introduced but not accompanied by an activity. Rawlings engaged the students by using stories about the object and analogies that the students would be familiar with. Rawlings use of stories, analogies, and questioning influenced what type information we incorporated into the fact sheets, and the availability of such information affected decisions about what objects to include in the collection.

Thus, the final criterion that our group considered when selecting objects to add to the collection was the educational value of an object. The story behind each object will be utilized by the engineering ambassadors as a teaching tool and a way to connect the object with the lives of the students. The engineering ambassadors will be presenting to secondary school students, so the concepts should be both stimulating and age appropriate. We concluded that each object in the collection must be able to be used in conjunction with some information or story that the students will find relatable and interesting. The purpose of bringing objects into the classroom is to spark students' interest in STEM fields and to show them the possibilities of a career in engineering. Due to popular stereotypes, students may be resistant to the idea of engineering. The object should serve as the vehicle by which the ambassador can broaden the conversation about engineering.

When we collected objects from various donors, the donor was always the first source of information about the object. The donor may have told us the object's name, purpose, material, history, or story. In every case, we were told by the donor which sector of transport the object came from. The donors often had collected objects that they never had worked with. As one donor informed us, engineers may not know the name or even the function of an outdated item until it breaks. There are such a large number of objects that comprise the transportation system of London that no one person can be an expert on all items. We found that the donors were the best place to start acquiring information about the objects. Based on the information we found from conversations with donors, we performed further research into each object. For the objects

that we had the least information on, we sent an email with photos to all TfL employees that challenged them to reply with information about the object. We found that this was a highly effective method for finding information as well as for publicizing our project within TfL.

Using the information we collected, we produced a fact sheet for each unique object, as shown in Appendix E. The fact sheets include the object's name, photos of the object itself as well as in situ, a brief introduction to the purpose of the object, a detailed description of how the it works, as well as any additional information such as stories or ways to present an object to students. These fact sheets are intended to be used as a resource for ambassadors who will be presenting using the objects. Ambassadors will be able to present using objects from outside their area of expertise using the information on the fact sheets. We chose specific information to include on the fact sheets based on how helpful the information would be to an ambassador who is unfamiliar with an object.

The name is an important piece of information to include on the fact sheet to ensure that the ambassador calls the object by the correct name when presenting. Also, the name will help ambassadors recognize what an object is so they can recall any information they know about it. The correct name is also important to have so that future research can be done and more information found for the object.

Photos are included on the fact sheet because they provide the ambassador with a more complete idea of how the object functions. The photo of the object alone shows ambassadors what orientation to present the object in. The in situ photo shows the context in which an object is used in engineering.

The brief description is included on the fact sheet because in order to explain the engineering principles behind an object, ambassadors must first know the context in which the item is used. This description also serves to inform ambassadors about what the purpose of the object is.

The detailed description of the object itself is included to educate the ambassador about how the object functions to achieve its purpose. The mechanics and materials of an object must first be understood by ambassadors before they can present this information.

Finally, additional information is included in the fact sheet to give suggestions to ambassadors on how to present the topics demonstrated by an object. This section includes any stories that might interest the students, comparisons to objects that the students might be more familiar with, or other objects that could be used to illustrate a concept in a more detailed way (Appendix E).

## Storage System

The method of storage for the objects is an important piece of the project, as the objects should be as well preserved as possible for the longevity of the artefact library. Although the collection is intended for handling as opposed to exhibition, the care given to the objects will affect the lifespan of the collection. Measures that protect the objects while they are in storage and during transportation are necessary for maintaining the quality of the objects.

During storage, objects should be in padded containers, wrapped or contained in such a way to avoid damage from moving. The proper size of these containers depends on the storage space available at each location. The objects of the collection should be divided amongst various containers based on what area of engineering they represent, so as to give the system more organization. Similar protective casing should be implemented when transporting an object, to protect the object in case of a fall or mistreatment.

From site visits, we observed that the three locations, London Transport Museum (LTM), Albany House TfL office (AHB), and Buckingham Palace Road TfL office (BPR) all have varying levels of space available. AHB has only a bottom drawer available for objects, BPR has three shelves available, and LTM has a large amount of floor space available for storage. Division of objects amongst these storage locations should be based on space available, as well as an even distribution of objects from different engineering areas if possible. Duplicates of items should be divided amongst the three locations, to achieve an even distribution of objects. To store objects, we bought plastic boxes with lids from Office Depot. Due to the relatively small size of most of our storage locations, we purchased nine nine-liter boxes, one fifty-liter box, and one sixty-four-liter box. We decided that each box would ideally contain objects from one particular area of engineering for organizational simplicity. In order to



minimize damage on loose objects, objects were encased with bubble wrap, which is an inexpensive solution. Larger objects such as track and bike components were stored at LTM, as it had the most space available. Objects relating to signals engineering were distributed evenly between the three locations, as they represent one of the largest categories in the collection. Duplicate objects were divided between the three locations.

When labeling objects, it is important to use the correct archival practice (Literature Review, p. 17). Each object in the artefact library is identified by a letter and number. The letter represents what area of engineering the object pertains to, such as T for track or E for electrical. This is followed by a dash and the object's number in the collection. A decimal and second number are required if there are duplicates of a certain artefact. For example, if a cable is represented by E-04 and we were to obtain two other identical cables, the first cable would become E-04.1, and the new additions would be labeled as E-04.2 and E-04.3. This labeling system allows for objects to be easily identified and flexibility for objects to be added.

Concerns over the treatment of the objects within the collection lead to necessary measures that would help guarantee that the objects are well cared for. For ambassadors to check out an object, they must sign a contract agreeing to handle and transport the object properly (Appendix F). This contract specifies when the object should be returned, details on how to properly handle the object, and confirms that the ambassador is aware of the repercussions should they fail to follow the guidelines of the contract. Any damage due to misuse of objects will receive a fine, and all other damage should be reported upon return of the object. While the rigidity of this process may deter some ambassadors from checking out objects, our sponsor liaison finds proper handling of the objects to be of utmost importance in order to preserve the collection for continued use in the future. Another factor considered was the best practice of record keeping for the whereabouts of an object. The contract should contain the ambassador's contact information, and what event they will be using the object for. The availability of an object should be included as part of the database, and edited by the custodian upon receiving a signed contract and checking an item out to an ambassador. This can be done by logging on to the database and editing the availability column for the object.

## Database

A database is an accessible structured set of a data held in a computer (database, 2013). For the artefact library created in this project, a database that could hold detailed records of each object and other pertinent information is required. As LTM already hosts a great deal of information, they prefer the database to be externally hosted or be very small.

There were several database options to be considered. Our sponsor liaison's initial recommendation was a Microsoft Excel document to be downloaded by each person who wished to view the database. Another possible option was a website or blog creator such as Wikispaces or WordPress. Microsoft Access can also be used to customize a database that can later be made into an accessible webpage. Table 1 is a comparison of the pros and cons of each option.

**Table 1. Pros and Cons of Possible Databases**

	Pros	Cons
Microsoft Excel	Widely used program – Comes on most computers, and most people would know how to use it.	File size would be very large with every object's information in it.
		Object information would be awkward to include – Excel was not designed to hold anything outside of a table.
		Object records would not have pictures due to file size limit.
Microsoft Access	Entirely customizable – Can change everything.	Not user friendly – even pre-made databases are difficult to navigate.
		Creator uses a mix of pre-made functions and code. Creating an accessible database would take a lot of time.
Wikispaces	Fairly customizable – Can change colors, layout, and navigation.	Does not look as professional as other database programs.
	User-friendly. Webpages created are easy to find, and a navigation pane is always present.	

	Easy to create and edit pages.	
	Has hosting capabilities – Documents/Pictures can be uploaded and directly downloaded from webpages.	
	Permission capabilities – Can give multiple people access to edit, and can be viewed by anyone.	
WordPress	Fairly customizable – can change layout, colors, and design.	Blog format would limit how objects were organized.
		Accessibility – Could not access WordPress from museum computers.

As seen in Table 1, the only database choice to have more pros than cons was the Wikispaces option. Wikispaces is a free web hosting service that allows for easy creation and editing of webpages. Content can be uploaded by administrators, and then downloaded directly from the site by anyone. Administrators would have to create or share an account. In discussions with the custodians of the collection, they expressed that they would not mind sharing or creating an account. We agreed to use Wikispaces for the artefact library database.

The custodians’ expectations of what should be included in the wiki (database) were discussed at length and can be summarized as follows:

- Every object record should contain the object location, object availability, object history, and some identifying number.
- The database should be viewable to everyone, but only edited by custodians.
- The database should be easy to use, and come with a tutorial for both the custodians and users.

The expectations above shaped the creation of the artefact library database. All other content and database decisions were left to our discretion, but with the expectation that the final product should look professional.

The database created is a reflection of the expectations of the custodians of the collection, who would be the main users of the database. An account was created at Wikispaces

to perform the work of creating a database, and a wiki (website) was created, located at [www.artefactlibrary.wikispaces.com](http://www.artefactlibrary.wikispaces.com). Screen captures of the wiki can be found in Appendix G.

The main page is a welcome and tutorial, such that the engineering ambassadors who may have never used Wikispaces before would be able to understand both how to navigate the wiki and find objects to take out.

An About page was created to give an overview of what engineering ambassadors do for the Inspire program, and the role of the artefact library. This page was not a necessity – engineering ambassadors will already know this information. However, as the wiki is on the web, anyone can find and view the page (searching google for "london transport museum artefact library" will direct to our page), so the page was added for context.

The most important page of the wiki is the Object List, which contains the database for the objects. From left to right, the contents of the table for each object are: identifier, category of transport or engineering, object name, location of object, availability, brief description, important information, and a photo.

The identifier is the letter-number combination that each object was labeled with, and is important for finding the right object. Should an ambassador like to check an item out, they can be sure they are getting the right object by using the identifier rather than the name, as some objects can be very similar in name.

The category of each object was added such that an ambassador looking for an object in their area of engineering or transport would be able to more easily find an appropriate object.

Item name, item location, and availability were all specifications from the custodians, and necessary for someone viewing the database to know where they can pick up an object if it is available.

The description is used as a brief overview, such that ambassadors viewing the database do not have to download the fact sheets or other links in the information column in order to get an idea of what the object is used for.

The information gathered is all contained in the information column, which contains a fact sheet for each object, and occasionally other related resources. For example, under the information column for a microprocessor are links for videos on the making of CPUs, and graphics about the expansion of computers in the world. Extra information that allow for relating the objects with the world is important so that ambassadors have the tools not to simply teach using an object, but to relate that object to engineering, and the work engineers do. Videos, graphics, and related articles were chosen to complement the fact sheets so as to give ambassadors an idea of how to connect an engineering object to the broader aspects and social implications of engineering.

The last column of the database contains a photograph for easy viewing of the objects so ambassadors can quickly find an object they know about, or an object that looks interesting.

Another page of importance on the artefact library wiki is the How to Use Objects page, which contains extra information on working with objects. Viewers can download handouts created for the training session containing sample activities one could use with children, questions they can prompt about objects, and a brief tutorial on using the wiki and working with children. This also serves as a place to download training session handouts should an ambassador miss the session.

The final page created was a Contact Page. Contact information for the custodians, and for enquiries about Inspire or the artefact library are available on other pages as well, but are repeated here for easy navigation.

Other aspects of the wiki, such as the color scheme, layout, and logo were designed to look professional and minimalistic. London Transport museum is a professional working place, and while this wiki is not under their hosting, it is a reflection of them. The shade of orange used was designed to match the orange of their logo, and the layout simple (content left and center, navigation right) so as not to distract from the content.

## Training Program

The training session is an essential part of the project, as it ties the objects, the storage system, and the database together. Various styles of training were investigated in order to create an effective program for ambassadors. We were able to attend two training sessions hosted by separate museums, where we gathered information on possible activities and structure for our program. The first was facilitated by the Horniman Museum and was aimed at engaging students using thought provoking questions. We saw that the most common and successful method of training was role playing activities. The second program was hosted by Poulter at the London Transport Museum and focused on preparing ambassadors to work with students during Inspire days. We observed the success of the role play, as ambassadors were asked to simulate typical interactions between students and facilitators at Inspire days. We also saw room for potential improvements, such as a longer session and more time for the activities.

Another successful component of the training at LTM was the evaluation forms at the end of the session. In the final portion of the program, attendees were asked to fill out a short questionnaire about their experience, such as their favorite part and where they saw room for improvement. After the training, we were able to access the results from the evaluations of Poulter's session and used these comments and suggestions to tailor our program to better suit the needs of the ambassadors. Poulter also gave us the results from a survey that was previously given to ambassadors about the Inspire program as a whole, including training days. Using these resources we learned that participants enjoyed the role play and other activities as it kept them engaged and gave experience. They would have preferred a longer period of time for the activities. In addition, there were other topics that the ambassadors were looking for in the session, such as specific examples to use with students and understanding what intellectual level is appropriate when trying to explain technological concepts. We observed what questions should be included to assess a training session, and used these to develop an evaluation for ambassadors.

We had several discussions with Poulter about our proposed training session in its various stages of completion. She expressed to us from the beginning that our training should be specific to the artefact library, and should involve a tutorial of the online database, as well as

how to use the objects to teach and engage students. At later meetings, Poulter made suggestions about the preliminary outline we had for the program. She expressed her concern over the time needed to accomplish all of the activities and advised that we keep the program concise, but still include all of the necessary components. Using these resources, we developed a training session that meets both the needs of our sponsor and the ambassadors.

The session itself will consist of a Microsoft PowerPoint with a script written for the facilitator, seen in Appendix H. The proposed schedule, as seen in Table 2, shows the different sections of the training, and the times that these will occur. The time allotted for each activity is based upon both the weight of its importance and also an estimate of how long it will take logistically. For example, the role play activity that will be done by the ambassadors is scheduled to take up to thirty minutes because of the high importance of this activity and also to give ample time for the participants to complete it.

**Table 2. Training Session Timetable**

<b>Time</b>	<b>Activity</b>
<b>17:00-17:10</b>	Arrival and refreshments
<b>17:10-17:30</b>	Introductions and Artefact Library
<b>17:30-17:35</b>	Handling Objects
<b>17:35-17:55</b>	Using Questions to Engage Students
<b>17:55-18:05</b>	Break
<b>18:05-18:25</b>	Artefact Library Tutorial
<b>18:25-18:50</b>	Sample Activities
<b>18:50-19:00</b>	Summary and Evaluation

The first ten minutes of the session are devoted to arrivals and refreshments, as to accommodate late arrivals. The facilitator will begin the program with introductions, goals of the session, and an icebreaker aimed to help transition the tone of the evening to a more interactive and engaging session. The first half of the session includes an introduction to the artefact library itself to give ambassadors a better understanding of its purpose and where it fits into the Inspire program. The ambassadors will then learn how to properly handle an object to

avoid damaging it or hurting themselves. Proper handling techniques will be provided for when the ambassadors allow students to handle objects. An activity on using questions to engage a young audience will also be included in the presentation. The facilitator will first present how to use questions to speak with students, followed by examples. Ambassadors will then be assembled into small groups, given a mystery object and instructed to ask each other questions about it in order to come to a conclusion on what the object is. This technique can be employed with students to keep them engaged, and to demonstrate that they may know more about an object than they expect. This activity can also show ambassadors that although they may not be experts on the objects in the library, they are still able to discuss these items.

After a ten minute break there will be a tutorial on the artefact library and the online database to help the ambassadors feel comfortable accessing the database and using it to locate and check out objects for Inspire Days. This will also include how to use the fact sheets to prepare for presentations. The facilitator will then share some sample activities that the ambassadors can use if they are unsure of what to present to the students. The final activity of the session is to role play with a partner as an ambassador and student. The “ambassador” will present an object to the “student” using the techniques discussed in the training and the fact sheet provided, and then the roles will be reversed. Finally the ambassadors will be asked to fill out an evaluation form for the session, which will conclude the training.

At each of the training sessions observed, facilitators gave out handouts in collaboration with the material of the presentation. This helped the participants to better understand the concepts, and also offered a point of reference if the participant wanted to look over the material at a later date. During the artefact library training session, the handouts located in Appendix I will be given out to the ambassadors. The first will be a paper copy of how to access and properly use the database. They will also receive a handout on how to effectively use questions. This will give them sample questions they can use with students, and also provide personal reminders of what questions to ask themselves when picking an object out of the collection for the first time. Finally the ambassadors will be given a sheet with some sample activities that can be used as an additional way to engage the students, or provide help if they are unsure of what to say.



The final component of the training program is the evaluation, shown in Appendix J. We based our evaluation on the one used in Poulter's training session. The evaluation asks what the ambassadors liked or disliked about the program and invites any suggestions that they may have. It also includes questions to evaluate how effectively the training helped them to feel confident engaging students with the objects and how comfortable they are with using the database and handling objects.

## Recommendations

In the interest of expanding and increasing the effectiveness of the engineering ambassador program, we recommend that the custodians continue to publicize the collection. All of the objects that we collected were given to us by people who heard about the project either through conversations, emails, or a short article that was published in the Transport for London (TfL) e-newsletter. Given the strong response we observed in the Transport for London community, we recommend continuing to publish updates in the e-newsletter in order to increase awareness of the collection and in the interest of adding more objects. Additionally, this collection should be publicized within other science, technology, engineering, and mathematics (STEM) communities, such as STEMNET. Other organizations may not be aware of the benefits of object-based presentations. Widely publicizing this initiative may inspire other organizations to explore the possibility of using objects to promote STEM fields to students. We recommend holding open workshops and publishing articles in organizations' newsletters to reach a wider audience.

