School of GeoSciences

DISSERTATION

For the degree of

MSc in GIS and Archaeology

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Holyrood Park
Stone Tools
Mobile Application
HPST

PART I: Research Paper
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Signed ____________________   Date _______________________________

"RCAHMS database for Holyrood Park. Includes, Site, Event and Bibliographic records provided in an MS Access database. Site locations, site area extents (extracted from Defining ScotlandsPlaces DSP) and the RCAHMS field survey extent and mapping (collected through dGPS).

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RCAHMS data to be used in Android Mobile application as part of the student project.
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Joint research project between RCAHMS and University of Edinburgh.

Data is Copyright RCAHMS"
Acknowledgements

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I also very grateful for the help from Trevor Cowie from the National Museum of Scotland for giving me sources on the artefacts found at Holyrood Park and for providing pictures of the artefacts that were in the NMS collection store. He helped answer any questions about the artefacts and introduced me to Peter McKeague.
I would like to thank Bruce Gittings and Alexandra Avery for supply images of their UAV flight over Holyrood Park. Also a special thanks to Holyrood Park Ranger Services for their cooperation in letting University of Edinburgh’s Department of Geoscience to fly their UAV in the Park. Finally I would like to thank the students from the MSc geosciences program for being a source of comradery throughout the academic year.
According to the National Museum of Scotland (NMS), the Department of Archaeology at the National Museum of Scotland holds the principal collection of artefacts for Scotland – in excess of 1 million items. Also, the Edinburgh council Museum holds another collection of Scotland’s artefacts within the city of Edinburgh. The management of these collections is currently constrained by the incompleteness of what should be standardised geographical information associated with the artefact record.

This project aims to provide the general public with awareness and understanding of the Prehistoric Archaeological landscape of Holyrood Park through an Android Mobile application. The main objective is to connect artefacts held by the National Museum and Edinburgh Museum with the landscape of Holyrood Park through the creation of an Android application. This application, HPST, will assist the public to learn about the artefact records by visualizing the artefacts’ locations, images, videos and site records. Second aim is to reconnect artefacts that are held by the NMS with the artefacts’ records and locations held by the Royal Commissions of Ancient and Historical Monuments of Scotland (RCAHMS). The public will be able to use the GPS technology on their handheld devices to locate their position within the landscape of Holyrood Park and find the artefacts that are located within their vicinity. The following options are provided for the user: 1. Google map, which identifies locations featuring cards that provide detail about artefacts. 2. Videos that shows experimental archaeology of how artefacts might have been manufacturing in the past. 3. Spreadsheet that contains the 1996 surveying data.

Keywords
Android, National Museum of Scotland (NMS), Royal Comissions of Ancient and Historical Monuments of Scotland(RCAHMS), Location Based Services (LBS)
1. Introduction

Historically, cataloguing of the National Museum of Scotland collection has emphasized the description and classification of the museum holdings or of their acquisition and their physical location within the museum displays or stores. The geographical detail tends to be recorded inconsistently; this inconsistency is due to the times of when and by whom the artefact was acquired. The archaeological collection and record of this museum was first systematically catalogued by Joseph Anderson, the keeper of the museum from 1869 to 1913 (Clarke, 2002. In 1892, the last tangible copy of the catalogue was printed. This was the result of the collaboration between George Black and Anderson. The continuation catalogue was created in typescript with index cards recording the physical location of the collections. This could be considered the first database of the artefact record held in Scotland. It was finally converted into a computerised database system in the late 1980s. Today the database system is known as the ADLIB, which is administered by the collection management department, providing a museum-wide service. The database is tailored to serve the management of the museum as a whole, rather than meeting specific requirements of departments within the museum (Cowie and McKeague, 2010).

The insufficiency of excavation detail and geographical location held by the museum’s catalogue was somewhat mitigated by the relationship between the Museum and the Society of Antiquaries of Scotland (SAS). The SAS proceedings were the bridge that connected the gaps between the artefact record held by the Museum and the details of the excavation and find location. This is why the lack, poor quality, and inconsistency of the data on geographies is rapidly becoming an impediment to the basic research, analysis, and presentation of results using the NMS catalogue. This worked well until 1985, when the collaboration between the two agencies was terminated (Cowie and McKeague, 2010). Figure 1 shows the area that is covered in the Holyrood Park Stone Tools (HPST) Android App.

This paper begins by discussing the aims and research questions of the HPST Android App. Secondly, discussion of the importance of providing the geographical location of artefacts that are held at the NMS and the combined site report held by the RCAHMS, by streaming those data to an Android smart phone. We explain why connecting these three elements is essential for enhancing general public knowledge. Furthermore, we discuss the utility of building a mobile application for connecting these three components while there is still a need to create a working database that connects the NMS artefacts database with the RCAHMS site records database and case studies. Finally, a brief flow diagram of the methodology is provided to explain the architecture of the app.
2. Aims and Research Question

The aim of this study is to develop an Android web application, ‘Holyrood Park Stone Tools (HPST),’ that allows tourists, local residents, and students who are interested in locating tool artefacts sites within the Holyrood Parks landscape. This application focuses on allowing the users to analyse the distribution of the tools throughout the park while providing links to further the users’ knowledge about the tool types through site reports, pictures of the artefacts, videos, and publications. The key objective of HPST is to show a proof-of-concept for providing the public with an open database resource on archaeological finds and sites held by the NMS, RCAHMS, and ECM. This project is intended to demonstrate that it is possible to reconnect stone tools found within Holyrood Park back to their site locations within the geoarchaeological landscape. The HPST Android app project links the themes and ‘hotlinks’ external sources, allowing users to filter through to find relevant data: plans; descriptions; archives; drawings; site records; published online sources; images; and videos. This type of application provides the general public with a research tool for the archaeological record that allows them to analyse different sources to create a complete foundation on which to build a conclusion.

The aims of this project are:

1. To reconnect artefacts held by NMS and ECM with the GPS points held by RCAHMS.
2. To link External Resources to the stone tools: Videos, site records, published material, etc.
3. To permit user navigation from their location to the find location of a specific artefact.
4. To create distribution Maps of artefact types and classes for user analysis.
5. To create an open database holding the artefact location, link to RCAHMS and NMS, Images.
The associated research questions of this project are:

1. Is it necessary to connect artefacts back to the landscape in which that they were found?
2. Do the tools that are being displayed provide an accurate representation to the user about that archaeological landscape?
3. What other research tools could be developed for informing the public, considering alternatives to a mobile application that could provide the user with more accurate knowledge than that provided in the application?
4. Is there a better application programming interface to give the user interface (UI) a more appealing environment that would engage more users?
5. Will the application substantially benefit the general public?

As the methodology of the archaeological recording of sites progresses towards digital tools, the potential for accessing and integration of digital archives gives the general public and researchers the ability to explore vast amounts of archival information as well as descriptions and illustrations of the finds. New integrated recording packages are available to archaeologists for use when working in the field, including Intrasis and the integrated archaeological database (IADB). These are two sophisticated systems that manage the data collected throughout the lifespan of an archaeological excavation in the field, including the post-excavation analysis and publication. This type of system will be able to be integrated into mobile applications, allowing a comprehensive view of information about the site that previously would have been a very tedious process to convert into digital database form, if it were not implemented into the methodology of the field work (Cowie and McKeague, 2010).

This project demonstrates the capability to create a “one-step shop” for ease of access to a range of information that provides the user a richer context on which to analyse and build conclusions about stone tool artefacts from Holyrood Park’s archaeological record. The overarching goal of this exploratory project is to allow the artefacts to come to life within the landscape, instead of being static within the museum’s collections or displays.

The reason for providing an archaeological catalogue that provides geographic references and background information about the objects is to help the public to recognize the value that archaeology can provide to create a better understanding of cultural heritage in the multi-cultural societies that we live in today. Archaeology can provide of mode of connection to one’s own heritage and promote pride in one’s own ancestry (Skeates, McDavid and Carman, 2012, 574). The mobile applications can provide a link to connect the academic professionals with the public. This will reate a bridge for what had previously been a wide gap that made it hard for the public to appreciate the value that archaeology can offer. This can be achieved by creating a public, user-friendly interface that provides straightforward terms and descriptions that the public can understand. With the increasing acceptance in archaeology for multiple perspectives on the past and multiple ways to interoperate the past, this type of mobile application would allow the public to construct their own interpretation of the past based on archaeological and historical evidence, and would provide the public a forum to share their interpretations. There are many projects in the works that are seeking to explore this same idea; these projects will be discussed in Chapter 5.
3. Rationale for Using a Mobile Application

The Internet has changed the way people pursue their daily activities. Almost three quarters of adults in Great Britain used the Internet everyday (73%) in 2013, with 6 out of every 10 adults (61%) using a mobile phone or portable computer to access the Internet 'on the go'. In 2013, more people than ever before used the Internet to view news information (55%), to access their bank accounts (50%), to seek health information (43%), or to buy groceries (21%). Access to the Internet using a mobile phone more than doubled between 2010 and 2013, from 24% to 53% (Office for National Statistics, 2014). With this change in the way people obtain information, the idea of creating a mobile application connecting artefacts back to the landscape has been created to offer the public a resource they may not have previously considered using. The Android platform offers the framework to permit this development to be possible, but also required were the multiple agencies that are making their data open and permitting the flow of information between the public and private sectors.

Three tables below present the statistics of the user community of internet and mobile internet. In Table 1, the different Mobile devices are listed, along with the percentage of people that use them according to age group and sex. Table 2 shows the increase of internet use on mobile devices through chronological time. Table 3 shows the activities for which people use the internet, underscoring the need for the field of archaeology to develop more mobile apps to inform the public about heritage and preservation within the local scale. These three tables help to explain why a mobile application is an ideal vehicle for presenting access to open-source archaeological data and why the present HPST exploratory project was conducted. Mobile technology has become more widely used in archaeology, but much work remains to be performed before it is a standard tool in this field; currently, many potential benefits of this technology are not being utilized. This technology will introduce new methods to inform the public and to protect archaeological sites. The more the public is informed about and learns to appreciate prehistory and historic sites, the more likely it is that these sites will be protected for future generations.

Table 1. Accessing the Internet 'on the go' by portable device type, by age group and sex, 2013 (Office for National Statistics 2014).

<table>
<thead>
<tr>
<th>Age group</th>
<th>Sex</th>
<th>16-24</th>
<th>25-34</th>
<th>35-44</th>
<th>45-54</th>
<th>55-64</th>
<th>65+</th>
<th>Men</th>
<th>Women</th>
<th>All</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mobile phone or smartphone</td>
<td></td>
<td>89</td>
<td>83</td>
<td>70</td>
<td>51</td>
<td>29</td>
<td>9</td>
<td>57</td>
<td>49</td>
<td>53</td>
</tr>
<tr>
<td>Portable computer (laptop, tablet)</td>
<td></td>
<td>42</td>
<td>43</td>
<td>41</td>
<td>34</td>
<td>26</td>
<td>11</td>
<td>35</td>
<td>29</td>
<td>32</td>
</tr>
<tr>
<td>Other handheld device (eg PDA, MP3, e-book reader, games console)</td>
<td></td>
<td>21</td>
<td>15</td>
<td>14</td>
<td>10</td>
<td>7</td>
<td>2</td>
<td>12</td>
<td>10</td>
<td>11</td>
</tr>
</tbody>
</table>

Table 2. Internet use on a mobile phone, 2010 to 2013 (Office for National Statistics 2014).

<table>
<thead>
<tr>
<th></th>
<th>2008</th>
<th>2009</th>
<th>2010</th>
<th>2011</th>
<th>2012</th>
<th>2013</th>
</tr>
</thead>
<tbody>
<tr>
<td>All</td>
<td>53</td>
<td>61</td>
<td>62</td>
<td>66</td>
<td>67</td>
<td>72</td>
</tr>
<tr>
<td>Men</td>
<td>57</td>
<td>66</td>
<td>64</td>
<td>68</td>
<td>68</td>
<td>74</td>
</tr>
<tr>
<td>Women</td>
<td>49</td>
<td>57</td>
<td>60</td>
<td>63</td>
<td>67</td>
<td>70</td>
</tr>
<tr>
<td>Age group</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>16-24</td>
<td>65</td>
<td>78</td>
<td>74</td>
<td>77</td>
<td>79</td>
<td>86</td>
</tr>
<tr>
<td>25-34</td>
<td>72</td>
<td>82</td>
<td>79</td>
<td>88</td>
<td>87</td>
<td>92</td>
</tr>
<tr>
<td>35-44</td>
<td>68</td>
<td>75</td>
<td>78</td>
<td>79</td>
<td>84</td>
<td>83</td>
</tr>
<tr>
<td>45-54</td>
<td>59</td>
<td>65</td>
<td>70</td>
<td>73</td>
<td>72</td>
<td>77</td>
</tr>
<tr>
<td>55-64</td>
<td>45</td>
<td>52</td>
<td>58</td>
<td>59</td>
<td>61</td>
<td>67</td>
</tr>
<tr>
<td>65+</td>
<td>16</td>
<td>20</td>
<td>22</td>
<td>27</td>
<td>32</td>
<td>36</td>
</tr>
</tbody>
</table>
Table 3. Internet activities by age group and sex, 2013 (Office for National Statistics 2014).

<table>
<thead>
<tr>
<th>Activity</th>
<th>Age group</th>
<th>Sex</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>16-24</td>
<td>25-34</td>
<td>35-44</td>
</tr>
<tr>
<td>Sending/receiving emails</td>
<td>87</td>
<td>89</td>
<td>86</td>
</tr>
<tr>
<td>Finding information about goods and services</td>
<td>65</td>
<td>77</td>
<td>77</td>
</tr>
<tr>
<td>Reading or downloading online news, newspapers or magazines</td>
<td>69</td>
<td>72</td>
<td>66</td>
</tr>
<tr>
<td>Social networking, eg Facebook or Twitter</td>
<td>93</td>
<td>84</td>
<td>66</td>
</tr>
<tr>
<td>Using services related to travel or travel related accommodation</td>
<td>46</td>
<td>65</td>
<td>58</td>
</tr>
<tr>
<td>Internet banking</td>
<td>55</td>
<td>76</td>
<td>62</td>
</tr>
<tr>
<td>Seeking health related information</td>
<td>46</td>
<td>59</td>
<td>56</td>
</tr>
<tr>
<td>Consulting wikis</td>
<td>60</td>
<td>55</td>
<td>52</td>
</tr>
<tr>
<td>Looking for information about education, training or course offers</td>
<td>62</td>
<td>40</td>
<td>38</td>
</tr>
<tr>
<td>Downloading software (other than games software)</td>
<td>55</td>
<td>47</td>
<td>35</td>
</tr>
<tr>
<td>Selling goods or services over the Internet</td>
<td>33</td>
<td>45</td>
<td>34</td>
</tr>
<tr>
<td>Telephoning or making video calls over the Internet via a webcam</td>
<td>40</td>
<td>39</td>
<td>28</td>
</tr>
<tr>
<td>Looking for a job or sending a job application</td>
<td>45</td>
<td>39</td>
<td>30</td>
</tr>
<tr>
<td>Participating in professional networks</td>
<td>16</td>
<td>23</td>
<td>23</td>
</tr>
<tr>
<td>Posting opinions on civic or political issues</td>
<td>13</td>
<td>15</td>
<td>12</td>
</tr>
<tr>
<td>Doing an online course</td>
<td>18</td>
<td>9</td>
<td>14</td>
</tr>
<tr>
<td>Taking part in online consultations or voting on civic or political issues</td>
<td>6</td>
<td>8</td>
<td>10</td>
</tr>
</tbody>
</table>

**4. Background**

Currently, Holyrood Park located in the middle of the city of Edinburgh in Scotland, is well-used and popular among tourists. Every day of the year, even on rainy, windy, and cold days, it is possible see people walking; climbing; or just simply taking in the view and tranquillity of the Park. It provides an oasis of tranquillity, away from the noises of crowded streets of the city. New technology and scientific developments have been changing the traditional use of Geographical Information Science (GIS) (Goodchild, et al., 2004). With this change, gaps can be bridged between artefacts and the landscape. Such a bridge can be constructed by technology in location-based systems, integrated recording packages, and open database and data sources. These resources allow the creation of databases for the public to disseminate general knowledge and to permit the interpretation of geoarchaeology.
Geoarchaeology is the study of the human past, based on evidence derived from the application of the earth sciences (especially geology, geomorphology, hydrology, sedimentology and pedology) to archaeological problems. There has been a growing consensus within the map generalisation research community that open research platforms will allow closer integration in terms of collaborative research, data abstractions, interoperability of functional components, and the augmentation of geo-spatial applications with generalisation capabilities. This desire has been evidenced through discussions at various meeting of the International Cartographic Association ICA commission on Generalisation and Multiple Representation (Beijing 2001, Ottawa 2002, Paris 2003, Leicester 2004), and described in Edwards et al. (2003). With the advancement of visual technology and open source data, geoarchaeology is not just a discipline to be used by researchers; it can now be shared and interpreted by the general public. This offers researchers new and valuable data from unbiased sources that are not constrained by their academic preconceived ideals. This is not to say that researchers’ interpretations are not important; rather, accounting for additional perspectives may reveal patterns not previously seen. With more ideas shared across disciplines, a more complete analysis of the archaeological record can be created.

4.1 Holyrood Park

Holyrood Park is an iconic part of Edinburgh’s skyline that lies at the heart of the city. The Park was formed by a volcano that erupted around 350 million years ago. The present day summit is the heart of the extinct volcano that in the past would have extended many meters higher than it does today. The first human inhabitants of the park are unknown, due to lack of archaeological evidence resulting from unfavourable soil, more recent inhabitant activities, and weather conditions. The first archaeological evidence that we have of human inhabitants occurs 9,000 years ago, when the first hunters and gatherers were moving throughout Scotland. The first humans who occupied this land are unknown because their traces have been erased through the decay of time.

The only archaeological evidence of these people discovered in the Park is a flint tool that was found at Whindy Hill, which can confidently be coupled with the early hunters and gatherers. The style of the tool can be cross-referenced with larger sites in Scotland that are dated to this period to make a definitive classification of the time period that it is associated with. There is very little evidence of these early hunters and gatherers because their belongings were adapted for a mobile life. The greatest change in lifestyle that occurred during the Stone Age was farming, which was first used in Scotland around 6,000 years ago. There have been various artefacts discovered that are associated with farming during this time period. However, the early settlements have not yet been discovered to give us more insight on how they were specifically using the land and how their villages would have been organized. The artefacts that can be ascribed to these early farmers are a flint knife and arrowhead from near the summit, and a stone axe from the gateway of Duddingston Church (Wickham-Jones, 1996).

The Bronze Age, which occurred 3,000 years ago, has the most archaeological evidence than any previous period at the Park. There was an swelling in population at this time, which increased human activity that left a deeper stain on the land then previous human occupation. There is a row of indistinct hollows on the dasse in the centre of the park that may mark the individual house sites from a Bronze Age settlement, but it is very difficult at the moment to date settlements of this type because of decay and more recent activities that have occurred within the Park that have made the archaeological record unclear. There was a Bronze Age hoard discovered in the late 18th that included spearheads and swords. Also discovered was a bronze sword, found in a bed of charcoal recovered from nearby slopes. The Bronze Age is the first period in the Park’s archaeological record showing evidence of human inhabitants. In 1778, a Bronze Age burial site was unearthed at the Windy Goal, comprising a cinerary urn in a stone lined cist, which was a widespread Bronze Age burial tradition. Bronze Age settlements were open farming villages that were not fortified. The Iron Age involved many changes in the settlement patterns left in the archaeological record. Conflicts were more likely to occur during this time than during previous periods. The Park contains four terraces of fortifications, and some of them may date to the Iron Age. Throughout the last 2,000 years, the Park has been impacted by inhabitants being more pervasive and often closely tied to the history of the city that started to grow nearby (McHardy and Smith, 2013). The hills of Holyrood Park bear evidence of fortifications, settlements and ancient farming. At the top of the
highly renowned Arthur’s Seat is a large fort enclosed by two ramparts. Above Samson Ribs and on the hillside by Dunsapie Loch are two more forts. Hut circle remains include a number on the hillside east of Hunters Bog. In the absence of excavation, it is very difficult to date these sites, but it has been estimated that they date from late Bronze Age to the Iron Age (MacSween, 1999).

Holyrood Park is presently designated as legally both a site of specific scientific interest and a scheduled ancient monument. The value of having a landmark declared a monument is twofold: it is embodied in the materiality as well as in the very existence in the landscape, and in the services that are designed around the monuments such as the Dynamic Earth Exhibit. The monetary value of the monument is perhaps more difficult to establish; it is not possible to assign a price tag like a real estate property, because it is priceless. The non-tangible value is imparted to individual visitors who derive benefits such as personal enrichment, education and alternate forms of leisure from visiting the park. These non-tangible values can be documented by applications such as the one explored in this paper (Skeates, McDavid and Carman, 2012). Holyrood Park offers visitors a gateway to cultural knowledge of the past; it serves as an important icon at the micro- and macro- levels. The concept of phenomenology, as used within the discipline of archaeology, describes the augmentation of an individual’s sense of place and their perception and interpretation of the landscape; this is important in shaping cultural identities.

4.2 Partnerships

The Department of Archaeology at the National Museum of Scotland provides curatorial expertise across the full chronological range of Scotland’s prehistory, from the first arrival of humans around 12,000 BC to around AD 1,100. There was an exploratory project undertaken by the NMS and RCAHMS to boost both respective databases to create a Museum artefact geographical interface that would reconnect the objects, held by the NMS, and the locations of their discovery, held by the RCAHMS. The project was undertaken in 2010 by Trevor Cowie and Peter McKeague. It showcases the great potential that an open database connecting over a wide range of resources would provide to research that, at present, would require searching through many different resources and ensuring that the data concerning the same object are consistently accurate. With the creation of a database like the MAGI Project, all of the resources and information would be checked for accuracy and consistency so that when research is needed for a specific object, the research tool would be able to provide reliable data to users of the tool. Such a tool would be authoritatively controlled by organizations that have knowledge of Scottish archaeology. Presently, there is no such tool that connects all of the data from each individual establishment to allow for a cross-platform search through all the materials held by each.

5. Previous Research Projects

For demonstration purposes, six case studies are discussed in this chapter to illustrate the potential and now ever-growing market for mobile technology with GPS capabilities gaining ground in public archaeology. With this technology, methodologies are changing for researching, locating, excavating, recording and protecting archaeological finds within the discipline of archaeology. This represents a movement away from diary-based site reports and towards mobile device tools to link with real-time development for creating models and theories while still in the field. There has been a lot of research already undertaken to provide archaeological information to users on handheld devices. In order to answer the questions about the locations related to the past, and to visualize that past in the present, mobile applications will be useful. Such applications will permit the analysis of difference ways the land was utilized and the breadcrumbs left behind through chronological time. Such analysis can be performed at the local level, as the HPST application permits, or on a much larger scale, such as the Archwilio application provides; both technologies will be discussed below. Most of these applications deliver information to tourists; the past landscapes come alive through virtual realities of the past. The following is a list of mobile applications related to heritage and archaeology:

1. The SCAPe project is one of the first of its kind in Scotland that uses mobile technology to connect with the public, providing them the tools to locate, record, and monitor sites that are related to the coast of Scotland. The very successful Shorewatch Project has originated from this collaboration (Shorewatch, 2014).
2. The Roman Reborn Project allows the public to view the past cityscape of Rome in a virtual reality tour and has been made into a layer of the Google Earth gallery (as of November 12, 2008), where it is known as the “Ancient Rome 3D” feature. Since its release, Google has become enthusiastic about promoting and supporting educational and scholarly uses of the tool (Wells et al., 2009).

3. The Boeotia Project in Koroneia, Greece has used GIS in their fieldwork methodology by recording points within ArcPad and DGPS tools for constructing a 3D model of the site and creating an Augmented Reality application, which is still being developed by the city administration. The virtual reconstruction will allow the public to superimpose the virtual reality onto the real environment. Allowing the public to use their phones to better understand how the past archaeological landscape would have appeared permits users to see beyond the ruins of the site as it sits today (Bintliff et al., 2010).

4. The Home Front Legacy app allows users to upload First World War data, view site locations, data and any images or documentation as a pin on the project’s online map of UK sites and projects in accordance with the historic environment record. Its goal is to help safeguard the physical legacy of the First World War (Council for British Archaeology, 2014).

5. The Archwilio app allows the user to access millennia of archaeological information specific to Wales, providing a resource to improve education and understanding of the importance and sheer variety of Wales’ archaeology. Also, it enables locals and visitors alike to discover more about the unique heritage and archaeological sites across Wales (Southwales.ac.uk, 2013).

One more candidate is the ‘digital digging app,’ an iPhone or iPad application that allows users to excavate through layers of material from different time periods, digitally digging back through the archaeology of the Cambridge region. Its goal is to recreate the experience of an archaeological excavation, allowing the user to excavate through the accumulated layers of an archaeological site (Cam.ac.uk, 2014).