Since TfL is looking to expand the scope of the Engineering Ambassador program, we recommend that the collection of items be expanded through the donation of appropriate engineering objects. The collection should ideally represent all aspects of transport engineering in London, but we were unable to procure any objects related to cable cars or busses. We therefore recommend that in the future, appropriate items from busses and cable cars should be sought after for the collection. This could be accomplished either by contacting people in those sectors or by advertising in the TfL e-newsletter that those objects are needed. Specific objects that would be ideal include the steering wheel and a push-to-stop button from a bus. Objects from this sector should comprise their own category, which we would term automotive engineering. If any suitable objects were obtained from a cable car, they should comprise a new category in the artefact library.

In regards to the storage system, we recommend that the guidelines created in terms of safe storage and keeping track of items be followed to allow for the system to function

smoothly. If more items are to be added to the artefact library, they should be labeled using the chemical and pen method that we used to label items that are already in the collection, and the identification number of the item should follow the identification guidelines that are stated previously. When storing objects for a collection, it is important to make sure that the storage area remains neat and organized for ease of use. A higher budget for more durable object protection such as special foam or more thickly padded carrying bags is suggested. If possible, we recommend that more locations be acquired for the storage of objects. This will increase the convenience for ambassadors borrowing objects.

The database should be kept up to date by the custodians. New objects collected should have detailed records created and added to the database using the current format. All links to external content and downloadable files should be regularly checked (once or twice per month) to ensure that they are still working, as links can break should the online content be taken down.

There are many improvements that could be made to the training program if the time and resources are available. In the evaluations of previous Inspire training sessions, the engineers were looking for experienced ambassadors to speak at the session on what techniques have been successful and what have not. Currently, this cannot be guaranteed, as Elizabeth Poulter, the Inspire officer, is the sole facilitator of these sessions, but it could be beneficial to add to the program at a later date. We also recommend that after the program is given, the evaluations be used to make any necessary changes or adjustments.

Beyond the scope of this project alone, we recommend that organizations like TfL or London Transport Museum should continue to try to promote STEM fields to students. Without advancements in STEM, a nation will stagnate in a number of fields that contribute to the quality of life of its people. The ability of a nation to provide health services, public transportation, and electricity for its people; to be prepared for war; and to produce products that are globally in demand are all dependent on STEM. Other nations, where these professions carry more prestige, will continue to surge ahead technologically and economically. We recommend that the development of interactive engineering programs continue in order to interest the minds of the new generation in STEM.

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## Appendices

### Appendix A - Sponsor Description

The London Transport Museum displays objects that tell the story of the development of London's public transportation system over the past 200 years. Artefacts varying from original poster art to train cars to uniforms have been preserved and exhibited with the goal of intriguing people in the transport heritage of London as well as the future of transportation engineering.

The museum has its roots in a small collection of Victorian horse busses and an early motor bus that were preserved in the 1920s by the London General Omnibus Company. The collection was first displayed to the public in the 1960s in Clapham, and it was moved to Syon Park in 1973. In 1980, the museum acquired and moved into the building that had previously housed the flower market at Covent Garden. At this time, the collection included some 1,000 objects, and that has increased to over 400,000 objects today. In 2005, the museum temporarily transferred all of its collections to the Museum Depot in Acton (Figure 3) while the cast-iron and glass building in Covent Garden underwent major refurbishment and renovation. When the museum reopened in 2007, attendance soared, and in the following year, the museum redefined its relationship with Transport for London and became a non-profit charitable organization (Johnson 2011-2012).

The London Transport Museum's main facility is located in the Covent Garden neighborhood of the borough of Camden (Figure 3). The museum also operates a depot in Acton which houses the collections that are not currently on display in the main facility. The Museum Depot is open to the public for select events throughout the year.





Figure 3. Location of Museum and Depot

Currently, the London Transport Museum boasts three levels of exhibits at the main facility in Covent Garden, including the Steam Underground, Growth of the Suburbs, 19<sup>th</sup> Century London Transportation, and several smaller showcases featuring modern transportation. The exhibits are arranged in chronological order, starting with 19<sup>th</sup> Century transportation on Level 2 (Figure 4). Level 2 features original and models of some of the first horse-drawn carriages, as well as photographs and artwork from and of the time period. Moving on in the chronology, Level 1 (Figure 5) features trains and carriages that were used on the first Underground lines and a collection of artefacts explaining how the new lines of communication stimulated the growth of the suburbs. The ground floor, Level 0 (Figure 6) features multiple smaller exhibits that take visitors through the more recent development of the Underground system, Transport during war times, and the growth of road vehicles during the 1900s. The last stop before the exit is the exhibit on Transport for London, the current governance of all the transportation in London, and a view of what could be coming up for transport in the future.



Figure 4. (left) Model horse drawn carriage. (right) Floor plan of Level 2.(Itmuseum.co.uk)

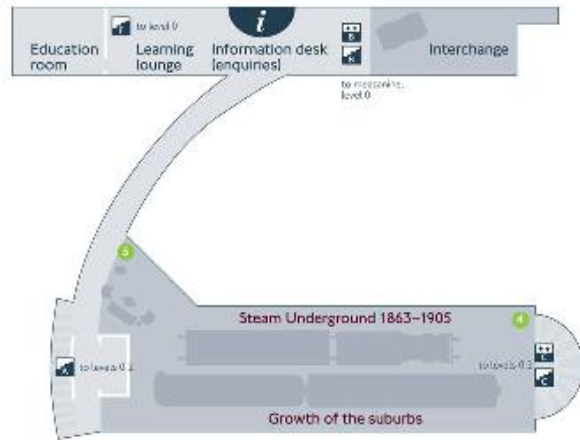


Figure 5. (left) Model steam train. (right) Floor plan of Level 1. (Itmuseum.co.uk)



**Figure 6. (left) Model of 1926 bus. (right) Floor plan of Level 0.(ltmuseum.co.uk)**

Most of the larger items (buses and trains) are kept at the London Transport Museum Depot in Acton. The Depot has limited hours and fewer activities, but has an impressive display of older trains, carriages, and buses that one can view and walk in (Figure 7).



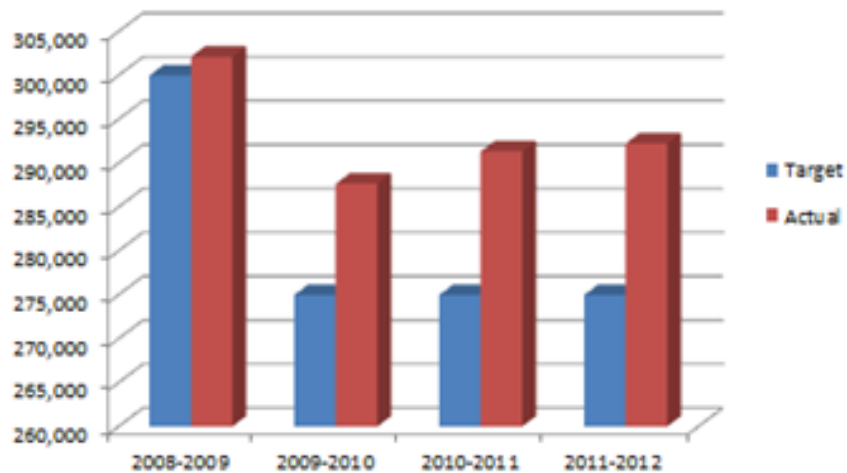
**Figure 7. Electric Sleet Loco at London Transport Depot. (Chris Adams, flickr.com/photos/chirs\_adams)**

Activities and special events are held frequently at the main Museum. Panels, film screenings, talks, discussions, engineering workshops, and evening exhibits are held a few times each month. Events range from the history of fashion to the exciting opportunities available in transport engineering. Actor-led sessions and tours are offered a few times a week, and guided and disabled tours are offered daily. The Activities Studio and All Aboard! exhibit on Level 0 is available for younger children to explore fun small sized models of trains and use blocks and small train models to build their own transportation system (Figure 8). The Museum also sponsors the Inspire program, which holds workshops every few weeks to encourage secondary students to pursue transport engineering and related sciences as a career. The workshops feature engineer planners, problem solving activities and a guided tour through London's transportation. Volunteers called engineering ambassadors conduct workshops in schools, where they speak to students about their work as an engineer, planner or in a related career and strive to excite students about science, technology, engineering, and mathematics (STEM).

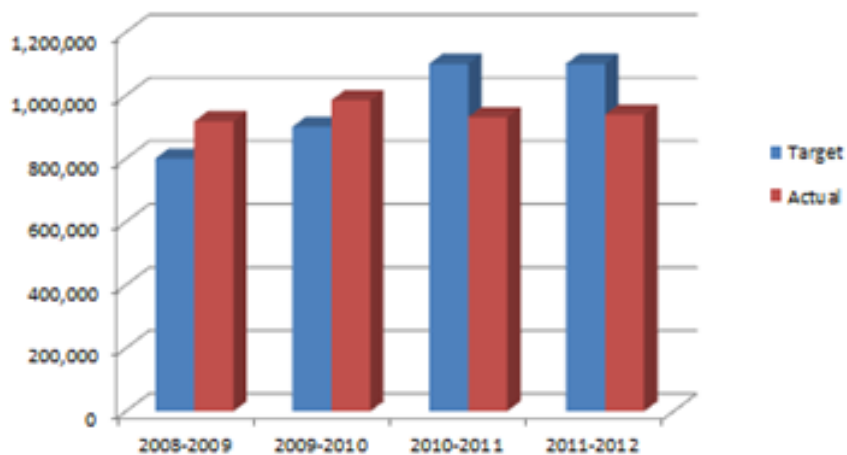


**Figure 8. AllAboard! exhibit/play area ([ltmuseum.co.uk](http://ltmuseum.co.uk))**

With such exciting showcases and activities to offer, London Transport Museum and Depot draw an average of 290,000 visits per year (Johnson 2008-2012). Their actual visitation rate has consistently exceeded their target since their re-opening in 2008 (Figure 9). Their website generates about 900,000 unique visits per year, and the target goal is to increase this number to 1.1 million hits per year (Figure 10).



**Figure 9. Graph of Target and Actual Museum and Depot Visits.**  
**Data from London Transport Museum Yearbooks (ltmuseum.co.uk)**



**Figure 10. Graph of Target and Actual unique Website visits.**  
**Data from London Transport Museum Yearbooks (ltmuseum.co.uk)**

The London Transport Museum derives its funding from several different sources including grants, donations and fundraising. As seen in Figure 10, voluntary income is the museum’s primary source of income, as it brings in almost half of the total revenue, largely in the form of core grants. Other main contributors to the total revenue are activities for generating

funds, such as renting out parts of the museum. The Museum’s venues are available for hire and in the 2011/2012 year, the facility hosted 16,000 attendees at various corporate events, conferences and auctions, which helped to raise profits considerably (Johnson 2011-2012, 2012). Admission fees and other museum operations, and education and engagement activities, account for a large portion of the charitable activities, shown in Figure 11, which contributes a substantial portion of revenue.

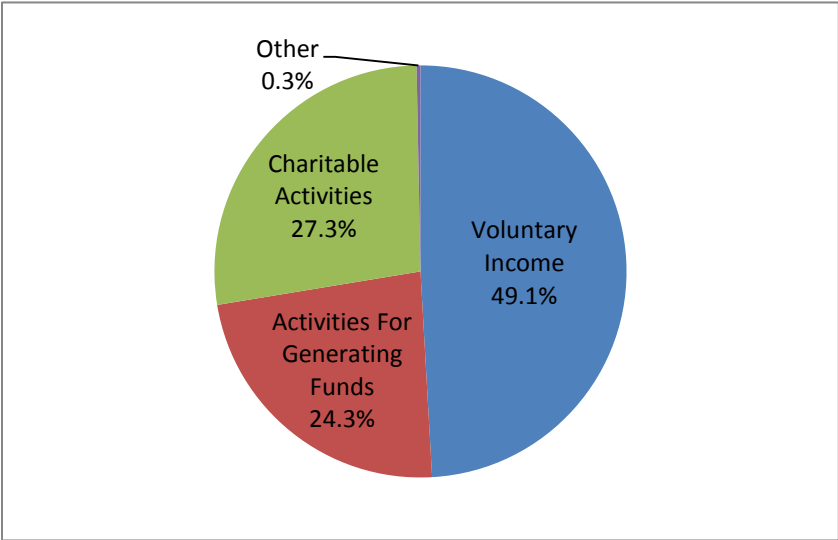


Figure 11. Pie Chart of Income

Expenditures of the museum consist mainly of the cost of generating these funds, and also charitable expenses such as access and museum operations, as well as education and engagement programs. The educational programs offered by the museum and the actual cost of operation of the museum account for over half of the total expenditures, and the resources used to fund these are about equal, as seen in Figure 12. Another slightly smaller portion of the total expenditure of the museum is devoted to its commercial trading operations. This consists of museum’s subsidiary company London Transport Museum (Trading) Limited (LTMTL). The remaining expenses are due to the cost of generating voluntary income and also maintaining and acquiring collections (Johnson 2011-2012, 2012).

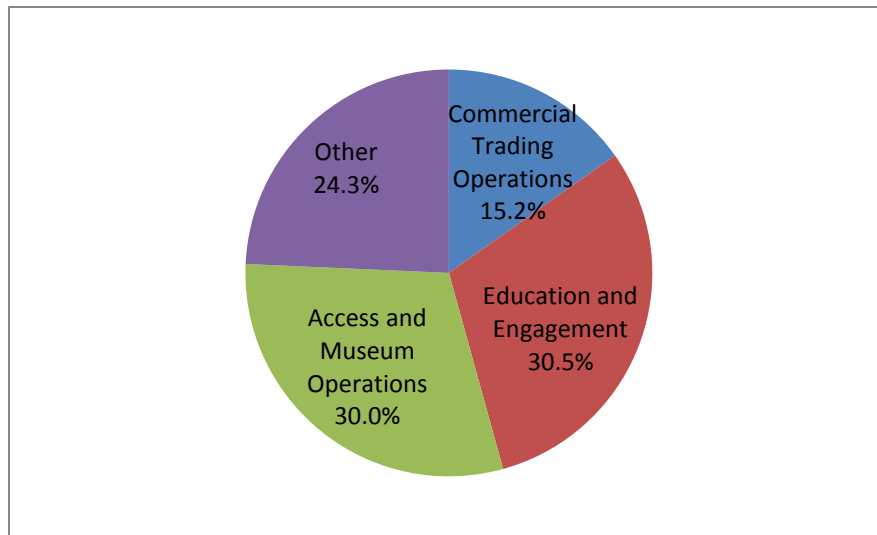
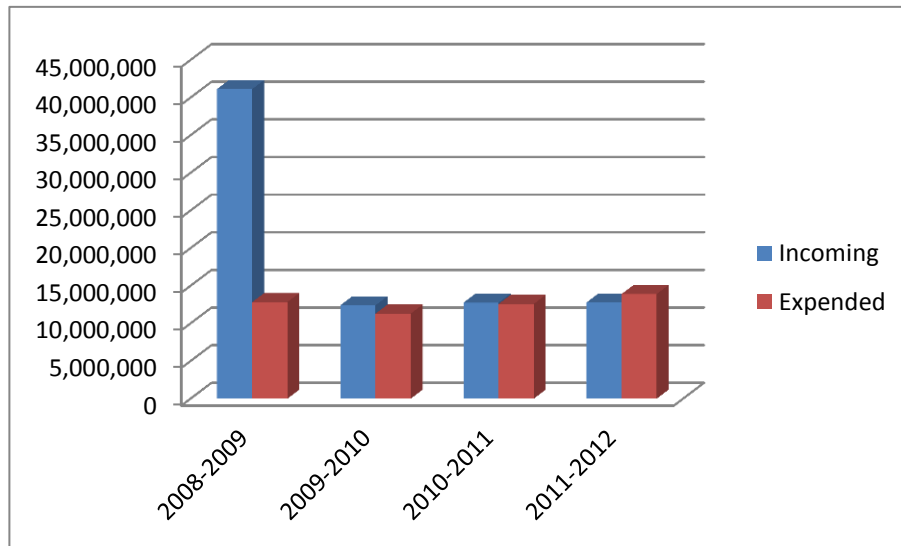


Figure 12. Pie Chart of Expenditures

The museum is a registered charity as of 2008, and relies on charitable donations for a small portion of its income. The museum offers a “Gift Aid” donation program upon the purchase of tickets. If a museum patron chooses the “Gift Aid” option upon purchase of their ticket, the tax is given to the museum, which amounts to a donation of 28p for every £1 (Opening Times and Tickets, 2012). Other sources of donations have been generously given to the museum, such as from the London Transport Museum Friends, and the Luke Rees-Pulley Charitable Trust (Johnson 2011-2012, 2012).

Over the past several years, the revenues and expenditures have remained stable at approximately £12 million per year. However, in the 2011-2012 fiscal year, the museum saw a deficit of about £1.5 million, with expenditures at their highest rate in the past four years. The anomalous peak in revenues in 2008 reflects the large grant that Transport for London gave the museum for future maintenance of the collections and facilities (Johnson 2008-2012).



**Figure 9. Total Resources**  
(Yearbook 2011-2012)

The London Transport Museum achieves its mission through the conservation of artefacts representing the rich history of London’s transport system and making them accessible to the public through a variety of exhibits and programs. The Inspire program is a relatively new endeavor which aims to encourage interest in STEM subjects in secondary school students. The goal of our project is to bolster the Inspire program through creation of an artefact library that engineering ambassadors from Transport for London can use in schools to stimulate interest in STEM subjects.