There are many different types of applications available to the public interested in archaeology; many of them permit the public to assist in the preservation of the past. Many are very subject-specific and built for the museum experience, meaning that the overall goal is to bring the museum to life through mobile experience rather than bring individual artefacts to life in accordance to their site location, instead of the context of the museums display. Such applications cater to tourists’ ever-growing appetites for virtual Reality (VR) and augmented reality (AR) for interaction when learning about the past in areas with a renowned archaeological landscape. Rome and Greece have become an even higher priority to provide a VR or AR experience to the public because of popular games like ‘Age of the Empires’. HPST unlike most of the mobile application in archaeology today is connecting the land and the artefact without worrying about the artefacts display in the museum but this could be add to the HPST in the future.
5.1 The Future of Public Archaeology

The following passage summarizes the current structure of education in Scotland:

“For environmental studies, pupils should use museums and buildings as sources of evidence for people in the past and should be able to sequence historical objects. All pupils should be encouraged to make informed judgements about the value for themselves and others of respecting and preserving particular aspects of community heritage” (Wise, 2002, 47).

The above statement shows that, with the goals of education today, there must be open, reliable research tools. The HPST is a proof-of-concept project that provides one avenue of research tool development. The MAGI project that was discussed in Chapter 3 would be another type of research tool that would aid students, the general public, and researchers. The Leicestershire County Museum has stated that archaeological knowledge consists of both the material finds and the intellectual interpretations or models we use to account for and describe these finds, It is this body of knowledge that has traditionally been presented to the public as archaeology. We have, as a society, perhaps been less concerned to enable understanding in the senses of either learning from the past or using our heritage of the past. These are processes rather than products, and that should not be wasted in the present constructs of society. Yet, they are the most powerful and relevant aspects of archaeology in that they relay the past to the present and provide archaeology with a role in today’s society. Learning from the past involves understanding the nature of change, appreciating human cultural, relating ourselves to the environment, and appreciating the relevance of the past.

There are two elements involved when using the past. People have a relationship to the historical environment that varies from total fascination to deep apathy. Nurturing or challenging these attitudes, or helping people to explore their attitudes, is something that museums do very well. They can also make a contribution towards the maintenance of cultural identities, which is the second major use of heritage. Archaeological skills should also be communicated to people; engaging in such communication is the nature of the work that archaeologists do. Not only are some people interested in how we know about the past, how museums also help to spread greater understanding of what archaeology involves and the issues connected with caring for our heritage. We must enable people to evaluate evidence, to understand the processes of archaeological investigation, and to change the way in which we communicate our findings to others (Skeates et al., 2012).

The future of archaeology involves having open resources for the public to view and learn from on their own terms, and not within the confines of museums or academia. One goal of an archaeologist is to preserve the past for the future generations. To be able to meet this goal, an archaeologist has to be able to connect the past with the present population. This helps people to have a sense of connection so that they will have a hand in the preservation of their own heritage. The SCAPE project is one of these projects that have shown the great potential for the public participating in the preservation process on their own accord, but with the guidance and standards of the Scottish and British archaeology communities. The website and mobile application for SCAPW provide extensive resources for training the public about site protection and management, useful information, guidelines and safety regulations, and how-to guides for using their mobile application. Archaeologists have a duty, both to colleagues and to the general public, to explain what they are doing and why (Renfrew and Bahn, 2004).
5.2 HPST

This project aspires to build a mobile application on the Android platform developed by MIT labs partnered with Google Labs. The data sources used for developing this application are:

1. Extraction of the Canmore records for Holyrood Park (buffered to 200m) as a Shape file with a copy as a table within MS Access, along with the descriptive text published on Canmore.

2. RCAHMS GPS survey line work from their archaeological survey of the Park (from 1998).

3. The Unique identifier for a site record is called the numlink, and this is embedded in all of the RCAHMS shape files.

4. NMS photographs of artefacts that were filtered out in the RCAHMS 1998 survey data for the purpose of this project. The artefacts were specially chosen for being a tool that would have been produced in the Stone Age, Iron Age, or Bronze Age. No tool after these three periods was selected; this limited scope is due to the exploratory nature of the project. The Google Maps application was used to display the data.

5. External resources used in the mobile application to hotlink the user to related content to learn more about the artefacts:

Table 4. Resources provided in the Home screen when the Online Resource button is clicked by the user

<table>
<thead>
<tr>
<th>External Resources:</th>
<th>Links:</th>
</tr>
</thead>
<tbody>
<tr>
<td>British Arrowhead Video</td>
<td><a href="https://www.youtube.com/watch?v=OCU6T_bZgFl">https://www.youtube.com/watch?v=OCU6T_bZgFl</a></td>
</tr>
<tr>
<td>Prehistoric Blog</td>
<td><a href="http://prehistorics-uk.blogspot.co.uk/">http://prehistorics-uk.blogspot.co.uk/</a></td>
</tr>
<tr>
<td>Flint Knapping E-Books</td>
<td><a href="http://flintknappinginfo.webstarts.com/">http://flintknappinginfo.webstarts.com/</a></td>
</tr>
<tr>
<td>West Lothian Megalith Portal</td>
<td><a href="http://www.megalithic.co.uk/search.php?query=Edinburgh&amp;country=3&amp;category=0&amp;county=62&amp;sitetype=&amp;days=0&amp;condition=&amp;ambient&amp;access=">http://www.megalithic.co.uk/search.php?query=Edinburgh&amp;country=3&amp;category=0&amp;county=62&amp;sitetype=&amp;days=0&amp;condition=&amp;ambient&amp;access=</a></td>
</tr>
<tr>
<td>Orkney Arrowheads Find Points to Scotland’s Earliest Settlement</td>
<td><a href="http://www.megalithic.co.uk/article.php?sid=2146413293">http://www.megalithic.co.uk/article.php?sid=2146413293</a></td>
</tr>
<tr>
<td>Accessing Scotland’s Past</td>
<td><a href="http://www.accessingscotlandspast.org.uk/">http://www.accessingscotlandspast.org.uk/</a></td>
</tr>
<tr>
<td>Wells O Wearie</td>
<td><a href="http://www.electricscotland.com/poetry/henderson/singalong/wav/112%20Bonnie%20Wells%20Wearie%20Bill%20McCue.wav">http://www.electricscotland.com/poetry/henderson/singalong/wav/112%20Bonnie%20Wells%20Wearie%20Bill%20McCue.wav</a></td>
</tr>
<tr>
<td>Dunsapie Hill Axe Hoard</td>
<td><a href="https://drive.google.com/file/d/0B6H8nDLbIzLwUEZHY1BtNHFQblk/edit?usp=sharing">https://drive.google.com/file/d/0B6H8nDLbIzLwUEZHY1BtNHFQblk/edit?usp=sharing</a></td>
</tr>
<tr>
<td>Further Reading</td>
<td><a href="https://docs.google.com/document/d/1eNSznmQrIYH671IZcfSVZ92aUTf-4Xhn0H6pi3I5fM/pub">https://docs.google.com/document/d/1eNSznmQrIYH671IZcfSVZ92aUTf-4Xhn0H6pi3I5fM/pub</a></td>
</tr>
<tr>
<td>Video on Leaf Arrowhead</td>
<td><a href="https://www.youtube.com/watch?v=OCU6T_bZgFl">https://www.youtube.com/watch?v=OCU6T_bZgFl</a></td>
</tr>
</tbody>
</table>
6. Methodology

Figure 2. Flow diagram of 3-tier architecture for HPST.

Figure 3 is a flow diagram showing how the HPST mobile application has a 3-tiered architecture (Longeley et al., 2010). Part 4 Source Layer (Data) is discussed further in the following subchapter. For parts 1-3, refer to the extended methodology in Technical Report Goetz (2014). Part 1 of the HPST explains the importance of the graphical user interface (GUI) demonstrating the key features that allow the user to view their location in accordance to the stone tools artefacts within the park boundaries. Part 2 addresses the functions available within the Android system that allow the user to view images, their location in accordance to the stone tool artefacts, descriptions from the RCAHMS, and images of the artefacts. Part 3 establishes the data server to have controlled access of the data sources from Part 4. In this application, RCAHMS data was used and converted into a Fusion Table that is used as the database that connects the content with the UI. The NMS and external resources are accessed remotely. Part 4 details the adjustments made to the data sources to be used in the mobile application. These parts are discussed in detail in the technical report, Goetz (2014).
1.1 Data Sources

The key data for the HPST application originated from the RCAHMS 1998 archaeological survey of Holyrood Park. The data of this survey were screened using Microsoft Excel to identify the stone tools and axeheads that were sourced from the Iron, Bronze and Stone Ages; the breakdown of types is shown in the technical report Goetz (2014). When using GIS in archaeology, it is important to understand how sites have been used in chronological time so that a better interpretation can be ascertained of how the artefact has ended up in its resting place, whether it was unearthed by walking along the surface or through an archaeological dig. The dualistic concept of space and place includes the pathways where movement might have occurred between different places and through space. GIS provides the tools to explore these qualitative themes in a quantitative environment. The data provided by the RCAHMS allow for different views of the landscape of Holyrood Park to be analysed. The photographs were sourced from the NMS collection held in Leith.

The RCAHMS runs their site classifications together into a single string (with combined period information where available). This is a limitation imposed by fitting their relational database into a flat GIS attribute table. For instance, the artefact numlink 52511 is classified as a MOULD (STONE) in the NMRS_point database that was provided by the RCAHMS for the purpose of this project. These data were originally viewed in ArcGIS, imported into a spreadsheet, and further manipulated in the Fusion Table database and Google Spreadsheet for the purpose of the HPST application. The RCAHMS stores the classification data in a separate table in their Oracle database that manages the terms from one of their thesauri against the site identifier (numlink, which has been provided with each of the 21 artefacts in HPST). Oracle allows the RCAHMS to record if the term is possible (the (STONE) added at the end of MOULD in the above example), to report the age of the site to which it can be ascribed, or to list the material that the object is made out of. The RCAHMS is partnered with the English heritage and RCAHMW. The ADS in York have published the vocabularies as linked data through the recently established Heritagedata.org website. Peter McKeague from the RCAHMS classified the data for the artefact sites previously supplied and added a cross reference to the persistent URI for each concept (through simply combining the ‘THE_TE_UID’ with the URI root for relevant thesaurus to calculate the URI for the concept). The Heritage Data website has vocabulary search widgets that can be added into webpages or apps. HPST was created in the MIT labs App Inventor, which does not allow for the implementation of syntax code. This highly resourceful tool was not able to be added to HPST at this time, but the implications of its use should be noted; it would provide the user more knowledge about archaeological terms. The widgets use the Heritage Data web services as their data source, and utilize the local browser cache to avoid repeated service calls to the same resource (Heritage Data, 2014).

In 2015, the RCAHMS and Historic Scotland will join together to form a new non-departmental public body. The new organisation will deliver the Historic Environment Strategy for Scotland (HESS), which is currently in consultation. This new organisation will be promoting the data standards for new partnerships and learning to ensure that people benefit from and value the heritage environment. This will provide a pivotal turning point for public archaeology in Scotland; projects such as MAGI and HPST can implement the standards of this new partnership to meet their overall aim of creating a tool that threads the past, present, and future heritage so that it becomes ingrained into everyday life. Such an objective is intended to remind people that they are connected to their city’s past landscape by way of the present landscape.
7. Problems

A common issue was found with the API that was used to create the mobile application: the MIT AI2 is restricted in the components that can be used and the graphical output of the UI.

The problems with the project involved not knowing enough about the background of programming and the fundamental concepts that are the basis of developing API, EDI, and UI. Finding the right API that would permit the connection of the artefact and the landscape to be viewed by the user presented a significant challenge. Selecting a the most efficient database was a goal, yet the programmer had to be able to understand enough. This made the app limited in the availability of user groups and in the manipulation of lists and searches within the UI.

The one aim that was removed from the desired goals for this project was to create a searchable database that would allow the UI to group all information related to one specific object type or group of artefacts within a given radius. The HPST had to be consolidated from the original goals stated in the dissertation proposal due to lacking the required programming background. This created problems until the decision was made to create a very simple block code that showed the proof-of-concept to allow for a working app but that did not provide the key components that would attract more users: search tool, database and independent app that was able to market the app to all user platforms. Using the MIT AI2, there is a limited library of coding blocks that can be used. However, the components of the phone (GPS, NFC, texting, camera, accelerometer, etc.) are all accessible in the coding block library, giving the designer additional options to customize the application.

8. Conclusion

This project focused on two main sources of data for association of those sources to create a proof-of-concept mobile app of Holyrood Park Stone Tools. This project demonstrates that communication between different data sources can be useful. For example, the Royal Commission of Ancient and Historical Monuments of Scotland focuses on site records and location, while the National Museum of Scotland focuses on preserving artefacts and performing research about the objects. By staying in a close working relationship, different sources of data can create a knowledge base that would be unmatched in terms of size, accuracy, quality and completeness. This would allow for an open source of information for education, research, and general knowledge for the public, providing a unique and exciting way to visualize past cultural heritage, reconnecting with the generations that have gone before, and keeping this connection so that future generations do not forget. The growth of technologies for the retrieval, handling, and visualisation of geospatial data has brought with it the demands on automated cartography to provide theory and methods that will allow their coherent operations (Meng, 2003), described in Edwardes et al. (2005).

Below are some of the key points resulting from this project:

- The future of education is in digital technology
- Future work would be to add the complete 494 data points to the application
- Eventually, the goal is to create a complete virtual reality of the entire landscape and to connect it with archaeological databases
- Much work remains to be performed to create a fully functional and complete archaeological database
- Applications should be designed to be compatible with all device types so that anyone can access and use
- Just because the artefact is connected to a point does not mean that is where it was originally located or manufactured: the quality of data and accuracy of the site location would need to be stressed within later versions of the mobile app
- The application would specify how the artefact was discovered and how the coordinate location connected to the artefact was documented
- Not all artefacts are in situ to their original location where they were used or manufactured. This will be clearly stated in future apps created by the Scottish public archaeology societies.
Another way to present the data as an open source tool, other than a mobile device or a searchable open database like the MAGI project, is proposed. A tool could be created in Google Earth similar to the Roman Reborn project discussed in Chapter 5. Google Earth is a platform that is promoted and used by educators, non-profit organizations, and research organizations. This makes them reliable and knowledgeable about standards and terms of agreement for consulting and working with creating. Google Earth could provide the future HESS another avenue for accomplishing their mission statement.
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University of South Wales (2013). New archaeological app is a first for Wales, University of South Wales. [online] Available at: http://www.southwales.ac.uk/news/2013/11/06/new-archaeological-app-first-wales/ [Accessed 13 May. 2014].


Holyrood Park
Stone Tools
Mobile Application
(HPST)

Part II: Technical Report
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1. Executive Summary

This supporting document complements the research paper Goetz (2014), by providing a different approach to an open data source for the public via handheld devices and describing the process used to create Holyrood Park Stone Tools (HPST) application. Chapter 2 gives a detailed overview of the background mentioned in Goetz (2014) and the technology used to perform this research, along with the reasons why this research project was selected and why AI2 was selected because of the easier to understand and develop block coding over the other IDEs that were syntax coding. Chapter 3 discusses the data sources used within this mobile application, with additional information discussed about other available sources. Chapter 4 explains in detail the methodology of the applications architecture and the internal composition of the two screens that constitute the UI in the HPST application -- components and behaviours and discusses the process that was followed to create a user-friendly interface for this application. Chapter 5 explains the limits of this application Finally, Chapter 6 concludes with the objective of this research paper and future research that may extend the present work.

The at the end of this document an Appendix of the Screens and all the block code used is provided with location in the M: drive of where important data is held.
2. Overview of Technology

In this exploratory project, the development of a proof-of-concept mobile application was performed to address the missing link between archaeological artefacts and their geographical location within the landscape. A new Android mobile application (app), named Holyrood Park Stone Tools HPST, was created using MIT’s Android App Inventor (AI2) using drag-and-drop block language for mobile Android devices. This chapter principally describes the API that Google Android provides and the advantages of using the Android platform. There were three different Android Developing Tools (ADT) investigated for exploratory proof-of-concept for the HPST app. Google labs main interface design environment (IDE) for Android development environment is based on Eclipse ADT and the newer Android Studio IntelliJ IDE. AI2 beta ADT was selected for the exploratory purposes of this project AI2 application programming interface (API). These three programming environments are discussed in this chapter to explain why AI2 was selected to develop the applicationAI2 in a graphical block code instead of syntax coding.

2.1 Android

In 2012, the Android platform became a major player in competition with more established mobile platforms such the Blackberry, iPhone, Windows Mobile, and Symbian OS. It has become the number one global smartphone platform, surpassing Symbian at the end of 2010. The Android consumer base has also continued to grow, with this phone being considered one of the most desired smartphone operating systems in the US. This claim is supported by the Android representing 50% of all new smartphone sales in 2012, which is double the sale of the iOS platform. Android phones constitute 37% of all smartphone sales in the U.S. (Darcey and Conder, 2012). With Android having such a large market base of users, it was the logical choice of API to create the HPST app.

The Android developers’ page provides an abundance of information about how to develop an Android app by providing training, API guides, references, tools, Google Services and samples. Android is a rich application framework that gives individuals the ability to create innovative apps and games through a Java language environment. One of the key features of Android is that the app framework can adapt to different devices. Android provides a unique resource configuration; for example, it is possible to create a single app binary that is optimized for phones and tablets. When the app is run, Android applies the correct resource set based on the constraints such as screen size, density, and locale. With the powerful and efficient ADT with Java IDE that has features for debugging and packaging apps, the IDE makes it easy to make the app available to any Android device (Android Developers, 2014). Android phones provide Location Based Services (LBS) allowing app technology to utilize the LBS. There are three different location systems held within the Android phone that connect to each other. These systems include the location positioning system (LPS), the global positioning system (GPS), and wireless technology (Wi-Fi). All are being used within the HPST App to help navigate the user to the artefact site location.
2.1.1 IDE Eclipse

Eclipse would provide a better application programming interface to the UI a more appealing environment that could potentially draw in a wider user group. The Android API was created by Google in 2007 and at its basic level is distributed by Linux. JAVA is the preferred programming language for most Android applications. Google developers have created a variety of application platforms for different types of coding language and needs. The Android Software Development Kit (SDK) is viewed in the Eclipse integrated development environment (IDE) using the Android Development Tools (ADT) plug-in. SQLite database support is integrated into the Android platform (Whipple et al., 2009).

The Android Developers webpage provides the Eclipse ADT bundle, which includes everything needed to begin developing apps (Android Developers, 2014):

- Eclipse + ADT plugin
- Android SDK Tools
- Android Platform-tools
- A version of the Android platform
- A version of the Android system image for the emulator

ESRI also supplies a SDK download for Eclipse with a complete library for using ArcGIS tools within an Android app. This platform was eliminated from consideration because of a learning curve that would have hindered the creation of a working app for the project if used through Eclipse, with ArcGIS being the supplier of the map.

In the beginning stages of the project, the goal was to use the ESRI ArcGIS developers SDK and APIs that can be downloaded from the ESRI’s Developers webpage. ArcGIS developer was not used because it proved to require significantly more background knowledge than time allowed and that a new programmer could fully understand in order to create a functional app. That platform would have been a good choice to use if the project had been undertaken by an experienced programmer who understood how to use all the tools provided in the SDK and how apply syntax coding for the desired user interface (UI). The ArcGIS developer permits the construction of applications for the web, mobile devices, and desktop computers using ESRI cloud services, Developers APIs, ready-to-use content, and self-hosted solutions.

The ArcGIS SDK tools (ArcGIS for Developers, 2014) include:

- Visualization of thematic maps that allow users of the app to explore and understand the geographic data that is being shown within the app
- Geocoding searches that can be displayed on the map being developed from the database that meets the app requirements
- Directions for optimal routes and calculation of drive times
- Ready-to-use content that includes basemaps, demographic maps, and imagery that allows the developer to create an interactive map with their data
- GeoEnrichment for demographic variables for a given study area
- Geotrigger to make the app location aware
- Spatial analysis to analyse the data spatially
- Real-time processing connects to sensor technology provided on the mobile device hardware
- Imagery of ArcGIS online services
- Data storage of customized REST endpoints to store and visualize content
- Offline editing
2.1.2 IDE Android Studio IntelliJ

The newest IDE is Android Studio powered by IntelliJ that provides newer features and improvements for the ever-increasing need for better graphics on the UI over the ADT. This platform is currently only in its beta stage of development, but will eventually become an official IDE (JetBrains, 2014):

- Smart Code completion
- On-the-fly code analysis
- Advanced refactorings
- Web development
- Enterprise development
- Code assistance and support for the most popular application servers
- Database tools
- UML designer
- Version-control tools
- Build tools
- Languages supported include JVM-based languages: Java, Scala, Groovy, Clojure, Kotlin, PHP, Python, Ruby and SQL

Android Studio IDE environment includes all of the above from IntelliJ IDEA but it also offers new features on top of IntelliJ. Android Studio offers (Android Developers, 2014):

- Flexible Gradle-based build system.
- Build variants and multiple APK generation.
- Expanded template support for Google Services and various device types.
- Rich layout editor with support for theme editing.
- Lint tools to catch performance, usability, version compatibility, and other problems.
- ProGuard and app-signing capabilities.
- Built-in support for Google Cloud Platform, making it easy to integrate Google Cloud Messaging and App Engine.

ADIs have become much easier to use, with built-in libraries and generic code segments that can be edited to fit the requirements of custom app designs. The problems that had risen when exploring Eclipse and IntelliJ IDE were that their tools were extensive, and knowledge of all of the above bulleted points was required to be acquired in order to effectively create the desired functionality.

2.1.3 App Inventor 2

Google labs also created the first App Inventor is a IDE that uses visual Block coding instead of syntax coding tool for creating Android Applications, which has now been taken over by MIT labs. HPST was created in the MIT App Inventor. Since the move of App Inventor from Google to MIT, a number of improvements have been added, and new research projects have been under development since 2013. App Inventor’s intuitive programming metaphor and incremental development capabilities allow the developer to focus on the programming logic of the app rather than the syntax of the coding language. App Inventor was first created in 2009 by Professor Hal Abelson of MIT while working at Google during a sabbatical. In 2011, Professor Abelson was granted permission by Google labs to develop App Inventor at MIT (Pokress and Veiga, 2013). App Inventor is a drag-and-drop tool for building mobile apps on an Android platform, making programming accessible to non-programmers. The block language allows anyone to develop their ideas into a working app without having to outsource their idea. App Inventor made this proof-of-concept project possible because of the simple-to-understand code blocks and implementation of ideas into a working UI that can be released as an open source to the public. Useful resources for nonprogrammers, who desire to create a marketplace for data that is otherwise only accessible to a very limited group, can now be accessible and easily manufactured with the App Inventor. The components and blocks used to create this application are discussed later in Chapter 3. Figure 1 shows the hierarchy of components within an AI2 App.
The App Inventor IDE includes:

1. Real-time testing and incremental development
2. Designer: provides an intuitive interface for selecting the app components and their properties
3. Block editor: provides graphical cues for programming the app’s behaviours
4. Open-source project for Android
5. Non-visible block components include sensor technology held with the phone, e.g.: GPS, camera, sound, clock, etc. Also, storage to Fusion Tables and other databases, connectivity: Bluetooth, WebViewer, etc. Also includes components that are connected to databases: Fusion Tables
6. Visible components: the parts users are able to see in the UI, including buttons, text boxes, and labels
7. Location services API

![Internal architecture of an App Inventor app.](image)

Since Google was the creator of App Inventor, it was a simple process to implement the Google Maps application into the UI. Using Fusion Tables for the database created maps within the Google Maps layout, with the data provided in the table when they were located by coordinates, postal code, or name of region. The Maps API v3 now offers two solutions to having a large database that renders quickly. If you have a large volume of geospatial data that can be served as KML, the KmlLayer class can render up to 50,000 features as an overlay that does not impact performance on any browser. To support data sets that are structured as tables, such as a database or spreadsheet, we have also now added the Fusion Tables Layer class for rendering data stored in Google Fusion Tables.

Google Fusion Tables is a fascinating new experimental Google research project offering storage, search, and management of large structured data sets in the cloud. Up to 100MB of data can be stored per table, and each row in a table can have an associated location, line, or polygon feature. Using the FusionTablesLayer class you can render features on an API map as a clickable overlay. When a feature is clicked, the application can access a copy of the complete row of data associated with the feature.
2.2 Google Fusion Table

Google Fusion Tables was selected as the most compatible database that was easy to connect with when using the AI2 tool for the proof-of-concept of the HPST app. The Fusion Table permitted a simple yet effect way to map GPS data of the artefact locations and to run spatial queries. The UI displays the results of the map queries for the user to analyse. The Fusion Table’s layer maps API v3.0 was used, which is becoming an increasingly powerful tool with extended functionality. The maps used in the HPST ‘Screen 2’ (referred to as the Map within the HPST UI) were customized with FusionTablesLayer class by rendering the artefact features on an API map as a clickable overlay with information balloons connected to the features. When a feature balloon is clicked, the application can access a copy of the complete row of data associated with the feature. Fusion Tables also supports an SQL-like query language, which can be used to filter the features shown on a map. The Map API can render up to 50,000 features as an overlay without compromising the UI performance. To effectively manage the large volumes of data, the native KMLayer class for Google Maps is used for optimal rendering instead of having a third-party parser that would cause a loss in the performance quality of the map when shown in the UI. The supported data used by the maps were imported in CSV format from Excel into the Fusion Table and then manipulated to provide effective information to the user.