## Appendix B – Higgins Armory Museum Handouts



### School Tour Evaluation

We hope that your class enjoyed its visit to the Higgins Armory Museum. Please help us ensure the continued high quality of our programming by filling out this evaluation and returning it to the Museum. You can drop it off at the Information Desk, mail it to the above address, or fax it to (508) 852-7697. Thank you.

Name (optional): \_\_\_\_\_

Grade: \_\_\_\_\_ Date: \_\_\_\_\_

School (optional): \_\_\_\_\_

Please rate the auditorium presentation:  Excellent  Good  Fair  Poor

Comments:

---

---

Please rate the gallery tour:  Excellent  Good  Fair  Poor

Comments:

---

---

Please rate your experience in the Castle Quest hands-on gallery:

Comments:

---

---

Please rate any optional program you participated in, such as workshops or role-plays.

Specify program: \_\_\_\_\_  Excellent  Good  Fair  Poor

Comments:

---

---

Was the material and presentation suitable for the age/grade level?  Yes  No

Comments:

---

---

What additional material would you like to have included?

---

---

How did you learn about the Museum's school tour program?  Brochure  Colleague

Other (Please comment) \_\_\_\_\_

---

---

Would you repeat this program next year?  Yes  No

Why or why not? \_\_\_\_\_

---

## Higgins Armory Museum

### Exhibits and Interpretation Philosophy

*Fun, engaging, exploratory: teaching with purpose, learning by accident*

A successful museum experience is based on a collaborative interaction of three key players:

- The visitor
- The institution and its collections
- The staff

Every object has multiple facets and stories: the Higgins Armory creates opportunities for visitors to explore the stories that are most meaningful to them.

We aspire to design exhibits and interpretation goals that encourage visitors to make personal connections:

- Objects are selected to offer multiple points of access
- Objects are presented in context to deepen the opportunities for meaning-making
- Interpretive content is layered and flexible to foster exploratory learning

We:

- Provide content through objects
- Encourage observation-based learning
- Aim to encourage intimacy between the visitor and the object
- Offer exhibits and programming that foster open-ended inquiry
- Utilize information in a way that encourages closer looking and deeper thinking
- Offer multiple opportunities for personal meaning-making

Through:

- Observation
- Hands-on experiences
- Interactivity
- Performance and demonstration
- Layered exhibit content using multiple media

All of this is grounded on *appropriate object stewardship* that preserves these treasures for future generations, and *scholarship to provide context and understanding* for interpretation of the collections.





# HIGGINS ARMORY MUSEUM

100 Barber Ave., Worcester, MA 01606 • (508) 853-6015 • www.higgins.org

## Education Program Evaluation

Name: \_\_\_\_\_ Age/Grade: \_\_\_\_\_

Organization/location: \_\_\_\_\_ Date: \_\_\_\_\_

Type of Program (Check all that apply & please indicate the name of the program in the space included):

Auditorium Presentation: \_\_\_\_\_

Workshop: \_\_\_\_\_  Role-play: \_\_\_\_\_

Outreach Presentation: \_\_\_\_\_

OverKnight  Birthday Party  Medieval Maidens

Have you visited the Museum before? Yes  No

Are you a member of the Museum? Yes  No

How did you learn about today's program?

Higgins Website

Higgins Calendar Brochure

Newspaper: \_\_\_\_\_

Other: \_\_\_\_\_

Please rate today's program on a scale of 1 (poor) to 5 (excellent).

1  2  3  4  5

What did you like best and what would you change about today's program?

\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_

Was the presentation age appropriate for the audience? Yes  No

Would you recommend this program to others? Yes  No

Would you repeat this program? Why or why not? Yes  No

\_\_\_\_\_  
\_\_\_\_\_

Use reverse side for additional comments.

*Thank you for your feedback!*

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# Learning from objects

### What we've learned about learning from objects

*Practical tips on using museum collections for learning*

#### **If you're displaying collections of objects...**

Visitors respond well to beautiful, valuable, nostalgic or striking objects, and like seeing 'the real thing', but most visitors do not think of most objects as being 'iconic', worth seeing for their own sake.

**Effective interpretation** is therefore crucial to establish an object's **significance**.

Effective displays give visitors a sense that they can interact with the object and its story, through direct physical experience (touch, hearing or smell as well as sight) or by offering any of a range of ways of finding out about the object (seeing a picture of who owned it, watching a video clip of it working, hearing oral history, starting a discussion with another member of their group about how it works).

Physical access to objects is important – far-away, barriered objects are not engaging. Good lighting and design really helps attract visitors' attention.

#### **If you're interpreting objects on display...**

Visitors look for a **guiding story** behind an exhibition and if it is missing they are often very disappointed and confused.

What really engages visitors is the context and the stories that go with an object. Interpretation can give different visitors' appropriate ways in to an object, depending on their interest and learning styles. Ever-popular are reconstructed scenes, immersive displays or dioramas designed to show how, where and when something was used.

Effective text encourages visitors to look longer and think more deeply about the object. Visitors like objects to be individually labelled so it's obvious what is what.

#### **If you're using 'mystery objects' to provoke discussion...**

Good mystery objects look unusual, but have a very common or definite purpose that people can relate to once they know what it is. Medical and household objects work well, particularly if they are shocking or curious. Historical and modern objects can both create interest, especially if they have a

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good related story. Less successful objects are those that are parts of a bigger object, or which have hidden properties which you can't see even once told about them.

## **If you're using questions to help people learn about an object...**

In a workshop session, use **questions** to enable people to work things out for themselves. Can you describe what you can see? What is it made of? Why do you think the maker chose those materials? Is it old or new? Who might have used it and where? What kind of person might have owned it?

## **If you're using objects that people can touch...**

Handling collections (objects people can touch) deserve respect and should be packed carefully, handled with gloves and so on. Exceptions can be made for visitors with visual impairments. By being able to touch objects, visitors engage more senses than just sight, and this can be very powerful. A handling collection is useful for outreach at history groups, nursing homes, schools, reminiscence groups and so on, allowing the museum to go out to groups who may not be able to visit the museum itself.

## **Further resources:**

Come on our training course **Learning in Museums** to find out more about how museums promote informal learning. Contact us on [learning@sciencemuseum.org.uk](mailto:learning@sciencemuseum.org.uk) to find out more.

Find out how to use objects to spark science discussions in the classroom, by visiting the Talk Science website <http://www.talkscience.org.uk/content/stimuliobjects.aspx>

Come on a **Talk Science** training course for teachers interested in generating class discussions on contemporary science topics [www.talkscience.org.uk](http://www.talkscience.org.uk).

### What we've learned about developing schools' outreach programmes

*Practical ideas on how to plan successful events you take out to schools*

#### When you're planning the content of your outreach...

Plan the topics of the session to be **fun, memorable and varied**. Choose things that the school can't do itself, hasn't the time to organise or simply wouldn't think of. It's good to have **special props or equipment**, and to use chemicals or materials that the school wouldn't usually have. The presentation style can also be more entertaining or **showbiz-like** than normal school. See if your existing events can be adapted for outreach.

Define just **two or three clear learning objectives** for each session, and link everything to the **National Curriculum** as this is the biggest attractor for teachers.

#### When you're working with primary school audiences...

Primary school children tend to have lots of **enthusiasm** for special events. Talk to teachers in the run-up to the booking about classes that might prefer a practical approach or who could be stretched more. You may be booked to give the same show to one or two classes at a time, repeating it through the day. Tailor the show to the appropriate **Key Stage**. You are likely to use the main school hall for your shows, so be aware you might have to clear your equipment during lunchtime.

#### When you're working with secondary school audiences...

With secondary audiences, you often have to work harder to earn their **respect, attention and trust**. A great demo or some arresting images can get their attention and provoke a reaction. You may be booked to present the show to a very big group at once, so be prepared.

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## **When you're scheduling outreach programmes...**

Work out how many sessions you can offer in a day, and the **costs** of taking your events out, including the travel and possible overnight stays if the distance is great. Set out clear costs for different options. Plan your calendar, noting periods like Science Week or local festival times, when you might get busy.

Try not to book just one event per school – offer them a **full day** of events. If you travel unusually far for a particular event, book other regional schools for the same period so as to make travelling more efficient.

Decide whether you need to have a formal **health and safety agreement** so that the school guarantees a safe place to work and appropriate supervision of children.

Keep in touch with teachers close to the event date, so they have the correct **expectations** and feel **informed and excited** about the event. When you leave for a venue, make sure you have the map, teacher's contact name, timetable for the day and any other details you need.

## **When you're planning your props and materials...**

Try to have props and materials that are specifically for use by the outreach programme. Store your props in a **safe and well-organised** way, to save time. Ensure your props are smart, clean and professional-looking, possibly with a uniform style, so that they give a good impression in schools.

## **After the show is over...**

Try to get **feedback** from pupils as well as teachers. You could video some pupils to get their reactions to the show. Prepare a feedback form (two sides of A4 maximum) for teachers to fill in, preferably before you leave the venue. Compare what people say the workshop was about with the learning objectives you identified, to see if they match.

Seek ways to **showcase** the project to maximise its benefits to your organisation and in order to share learning. It may be a good case study for other museums, or result in future collaborations.

**Further resources:**

See what the Science Museum's Outreach Team is up to at the moment:

[www.sciencemuseum.org.uk/outreach](http://www.sciencemuseum.org.uk/outreach)

Visit [www.anim8ed.org.uk](http://www.anim8ed.org.uk) to see the results of a schools outreach project involving the National Media Museum.

See a Teachers TV programme about Science Museum outreach sessions with KS3 children:

<http://www.teachers.tv/video/27087>

Find out what we've learned about developing science shows and workshops by reading other sheets in the *What we've learned* series:

- What we've learned about writing and performing science shows
- What we've learned about developing workshops

If you're a teacher, visit our training pages to see what opportunities for Continuing Professional Development we currently offer:

[http://www.sciencemuseum.org.uk/educators/whats\\_on\\_for\\_teachers/professional\\_development.asp](http://www.sciencemuseum.org.uk/educators/whats_on_for_teachers/professional_development.asp)  
[x](#)

See easy-to-copy science experiments by the Science Museum's science comedy troupe Punk Science in their book *Do Try This At Home* by Jon Milton.



### What we've learned about running discussion events

*Practical tips on running effective discussion events with adults and schools*

#### When you're planning the event content...

Choose a topic that is **controversial**, issues-based and which people really care about. Make sure it relates to the National Curriculum if you want to attract schools.

**Pilot** your activity on a small scale to see which discussion questions and angles get people talking best.

Come up with a short, attention-grabbing **title** – perhaps a powerful question or statement that embodies the topic – for marketing the event.

Invite a **range of speakers** to participate, representing a range of views and backgrounds. Brief speakers on the level of content as well as the length of their contribution (probably no more than ten minutes initially).

#### Setting up the event...

**Minimise noisy distractions** and keep the venue at a comfortable temperature. Make refreshments available if possible.

Set up the room so that participants can **see and hear** each other. Seek to minimise the 'them and us' feel between audience and speakers.

Arrange amplification for speakers and a roving microphone for audience questions (if appropriate).

#### During the event...

Make every effort to **welcome** the audience, smiling and personally greeting as many as possible to promote their sense of engagement and confidence.

**Set the tone** of the event using an effective facilitator who sets and implements ground rules for encouraging wide participation, and keeps speakers to time.

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**Kick off** the event with information-rich presentations – short films, quizzes, objects, comedy, demonstrations etc – to stimulate the debate.

Use a vote or other technique to gauge opinion before, during and after the event.

**Enable discussion**, perhaps starting in small groups and then joining together. Encourage dialogue using open questions. Seek to give all participants a sense that they are contributing to a worthwhile and meaningful debate.

**At the end...**

Offer a handout or other material that encourages the audience to **continue the debate**.

**Further resources:**

Come on a **Talk Science** training course for teachers interested in generating class discussions on contemporary science topics [www.talkscience.org.uk](http://www.talkscience.org.uk)

Contact Beth Hawkins ([beth.hawkins@sciencemuseum.org.uk](mailto:beth.hawkins@sciencemuseum.org.uk)) with any questions about the *Talk Science* project.

Find out more about running a discussion event in our Events DIY: [www.danacentre.org.uk/aboutus/eventdiy](http://www.danacentre.org.uk/aboutus/eventdiy)

Find out about how to evaluate a discussion event by reading another sheet in the *What we've learned* series:

- What we've learned about evaluating discussion events

Find out about free training in promoting dialogue through events with the UK Association for Science and Discovery Centres' Dialogue Academy [www.dialogueacademy.org.uk](http://www.dialogueacademy.org.uk)

### What we've learned about evaluating discussion events

*Practical tips on evaluating discussion events aimed at adults, gained through our experience with running the Dana Centre, our adults-only café and events space.*

#### When you're planning the event...

Seek to promote successful dialogue by aiming to ensure that speakers and participants feel:

- **physically comfortable** and can see and hear adequately
- **emotionally comfortable**, with a sense they belong at the event
- that their **intellect is respected**, their **contribution valued** and they have **learned something**
- that the event generates **social capital** by being worthwhile and constructive.

Select a topic that has **controversial angles**, and then research up to five themes to tackle during the event. To get an insight into attitudes towards the topic, consider running a focus group – a structured discussion with 8-10 potential audience members. Then agree the **aims and objectives** for the event and invite a balance of speakers to contribute, plus a chairperson.

#### To gauge whether the event is a success...

Depending on the resources available, you could **observe** the event, and/or **conduct a survey**.

Observation is a simple but valuable tool. Use an observation sheet to note:

- whether all can see and hear, how many stay to the end or beyond
- discussion length, how much the chair has to intervene and why
- discussion quality – does the debate move forward?
- whether all participate, do people take sides, is anyone losing interest
- level of emotional engagement throughout, and how people seem at the end.

There are many options for conducting a survey, including:

- self-completion paper questionnaires are quick and cheap but you have no control over the sample, and tend to hear predominantly from dissatisfied customers
- interviews face-to-face or on the phone are time-consuming but you can choose a representative sample of people, and probe for more detailed answers
- postal questionnaires can be effective but you may need to send follow-up letters to reach a return rate of 60% at which the data is considered reliable

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- email questionnaires can be effective especially if sent out on Fridays, as people answer them at work
- web pop-up surveys tend to get a low response rate but may sometimes be the only way.

You can **interview the speakers** to see how they felt about the event.

A focus group conducted after the event gives a rich insight into audience members' reactions, but will not yield data from which numerical conclusions can be drawn.

### To make future events even better...

Compare your survey or observation results with the original aims and objectives, and report back to the team the positives and negatives for constructive future planning.

### Further resources:

Find out about how to run a discussion event by reading another sheet in the *What we've learned* series:

- What we've learned about running discussion events

Read more about the indicators that dialogue is taking place in an event and afterwards:

[www.danacentre.org.uk/documents/pdf/questionnaire\\_recipe\\_book.pdf](http://www.danacentre.org.uk/documents/pdf/questionnaire_recipe_book.pdf)

See a planning guide for a discussion event:

[www.danacentre.org.uk/aboutus/eventdiy/planning\\_guidelines](http://www.danacentre.org.uk/aboutus/eventdiy/planning_guidelines)

Find out how to run a focus group:

[www.danacentre.org.uk/aboutus/eventdiy/focus\\_groups](http://www.danacentre.org.uk/aboutus/eventdiy/focus_groups)

Read more about how to observe an event:

[www.danacentre.org.uk/aboutus/eventdiy/observing](http://www.danacentre.org.uk/aboutus/eventdiy/observing)

See a sample audience questionnaire: [www.danacentre.org.uk/aboutus/eventdiy/audience-questionnaires](http://www.danacentre.org.uk/aboutus/eventdiy/audience-questionnaires)

See a sample interview with speakers:

[www.danacentre.org.uk/aboutus/eventdiy/speaker\\_interviews](http://www.danacentre.org.uk/aboutus/eventdiy/speaker_interviews)

Read a paper on how to write good questionnaires:

[www.danacentre.org.uk/documents/pdf/questionnaire\\_recipe\\_book.pdf](http://www.danacentre.org.uk/documents/pdf/questionnaire_recipe_book.pdf)

## Appendix D - Interview Script

We are students from Worcester Polytechnic Institute conducting research on the use of objects in museum outreach programs. With your permission, we may use your responses in an academic paper. Any contribution you make will be cited accordingly.

### Identifying Objects

What are the gaps in the collection as it stands? What objects would fill those gaps?

What was this object used for?

When was the object in use?

What advances in technology led to this object's invention and what advances led to its retirement?

Why is this object important? What technological gap did the object fill?

What engineering principles does this object demonstrate?

How might an engineering ambassador connect this object to students' lives?

What are difficult concepts to convey to students?

What objects would make difficult concepts easier to convey to students?

Are any objects in this collection less helpful in demonstrating engineering concepts?

### Storing Objects

How do you organize objects in multiple locations?

How are objects identified in the system?

How does the museum keep track of objects lent out?

### Cataloging Objects

How does the museum catalog its items?

What is the basis for organizations of items in catalog (chronological, material, use)?

What type of system is used (records, online database)?

What type of information is relevant to include on the site for each item?

How did you find the required information for each object?

How do you maintain the catalog?

### **Object-based Programming**

How long has the program been running?

Why was it started?