If the NMS and RCAHMS decided to invest in the creation of a fully functional MAGI project and the budget allowed for an API for mobile app service to complement the web service, they would want to select ESRI for developing the maps API. This is because the underlying data structure for the mapping service of PASTMAP and CanMAP are under the ESRI ArcIMs web-GIS browser, and it would be an easier process to import that data into the mobile API with the new ESRI developer ADT bundle (Cowie and McKeage, 2010). For the purpose of the proof-of-concept, there were three queries that were made available for the HPST of three artefact types having the largest quantities of data with which to create a Distributin Map. The overall quantity of the three types is small, because the overall dataset of stone tools and tool artefacts was limited to the 1998 archaeological survey that provided the GPS points of the tools (Goetz, 2014).

The Fusion Tables API allows for the use of HTTP requests from AI2 to programmatically perform these tasks, which are also available in the Fusion Tables web application:

- Creating a table from the extract of the Canmore records for Holyrood Park from Microsoft Excel worksheet
- Reading and modifying the table and column names and types
- Inserting, updating, and deleting rows and columns
- Creating, updating, and deleting layers: charts, maps, cards, pins
- Querying rows in tables from AI2

These tasks were explored when calling on the Fusion Table from the AI2 with block language. The final HPST that was constructed for the proof-of-concept did not create behaviour to update, delete, or add rows of data. It was not selected because its use generated incorrigible error messages. The more complex methods that were originally planned to be conducted in the UI were simplified to ensure that the app would not have errors when it was packaged. The end product now features a spreadsheet that permits easier reading of the data, instead of calling on the Fusion Table to be shown within the applications UI. Google Fusion Tables draws a small amount of data from the table and displays it in the info window that appears when the user clicks on a map feature balloon. It is possible to customize the content and appearance of this info window. The KML format below is customized to display the data provided in the UI of the Google Maps API of the dDistributIon Map of all the stone tool data held in the Fusion Table. It also displays the extra four Distribution Maps created for the user to analyse the distribution of the artefact class types. The data held in the Fusion Table was required to be customized to fit the needs of the user. The Fusion Table seemed the best choice for the database for the HPST app because the customizable capabilities and the FusionTableControl library provided within AI2 allowed for the implementation of the external data in the UI. The components and event blocks for the Fusion Table are discussed in more detail in Chapter 4.
2.2.1 Google Drive

Google Drive was used for this application to provide a data storage location that could be called on and shared. The HPST app has 11 components (buttons and ListPickers) that call on data stored on the Google Drive. These include the five maps made within the Fusion Table. A slideshow of 3D images was created in ArcScene to allow the user to view the elevation of Holyrood Park and the surrounding landscape. If this project were to be extended in the future, it would be advantageous to provide an orthophoto draped over a DEM made from a UAV flight would give an even richer 3D view of Holyrood for users of the application. There are also slides of the images provided from the UAV flight in Holyrood Park by Bruce Gittings and Alexandre Avery from the University of Edinburgh Geoscience Department that have been copied and made into a slideshow within the HPST Google Drive.

3. Data

As stated in the research paper (Goetz, 2014), the principal data for the Holyrood Stone tools (HPST) app has been assembled from two sources:

3.1 National Museum of Scotland

In 2003, the NMS set new goals to be launched for “a world class museum service that informs, educates and inspires with a goal ‘to preserve, interpret, and make accessible for all the past and present of Scotland.’” Foremost among the set of strategic aims developed to achieve this vision was “the development, management, conservation and interpretation of the NMS collections, to ensure their preservation and benefit to the public” (Cowie and McKeague, 2010). The Shorewatch Project had had great success in working with local groups and societies to locate record and monitor sites on the coast of Scotland. The success of the public participating in this project shows that there is room to grow mobile technology for the general public to use. Recent research with archaeology and mobile technology has largely focused on providing the public a tool with which to record finds and to alert preservation offices about sites that are being exposed and eroded by nature or by humans. The NMS holds 11 of the 21 artefacts: Flint Arrowhead; Iron Axehead; Stone Axehead; Flint Knife; Stone lamp; Flint Microlith; Stone Mould; Flint Scraper; two Bronze Socketed Axeheads; and Whetstone. The Edinburgh Council Museum (ECM) holds a remaining seven artefacts: Neolithic Flint Arrowhead; Bronze Age Arrowhead; Flat Axehead; Lithic Implement; Microlith Scraper tool; Flint Scraper Tool; and Neolithic Flint Scraper tool. There are three artefacts from the database that are not associated with an official organization’s artefact collection; these are: Leaf Arrowhead; Midden unidentified flints; Polished Axehead.

When creating the database for the application, there was a column created for the NMS URL to connect each of the artefacts with the NMS database system known as the ADLiB. The problem encountered when implementation of the block coding occurred was that the publicly accessible searchable collections database connected to the NMS collection stores were woefully inadequate in both terms of coverage and of information supplied and the quality of the search engine. Therefore, linking the artefacts from the HPST app to the NMS collection database was limited to only 2 artefacts. Table 1 provides the list of artefacts with the the organisation artefact collection they are held.

The two databases do, however, complement one another, since the RCAHMS records for the 21 artefacts being accessed in the HPST app have no photographs, whereas the two that are able to be queried in the NMS collection database are able to be visualized. The development of the HPST app has helped to clarify the problems associated with each database. The NMS is lacking in completeness. In contrast, the RCAHMS lacks a source tool linking and showing all items within small and large scales together. The HPST app has been able to connect both databases to create an overview of stone tools within Holyrood Park and to create distribution maps to allow analysis of artefact type through an open source, rather than being closed off for research purposes and requiring special permission for use of the data. It is important to note that providing these open sources of data can increase participation among the public.
Table 1. Class (type) of the artefacts, Numlink that connects the artefact to the Canmore website and site report, and which institution has the artefact in their collection.

<table>
<thead>
<tr>
<th>Artefact Type and Classification</th>
<th>NUMLINK</th>
<th>Image Ownership</th>
</tr>
</thead>
<tbody>
<tr>
<td>WHETSTONE</td>
<td>52240</td>
<td>X.AL 40 (NMS)</td>
</tr>
<tr>
<td>KNIFE (FLINT)</td>
<td>52270</td>
<td>X.AB 3026 (NMS)</td>
</tr>
<tr>
<td>ARROWHEAD (FLINT)</td>
<td>52271</td>
<td>X.AD2402 (NMS)</td>
</tr>
<tr>
<td>SOCKETED AXEHEAD (BRONZE)</td>
<td>52461</td>
<td>X.DE 129, X.DE 110 (NMS)</td>
</tr>
<tr>
<td>MOULD (STONE)</td>
<td>52511</td>
<td>X.CM 28 (NMS)</td>
</tr>
<tr>
<td>AXEHEAD (STONE)</td>
<td>52117</td>
<td>X.AF 116 (NMS)</td>
</tr>
<tr>
<td>HUMAN REMAINS, AXEHEAD (IRON), COIN(S)</td>
<td>52548</td>
<td>X.RY 10 (NMS)</td>
</tr>
<tr>
<td>HOARD (POSSIBLE), PYGMY CUP, SOCKETED AXEHEAD(S) (BRONZE)</td>
<td>52550</td>
<td>X.DQ 89, X.DE 16 (NMS)</td>
</tr>
<tr>
<td>LAMP (STONE)</td>
<td>52129</td>
<td>X.BG 409 (NMS)</td>
</tr>
<tr>
<td>MICROLITH</td>
<td>52159</td>
<td>X.ABA 178 (NMS)</td>
</tr>
<tr>
<td>SCRAPER (TOOL) (FLINT)</td>
<td>157305</td>
<td>X.AB 1529 (NMS)</td>
</tr>
<tr>
<td>MIDDEN, UNIDENTIFIED FLINT(S) (FLINT)</td>
<td>52272</td>
<td>N/A</td>
</tr>
<tr>
<td>POLISHED AXEHEAD (STONE)</td>
<td>157276</td>
<td>N/A</td>
</tr>
<tr>
<td>LEAF ARROWHEAD (FLINT)</td>
<td>157208</td>
<td>?</td>
</tr>
<tr>
<td>FLAT AXEHEAD(S) (BRONZE), HOARD (BRONZE)</td>
<td>110564</td>
<td>ECM</td>
</tr>
<tr>
<td>SCRAPER (TOOL) (FLINT)</td>
<td>168492</td>
<td>ECM</td>
</tr>
<tr>
<td>ARROWHEAD (FLINT)(NEOLITHIC)</td>
<td>240181</td>
<td>ECM</td>
</tr>
<tr>
<td>ARROWHEAD (BRONZE AGE)</td>
<td>273412</td>
<td>ECM</td>
</tr>
<tr>
<td>MICROLITH, SCRAPER (TOOL)</td>
<td>295832</td>
<td>ECM</td>
</tr>
<tr>
<td>SCRAPER (TOOL) (FLINT)(NEOLITHIC)</td>
<td>295833</td>
<td>ECM</td>
</tr>
<tr>
<td>LITHIC IMPLEMENT (FLINT)(NEOLITHIC)</td>
<td>300213</td>
<td>ECM</td>
</tr>
</tbody>
</table>

3.2 Royal Commissions of Ancient and Historical Monuments of Scotland

For this exploratory project, only a small number of artefacts were selected to be able to analysis and gauge the potential of the mobile app that connects artefacts to their original find spot through GIS. Even so, the range of material was sufficient to permit the aims of this project to be accomplished, revealing the potential of creating an application that visually connects artefacts back to the landscape. This project revealed challenges when gathering data from multiple bodies to create an open data source that is appropriate for the public to view. This project would benefit from having a resource tool similar to that of the MAGI project, discussed in further detail in Goetz (2014). This app demonstrates that the MAGI are in need of development in the very near future so that Scotland can have a platform on which to build apps for the public to understand and see the distribution of artefacts within the Scottish landscape. There must be a standardised system of sharing information from each organisation within Scotland that possesses data pertaining to the prehistory and history of Scotland. The aim of MAGI was to provide a single location-based geography, matching the objects catalogued by the NMS to the relevant RCAHMS database record. The data provided by the RCAHMS had GPS coordinates of the artefacts from the 1998 Archaeological survey of Holyrood Park:

1) Extract the Canmore records for Holyrood Park as a Shape file with a copy as a table within MS Access along with the descriptive text the RCAHMS published on Canmore.

2) Copy the RCAHMS GPS survey line work from our archaeological survey of the Park (from 1998).
3) The unique identifier for a site record is called the NUMLINK, and this is embedded in all our shape files.

The dualistic concept of space and place includes the pathways where movement might have occurred between different places and through space. GIS provides the tools to explore these qualitative themes in a quantitative environment (Goetz, 2015). The data have been split into four maps that permit the user to analyse the landscape in this way. There were three maps created of the three most frequently-occurring artefacts in the tools database. These three include: axehead, arrowhead, and scraper. Even though the original paths traversed by the users of these tools have succumbed to modern society, the tool can still be used to understand and develop theories about why these objects were discovered in their established locations. However, it is important to note that when looking at the stratigraphic archaeological layers, we have to consider modern influences and how our present geography is not the same land and pathways laid out in the past. The context of the artefact distribution within the modern landscape must be carefully examined before a final theory can be generated.

Also, areas that have been more populated and explored, such as Holyrood Park, have such a long history of continuous human occupation, meaning that objects left from the past have a greater chance of moving than in areas of discontinuous occupation and smaller population. This continuous occupation has given Holyrood Park a very rich and unique archaeological record that can now be made into a digital form to allow the general public to grasp the vastness of the record. The HPST project aim is to show a proof-of-concept that can be extended in the future to unlock information held in separate databases to a wider audience. This can help to generate awareness of how valuable the archaeological record is and how to conserve and protect it for the future generations. Figure 2 provides a breakdown of the four materials of tool types that are being displayed in the HPST app. There are 21 artefacts in the database. The original file from the RCAHMS had 494 different subclasses; from these, a filter was applied to identify tools that would create a database that was consistent with the type and material that would lead to the accurate display of data.

![Figure 2](image)

*Figure 2. The artefact material types on the X axis and how many instances of each type are found on the Y axis, within the HPST App Databas*
3.2.1 Artefact type

When analysing the data it was quickly realized that the NMS ADLiB database didn’t have publically available information to 19 out of the 21 artefacts held in the HPST App database. There are 10 different artefact classes that are provided for the 21 artefacts in the HPST database. Figure 3 shows the breakdown of type in pie chart form. Arrowhead type class has 4 individual arrowheads in the database and only one out of the four has a picture provided by the NMS. The other three are either unknown or in the ECM artefact collection. The first of the arrowhead is flint and was found around Arthurs Seat. The second arrowhead out of the 4 was a leaf arrowhead made from flint, numlink to the Canmore site record is 157208. The leaf arrowhead seems to have been misplaced and might still be with the individual who found it. Neither the ECM nor the NMS have it in their collection. The third arrowhead out of the collection of four arrowheads is a Neolithic-type arrowhead made from flint; the numlink to the Canmore site record is 240181. The Neolithic arrowhead is held by the ECM. There are no photos provided for the 7 artefacts held by the ECM. The fourth is a Bronze Age arrowhead; the numlink for the Canmore records is 273412. Table 2 shows the four Arrowheads in the HPST app collection. The Image column was introduced when images started to be added to the HPST app. This column provides the NMS artefact Collection Number in their collection store and database.