Has the program been evaluated? What has been learned from evaluations?

How is the program evaluated?

How has the program changed based on feedback and evaluations?

How are staff members trained in the use of objects?

What works well or needs improvement in the current training?

What do staff members expect to have gained after completing a training session?

What planning goes into a school visit?

How can you ensure a class is both excited and educated by a visit?

## Appendix E - Fact Sheets

### Wiring Cables Fact Sheet

**Category:** Signalling: S-01, S02.1-2.9, S18.1-18.2

**Introduction:**

S01 – This is basic piece of wire that can be used in comparison with the other cables in terms of size and amount of insulation.

S02 - These are pieces of trackside cable that carry signals into other parts of the railway system. They also deliver current to the power rail of the train tracks. The red curly cables are known as 'pigs tails', and are used to reduce vibration into the equipment.

S18- These are jointed signalling cables. The conductors carry a current that signals components on the rail.

**Photographs:**



All cables



S 02.1



S 01



S18.2

**Detailed description:**

The pig tails have much more insulation than the small wire. This is because the small wire is used in a covered/protected area and is not exposed to the elements. The trackside cable,

however, is in the open and could be exposed to more extreme conditions. To protect from signal loss due to heat, cold, or exposure to moisture, a thicker insulating layer is used around the wires.

The small wire is known as stranded wire. Instead of having one solid piece of wire inside the insulator, there are multiple smaller wires. This particular wire has seven strands, which is the smallest amount of wires in a stranded wire. Other wires can have up to a hundred separate wires inside the insulation. These multiple wires give the wire much more durability than a single wire, which is more prone to breaking when it is bent or twisted.

The largest cables, S18.1-.2 are jointed signalling cables. Looking at the cross section, the actual conductors inside are relatively small. The majority of the cable is made up of insulation. This helps prevent faulty signalling.

**Additional Notes:**

Ask students what they see that is different between the cables. Notice that the pig tails have copper connectors on them while the small wire does not. When implemented in a system, the small wire would either have small connectors on the end or be soldered, which is the process of joining metals by melting another metal in between them. The sizes of the basic wire and the jointed signalling cable can also be compared so students can see the varying different sizes needed to run the tube.



## Wooden Key Fact Sheet

**Category:** Track: T-15

### Introduction:

This wooden block was once used as a method of securing tracks to the sleepers of the rails. Because they were essentially blocks of wood, it was not very technologically advanced, and they have since been replaced with more secure metal fittings.

### Photographs:



Wooden Key



Wooden Key on track

### Detailed Description:

The wooden key is roughly rectangular blocks made of hardwood. The function of the key is to hold in place the rail that supports the weight of the train. The block, which has rounded edges, is wedged between the rail itself and the chair, which is the metal piece that connects to the sleeper to the rail.

### Additional Notes:

The wooden block was a relatively primitive way to hold the rail stable. The Pandrol clip and metal springs, as shown below, are improved methods that have replaced the wooden key. Over time, the wood needed to be replaced more frequently than the modern metal fasteners. This item can be shown with the Pandrol clip. Students may be surprised to learn that these two objects, which look very different, are designed for the same purpose.



Steel Spring Fastener

## Air Hose and Fitting Fact Sheet

**Category:** Track: T-10

### Introduction:

Air hoses are used for the signalling of trains, and currently being replaced by electrical signalling systems.

### Photographs:



Air Hose and Fitting

Air Hose and Fitting in situ

### Detailed description:

This hose can be used on various types of air operated signalling kits, but primarily point machines. A point machine switches the direction of the track, and this can be powered by the air hose. Over time, this object can be subject to degradation due to sunlight and extreme weather conditions, which could cause a signal failure. Air is very good at delivering power and its effect is almost instantaneous.

### Additional Notes:

The students could be asked what they think the object might have been used for, and what they think went through the hose.

The pressure aspect of the hose could also be talked about in comparison with its thickness. It could be compared to a balloon, in the sense where there is pressure pushing outward in all directions, and if there is too much the balloon walls will pop because they are so thin. Therefore, the walls of this air hose need to be so thick so it will not burst due to the high pressure.

## Bicycle Chain Fact Sheet

**Category:** Bicycles: B-07

### **Introduction:**

Bicycle Chains propel the cycle by transferring the power from pedalling to the wheels. The bike chain is made up of many links and rests on the gears of the chain ring.

### **Photographs:**



Bicycle Chain



Chain on Bicycle

### **Detailed description:**

As the chain ring is rotated by the pedalling of the cyclist, the chain is turned, which provides the power to the wheels, thus moving the bike forward. The concept of the bike chain was first developed in the 16<sup>th</sup> century, but was not carried out because the remaining technology was not available yet. The chain must be lubricated to ensure that it will not stick to the surface of the chain ring.

### **Additional Notes:**

This object can be shown with the chain ring and other bicycle components to demonstrate its use and relative placement.

## Cab Phone Fact Sheet

**Category:** Track: T-21

**Introduction:**

This phone was used by the driver of the train on the underground. The phone can be used to make announcements to the passengers on the train and also calls to the station.

**Photographs:**



Cab Phone

**Detailed description:**

This phone was located in the front cab of the trains and could make two different types of calls. By holding down the black button, the driver could make announcements to the passengers on board through the speakers. It could also be used as a regular phone to make calls to the station. Today these phones are no longer in use. The driver can do all announcements and communicate with the station through a speaker system in the front cab.

**Additional Notes:**

The driver also has a computer system with automated announcements that will play throughout the train when selected. This demonstrates how technology has developed to a more computerized system.

## Camera Card Fact Sheet

Category: Electrical: E-03

### Introduction:

This is the memory card from an old camera. It holds 32MB worth of data, which at the time might have been a few hundred pictures.

### Photographs:



Canon camera card

### Detailed description:

While 32MB seemed like a lot of memory at the time of this card's production, it now would only be able to fit less than a dozen photos on it. This is because cameras have become more technologically advanced and can take more detailed photographs, causing each picture to have a larger file size. Camera cards today are now more compact and have much more space, 8GB and 16GB cards are now common, which is 250 and 500 times more space, respectively.

### Additional Notes:

This object can be used to explain the prefixes 'mega' and 'giga', can also show that computer hard drives now can hold terabytes of information.

## Capacitor Fact Sheet

**Category:** Electrical: E-07, E-08

**Introduction:**

Capacitors are used to store charge in electrical devices.

**Photographs:**



Capacitors

**Detailed description:**

The (left) pale green capacitor is a 40 $\mu$ F paper capacitor encased in a metal shell from circa 1950. It has a rated value of 150 V DC. The (right) silver-coloured capacitor has unknown ratings, but is enclosed in a metal shell and sealed with an insulated plastic/glue mixture at the bottom.

**How capacitors work:** Capacitors contain two conductive plates separated by some non-conductive material (ceramic, mica, air) called the dielectric. Electrons flow from a power source to one plate (the plate connected to the negative side of the power source), and the other side of the plate loses electrons to the positive side of the power source. Charge will store between the plates of the capacitor, and the potential voltage across the capacitor will become equal (in voltage) to the power source across it. When the power source is disconnected, the capacitor itself can become a power source and will discharge the stored energy until empty.

**Additional Notes:**

If the rated value of a capacitor is exceeded, the capacitor will often explode, as shown in the picture below. A possible activity would be to bring in a low rated capacitor and blow it for students to see.



(Wikipedia.org)

**Anonymous story:** A man and a few of his friends worked with electrical equipment for U.S.A.F. A friend decided to charge a capacitor and leave it in the man's pocket. Later that day, someone tried to pickpocket the man, only to get shocked by the capacitor as his fingers made a connection across the terminals, thus providing a path for the capacitor to discharge across his fingers.

## Chinese Hat Fact Sheet

**Category:** Signals: S-03

### Introduction:

This object is designed to keep debris away from cables in the signal control room in order to prevent signal failures.

### Photographs:



Chinese Hat



Chinese Hat on cable

### Detailed description:

Much like the name suggests, this object is shaped like a Chinese hat. It is made out of a metal thread surrounded by a plastic mould to prevent conduction. The wide base of the hat is screwed onto cables in the signal control room in order to keep debris from falling on it and interfering with the signals or causing failures.

### Additional Notes:

This object can be shown with the trackside connection cable. It can be screwed into place and then the students can be asked what they think the object does based upon the name and what they can see.



## Composite Conductor Rail Fact Sheet

**Category:** Track: T-06

**Introduction:**

This is a cross section of railway track – the darker grey part is made out of stainless steel, while the rest is aluminium.

**Photographs:**



Composite Conductor Rail

**Detailed description:**

Railway track needs to be wear resistant so that it can be in use for a long period of time. Because the track needs to be able to pass an electrical current through it, a conductive material is also required for the track. Tracks used to be made of stainless steel, but it is not highly conductive. TfL is also aiming to reduce their carbon footprint, so they wanted to use a more conductive material to avoid large power losses. While aluminium is highly conductive, it is relatively soft and therefore not wear resistant. In order to find a way around this, tracks were created out of aluminium with a stainless steel cap. When this piece wears down, they can be easily replaced with a new piece of stainless instead of replacing the whole track.

**Additional Notes:**

Ask students what they notice about the piece before you explain that there are two different types of metal. Then ask for reasons why, and guide them to the correct solution. This can be really helpful in keeping the students engaged in the object. The rails that support the weight of the train are made out of stainless steel so they are strong enough to support the train.

This could be shown with the T piece to show how the T piece separates bits of rail.

## Compressor Piston Fact Sheet

**Category:** Trains: T-09

### **Introduction:**

Compressed air is the driving force behind the braking system of most trains. The air is compressed by a piston in a cylinder and the high-pressure air powers the brake cylinder.

### **Photographs:**



Piston

### **Detailed description:**

This piston fell off of a train operating on the Piccadilly Line. The piston is cast from an aluminium alloy because it is lightweight, and was used to power the braking system of the train. The air that is compressed by a piston in the air compressor flows through hoses to the braking cylinders. The flow of air is controlled by valves. The compressed air pushed on another piston in the braking system and activates a mechanical linkage that presses a brake shoe to the wheel. The friction between the brake shoe and the wheel stops the train.

### **Additional Notes:**

This piston is from a train from the Piccadilly Line but can be compared to those from other sources that the students would know of. Pistons are used in air compressors as well as engines. Things like the sizes and weights can be compared to give the students a better understanding.

It can also be discussed that this piston fell off of the train onto the track, causing the front of the train to stop, and the back end to lift up off of the track.

## Concrete Core Fact Sheet

**Category:** Civil: Co1

### **Introduction:**

This concrete core is a sample from the Hammersmith flyover. Core sampling is used to test the strength of concrete.

### **Photographs:**



Concrete Core



Hammersmith Flyover

### **Detailed description:**

Cores samples are taken from concrete using core drilling machines that cut using industrial diamond. The samples taken are then examined to determine the strength of the material. The concrete in the structure must be strong enough to withstand the load due to all the vehicles. A strong concrete sample will have a uniform mixture between the large and small components. There will also be few small air bubbles and no large ones.

### **Additional Notes:**

This is a good object to start a discussion about different materials and their properties. The students may be interested in the various types of materials that can be seen in the core sample. They can also see the number of air bubbles and a discussion can be had based upon those observations to determine if the sample is good. Students can also discuss the relative hardness of different materials and why diamond is needed to cut concrete. Additionally, students can discuss weights and densities of materials, since concrete is used in bridges because it is lighter than the asphalt that is used to make roads.

## Contacts Fact Sheet

**Category:** Signals: S-08.1, S-08.2, S-09, S-10

**Introduction:**

Contacts bridge the gap between two sources, much like a wire.

**Photographs:**



Contacts

**Detailed description:**

Contacts are made of conductive metals. They work to connect different sources and carry a current in order to relay a signal. When the connection is open, the current does not flow through and the signal is off. When the contact is closed, and the two metals are touching, the current is able to flow through and the signal is turned on. S-08.1 and S-08.2 most likely broke off of some type of relay.

**Additional Notes:**

Can compare the different contacts to each other, and talk about possible uses for each of them.

Additionally, students can look closely at S-09 and S-10 and see a dark red-brown substance on the places of contact. This is chrome oxide, a type of rust. Signal cannot travel across this corrosion, so these parts were replaced.

## Darlington Transistor Fact Sheet

**Category:** Signals: S-11

### **Introduction:**

A Darlington transistor is a power switch, the electrical version of a mechanical switch.

### **Photographs:**



### **Detailed description:**

When a current goes through the Darlington pair, the switch is activated and current is allowed through to the rest of the circuit. This pair of transistors also amplifies the current going into the switch, making it much larger on the output side of the switch. This device helps to control and regulate the amount of power going into another part of the circuit.

### **Additional Notes:**

You can compare this item to something like a megaphone, you can switch it on and when sound goes in one end, it comes out much louder on the other end. This switch has the capability of choosing which 'volume' of power comes out of the output.

## Door Pads Fact Sheet

**Category:** Track: T-17.1, T17.2

### **Introduction:**

The door pads are located on the edge of the doors, and create a seal when the doors close.

### **Photographs:**



Door Pads



Door Pads in situ

### **Detailed description:**

The pads are made of rubber and are shaped to fit into one another. When the doors close a seal is made between the pads, blocking anything from getting in or out of the doors.

### **Additional Notes:**

At one point in time, a bunny got caught in between the doors, and because the door pads were hollow, the rubber conformed around the bunny and the train kept going. Because of this incident, there is now a wood insert placed in the pads so if something is caught in the doors they will not fully shut and the train will not be able to go on.

## Emergency Button Fact Sheet

**Category:** Track: T-20

**Introduction:**

This button was used to make emergency stops on the tube.

**Photographs:**



Emergency Button

**Detailed description:**

This button would have been located somewhere in the cab of a train. A key was needed to reset the button before it could be pushed again. By pushing the button, a connection is made between the point on the bottom of the object, and this contact signals the stop.

**Additional Notes:**

This can be shown with some of the electrical contacts to better explain the connections being made within the object.

## Conducting Fish Plates Fact Sheet

**Category:** Track: T-22, T-23

**Introduction:**

These plates join rails together, with the thinner copper piece being significantly more conductive than the thicker aluminium plate.

**Photographs:**



Conducting fish plates – Copper is top, aluminium bottom.

**Detailed description:**

Each of the plates is supposed to have four holes that line up when the plates are put on top of each other, and are secured together with bolts. The large fish plate is defective because it only has three holes, and they are misaligned.

**Additional Notes:**

Ask students why the parts might be defective, or why they don't work together.



## Front Basket Fact Sheet

**Category:** Bicycles: B-03

**Introduction:**

This basket is on the front of Barclays Cycles, which can be seen all across London.

**Photographs:**



Front End Basket



Basket on bicycle

**Detailed description:**

The basket of the Barclays Cycles (Boris Bikes) is mounted on the front of the cycle and is open at the sides. An elastic band keeps the riders possessions securely in the hand basket. A metal screen front plate is mounted onto the front of this frame to keep items from sliding out between the bars. The basket is made out of an aluminium alloy, which provides a lightweight, but yet strong frame.

**Additional Notes:**

Students may be surprised about how lightweight this object actually is. The metal makes it seem like the basket would be heavy, but because of the aluminium alloy, it can be picked up and passed around with ease. Aluminium is an important material in many types of transport engineering, from bikes to train to airplanes.

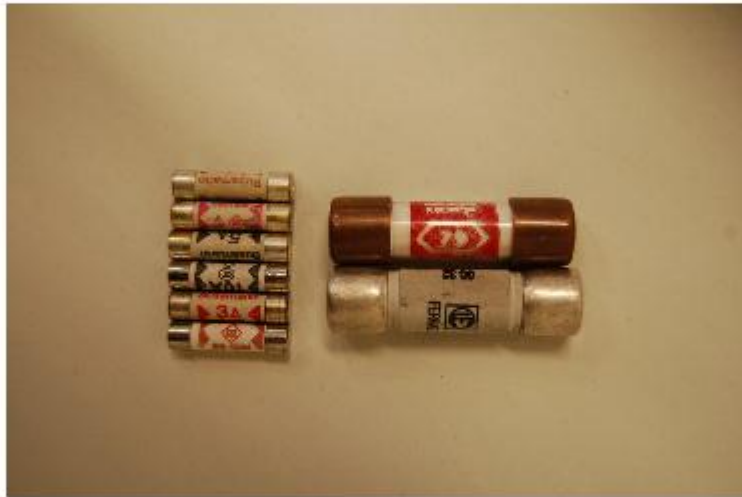
## Fuses Fact Sheet

**Category:** Electrical: E-11.1-E11.9

### **Introduction:**

Fuses are a type of low value resistor that protects from overcurrent in a circuit. When too much current flows, a metal strip on the inside melts which stops the fuse from working and breaks the circuit, protecting the rest of it from this overcurrent. Without a fuse, overheating and possibly fires can occur in circuits.

### **Photographs:**



Various fuses

### **Detailed description:**

Smaller fuses are used for domestic purposes, while larger fuses are used in various signalling circuits of London's transportation. These signalling circuits require much more voltage to function, which means that they need to be able to handle higher current levels. To manage these high current levels, larger pieces of metal are needed within the fuse.

### **Additional Notes:**

Easy way to explain how fuses work: People going over a bridge represents the current, when more people are on the bridge than it can handle, the bridge breaks, and no more people can cross the bridge.

## Hard Disc Drive (HDD) Fact Sheet

**Category:** Electrical: E-12

### **Introduction:**

Hard drives are used to store information in computers. Computers now control most aspects of transport: the interpretation of signals, the detection of oncoming trains, the speed, and much more. Computers are inside trains, busses, cars, stations, and control rooms.

### **Photographs:**



Hard Disc Drive

### **Detailed description:**

A hard disc drive (HDD) uses magnetic recording similar to old cassette tapes to store information on rotating disks. Magnetic heads are arranged on a moving arm to read and write the data to the surface of the disk in a random-access manner. This means that the data can be written and read in any order, rather than sequentially.

This hard drive is a Caviar 22100 was made in Singapore in 1996 and can hold 2.1 Gigabytes (GB) of data for a desktop computer.

### **Additional Notes:**

In 1996, 2GB was the average size of a computer hard drive. A 2GB could hold about 360 mp3 tracks.

In 2006, the average size of a hard drive was 320GB. This could hold about 57,600 mp3 tracks.

In 2013, the average size is about 1TB (1000 GB) for desktop computers. This could hold about 180,000 mp3 tracks.

## Hawkbox Tuning Unit Component Fact Sheet

**Category:** Signals: S-17

### **Introduction:**

This object is part of the hawkbox tuning unit, which sets up signals that tell the train to stop, go, slow down, etc.

### **Photographs:**



Hawkbox Component



Hawkbox Tuning Unit

### **Detailed description:**

This unit is used to set a coded frequency that is then sent to the train. The equipment of the train reads this signal as it passes over that section of track and is signalled to brake, slow down, speed up or other variations. This particular tuning unit is from either the Victoria or Bakerloo lines.

### **Additional Notes:**

This might be a hard concept for students to understand. Try comparing it to a traffic signal or a walk signal for a pedestrian.

Another option might be to talk about an automatic door. When a person approaches the door and stands in front of it, the door is signalled to open (go) or close (stop).

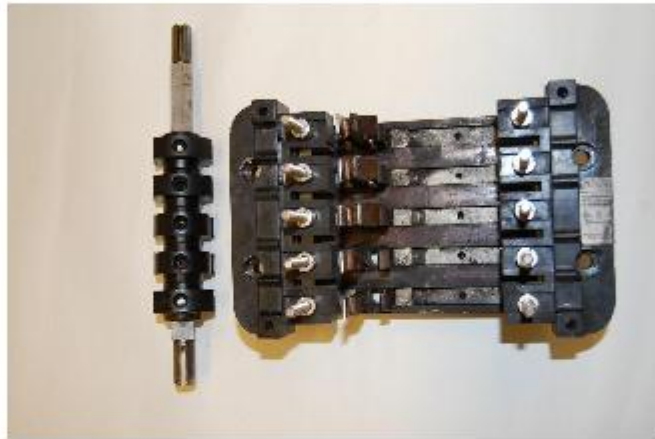
## Indication Contact Arrangement Fact Sheet

**Category:** Signals: S-13, S-14

### **Introduction:**

This object is a dismantled part of a train stop, which applies the brakes on a train if it misses a signal.

### **Photographs:**



Indicator Contact Arrangement

### **Detailed description:**

This object is from a HO type train stop. It functions to apply the brakes on the train if the train goes past a danger signal leading to SPAD (Signal Passed At Danger). When the danger signal is passed, the train stop triggers the trip arm to be raised, which is the stop position. On the train there is a trip cock, which will come into contact with a raised trip arm and stop the train.

### **Additional Notes:**

This might be a hard object to explain, but it could be comparable to a safety belt in a car. If you pull on a safety belt it will lock and stop itself. Similarly, the trip arm will catch the trip cock on the train and stop it from going any further.

## Indicator Push Rods Fact Sheet

**Category:** Signals: S-05.1, S-05.2

### Introduction:

These indicator push rods are from a M63 point machine, and are used to create a contact to signal the position of the track at the switch.

### Photographs:



Indicator Push Rods



Push rods in point machine

### Detailed description:

Indicator push rods are a component of a M63 point machine. The M63 point machine was developed in 1963 and is used to change the direction of travel of the train by switching the rails. There is an arm on the machine that is moved when the rail is switched. This arm pushes in the indicator push rod into the machine, which creates a contact that signals that the rail has been switched.

### Additional Notes:

The red rod is more effective because it has a smaller surface area. The grey one worked well to signal, but kept getting stuck so the signal would be kept permanently in the on position.

This object could be shown with the short key, as they are both used in point machines.

## Inner Tube Fact Sheet

**Category:** Bicycles: B-04

### Introduction:

The inflated inner tube is inside of the tyre of the bicycle and maintains air pressure. It is made out of rubber in order to reduce air leakage and is non-porous.

### Photographs:



Inner Tube



Barclays Bicycles

### Detailed description:

The inner tube has two main components, the rubber tubing and the valve. The rubber tubing is inflated to a certain pressure to keep the tyre hard. The valves come in two main varieties, Presta and Schrader. Presta valves are thinner and most commonly used by road bikers. They have a top part that needs to be unscrewed, and then a pin that needs to be pushed for deflation. Schrader valves are more commonly used for mountain bikes, and there is no top portion to be unscrewed, but rather a pin needs to be inserted to deflate the tube.

### Additional Notes:

This item can be shown along with the rest of the bicycle components, especially with the rear hub.

Rubber was chosen for the inner tube because it holds air, it is flexible, and it is strong enough to withstand the pressure from the air inside it and the wear of use on a tyre.

Students can talk about how having a tyre with a big circumference is necessary with a bike because one revolution of the wheel will result in a longer distance travelled.

## Left Hand-Crank and Chain Ring Fact Sheet

**Category:** Bicycles: B-04

**Introduction:**

This object transfers the motion of the rider's pedalling to the bicycle chain. The object is made up of a pedal connecting to the chain ring.

**Photographs:**



Left-Crank and Chain Ring



Bicycle Crank and Chain Ring

**Detailed description:**

This object consists of a pedal connected to a chain ring by an aluminium alloy frame. The crank is connected to the bike at the centre of the chain ring. As the cyclist pedals, the rotational motion is transferred to the chain ring, upon which the chain of the bicycle rests. The teeth on the chain ring are meant to connect with the links of the chain, and thus transfer the power to the wheel as the chain moves.

**Additional Notes:**

This object can be shown along with the bicycle chain and the rest of the bicycle collection.



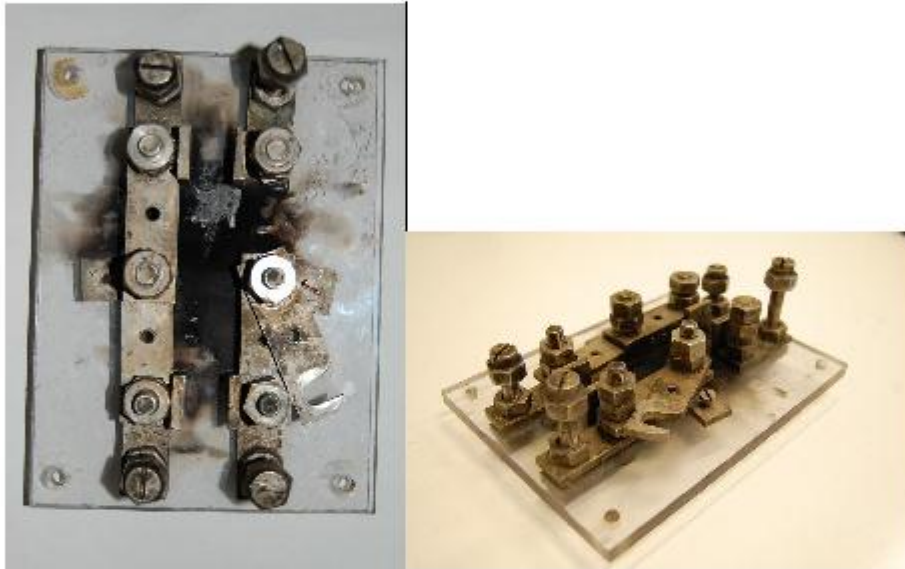
## Link Box Fact Sheet

**Category:** Signals: S-12

### **Introduction:**

This device can be found in a box along the tracks. It's used to feed electricity to other devices.

### **Photographs:**



Link Box

### **Detailed description:**

This is a piece of a link box. A cable can be fed from the track to the box, and back out again on either side. Cables can be connected to the middle three joints of each row to feed off to other devices that may need power. The bottom glass is made of a carbon material, and the top links a conductive metal.

### **Additional Notes:**

There's black scorch marks on the middle of the device where it "exploded". While raining, water leaked into the casing of the link box and onto this device, and created a bridge between the two rows of contacts. The carbon bottom, which can be conductive, helped produce a pathway for electricity to flow between the two rows. This caused a short circuit between the two rows resulting in sparks between them.

## Maglock Fact Sheet

**Category:** Track: T-18

**Introduction:**

This lock was used for doors in the underground and functions to lock and unlock doors using electromagnetism. Maglock is short for "magnetic lock."

**Photograph:**



Maglock

**Detailed description:**

The maglock functions as a lock using electromagnetism, which locks the doors when the maglock is energized, and releases it when there is no current. The electromagnet essentially creates an attraction force so strong that the doors cannot be separated, thus locking them together. Maglocks are advantageous because of the quick locking mechanism, with an immediate release when the power is cut. Also, minimal maintenance is required since there are no moving parts to this component.

**Additional Notes:**

This particular maglock is defective because of a faulty close reading.

This can be shown with the other components of the door such as the spring door arm and the door pads. This object can be compared to the magnets used inside a refrigerator door that keep the door shut. The magnets in refrigerators, which aren't electromagnets, are much weaker than the magnets used on train doors, but they serve a similar purpose.

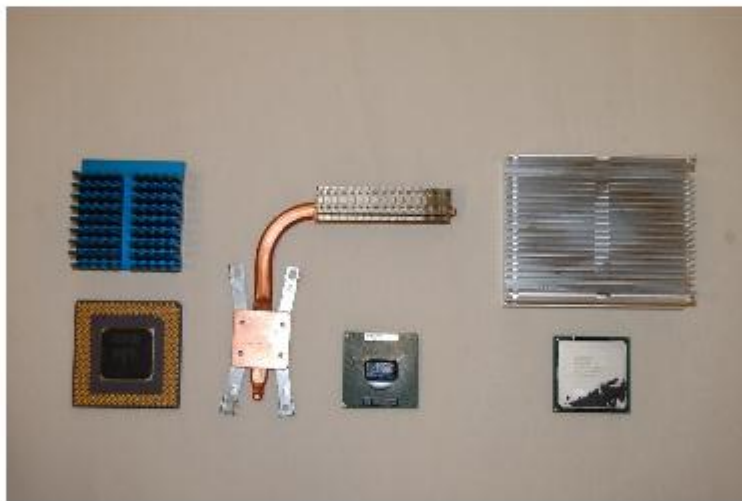
## Microprocessors / Heat Sinks Fact Sheet

**Category:** Electrical: E-01-E-06

### **Introduction:**

Microprocessors are chips consisting of millions of transistors and capacitors that act as the 'brain' of a computing system. We unknowingly are affected by millions of microprocessors every day, as they are in almost every advanced electronic system. Because microprocessors have the tendency to heat up, heat sinks are used to help disperse this heat away from the chip so that they don't overheat and become damaged. Heat sinks are made out of highly conductive metals such as a mix of aluminium and copper, or silver (though those are more expensive). They have a number of metal ridges that increase the surface area of the metal that is in contact with the air, which cools the device faster.

### **Photograph:**



Microprocessors and corresponding Heat Sinks

### **Detailed description:**

Grey microprocessor / blue heat sink: Developed in 1996, ran at 120MHz, from a desktop computer. The cost of this microprocessor at the time was around £1500, while chips today are much faster and cheaper. However, it is important that these chips remain functional for a long period of time because there are still many implemented in today's transport systems. It takes a while to build and implement a complicated transportation system, and by the time it was completed the technology within these chips was already obsolete,

however it is too expensive and time consuming to change all of these chips when the old ones are still functional.

**Thick green chip / grey heat sink:** This is a third generation Pentium processor from around '04. This object comes from a desktop computer.

**Thin green chip/ bent heat sink:** This is from a laptop around '08. Chips is located within the central part of the computer, the heat has to travel farther to get out of the device. This configuration uses a copper strip to conduct the heat across it and then through the heat sink to the outside of the laptop.

**Additional Notes:**

These items are present in many parts of London's transportation system. One important use of microprocessors is within the many signalling systems of the underground. Microprocessors send out the information that allows other parts of the system to know whether or not a train is present at a platform or when another train is coming. Smaller, more advanced microchips are used in Oyster cards to keep track of how far you've travelled and what fees have been paid.

When presenting with these objects, you can ask the students what the objects might be or where they might be used.

Ask which heat sink they think goes with which chip.

## Pandrol Clip Fact Sheet

**Category:** Track: T-02, T16

### **Introduction:**

Pandrol Clips fasten the rails to the sleepers and holds the rail in place. The biscuit sits between the Pandrol Clip and the rail to provide electrical insulation.

### **Photographs:**



Pandrol Clip



Biscuit



Pandrol Clip in use

### **Detailed description:**

The Pandrol Clip is made by the company Pandrol who first started manufacturing rail fastenings in 1937. This steel clip is meant to hold the rails to the sleepers and this particular model is called the "e-clip." One challenge this design addresses is the vibration of the rail as the train passes over it. The advantages of this model include a long service life, few components, a high level of safety and security, and it is also virtually maintenance free.

The biscuit is relatively new, and not used on older rail lines. The biscuit sits between the rail and Pandrol Clip, so that the metal of the Pandrol Clip doesn't touch the metal of the rail.

**Additional Notes:**

This object can be shown with the other track components. It also appears and functions similarly to a paperclip, so this may be helpful in explaining the object to student.

## Post Tensioning Cable Fact Sheet

**Category:** Civil: Co2

### **Introduction:**

This reinforcing cable was taken from the Hammersmith Flyover. It has a steel core surrounded by a rubber shell, and is used to provide structural support to the bridge. It was one of the new types of cables implemented in the bridge after repairs done in 2011.

### **Photograph:**



Post Tensioning Cable

### **Detailed description:**

This cable has a steel core surrounded by a rubber shell. The cable is held in tubes which run down the central reserve both internally and externally. This means that the cable can move freely which allows for the ability to adjust the cables if needed and de-stress the tendons before doing repair work. Each steel tendon is coated with grease so it can easily move. This new system was put into place after the emergency closure of the Hammersmith Flyover in 2011.

### **Additional Notes:**

This object can be talked about with the concrete core sample from the Hammersmith Flyover. The story of repairs to the Hammersmith Flyover can also be told to the students to give them more of a background. The bridge was built in the early 1960's from reinforced concrete. The bridge was originally heated, but when that system was no longer used, the bridge was salted to prevent ice in the winter months. This salt corroded the structure and the bridge had to be repaired in 2011.

## Pressure Switch Fact Sheet

**Category:** Track: T-11, T-12

### **Introduction:**

Pressure switches are used to detect changing air pressure to make electrical switches.

### **Photographs:**



Pressure Switch

### **Detailed description:**

The (left) black pressure switch is an older (60's/70's) pressure switch used in the Piccadilly line to open and close doors. The (right) blue and red pressure switch is a newer pressure switch also used in the Piccadilly line from circa 2004. The blue shaft is for falling pressure, and the red shaft is for rising pressure. Air compression is useful for the opening/closing of doors because it is less prone to break, cheaper, and faster than mechanical doors.

### **Additional Notes:**

The black device can be opened by pulling the front plate off. Show students the inside of it to show how complicated the switches were compared to the newer one.

Air pressure is also used to power the braking system of train for similar reasons: fewer moving parts mean less maintenance over time.



## Rail Fastenings Fact Sheet

**Category:** Track: T-01, T-13, T-14

### Introduction:

The screw spike is used to connect track components to the wooden sleepers. Nuts and bolts are used throughout the railway system as a means of fastening objects together. Washers are placed between the bolt and the component that it is attached to in order to disperse the load that is being placed on the object, making the components more durable and less susceptible to failure.

### Photographs:



Screw Spike



Nut and bolt



Nut and bolt in situ



Washer

**Detailed description:**

The modern screw spike has been adapted from several past models of rail spikes. The earliest spikes looked like large nails and were once hammered by hand into wooden rails, in the earlier years of the railroad. Screw spikes are more common today, and although they are more expensive to manufacture, they have double the fixing power than that of a traditional rail spike. The nut and bolt are oppositely threaded in order to attach them. When tightened together, it compresses the objects that are being held together, and outward forces act on the nut and bolt, holding them together securely. Over time they might loosen slightly, and regular maintenance is required to assure that they remain tight to avoid any accidents. The outward forces that act on the nut and bolt are dispersed more evenly by the presence of large washers.

**Additional Information:**

The different fastenings can be compared to the "normal" sized versions of the object that students may be familiar with such as the screw spike compared to an average screw.