Table 2. List of the Arrowheads held in the HPST App

<table>
<thead>
<tr>
<th>Artefact Type</th>
<th>NUMLI NK</th>
<th>Images</th>
<th>SITE</th>
<th>Site Location</th>
</tr>
</thead>
<tbody>
<tr>
<td>ARROWHEAD (FLINT)</td>
<td>52271</td>
<td>X.AD 2402</td>
<td>252</td>
<td>EDINBURGH, HOLYROOD PARK, ARTHUR’S SEAT</td>
</tr>
<tr>
<td>LEAF ARROWHEAD (FLINT)</td>
<td>157208</td>
<td>?</td>
<td>3759</td>
<td>EDINBURGH, HOLYROOD PARK, ARTHUR’S SEAT</td>
</tr>
<tr>
<td>ARROWHEAD (FLINT)(NEOLITHIC)</td>
<td>240181</td>
<td>ECM</td>
<td>5182</td>
<td>EDINBURGH, HOLYROOD PARK, ARTHUR’S SEAT</td>
</tr>
<tr>
<td>ARROWHEAD (BRONZE AGE)</td>
<td>273412</td>
<td>ECM</td>
<td>5903</td>
<td>HOLYROOD PARK, ARTHUR’S SEAT</td>
</tr>
</tbody>
</table>

The second class type, being composed of a larger amount of artefacts, is the axeheads. For the purpose of this project, all axehead types recorded in Holyrood Park were grouped together. At Dunsapie Crag, for example, the axes had been placed in a small hole prepared for their reception next to a low bedrock.
outcrop. While this evidence for preparation of the site is unusual, the close association with natural rock surfaces recalls the setting of several Early Bronze Age axe deposits in Scotland. In 1976, for example, two bronze flat axes were found in the ravine known as the Pass of Ballater, in the upper valley of the River Dee in Aberdeenshire. The axes were lying, one on top of the other, about halfway up the granite cliffs of the ravine (Ralston, 1984: pp. 77-78). These two examples support the argument for grouping different axehead types into one Distribution Map (Beek et al., 2001). Neither of these axes was decorated, but at least one appears to be in pristine condition. The current heavily corroded condition of the axes from Dunsapie Hill belies the fact that they may still have been in very fine condition when they were committed to the ground.

The hilltop situation, dramatically overlooked by the summit of Arthur’s Seat, may also have been significant to the people who deposited the axes at this spot. The axeheads are not being reclassified from the original class given in the RCAHMS 1998 survey data. The purpose of seeing a distribution pattern within the landscape of Holyrood is to allow the users to see where, within the Park’s landscape, people seemed to be concentrated. The axehead types include bronze and iron, which is contrary to the name given to the app. The axeheads are the exception to the Stone tool types provided in the App.

The first of the five axeheads is a socketed axehead that is made from bronze material; the numlink to the Canmore site record is 52461. However, this item could not be located within the ADLlib NMS database. The second is an axehead made of stone; the Canmore numlink to the site record is 52117. The third is from a hoard found near Queens Drive, east of Samsons Ribs. It is a socketed axehead made from bronze material. The Canmore site record numlink is 52550. The NMS provides pictures of this artefact; the Scran catalogue number is X.DQ 89 and X.DE 16. The fourth is a flat axehead made from bronze material and was associated with human remains in the site report 110564 held by Canmore. This axehead is held by the ECM. The fifth and final axehead in the HPST database is a polished axehead made from stone. The Canmore numlink to the site record is 157276. This item is not held by any official artefact collection. It could still be in the possession of the individual who found it. Table 3 shows how the axeheads were classified and, if there were other artefacts that were associated with the axehead, it is shown in the Artefact Type column, which is the HPST App spreadsheet heading that was changed to Type.

<table>
<thead>
<tr>
<th>Artefact Type</th>
<th>NUMLINK</th>
<th>Images</th>
<th>SITE</th>
<th>Site Location Name</th>
</tr>
</thead>
<tbody>
<tr>
<td>SOCKETED AXEHEAD (BRONZE)</td>
<td>52461</td>
<td>NMS: X.DE 129, X.DE 110</td>
<td>413</td>
<td>EDINBURGH, HOLYROOD PARK, ARTHUR’S SEAT</td>
</tr>
<tr>
<td>AXEHEAD (STONE)</td>
<td>52117</td>
<td>NMS: X.AF 116</td>
<td>114</td>
<td>EDINBURGH, DUDDINGSTON PARISH CHURCH</td>
</tr>
<tr>
<td>HUMAN REMAINS, AXEHEAD (IRON), COIN(S)</td>
<td>52548</td>
<td>NMS: X.RY 10</td>
<td>81</td>
<td>EDINBURGH, HOLYROOD PARK, ARTHUR’S SEAT, WINDY GOWL</td>
</tr>
<tr>
<td>HOARD (POSSIBLE), PYGMY CUP, SOCKETED AXEHEAD(S) (BRONZE)</td>
<td>52550</td>
<td>NMS: X.DQ 89, X.DE 16</td>
<td>83</td>
<td>EDINBURGH, HOLYROOD PARK, ARTHUR’S SEAT, QUEEN’S DRIVE</td>
</tr>
<tr>
<td>FLAT AXEHEAD(S) (BRONZE), HOARD (BRONZE)</td>
<td>110564</td>
<td>ECM</td>
<td>630</td>
<td>EDINBURGH, HOLYROOD PARK, DUNSAPIE</td>
</tr>
<tr>
<td>POLISHED AXEHEAD (STONE)</td>
<td>157276</td>
<td>N/A</td>
<td>3963</td>
<td>EDINBURGH, HOLYROOD PARK, ARTHUR’S SEAT</td>
</tr>
</tbody>
</table>

The third artefact class type is the scraper. For the purposes of this project, microlith artefact types and scrapers are grouped together for the third Distribution Map. This was done because one of the microliths is a scraper and the second has not been given a classification for tool type, just that it is a microlith. To be able to create more maps for the user to compare patterns within the landscape by the deposits of the artefact types, it was decided to group the two types into one map. For the purpose of the map, they are defined in the spreadsheet and on the map itself. There has been an aim to ensure that the user is not being misled by the material that is presented in the maps. None of the names have been changed from the original data provided for this project by the RCAHMS, and links to the records are provided with the artefact points displayed on the map. However, the only instance where there is no extra detail about the
artefact is when the user selects the button ‘Navigate to Artefact Location’. Each of the five maps has balloons that hold details about the artefact. Table 4 shows the complete list of scrapers and microliths shown in the scraper Distributin Map and held in the Fusion Table.

Table 4. List of the scrapers and microliths held in the HPST app.

<table>
<thead>
<tr>
<th>Artefact Type</th>
<th>NUMLINK</th>
<th>IMAGE</th>
<th>SITE</th>
<th>Site Location Name</th>
</tr>
</thead>
<tbody>
<tr>
<td>MICROLITH</td>
<td>52159</td>
<td>X.ABA</td>
<td>178</td>
<td>EDINBURGH, HOLYROOD PARK, WHINNY HILL</td>
</tr>
<tr>
<td>SCRAPER (TOOL) (FLINT)</td>
<td>157305</td>
<td>X.AB</td>
<td>1529</td>
<td>EDINBURGH, HOLYROOD PARK, LONG ROW</td>
</tr>
<tr>
<td>SCRAPER (TOOL) (FLINT)</td>
<td>168492</td>
<td>ECM</td>
<td>4345</td>
<td>EDINBURGH, ARTHUR'S SEAT</td>
</tr>
<tr>
<td>MICROLITH, SCRAPER (TOOL)</td>
<td>295832</td>
<td>ECM</td>
<td>5990</td>
<td>HOLYROOD PARK</td>
</tr>
<tr>
<td>SCRAPER (TOOL) (FLINT) (NEOLITHIC)</td>
<td>295833</td>
<td>ECM</td>
<td>5991</td>
<td>HOLYROOD PARK</td>
</tr>
</tbody>
</table>

The remaining six artefacts out of the 21 are all separate artefact types that cannot be grouped together to make a type Distributin Map. Therefore, they are only shown in the overall Distributin Map of all 21 artefacts. These six are all made from some type of stone material. Table 5 shows the variety of tools that can be made from stone material found in the Scottish landscape. There are nine different tool types presented in the Holyrood Park Stone tools Android mobile application.

Table 5. List of Remain Artefact types in the HPST App.

<table>
<thead>
<tr>
<th>Artefact Type</th>
<th>NUMLINK</th>
<th>IMAGE</th>
<th>SITE</th>
<th>Site Location Name</th>
</tr>
</thead>
<tbody>
<tr>
<td>WHETSTONE</td>
<td>52240</td>
<td>X.AL</td>
<td>40</td>
<td>EDINBURGH, HOLYROOD PARK, SALISBURY CRAGS</td>
</tr>
<tr>
<td>KNIFE (FLINT)</td>
<td>52270</td>
<td>X.AB</td>
<td>3026</td>
<td>EDINBURGH, HOLYROOD PARK, ARTHUR'S SEAT</td>
</tr>
<tr>
<td>MOULD (STONE)</td>
<td>52511</td>
<td>X.CM</td>
<td>28</td>
<td>EDINBURGH, HOLYROOD PARK, DUNSAPIE</td>
</tr>
<tr>
<td>MIDDEN, UNIDENTIFIED FLINT(S) (FLINT)</td>
<td>52272</td>
<td>N/A</td>
<td>253</td>
<td>EDINBURGH, HOLYROOD PARK, DUNNINGSTON</td>
</tr>
<tr>
<td>LITHIC IMPLEMENT (FLINT)(NEOLITHIC)</td>
<td>300213</td>
<td>ECM</td>
<td>6035</td>
<td>HOLYROOD PARK</td>
</tr>
<tr>
<td>LAMP (STONE)</td>
<td>52129</td>
<td>X.BG</td>
<td>409</td>
<td>EDINBURGH, HOLYROOD PARK, ARTHUR'S SEAT</td>
</tr>
</tbody>
</table>
4. Extended Methodology

The HPST App follows client server architecture is built around two corresponding activities, components and behaviours, which constitute the internal parts to create a functional UI. These two parts roughly correspond to the two main windows used in App Inventor. The component designer specifies the objects (components) that constitute the UI. The block editor programs the constraints (behaviours) relating to how the objects in the UI respond to user actions and connect with components external to the App Inventor by creating behaviours to call upon the data that will be implemented into the application to meet the required aims of the project.

Event handlers in App Inventor are a single-threaded processing model in which only one event is executed at a time. If an event is executed for a long period of time, the entire application will appear to be frozen while the system waits for the handler to complete. During this time, new events are queued, and the corresponding handlers will be executed in order as the previous events are completed. However, system actions within an event handler – e.g. initiating web or GPS requests – are executed as parallel threads by the underlying Android operating systems. In the two sections below, the events are discussed in the context of Screen 1 and Screen 2 (Turbak et al., 2014).

The UI was split into two parts: Screen 1 (Home) and Screen 2 (Map). Screen 1 is the main screen that provides extra information on the artefacts, with links to online resources. Screen 2 provides map navigation to a specified artefact, as well as five maps of the artefact types for analyses of the artefact pathways by viewing their distributions in the landscape. The split design method permitted a better-designed UI to be created, with each screen having a focused theme. This allows for each screen’s block code to work optimally for quality of rendering and for optimal performance. By doing this, the two main aims of the app were able to be fulfilled. The artefacts were able to be connected back to the landscape, and lists of useful resources for background information about stone tools were supplied in the UI. The creation of the two main themes permits more resources to be added than would have been possible if all components were instead located in a single screen.
### 4.1 Screen1 ‘Home’

<table>
<thead>
<tr>
<th>Component :</th>
<th>Palette Group:</th>
<th>What its named:</th>
<th>Purpose:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Horizontal Arrangement</td>
<td>Basic</td>
<td>HorizontalArrangement4</td>
<td>Arranges the Mange Screen buttons</td>
</tr>
<tr>
<td>Button</td>
<td>Screen Arrangement</td>
<td>Home</td>
<td>Takes user to the Main screen</td>
</tr>
<tr>
<td>Button</td>
<td>Basic</td>
<td>Map</td>
<td>Takes user to Screen 2, containing Map blocks</td>
</tr>
<tr>
<td>Button</td>
<td>Basic</td>
<td>Exit</td>
<td>Closes application</td>
</tr>
<tr>
<td>Label</td>
<td>Basic</td>
<td>Welcome</td>
<td>Thanks the user for visiting the HSPT App</td>
</tr>
<tr>
<td>Button</td>
<td>Basic</td>
<td>Manual</td>
<td>Tells the user what the components on the user interface will do for them</td>
</tr>
<tr>
<td>Horizontal Arrangement</td>
<td>Screen Arrangement</td>
<td>HorizontalArrangement7</td>
<td>Arranges two button components</td>
</tr>
<tr>
<td>Button</td>
<td>Basic</td>
<td>UF (User Feedback)</td>
<td>Use webviewer to view User Feedback form within the UI</td>
</tr>
<tr>
<td>Button</td>
<td>Basic</td>
<td>AS (Artefact Spreadsheet)</td>
<td>Accesses with webviewer the spreadsheet made from the Fusion Table data</td>
</tr>
<tr>
<td>Horizontal Arrangement</td>
<td>Screen Arrangement</td>
<td>HorizontalArrangement5</td>
<td>Arranges two-button components to slide shows made with Google Slides</td>
</tr>
<tr>
<td>ListPicker</td>
<td>Basic</td>
<td>AI (Artefact Images)</td>
<td>calls on a list made in the block editor that holds HTTP links of slide shows made in google drive holding images of 10 artefacts</td>
</tr>
<tr>
<td>ListPicker</td>
<td>Basic</td>
<td>UAV (UAV Images)</td>
<td>Calls on a list made in the block editor that holds HTTP links to slides shows made from the UAV flight over Holyrood Park</td>
</tr>
<tr>
<td>Horizontal Arrangement</td>
<td>Screen Arrangement</td>
<td>HorizontalArrangement6</td>
<td>Arranges a list button and a button of resources to learn more about the artefact</td>
</tr>
<tr>
<td>Button</td>
<td>Basic</td>
<td>HP (Holyrood Park)</td>
<td>Calls on the Canmore records that were queried for Holyrood Park within the UI</td>
</tr>
<tr>
<td>ListPicker</td>
<td>Basic</td>
<td>OR (Online Resources)</td>
<td>calls on external HTTP links to provide the user additional information</td>
</tr>
<tr>
<td>Web Viewer</td>
<td>Other</td>
<td>WebViewer 1</td>
<td>Non-Visible component that reads URIs to view in app</td>
</tr>
<tr>
<td>Fusion Control</td>
<td>Other</td>
<td>FusionControl1</td>
<td>Manages interactions with the app's Fusion Table</td>
</tr>
<tr>
<td>Notifier</td>
<td>Basic</td>
<td>Notifier1</td>
<td>Displays message of which screen the user is on</td>
</tr>
</tbody>
</table>
Screen 1 is the home screen that is filled with buttons providing the user with background information about artefacts that can be viewed in Screen 2 (Map). Figure 4 is a flow diagram of the internal architecture of Screen 1. Table 6 provides a breakdown of the entire component group, names associated with the components in the UI, and their purposes.

**Figure 4. The internal architecture of the HPST App Screen 1.**

The main components that have been used in the HPST app Screen 1:

1. **Webviewer**: Component that communicates between HPST and Javascript code running in the webviewer page. In the app code block, different behaviours of the webviewer were used to transfer external resources into the app. These include: videos, site reports, images, e-books, blogs, spreadsheets, slides, maps, etc. Webviewer provided the foundation for linking and creating an app that is able to compile outside sources that provide more information than is provided in the Fusion Table database. There are two behaviours that were used most often from the webviewer library. Figure 5 shows the behaviour of WebViewer.GoToUri, which allows the webpage to be viewed within the UI.

![Figure 5. User feedback form in the UI of screen 1.](image)

2. **Listpicker**: Button that is visible when the UI starts. In HPST Screen 1, there are three ListPicker buttons that display text options for the user to select. The text is specified in the block editor by selecting from the index of global variables that were defined and converted into a list.
The **ListPicker** component was added for the user to view the details of the button that displays the Fusion Table card layer. The data in the Fusion Table was converted into a KML card display to achieve a more appealing interface than a spreadsheet. Figure 6 shows the behaviour that is executed when the ‘Online Resources’ ListPicker is tapped.

![Image of ListPicker behaviour](image)

**Figure 6. ListPicker behaviour for Online Resources when tapped in the UI.**

4. **ActivityStarter**: Figure 6 shows the behaviour for viewing the webpage outside of the UI. This option was used when the user desired to be able to select from a list of resources and to view the webpage. However, at this preliminary stage, the user is redirected to an HTTP outside of the UI.

5. **FusionTableControl**: Stores, shares, queries and visualizes data tables. This component in Screen 1 is used for querying the data table. In order to use the *FusionTableControl* component, the Google Applications Programming Interface (API) key is needed. The Google Console provides different services that can be used in the App. Figure 7 shows the behaviour for calling the Fusion Table ApiKey and how to *forgetLogin* so that users that do not have a google account are still able to view the Fusion Table data.

![Image of FusionTableControl behaviour](image)

**Figure 7. Screen 1 initializing behaviour when the screen is opened.**

6. **Notifier**: This component has been added to buttons for user navigation purposes (refer to Figures 15-20 in Chapter 4.3), showing the behaviours of the notifier for Screen 1 (Home). Figure 7 shows the notifiers that are call when Screen 1 is initialized.
4.2 Screen 2 ‘Map’

Screen 2 is the component of the UI that allows the user to view the artefact within the landscape of Holyrood Park. This was the main goal of this project. The user is given their location on a Google Map and then provided navigation instruction on how to get to the particular find spot of the artefact they are interested in navigating to. Google Maps JavaScript API V3 allows for a simple code block to be created that will connect to a base map of predefined points of interest that are stored within the ListPicker in the block editor. The layers that are available in the map UI of the HPST Android app are listed below. The layers are a collection of objects that have been added on top of the Google base map for the user to have more options about how to get from their current location to their desired location. The layers are rendered into one object by tile overlay. Figure 8 shows the internal architecture of Screen 2 in the HPST Android app. Table 7 is the complete list of the components held in Screen 2.

Figure 8. HPST internal architecture.
<table>
<thead>
<tr>
<th>Component:</th>
<th>Palette Group:</th>
<th>What its named:</th>
<th>Purpose:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Horizontal Arrangement</td>
<td>Basic</td>
<td>Horizontal Arrangement1</td>
<td>Arranges the Mange Screen buttons</td>
</tr>
<tr>
<td>Button</td>
<td>Screen Arrangement</td>
<td>Home</td>
<td>Takes user to the Main screen</td>
</tr>
<tr>
<td>Button</td>
<td>Basic</td>
<td>Map</td>
<td>Takes user to Screen 2 that has the Map blocks</td>
</tr>
<tr>
<td>Button</td>
<td>Basic</td>
<td>Exit</td>
<td>Closes application</td>
</tr>
<tr>
<td>Label</td>
<td>Basic</td>
<td>Google Maps</td>
<td>Label for the Map page so that the user knows what to expect</td>
</tr>
<tr>
<td>Button</td>
<td>Basic</td>
<td>Manual</td>
<td>Tells the user what the components on the user interface will do for them</td>
</tr>
<tr>
<td>ListPicker</td>
<td>Basic</td>
<td>SA(Navigate to Artefact Location)</td>
<td>supplies a list of Artefact types and takes the user to the location on Google Maps, leaving the application interface and linking the user to Google Maps</td>
</tr>
<tr>
<td>Button</td>
<td>Basic</td>
<td>ArcScene</td>
<td>calls on an external component from Google Drive Google Slide of 3D images of Holyrood Park</td>
</tr>
<tr>
<td>Vertical Arrangement</td>
<td>Screen Arrangement</td>
<td>VerticalArrangement1</td>
<td>Arranges the label and buttons for the distribution maps of the three most prevailing artefact types found in the Park for the 1998 survey</td>
</tr>
<tr>
<td>ListPicker</td>
<td>Basic</td>
<td>InfoCard (Map Balloons info)</td>
<td>Displays Fusion Table card layers of the artefact information</td>
</tr>
<tr>
<td>Vertical Arrangement</td>
<td>Basic</td>
<td>DM ()</td>
<td>Label for the dDistribin Map</td>
</tr>
<tr>
<td>Label</td>
<td>Basic</td>
<td>EnterAddress</td>
<td>Explains what the three buttons below link with</td>
</tr>
<tr>
<td>Horizontal Arrangement</td>
<td>Screen Arrangement</td>
<td>Horizontal Arrangement2</td>
<td>Arranges the three distribution map buttons</td>
</tr>
<tr>
<td>Button</td>
<td>Basic</td>
<td>Axehead</td>
<td>Links to Fusion Table Google Map of pin point locations of the Axehead artefacts found in the park</td>
</tr>
<tr>
<td>Button</td>
<td>Basic</td>
<td>Arrowhead</td>
<td>Links to Fusion Table Google Map of pin point locations of the Arrowhead artefacts found in the park</td>
</tr>
<tr>
<td>Button</td>
<td>Basic</td>
<td>Scraper</td>
<td>Links to Fusion Table Google Map of pin point locations of the Scrapers artefacts found in the park</td>
</tr>
<tr>
<td>Horizontal Arrangement</td>
<td>Screen Arrangement</td>
<td>Horizontal Arrangement3</td>
<td>Arranges the two additional maps</td>
</tr>
<tr>
<td>Button</td>
<td>Basic</td>
<td>HM (Heat Map)</td>
<td>Displays a heat map created in the Fusion Table Google Map</td>
</tr>
<tr>
<td>Web Viewer</td>
<td>Other</td>
<td>WebViewer1</td>
<td>Non-Visible component that reads URIs to view in app</td>
</tr>
<tr>
<td>Fusion Control</td>
<td>Other</td>
<td>FusionControl1</td>
<td>Manages interactions with the app's Fusion Table</td>
</tr>
<tr>
<td>Location Sensor</td>
<td>sensor</td>
<td>LocationSensor1</td>
<td>Sense GPS info to report where the phone user is currently located</td>
</tr>
<tr>
<td>Notifier</td>
<td>Basic</td>
<td>Notifier1</td>
<td>Shows message of user’s current screen</td>
</tr>
<tr>
<td>----------</td>
<td>-------</td>
<td>-----------</td>
<td>---------------------------------------</td>
</tr>
<tr>
<td>ActivityStarter</td>
<td>Other</td>
<td>ActivityStarter1</td>
<td>Launches Google Maps</td>
</tr>
</tbody>
</table>

The Maps API has several types of layers (Android Developers, 2014):

- The Google Maps data layer provides a container for arbitrary geospatial data. GeoJSON data was used to display the artefact point on Google Maps created in the Fusion Table. Figure 8 shows the block code to create a base map that shows the points of interest.

- The Fusion Table layer renders data contained in the Google Fusion Table. This was performed for the five map buttons on Screen 2: Arrowhead, Axehead, Scraper, Heat Map, and Map of all artefacts. There were four Fusion Tables created for each of these. However, they could have been queried within one Fusion Table having four map layers. Figure 9 show the blocks that call on the fusion table and the base map made in fusion table. Figure 10 shows the FusionTableControl.GotResults.

- The KML layer renders KML and GeoRSS elements into a map API V3 tile overlay. KML code used for displaying card information when the balloon points are clicked on the four Fusion Table maps.

- There are added layer tiles that have been established by the Google Maps API: traffic, transit, bicycling, weather, and points of interest near the destination or current location.

Figure 9. Procedure constructed and called upon in the FusionTableControl for creating the Map that Google Maps API calls to acquire the user’s recorded location.

Figure 10. Block GotResults calls on the data from the Fusion Table to show the base map with the points of interest.
There is no introductory text for this list. Supply it here.

1. Webviewer: Used to display the Distributin Maps in the UI. Figure 12 is an example of the axehead button behaviour. This map was made in a Fusion Table, but can be published separately from the Fusion Table control to allow for the Google Maps API components to be part of the map. For example, functions include being able to zoom in and out, and tapping on the balloon points of the artefacts site locations to learn which point is associated with each artefact.

2. Listpicker: Button that is visible when the UI starts. In HPST Screen 1, there are three listpicker buttons that display text choices for the user. The text is specified in the block editor by selecting from the index of global variables that were defined and compiled into a list. When the user taps the ‘Navigate to artefact location’ button in the UI, it calls on a list of artefacts for the user to select, and then calls on a global index list of data URIs. Figure 12 shows the behaviour for ‘Navigate to artefact location’. For example, if the user is within the Google Maps API and marks the artefact location using ‘Select Location’, this action calls the block code in Figure 10.