Screw spike and average screw

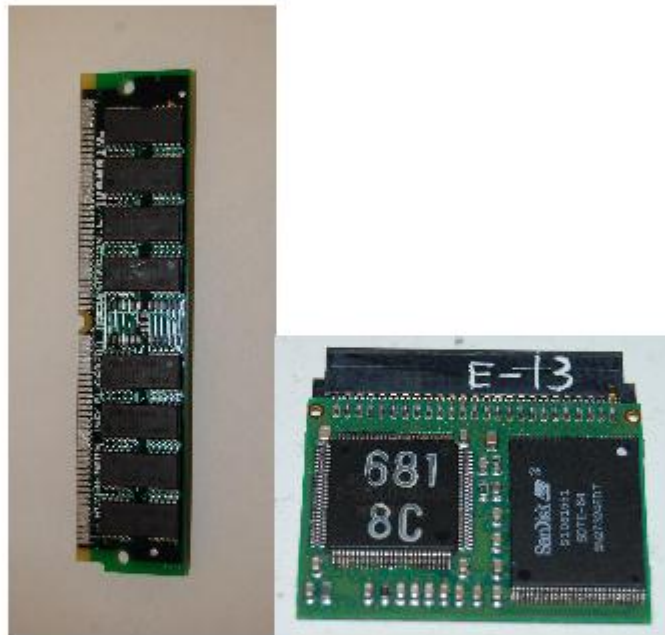
## Random Access Memory (RAM) Fact Sheet

**Category:** Electrical: E-10, E13

### **Introduction:**

RAM is used as memory storage for running programs on a computer. More RAM means that more programs are able to run at the same time, and faster.

### **Photographs:**



(left) RAM for Desktop Computer; (right) Internal RAM for small devices (like phones)

### **Detailed description:**

Prior to 2002, Single Data Rate (SDR) RAM was used in most computers. In the most basic sense, computers run on clock cycles. SDR RAM reads data on only one part of the cycle (either rise or fall). The next generation of this is Double Data Rate (DDR), which reads data on both the rise and fall of the clock cycle, making DDR twice as fast as SDR. DDR was replaced by DDR2 and now DDR3, which run much faster than DDR. As of 2013, DDR3 is used in most new computers.

This particular stick of RAM is 8MB (Less than  $1/10^{\text{th}}$  of a GB) DDR from a computer in the early 90's.

## Rear Hub Fact Sheet

**Category:** Bicycle: B-o8

### Introduction:

The rear hub is the centre part of the back wheel, to which the spokes are attached. It also includes the hub gear and the hub brake.

### Photographs:



Rear Hub



Rear Hub on bicycle

### Detailed description:

The rear hub is the central part of the back wheel. The holes in the two outer wheels are meant for the spokes of the wheels to attach to. The gears and brake rest on the teeth of the main hub and allow for the rider to propel by pedalling. The braking mechanism is powered by the brake lever on the handle bars of the bike. It works to stop the chain from moving which in turn stops the wheel.

### Additional Notes:

This can be shown with other items from the bikes. It can also be demonstrated that the hub allows for rotation in one direction, but not in the other. The students can both hear this (with the clicking of the gears in the correct direction) and also feel this difference by turning the hub themselves.

## Rebar Fact Sheet

**Category:** Civil: C-03, C-04, C-05

### Introduction:

These rods of metal are rebar, which is short for reinforcing bar, from Kings Gate House. They are made out of steel and line the inside of concrete structures to give them more support. The yellow piece of plastic on the end of the larger bar is a mushroom cap, which protects from sharp edges. The foam piece is a formwork reinforcing spacer.

### Photographs:



Rebars, mushroom cap & spacer



Rebars and caps on site

### Detailed description:

The ridges that line the bar are in place so that there is more of a mechanical connection between the steel and the concrete. The thinner piece of rebar would be placed vertically within concrete, and the thicker piece of rebar would be placed horizontally. The thicker bars are needed for the horizontal pieces because there are larger forces acting on them than on the vertical bars. Because the ridges of rebar bond with the cement, the bar needs to be set in place. The spacer holds the thin rebar piece in place. During construction, the temporary yellow mushroom cap is placed on top for safety. It will protect workers from injuring themselves on the exposed rebar to an extent.

### Additional Notes:

Have students notice the difference between the inside of the rebar and the outside, it is shinier on the inside, because the steel rusts over time. Ask them what they think the ridges on the bar are for, or what they think the yellow cap is for.

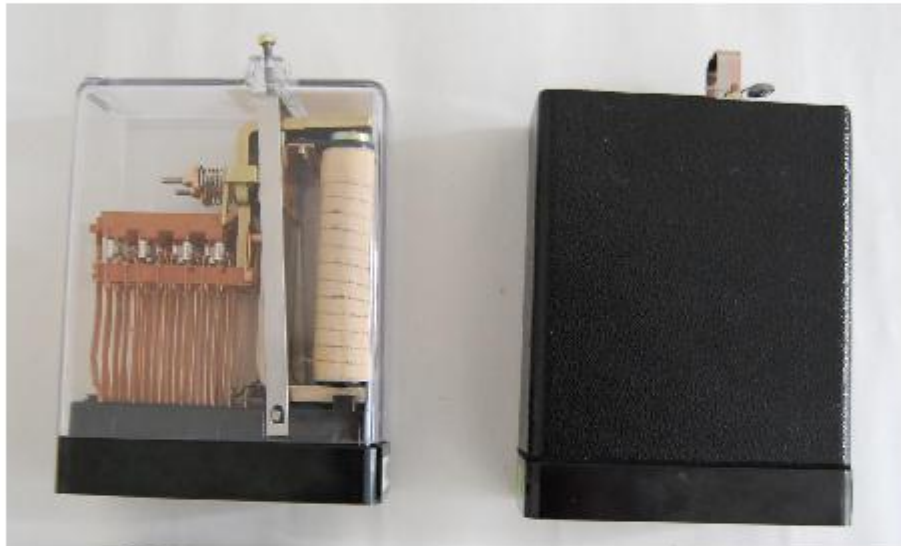
## Relay Fact Sheet

**Category:** Signals: S-15, S-16

### **Introduction:**

A relay is an electrical switch used in signalling systems and many other electromechanical devices.

### **Photographs:**



Q Relay

Time Delay Relay

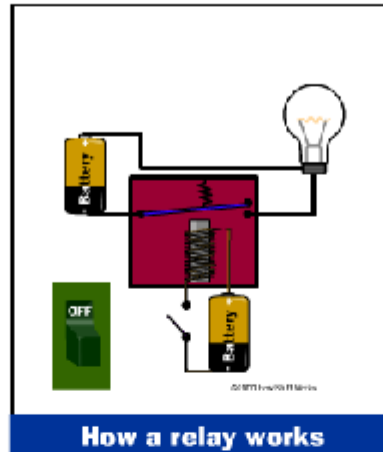
### **Detailed description:**

The (left) clear relay is a Q relay and the (right) covered relay is a time delay relay used in the Underground signalling system. In general, relays work so that a small amount of power (from say, a low-power electronic circuit or dashboard) is able to move an armature to switch a larger amount of power. It does this by using an electromagnetic, spring, electrical contacts, and armature. A small amount of power would drive an electromagnetic, which attracts an armature that will move to connect another circuit. This way, the second circuit (of usually higher power applications), can be "switched" by the low-power circuit.

### **Additional Notes:**

The relays in this collection are used for switching applications for London Underground. A much smaller relay (smaller than a 5p coin) would be used in your cell phone. A much larger

one would be in a washing machine. You can generally demonstrate the size of these with your hands.



(howstuffworks.com)

## Resilient Pad Fact Sheet

**Category:** Track: T-03, T-04

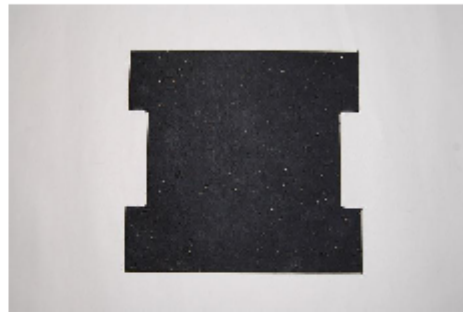
### Introduction:

The resilient pad sits between the flat bottom rail and the concrete sleeper. They are used to weaken the impact to prevent degradation to the sleeper.

### Photographs:



Good resilient pad



Poor resilient pad

### Detailed description:

The thickness, electrical properties, and resilience are all important factors when designing and selecting resilient pads. The thickness is needed to increase the impact attenuation, with thicker pads being best for high speed trains. Electrical properties are essential to the pads because they are needed to insulate the rail to ensure track signalling. A high resilience can decrease the noise and vibration.

### Additional Notes:

About 6 or 7 years ago, about 2,000 resilient pads in a section of the underground were replaced with ones made with recycled rubber (object T-03). During the morning commute, the trains stopped running and the signals were no longer working. When the engineers went in to fix the problem, they discovered that all the electricity had been earthed. It had started to rain that morning and water had come into contact with the resilience pads. Since the pads were not pure rubber, they allowed for more conduction of electricity and therefore lost the signals to the earth. From this, engineers realized that they could no longer use recycled rubber in the pads, and electrical properties were added to the list of requirements for the selection of resilient pads.



## Retroreflector Fact Sheet

**Category:** Civil: C-06

### **Introduction:**

This is a surveying prism, also known as a retroreflector, which is used when surveying land or different site areas to measure distances.

### **Photographs**



Retroreflector, or Survey Prism

### **Detailed description**

The prism uses a beam of light that is emitted by an electronic distance measurement (EDM) device. The light (laser) is sent from the EDM device to reflect off the prism. It uses the reflection of this beam of light to measure the distance between the device and another point that is being surveyed. By doing so, a computer can detect if a building has moved, and thus can determine if underground construction is causing any disturbance. These prisms can be seen mounted on buildings near construction sites, such as at the Tottenham Court Rd station, as it is currently undergoing upgrades.

### **Additional Notes**

The eyes of a cat are very similar to retroreflectors, which is what makes cat's eyes glow when light is shined on it. This object can also be compared to the reflectors on the back of a bicycle (see B-05). Encourage students to check buildings for these reflectors next time they are near a station undergoing construction.

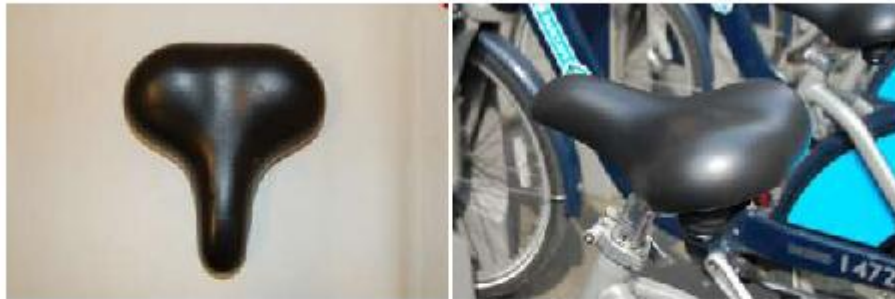
## Saddle Fact Sheet

**Category:** Bicycle: B-01

### Introduction:

The bicycle saddle is located on the saddle post of a bicycle. This is the part of a bike that the passenger sits on.

### Photographs:



Saddle

Saddle on bike

### Detailed description:

The first bicycle, the Draisienne (1818), used one large wheel which the rider sat atop, with one smaller wheel in the back for support. Early bicycles were the mode of transport while lighting street lamps, so they were tall to suit this purpose. Riding for long periods of time must have been extremely uncomfortable, because the saddle was little more than a plank of wood. Saddles developed from a plank of wood to a more convex shape similar to current saddles. It wasn't until late 20<sup>th</sup> century that real progress was made in changing the design of the saddle, due to concerns about comfort.

Bicycle saddles now have a complex shape and cushioning to best fit human riders. They're primarily made of a moulded nylon-based plastic and some form of cushioning (usually closed-cell foam, a form of latex foam). The materials in the seat can range from vinyl, leather, Kevlar, canvas, rubber or nylon.

### Additional Notes:

Encourage students to understand that the shape of the saddle is designed to be most comfortable and/or ergonomic for riders. This discussion can lead into the engineering and design behind the chairs and desks they use, chairs at home, beds, benches, and more broadly, the use of engineering to improve human life.

This item can be shown with the Inner Tube, Bicycle Chain, Wheel Reflector, and Crank.

## Seat Clamp Fact Sheet

**Category:** Bicycles: B-02

### **Introduction:**

The seat clamp is placed around the seat post of the bike, and clamps into place in order to adjust the height of the saddle.

### **Photographs:**



Seat Clamp



Seat clamp on seat post

### **Detailed description:**

The seat clamp is made out of aluminium and consists of a ring and a screw, which can adjust the size of the ring. The clamp is placed around the seat post in order for the rider to select a desired height. When the clamp is open, the post can move freely and the saddle can be raised or lowered to the rider's preference. When the desired height is reached, the clamp is tightened via the screw, keeping the saddle in place.

### **Additional Notes:**

This can be shown with the other parts of the bikes.

Like the bicycle basket, this object is made out of aluminium so that the bike is as lightweight as possible.

## Short Key Fact Sheet

**Category:** Track: T-07, T-08

### **Introduction:**

This is a short key from a point machine. It functions to lock the rail in place after it has been switched by the point machine.

### **Photographs:**



Broken Short Key

Short Key

### **Detailed description:**

These are from a point machine first designed in 1912. When the rail is switched, a bar runs along the short key and fits into the notches cut into the short key. This functions as a lock and holds the rail in that position until it needs to be switched again.

### **Additional Notes:**

The two short key can be shown to the students together, and they can try to figure out what went wrong and how this can be changed. The weld on the broken one was poorly done and because of the angle of the weld, it caused too much stress so the piece broke off.



Short Key in situ

## Spring Door Arm Fact Sheet

**Category:** Track: T-19

**Introduction:**

This object is used to open and close the doors on the tube.

**Photographs**



Spring Door Arm

**Detailed description:**

The spring door arm is the mechanism that opens and closes the train doors on the Underground. The arm starts in the horizontal position as shown in the picture. A vertical component rises up and pushes the arm up along a track, rotating it  $180^\circ$ , and closing the door as it rotates. The spring component allows for passengers to open the doors slightly if something is stuck.

**Additional Notes:**

Both the rotary movement and the spring mechanism can be shown to students because it will be easier for them to understand.

This can be shown with the door pads, as they are both parts of the doors, and have components to avoid getting things stuck in the door.

## 3 Core Signal Wiring Cable

**Category:** Signals: S-04

**Introduction:**

This wiring cable was used for signalling in the underground.

**Photographs:**



3 Core Signal Wiring Cable

**Detailed description:**

This signalling wire was used for "track side" installation. It is very robust so that it can handle both the extremes of British weather, and also the high vibrations of the railway track.

**Additional Notes:**

This can be shown with other wire cables to compare and contrast them.

## THYRISTOR FACT SHEET

**Category:** Signals: S-o6

**Introduction:**

A thyristor is a three-way switch that uses a small amount of power to control a much larger amount of power.

**Photographs:**



Thyristor

**Detailed Description:**

The switch is on if there is a current running through the thyristor. They are used as opposed to simple switches because they can handle large amounts of power – which is often necessary in railway systems.

**Additional Notes:**

Thyristors are present in the motors that control line changes in railways systems. Both states of the switch represent a line, and changing the current across the thyristor will send a signal that changes the line that the train will go on.

## T Piece Fact Sheet

**Category:** Track: T-05

**Introduction:**

This is a non-conductive electrical separation piece between rail sections that is made out of nylon (a good insulator).

**Photographs:**



T-Piece

**Detailed description:**

In railway tracks, separations are made so that the track is divided into different sections. These sections are used for signals purposes and either have current passing through them or are earthed depending on whether or not a train is present on that piece of track. If these T sections are even slightly misaligned, it is at a greater risk for damage by the rail cars. If the insulating piece wears down, electricity might be able to jump the gap between rail sections, causing a signal failure at that point in the tracks. This could be prevented by making the sections thicker (this piece is 6mm thick), however this makes the mechanical separation between the railways even greater, allowing for less mechanical stability in the tracks.

**Additional Notes:**

Good item to have students ask what they think it is used for. Can also show with the composite rail to show how it lines up for separations between the rails.



## Water Meter Fact Sheet

**Category:** Civil: C-07

**Introduction:**

This is a water meter, which measures how much water is flowing at a given point in time. As opposed to mechanical water meters, this meter takes its readings with the help of electromagnets.

**Photographs:**



Water Meter

**Detailed description:**

The presence of the magnetic field on the metering tube allows for the speed of the water to be determined (it detects how many tiny ions in the water go by the magnet). One magnet would be on the inside of water pipe to detect the water speed. The meter and magnet along the back measure the electromagnetic fields from the magnet in the pipe to measure the water speed. Because this meter implements the use of magnets, there is no need for a mechanical measuring device for the meter that comes into contact with the water, so none of the meter will be worn down by the flow of rushing water, making it longer lasting.

**Additional Notes:**

Have students guess what it is used for. Emphasize that water never touches the actual meter, just the magnet that would be in the pipe. This can also be shown with the Maglock, which uses electromagnets for a locking mechanism.

## Wheel Reflector Fact Sheet

**Category:** Bicycles: B-05

### **Introduction:**

The wheel reflector is mounted onto the back wheel of the Barclays Cycle. Its purpose is to make the bicycle seen by motorists especially at night.

### **Photographs:**



Wheel Reflector



New reflector on bicycles

### **Detailed description:**

The wheel reflector uses retroreflection to give off light to warn motorists of a cyclist. The actual reflector portion is made of plastic and is smooth on the outside. The inside is made up of angled microprisms or spheres which help to create total internal reflection when the light from headlights hits the inner surface of the reflector. It then sends the reflected light back to its original source, which is the operator of the vehicle.

### **Additional Notes:**

The wheel reflector in the left picture was an older model, and there was an issue where they kept falling off the bikes. Asking the students how they would fix this problem and then guiding them through a discussion with some possible ideas could help to better engage them with this object (there are now stickers in place of the wheel reflectors. If the students do not reach this conclusion on their own, they could be guided to it with some hints).

These reflectors are not used on many bikes anymore – the reason being they kept falling off.

# Appendix F - Object Borrowing Agreement (contract)



## COMPLETE AND RETURN THIS CONTRACT TO THE CUSTODIAN BEFORE CHECKING OUT OBJECTS

Name: \_\_\_\_\_  
Email: \_\_\_\_\_  
Phone Number: \_\_\_\_\_  
Object Name and ID Number: \_\_\_\_\_  
Event Name: \_\_\_\_\_  
Event Location: \_\_\_\_\_

By signing this contract, I agree to:

- Follow all handling guidelines on the attached sheet.
- Use the object carrying case at all times.
- Return the object within 72 hours of the conclusion of the event.
- Return the object in the same condition as when it was taken out.
- Report any damage to the custodian.
- Return object directly to the custodian at the location where the object was checked out.

It is understood that objects in this collection will suffer wear due to frequent handling, but damage due to misuse or improper handling will result in a fee to be determined by the custodian.

Note any pre-existing damage here:

\_\_\_\_\_  
\_\_\_\_\_

Signature \_\_\_\_\_



## **SEPARATE THIS SHEET AND KEEP FOR REFERENCE**

The objects in this collection should be handled with care just like any other museum objects. How well they are handled will determine the lifetime of this collection. Proper handling techniques are necessary to preserve the object as well as to protect the person handling it.

- Handle objects in a calm and safe environment – no horseplay.
- Always discuss how objects should be handled before passing them around to students.
- Do not eat or drink around the objects.
- Wash your hands before and after handling an object.
- Be very careful when lifting objects. When possible, handle them over a table or desk.
- Before picking up an object, consider where you will put it down.
- Always use both hands to lift an object.
- Pick up and support an object from the heaviest or strongest part.
- When transporting objects, always use a padded carrying case.
- If you are transporting multiple objects, place the heaviest objects beneath lighter ones.
- If an object gets damaged, report the damage to the custodian immediately.
- Always return an object to the custodian from whom you borrowed it.



## Appendix G - Database Screen Captures

London Transport Museum

home


**London Transport Museum Artefact Library**

Welcome to London Transport Museum's Artefact Library Page!  
This wikispace is a tool for Engineering Ambassadors to view and download information about objects in the artefact library.

**How To Use This Wikispace**

Use the navigation pane on the right to view a list of available objects and other resources for Ambassadors.

Click on [Object List](#) to see a list of objects available. Find useful information and links on the object under the information column, and in the right navigation pane.

ID	Category	Item Name	Location*	Available?	Description	Information	Photo
B01	Bicycle	Bicycle Saddle	London Transport Museum (LTM)	Yes	Saddle from Barclays Bicycle	<a href="#">Saddle Fact Sheet.docx</a> <a href="#">Details</a> <a href="#">Download</a> 61 KB <a href="#">3D Printing of a Bicycle Saddle</a>	

Find the location of the object and contact the appropriate custodian to arrange for pick up:

LTM - London Transport Museum, Covent Garden, London. Contact Liz Poulter at [Elizabeth.Poulter@ltmuseum.co.uk](mailto:Elizabeth.Poulter@ltmuseum.co.uk) for availability and pick up.  
 BPR - Buckingham Palace Road, London. Contact Ian Rawlings at [Ian.Rawlings@tpe.ifi.gov.uk](mailto:Ian.Rawlings@tpe.ifi.gov.uk).  
 AHB - Albany House, 55 Broadway, London. Contact Rowan Joachim at [Rowan.Joachim@tpe.ifi.gov.uk](mailto:Rowan.Joachim@tpe.ifi.gov.uk).

Print out and sign the [Object Borrowing Agreement](#) and give it to the custodian upon pick up.


 Object Borrowing Agreement

Figure 13. Database Home Screen

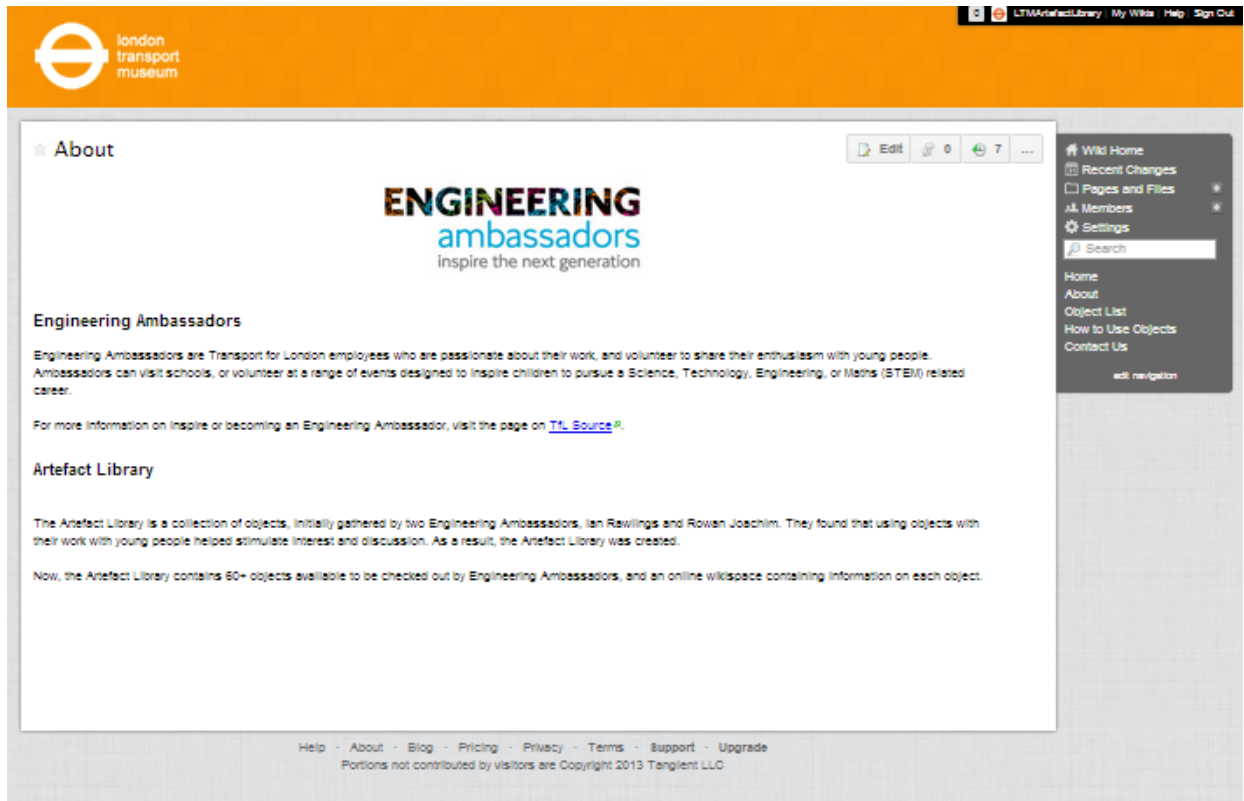






Figure 14. Database About Page

london transport museum

LTMAnatLibrary My Wiki Help Sign Out

### Object List

Edit 0 38 ...

ID	Category	Item Name	Location	Available?	Description	Information	Photo
B01	Bicycle	Bicycle Saddle	London Transport Museum (LTM)	Yes	Saddle from Barclays Bicycle	<a href="#">Saddle Foot Sheet.docx</a> <a href="#">Details</a> <a href="#">Download</a> 61 KB <a href="#">3D Printing of a Bicycle (video)®</a>	
B02	Bicycle	Seat Clamp	London Transport Museum (LTM)	Yes	Seat Clamp from Barclays Bicycle	<a href="#">Seat Clamp Foot Sheet.docx</a> <a href="#">Details</a> <a href="#">Download</a> 74 KB	
B03	Bicycle	Front Basket	London Transport Museum (LTM)	Yes	Front Basket from Barclays Bicycle	<a href="#">Front Basket Foot Sheet.docx</a> <a href="#">Details</a> <a href="#">Download</a> 64 KB	
B04	Bicycle	Innertube	London Transport Museum (LTM)	Yes	Innertube from Barclays Bicycle	<a href="#">Inner Tube Foot Sheet.docx</a> <a href="#">Details</a> <a href="#">Download</a> 305 KB	

Wiki Home  
 Recent Changes  
 Pages and Files  
 Members  
 Settings  
 Search  
 Home  
 About  
 Object List  
 How to Use Objects  
 Contact Us  
 edit navigation

Figure 15. Database Object List

## Appendix H - Training Program Power Point and Script





**ENGINEERING**  
ambassadors  
open | connect | grow | learn

## Aims

- To learn how to use the online database
- To understand how to properly handle objects
- To discover innovative ways to teach young people about engineering using objects

MUSEUM OF LONDON

MUSEUM OF LONDON

MUSEUM OF LONDON

~2 mins

The three goals of this training are:

To learn how to use the online database located at [ArtefactLibrary.wikispaces.com](http://ArtefactLibrary.wikispaces.com)

To understand how to properly handle and care for objects

To discover innovative ways to teach young people about engineering using objects

# Timetable

Time	Activity
17:00-17:10	Arrival and refreshments
17:10-17:30	Introductions and Artefact Library
17:30-17:35	Handling Objects
17:35-17:55	Using Questions to Engage Students
17:55-18:05	Break
18:05-18:25	Artefact Library Tutorial
18:25-18:50	Sample Activities
18:50-19:00	Summary and Evaluation

~2 mins


Briefly go over the timetable with attendees.

Here is a more complete timetable for your use:



Time	Activity
17:00-17:10	Arrival and refreshments
17:10-17:25	Introductions and Icebreaker
17:25-17:30	What is the Artefact Library
17:30-17:35	Handling Objects
17:35-17:55	Using Questions to Engage Students
17:55-18:05	Break
18:05-18:20	Artefact Library Tutorial
18:20-18:30	Sample Activities
18:30-18:50	Role Play Activity
18:50-19:00	Summary and Evaluation


# Icebreaker

- Your name
- One tool/ object you use at work on a daily basis
- A fun fact about you!



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ambassadors  
inspire, connect, grow, learn

UNIVERSITY OF LONDONImperial College London



~10 mins

Go around the room and have each person share their name, one object/tool they use at work on a daily basis, and a fun fact about themselves. This should be about a maximum of 10 minutes long. If there is a large amount of people in the room (over 15), the fun fact can be cut from this exercise.

After everyone has spoken, ask if anyone has brought in an object they have mentioned into an Inspire Day or a school visit. If they have, ask them what they did with it. If not, explain that this can be beneficial to their presentations, and learning techniques to present objects is one of the goals of the training session.

Mention that there is an artefact library of objects than ambassadors can use to check out items for school visits or Inspire Days.

## What is the Artefact Library?

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ambassadors  
inspire | connect | grow | learn

- A collection of engineering objects from different sectors of TfL
- To help interest students in engineering through the use of objects

Mayor of London



Transport for London

~5 min



The artefact library is a collection of engineering objects that ambassadors can bring to presentations to teach students about engineering concepts. The objects are located at 3 different locations across London.


There is currently a lack of interest in engineering amongst youth and it is often seen as a "dirty job". If this trend continues it could hurt the country technologically and economically if there are less people entering a STEM (science, technology, engineering, and mathematic) field. The Inspire program targets secondary students in order to interest them in a career in these fields. Studies show that students are much more engaged when participating in object-based learning, rather than with traditional lecture-based learning, so the library can be a useful tool as it will loan objects to ambassadors for use in Inspire presentations.

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## Handling Objects

- Support from the heaviest part and hold with two hands
- When possible handle object over a table or desk
- Always encourage proper handling with students
  
- [See database for more instructions and object contract](#)

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~5 mins

Objects should be lifted carefully with both hands. If it is possible they should also be held over a table or desk in case of an accidental fall. Encourage these guidelines with the students if they are handling the objects. These objects are now part of a collection that will be used by over a hundred ambassadors and need to be kept in good condition.

On the wiki there is more information about object handling, and also a contract that ambassadors will need to sign when checking out an object. This contract have information about handling objects that ambassadors can keep, and also a page to sign where it details the conditions of taking an object out of the collection. These include handling with care, returning the object within 72 hours of the Inspire event, using the carrying bag, and also returning the object in the same condition of which it was checked out. Remind ambassadors that they will need to print and sign this contract, and then give it to the custodian to put on file upon checking out an object.

## Using Questions to Engage

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- Use questions to guide the discussion
  - What might this be used for?
  - What might the purpose be?
  - What other objects do the same job?
- You know more than you think!



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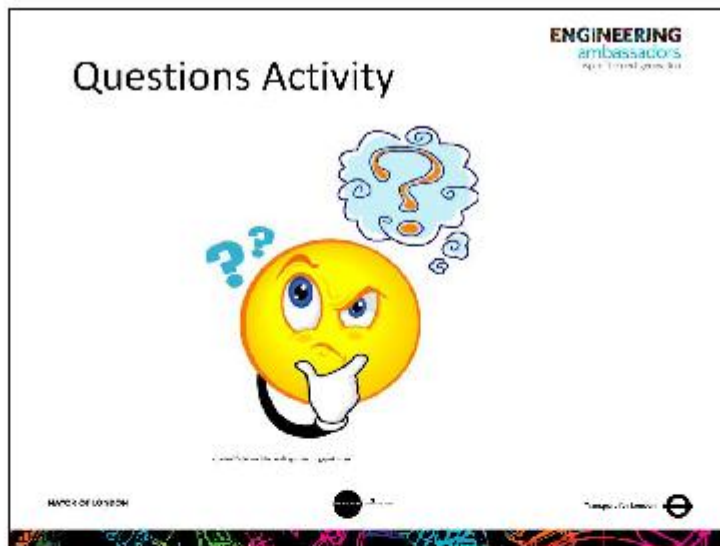
~10 mins

Pass out the Using Questions hand-out (can be found at [ArtefactLibrary.wikispaces.com](http://ArtefactLibrary.wikispaces.com) under How to Use Objects)

Using questions can help guide the discussion, and keep a student actively engaged. These questions could include: What might the object be used for? what is the purpose of this object? What object do the same job? There are more of these questions on the hand-out provided.

These questions can also help students to understand that they know more about the objects than they thought. By answering these questions they can gain insight into parts of the object and together this can form the bigger picture. This can also help the ambassadors learn more about the object by asking themselves similar questions and then piecing together the answers if they are unsure about an object.

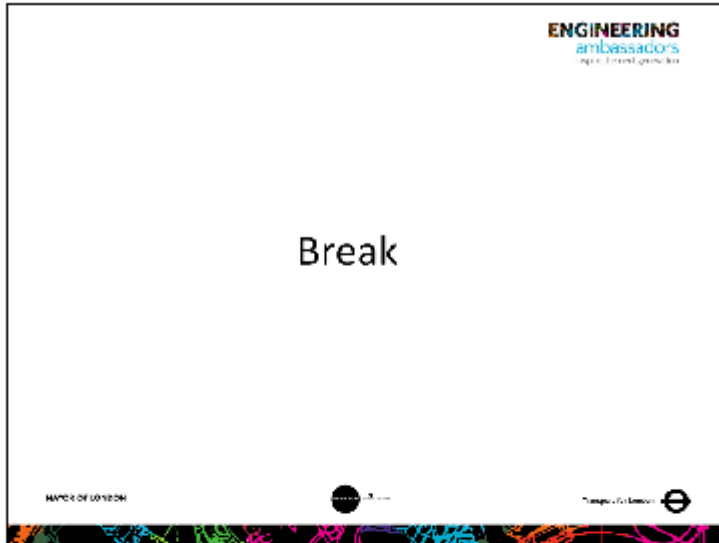
Emphasize to attendees that they should utilize questions when working with students, rather than lecturing. Ask questions and allow students to try to figure out the answer rather than just giving it.



~15-20 mins

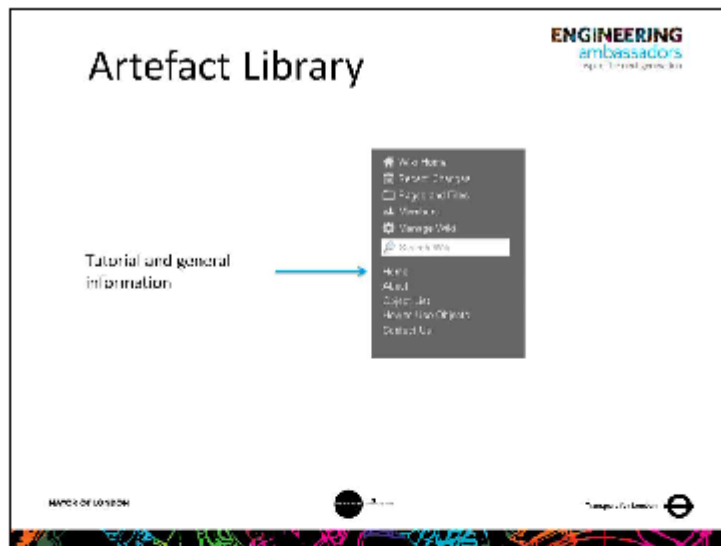
Break the ambassadors into group of 2-4 and give each group 1-4 objects from the artefact library (alternatively, use pictures of objects) without telling them what the object is or does. One person from each group should ask the others questions, using samples from the hand-out or making their own questions. The goal is to try to come to a conclusion about what the object is. Time permitting, each group member can lead the questioning with the object they were given.