4. ActivityStarter: Table 6 shows the behaviour for viewing the webpage outside of the UI, which was done when wanting the user to be able to select from a list of resources and be able to view the webpage outside of the UI. Figure 13 shows the block code for the button ‘Map Balloons Info.’ This button required that a second activity starter be connected in the Designer editor, because the first ActivityStarter was used to connect with Google Maps for finding the location of the user so that the Google maps API could be used for navigation. Table 8 shows the parts that were defined in the designer editor of the first ActivityStarter. These properties were not completed for the Second ActivityStarter. Instead, the property behaviours that were needed were added to the block editor to specify which properties were needed when calling on the external resources of documents created in Google Docs and held in the Google
Drive. Figure 14 shows the behaviours connected to the activity properties shown in Table 8.

Figure 13. The event raised when the button ‘Navigate to artefact location’ is tapped. It calls on the list of 21 artefacts and then connects with the Google API to get the user from A to B.

Table 8. Activity Starter Properties for launching Google Maps API, defined in the Designer interface.

<table>
<thead>
<tr>
<th>Property</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>action</td>
<td>android.intent.action.View</td>
</tr>
<tr>
<td>activityclass</td>
<td>com.google.android.maps.MapActivity</td>
</tr>
<tr>
<td>activtypackage</td>
<td>com.google.android.apps.maps</td>
</tr>
</tbody>
</table>

Figure 14. The behaviour that is raised when the Ballon info card button is tapped in the UI Screen 2.

5. FusionTableControl: For acquiring the base map from the Google Maps API is shown in Figure 9.

6. Notifier: The notifier component has been added to buttons for user navigation purposes. Figures 20-24 in Chapter 4.3 show the behaviours of the notifier for Screen 2 (Map).

7. Location Sensor: Indicates that a new location has been detected by recording the latitude and longitude of the current location of the device. This employs the device’s Android GPS capabilities with Wi-Fi or Mobile data. It is automated by the Google Maps API V3 coding.

The impact and implications of using the phone’s location sensor will be discussed here. The app will request permission from the user to access their location. Therefore, the user should be aware that these data are being shared. Any apps such as the HPST, which collect and share private data, should make it clear just how that data will be used. These data are held in Google Cloud Storage, which provides the REST API, command line tools, and an online browser to create, share, and manage data. The HPST Android app required the API KEY for connection to the cloud and drive services of Google. Figure 15 shows the report page for the app that would be used by the developer to follow the project progress. When the user downloads the app onto their phone, they are asked if they are willing to allow for the collection and storage of their location information. This allows for the developer to see how the app is being used, allowing for better block code to be generated to notify users of the problem points within the landscape and providing them options for how to circumvent the problem.
Figure 15. Google report for the App inventor HPST app.
4.3 User Interface Design Process

The user interface design process is referred to in the research report by Goetz (2014). The Interactive Development Environment (IDE) in App Inventor is designed to make the process of coding effortless while handling data from external resources. It is the app designer’s (programmer’s) responsibility to conceptualize the app to be triggered by end user response, time, or external events, and to design the appropriate response to the event handler. Therefore, the aim is to create a user-friendly interface function within the app that is user-initiated, to make it easier to understand the information being presented in the UI. The HPST app mostly consists of input forms. It uses button-click events to trigger response from the app. The geographical data responds to taps and drags on the Android phone’s UI. The user testing stage of this project was not able to be conducted because the process of creating a functional app exceeded the projected time requirements.

The following requirements were specified for the purpose of creating a user-friendly application:

1. User should be able to find a list of artefact types to select from
2. User should be able to navigate from their current location to the point of interest
3. User must be able to access the map and data based on the artefact type
4. User must be able to gain background knowledge about the artefact and be able to analyse a distribution Map if there are enough artefacts of the class to create a Distribution Map
5. Maps should be readily available
6. User interface should be easy to navigate
7. Users should be able to have external resources running in the background and
8. Artefacts should have types and time periods if available

Reliability Requirements:

Educators and learners are the primary audience, as App Inventor is academic project. App Inventor’s library of blocks includes the most basic computational constructs such as conditionals, procedures, variables, and data structures. College and high-school faculty have successfully used App Inventor in their courses for over four years (Gray et al., 2012; Wolber, 2011; Ericson and McKlin, 2012; Morelli et al., 2010). App Inventor only runs on Android; allowing the coding blocks to focus on one operating system provides more functionality for the end user than would be possible if App Inventor were created for cross-platform implementation, according to (Pokressand Veiga 2013).

You must provide an introduction to this bulleted list:

1. Data: the data have been acquired from reliable sources
2. Software: App Inventor is associated with the Android OS, allowing the sending and receiving of information from many of the components of the phone (GPS, NFC, texting, camera, accelerometer, etc.). These features would not be possible if required to navigate across platforms.

The following error-prevention strategies were used:

1. All component properties are set based on their initial values in the component designer
2. All variable definitions and initializations are performed in the Screen.Initialize event handler
3. Testing of each individual block has returned the variable desired
4. Activating and deactivating blocks help to debug and test blocks for errors or unwanted variables

Various views were determined to promote easy usability of the app:

1. Map View: It was decided to make it easier for the user to navigate and since the area is small in relative scale, the Distribution Maps were imported into the UI.
2. Navigation View: it was decided to send the user outside the UI when the navigation to a specified artefact was selected from the ListPicker
3. Textual View for the Point of Interest: textual information based on the artefacts of interest are provided within the maps and through a button that calls on a ListPicker of four maps. This brings the user outside of the UI to an HTTP page with the card details. This was done because there were problems trying to view the cards within the UI through a button.

4. Location View: Description of the current location of the user should be represented graphically using a marker or balloon within the Google Maps API.

5. Manual: User is provided with an information page that can be viewed when the Information button is clicked in Screen 1. Screen 2 displays the manual on the UI screen instead of providing a button.

At this stage, implementation of the design interface had been completed. There was an emphasis ensure that the user would not get lost within the app or when using the external resources. The Figures 16-21 below show the code block used in the block editor of AI2 to manage navigation between screens. These three figures are the block code for Screen 1. The block code for Screen 2 is shown in Figures 21-25. These buttons and behaviours were an important part of the UI so that the user is able to navigate through the app with ease.

Figure 16. Block editor behaviour for the button 'Home' component.

Figure 17. Display of exiting the app following user confirmation.

Figure 18. Block editor behaviour for the button ‘Exit’ component.

Figure 19. Block Editor behaviour for the ‘Map’ component.
Figure 20. Behaviour that is raised when Screen 2 is closed and control has returned to the Home screen.

Figure 21. Event that is raised when the Android device’s Back button is hit when in the main UI. This, however, is not raised when the user has been directed to view external links that are not shown inside the UI.

Figure 22. Event raised when the user taps and releases the device’s Back button when in Screen 2.

Figure 23. Event raised when user taps on and releases the Map button in Screen 2.

Figure 24. Event raised when the user taps and releases the Exit button in Screen 2.

Figure 25. Event raised when user taps and releases the Home button in Screen 2.
Emphasis has been placed on making the UI easy to navigate for the user so that they do not get lost within the application; this is termed Navigation or Way-Finding Problems. Therefore, a brief description is provided on the UI screen explaining what the buttons provide and a horizontal layout at the top of the UI for toggling between the two screens. Buttons were incorporated at the top of the screen to manage this navigation. The manager button notifies the user about which screen they are in and, when exiting the app, verifying that they really desire to exit. The buttons provided are: Home, Map, and Exit, shown in Figures 16-54. With this method established, there is only one screen active at any time. This method also provides a safety mechanism to avoid overusing the memory on the phone. The Android responses to the navigation are shown in Figure 26.

Figure 26. Notification that the user will view when moving between screens.

5. Limitations

Some limitations were noted when the app was evaluated during development and after the finished product was constructed. The IDE has constraints to the graphical output and the complexity of available tools that can be used. Also, the project was constructed by a non-expert coder, which affects the overall structure of the application. The Visual blocks made it possible to create an application; otherwise, it would have been extremely difficult to produce a working exploratory app.

Since the project was exploratory in nature, the data set that was used was limited, making it not an ideal tool to perform cross-comparisons for research purposes. However, the proof-of-concept presented in this document demonstrates the potential for creating an app that could be used as a quality tool for research.

The area of Holyrood Park was selected over other potential sites within Scotland due to its location in a popular tourist city and right at the center for all to see. Additionally, the Park was selected because of the availability of recent survey data from 1998 that used more recent field methods, providing access to the coordinate locations of all the tool artefacts that were included in the apps database. The following list includes some of the limitations of the app:

- Just because the artefact is connected to a point does not mean that is where it was originally located or manufactured.
- Not all artefacts are in situ to their original location from when they were used or manufactured.
- User groups are limited to Google account holders when viewing data held in Fusion Table or Google Drive.
This research has concentrated on using technologies based upon an Android phone platform and that allow users to find their location in the landscape and to navigate to a specific archaeological artefact. A high importance has been given to the user interface, providing extra resources for the user to learn and to view more than just a static point in the landscape. This research acts as a base study to create mobile applications with GPS recordings of archaeological sites within Holyrood Park; this work can be extended further in the future, with various additions. One of the developments would be to market the app through leaflets handed out to the public with the QR code printed on the leaflet, or to have laminated QR codes that would be strung around trees and signs within the park boundaries that would be seen by visitors and would allow them to scan the code from the mobile device for download. This would only be done with the permission of the Ranger Services, NMS, and RCAHMS. All three bodies would be given complete access to the Google Drive that the application data is stored on, in order to create an open source for all three organizations to work with. It would be ideal for RCAHMS, NMS, and any other body such as the Edinburgh Council Museum and the Society of Antiquaries, to have access to the Google Drive. It would also be useful to establish a closed blog between organisations for updates to the database to be shared and to ensure that all data is accurate, complete and accessible to all users.

AI2 provides the tools for programming an app to anyone who is willing to try, without cost and without requiring a knowledge base of coding. Developing apps like HPST could thus be accomplished quickly, cheaply, and easily. Only one person within one of the agencies would be needed for management and upkeep of the projects. This would be valuable in the long run, when the needs of the public to have access to archaeological data and locations outweigh the cost of creating a working product. From Chapter 2, Figures 1-3 show the statistics related to internet use and gives an idea of the need for mobile technologies that can help people to access archaeological resources.

It would be very beneficial to move the application layout in the future to the IDE Android Studios. This would allow for improved display graphics and tools to create an attractive UI that would keep the public interested in the app. This exploratory project was not developed in Eclipse or IntelliJ because it was developed by a non-programmer. The Android platform has extensive capabilities to support a variety of different services. The proof-of-concept HPST app shows how GPS data of artefacts can be linked with Google Maps to create Distributing Maps and location-based services so that the user is able to get from their current point in the landscape and be shown how to travel to the artefact location, using the Google Maps service and the creation of maps within a Fusion Table converted into a database. Android enables the app developer to utilize the features of mobile devices and tailor the needs to the target user.
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8. APPENDICES

APPENDIX A

A1  APK file location........................................................................................................31
A2  Example output recording file location.......................................................................31
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APPENDIX A

A1. Block coding APK placed at: \s1359319\dissfinal\AI2 \Fihi's project needs to be downloaded to Android. You can either upload to your phones SD card or send the APK file to your email and then open your email on your Android Device

A2. Screen shot video recording of HSPT found at: \s1359319\dissfinal\AI2 \Recording

A3. Date made for the HPST held at: \s1359319\dissfinal\AI2 \GoogleDrive

A4. Screen 1 Ai2 Designer component Screen where the UI was created and the Block Code where the components behaviours were determined. Following the Screen shots of the Designer and Block Screens are the expanded clips of the Block components with their behaviours. The blocks are pretty much self-explanatory

Figure 3. Ai2 HPST Designer Component Screen 1

Figure 4. Ai2 HPST Block Editor Screen 1
A5. Screen 2 AIi2 Designer Component Screen where the UI was created and the Block code screen where the components behaviours were determined. The tricky part of this procedure is constructing the Uri. Using the embeddable link provided by the Fusion Table service, this looks like this:

https://www.google.com/fusiontables/embedviz?q=select+col2+from+12DH6q9AvG9AVQRrdJZiTmqxUr_5P1azE8808vBuK&viz=MAP&h=false&lat=55.947396309905905&lng=-3.159206550262411&t=1&z=13&l=col2&y=2&tmplt=2&hml=ONE_COL_LAT_LNG

This is a Google base Map query that tells the UI how to centre the app on a certain latitude and longitude (lat=55.947396309905905&lng=-3.159206550262411), how far to zoom in (z=13), and what table (t=1) and what column number (l=col2) that should be displayed. To construct this Uri, the HPST app uses the *make text* block.

![Figure 5. AI2 HPST Designer component Screen 2](image-url)
Figure 6. Ai2 HPST Block Editor Screen 2