Conclude the activity by summarizing that even if they didn't know what the objects were used for, they could still find a lot of information about it by asking these questions. Remind attendees to try to use the practice with students, so that they have the chance to try to figure out an object's purpose before being told.



~ 10 mins





~4 mins

Pass out the hand-out on **Accessing the Artefact Library** (can be found at [artefactlibrary.wikispaces.com](http://artefactlibrary.wikispaces.com) under the **How To Use Objects** page).

This is the navigation panel for the database, and this slide details each section of the panel.

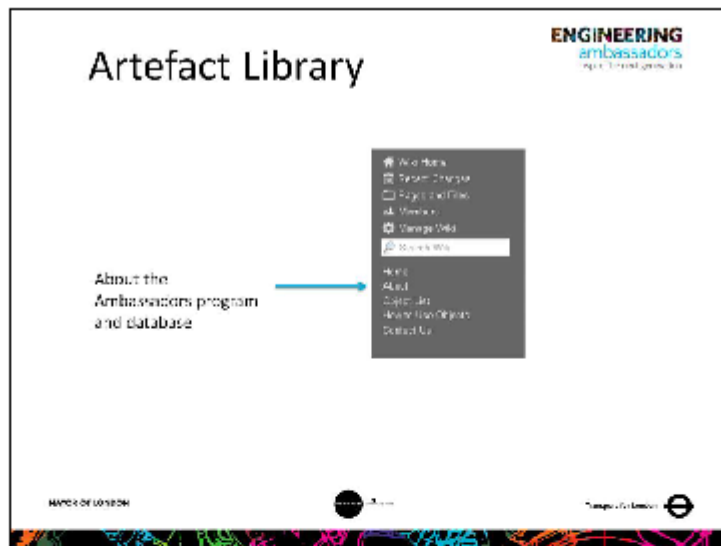
**Click. Home.** The first section takes you to the Home page. There you can find a tutorial of how to use the database and general information.

**Click. About.** The About section tells about the Engineering Ambassadors and a brief overview of the artefact library.

**Click. Object List.** This is the Object List page. This is where the ambassadors can go to view the list of objects and also see the location, fact sheet, and availability of the object. How to check out items will be explained on the next slide.

**Click. How to use objects.** The how to use object link directs you to additional information such as the hand-outs from this presentation, and links to tips for working with children.

**Click. Contact Us.** This link contains the contact information for the three custodians of the collection, and the email alias used to find more information about Inspire.



~4 mins

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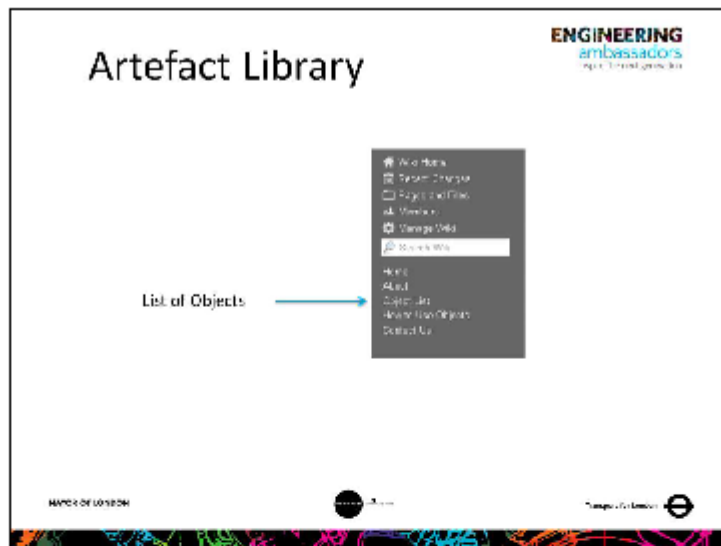
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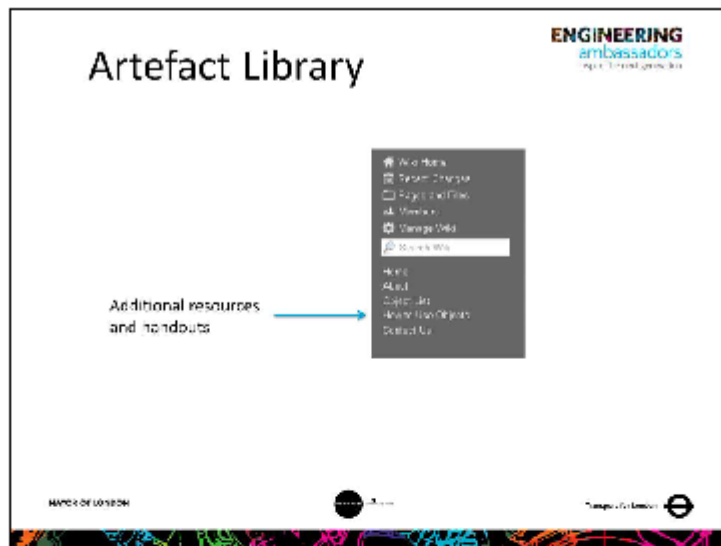
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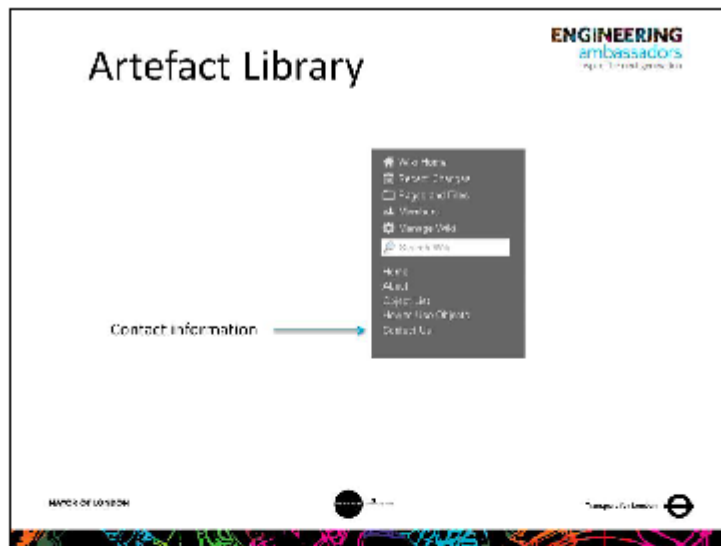
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# Artefact Library



ID	Image	Title	Location	Availability	Fact Sheet	Additional Information
001		Bicycle Bell	London Transport Museum, 225 Whitechapel Road, London E1 1BB	Yes	<a href="#">Bicycle Bell Fact Sheet</a>	
002		Bicycle Bell	London Transport Museum, 225 Whitechapel Road, London E1 1BB	No	<a href="#">Bicycle Bell Fact Sheet</a>	

Additional Information

~6 mins

This slide is a tutorial about the Object List page.

**Click. Identification number.** This is the identification number. Each object has this and is a letter followed by number(s). This is found on all of the objects and helps the custodian keep track of the object. This is the number ambassadors should refer to when they want to check out an object.

**Click. Location.** There are 3 locations that the object can be: London Transport Museum, Buckingham Palace Road, and Albany House. The addresses for these locations, the Borrowing Contract, and the contact information for the custodians can be found at the bottom of the object list page. Contact the custodian at the object location to arrange to pick up an object. Print & sign the Borrowing agreement and give it to the custodian when you pick up an object.

**Click. Availability.** This shows the availability of the object: yes for available and no for not available.

**Click. Fact Sheet.** This is the fact sheet which is a resource that will be discussed later in the training. Fact sheets contain information about the objects, and contain sample discussion points or other interesting information.

**Click. Additional Information.** The additional information is anything that can help with understanding of the object. Some are unrelated, but interesting segues that can help steer conversation into general engineering topics.

## Using Fact Sheets

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**Category** →

**Photographs** →

**Additional Notes** →

**Resilient Pads**

**Introduction**

**Detailed Description**

← **Introduction**

← **Detailed Description**

The screenshot shows a fact sheet titled 'Resilient Pads'. It is divided into sections: 'Introduction', 'Detailed Description', and 'Additional Notes'. There are two photographs of the resilient pads. The 'Category' label points to the top left of the sheet, 'Photographs' points to the two images, and 'Additional Notes' points to the bottom section. The 'Introduction' and 'Detailed Description' labels point to their respective text sections on the right side of the sheet.

~10 mins

This is a sample fact sheet about resilient pads.

**Click. Category.** This is the category. Each object is placed into categories (signals, track, electrical etc.) and then given a letter and number based on that. The identification number follows the category. Ambassadors can use the category to find objects they've used.

**Click. Introduction.** The introduction gives a brief overview of the object. A more detailed description is found below.



**Click. Photographs.** This is the photographs section. In many of the fact sheets there is a picture of the object itself, and a picture in situ so the ambassador will be able to better understand the context of the object.


**Click. Detailed Description.** This is the detailed description section. This is intended for the ambassadors use and NOT a script of what to say to students in schools. The section is oftentimes a bit too complicated secondary students to understand. The section is intended to give background and context for ambassadors, so that they can answer questions students may have.

**Click. Additional Notes.** This is the additional notes section. It contains anecdotes, analogies, and fun facts about the objects. This is the section that can be used to help ambassadors when speaking with students. Relating objects and concepts to things students know about will help keep them engaged.

## Sample Activities

- Create a mystery for students to solve
- Ask how students would improve a broken object
- Tips:
  - Have students work in small groups
  - Tell a story!

MAPS OF LONDON

Maps of London

~ 10 mins

Pass out **Activities Hand-out** (can be found on [ArtefactLibrary.wikispaces.com](https://www.artefactlibrary.wikispaces.com/How+to+Use+Objects) under **How to Use Objects**).

These are examples of some sample activities that can be used if an ambassador is unsure of what to say, or gets stuck when talking with students:

- Creating a mystery can be a fun way to keep students engaged.
  - show students a mystery object and have them work as a team to solve what it is
  - show a broken object and have them work as a team to try to solve why it didn't work
- Ask how students would improve an item
  - What improvements could be made to a bicycle basket? A train?
  - How would students "fix" a broken item? For example, the wheel reflector of a Boris bike (in the collection) kept falling off the back. Reflectors are a very important part of the bike because of safety concerns so this problem needed to be fixed. Ask student how they would find a solution to this problem (there are now sticker reflectors on many of the bikes)
- Bring in an old and a new tube map to show the students. Ask them to compare and contrast the maps, and ask how they would get from point A to B on both of the maps. Links to old London tube maps can be found on the artefact library database.

There are more activities and more detailed descriptions can be found on the hand-out.



## Role Play Activity

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Age 11-16 and 16-18



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~20 mins



Give each ambassador an object and a corresponding fact sheet, or use the objects they were given in the questions activity. Split them into small groups and have one person pretend to be the ambassador while the others are students. The ambassador should present the object to the students using the fact sheet and the techniques talked about during the session. Depending on group sizes, prompt them to change roles every few minutes.


After ending the role plays, ask ambassadors if they felt more confident speaking with students using objects after the exercise.

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## Summary and Evaluations

- Use the **handout** provided for help accessing the **database**
- When presenting remember to:
  - Use the fact sheets to learn about the objects before presenting
  - Make objects or concepts relatable
  - Engage students using questions and activities
  - Have fun!!
- **Please fill out an evaluation form**

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~ 10 mins

**Remind the ambassadors to refer to the handout if they have trouble accessing the database.**

**Remind them to read the fact sheets before presenting and make presentations fun and engaging using the tips covered in this session.**

**Most importantly, have fun with the students!**

**Pass out evaluations & ask them to fill them out before they leave.**

Thank You

# Appendix I - Training Session Information Handouts

## Using the Artefact Library



Go to [www.ArtefactLibrary.wikispaces.com](http://www.ArtefactLibrary.wikispaces.com)



Find useful information on the right-hand navigation pane. Click on Object List to view the object collection.

Identification Number	Location	Availability	Fact Sheet	Image
1001	London Transport Museum (LTM)	Available from Tuesday to Friday	<a href="#">Download Fact Sheet</a> <a href="#">Download Object List</a>	
1002	London Transport Museum (LTM)	Not on display	<a href="#">Download Fact Sheet</a> <a href="#">Download Object List</a>	

Additional Information



At the bottom of the Object List, or on the Contact Us page, find the contact info for the custodian of the object location.

<sup>1</sup> location

LTM - London Transport Museum, Covent Garden, London. Contact Liz Poulter at [Liz.poulter@london-tmuseum.co.uk](mailto:Liz.poulter@london-tmuseum.co.uk) for availability and pick up.

BTR - Buckingham Palace Road, London. Contact Ian Rawlinson at [Ian.Rawlinson@btr.co.uk](mailto:Ian.Rawlinson@btr.co.uk).

W 12 - Albany House, 50 Broadway, London. Contact Rowan Joachim at [Rowan.Joachim@w12.gov.uk](mailto:Rowan.Joachim@w12.gov.uk).



Print & sign the Object Borrowing Agreement, located on the Home page, and at the bottom of the Object List page. Give Agreement to custodian upon pick up of an object.



## Using Questions to Engage Students

When trying to engage students in an object-based activity, students may not be familiar with what an object is. By asking the right questions, a facilitator can guide the conversation and help the students realize they know more than they might have expected. Using the knowledge that they already have encourages the students to explore the object further.

Sample questions include:

### The purpose of the object –

- What might this object be used for?
- When was it used?
- Where was it used?
- Who might have used it?
- Is this object good at its job?
- What else might the object have been used with?
- What other objects do the same job?



### The properties of the object -

- What size is it? Big or small?
- What shape is it?
- How might the shape have influenced how it was used?
- What is it made of?
- Is it one material or many?
- Is it made from new or recycled materials?
- What purpose might the materials serve?
- Is the object solid or is it multiple pieces connected together?
- Is it heavy or light?
- Is it fragile or strong?
- Is the object functional or broken?
- Is this the whole object or is this only a part of something bigger?
- Is the object decorated or plain?
- Does the object appear similar to another common object?

### The production of the object –

- How was this object made?
- Was it easy or difficult to produce?
- Can this object be improved?
- How has the object improved over time?
- What environmental impacts might this object or its production have?

## Sample Activities

As an Engineering Ambassador, it is your goal to show students that engineering is an exciting field to enter. One way of engaging students is through the use of interactive activities. These activities will allow them to use their creativity to find solutions to some basic problems that simulate what an engineer may face while on the job.

### Some ideas for activities:

- Use tube maps (visit the artifact library database for old tube maps). Activities with maps:
  - Comparing old/new tube maps, ask why the addition of new lines such as the Jubilee line or Hammersmith & City line were beneficial to the underground.
  - Asking students to find the best way to get from point A to B, choosing your own starting and ending points. Add in road blocks such as a line closure or a broken down train at a certain station. Give the activity a backstory to make it more entertaining (such as being late for something or hurrying to meet a celebrity).
  - Have students create a new tube line. Give them two points that they have to connect, and challenges such as not being allowed to cross more than a certain number of lines, giving them other stations that they have to pass through on the way to their destination, or telling them that they can't cross a certain line at all.
- Create mysteries for the students to solve.
  - Show groups of students an unknown object and have them work as a team to find out what it might have been used for, giving them a few clues along the way.
  - Show a few objects at once and ask the students which object they think would be used for a certain purpose.
  - Have students discover why a certain item might have stopped working, or ask students what the object might have affected after breaking.
- Ask students how they would improve a broken object, or the design of a current object given its limitations. If applicable, tell students how the object has been improved by engineers since its creation.
- Have students create their own item that improves the transportation system, whether it be creating a new design for a bus, a better way of organizing a train station platform, or making a new type of train carriage to hold more passengers or be more comfortable. Giving them a specific challenge might help to put them on the right track for a new idea.

### Tips for student activities:

- Have students work in small groups from 2-4. This allows for students to share their ideas and get feedback as well as build upon the ideas that their peers may have.
- Let the activity have a story behind it. Instead of saying 'design a new train', tell a story about how the Queen wants a private railway from her palace to her favorite restaurant across the Thames, or if you're going for something more realistic, talk about how a new train would have been beneficial when there were thousands of people in London for the Olympics.
- Possibly bring in small candies as prizes for the groups with the most efficient solution to a problem as an incentive.

## Appendix J - Training Session Evaluation

### Training Evaluation Form

Thank you for attending our training session! We would greatly appreciate any feedback that you may have on the session to help us make improvements in the future.

Please circle the response that best represents your opinion:

How would you rate the overall training session?	Very Poor	Poor	Average	Good	Excellent
I feel more confident in my ability to engage students using objects.	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
I am aware of how to properly handle the artefacts.	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
I understand how to access the database.	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
I understand how to check out an object.	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
The training session was informative and helpful.	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
I enjoyed the training.	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree

1. What part of the training did you find the most effective?
2. What activity did you enjoy the most?
3. What would you suggest to improve the training session?
4. How likely are you to use the artefact library in the future?  
(Not likely, likely, very likely)
5. Any additional comments?



## Appendix K - Sample Database Survey



### Sample Artefact Library Database Survey

1. Overall, how would rate the quality of the artifact library database?

Very Poor      Poor      Average      Good      Excellent

2. How useful did you find the information available about each object? (1 being not useful at all, and 10 being very useful)

1    2    3    4    5    6    7    8    9    10

3. How easy was the database to navigate?

Very Easy    Somewhat Easy    Average    Difficult    Very Difficult

4. What did you like about the artifact library database?

5. How would you improve the artifact library database?

6. Additional Comments:

