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## **Acknowledgements**

Day by day, society is becoming more aware of the environmental impacts that plastic and other waste have on the natural environment. Consequently, more people are interested in reducing the amount of waste that they produce.

The purpose of this project is to develop a waste tracking mobile application to help people to reduce and recycle more of the rubbish they produce.

The project explains the development process of the mobile application, which led to the outcome of a fully functioning app. From the user testing, the app was found to be highly user friendly and provided most of the desired functionality. Overall, the delivered application was able to help users with tracking and reducing their rubbish waste, which successfully meets the aim and objectives for this project.

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# **Chapter 1**

## **Introduction**

### **1.1 Project Background and Motivations**

With an increase in awareness towards environmental issues, many people are trying to change their lifestyles to help reduce the negative impact on the environment. Increasing the amount that we recycle is one common change that people attempt to make.

Seemingly simple enough, understanding which items can be recycled and which waste points are correct to use can be very confusing; this may lead to loss of motivation to recycle.

This project aims attempt to simplify the process through the creation of a Waste Footprint application for smartphones. Firstly, the user will scan the barcode of a common supermarket item and the app will identify the material information of this product. Using this information, the app will calculate whether the product can be recycled and if so, will search for the nearest recycling locations. This will help to give the user an idea of how sustainable the product's packaging is.

### **1.2 Aim and Objectives**

The aim of this project is to create a mobile application that tracks the rubbish produced and recycled by a user to help them reduce their waste footprint. To help meet achieve this aim some objectives have been set up that should be completed. They go as follows:

1. Research into application platforms that are designed for smartphones.
2. Research into the process of User Experience (UX) design.
3. Research into an existing barcode to product API.
4. Search into behavioural Gamification Theory.
5. Find suitable agile task management programs.
6. Design app to work with existing APIs.
7. Enable usage of the smart phone camera to scan barcodes.
8. Develop UIs that all have high amounts of usability.
9. Implement features that give the user a sense of achievement whilst doing repetitive tasks.
10. Develop an app that works on most modern smartphones.
11. Create Graphic summary of waste the user has disposed.
12. Employ a regular testing process during development.
13. Test the app with participants to ensure:
  - (a) App is straightforward and easy to use.
  - (b) Works on different Smartphone brands.

# **Chapter 2**

## **Research**

Before designing and implementing the Waste Footprint deliverable it is important that research into development techniques and tools is completed. The research will begin by covering a variety tools that support the development process and then reviewing any existing applications that have some relevant functionality to this project. Finally, a discussion of materials that evaluate which findings can be applied whilst developing this project, will be summarised.

### **2.1 Agile Practises**

In the introduction section there is a list of objectives set for this project. Of these, objective 5 is to “Find suitable agile task management programs”. To use an agile based tool within the project, it makes sense that an Agile based methodology is also used during the whole development process. It makes these tools a lot more effective. As this project will only be handled by one programmer, it would be practically impossible to employ a pure Agile methodology. However, it is possible to employ specific agile methodologies that are suitable for a project of this size.

#### **2.1.1 Kanban**

Kanban is an agile based practise that encourages people to visualise and separate their work into smaller manageable tasks. These tasks are then plotted onto a physical or virtual pin board. The pin board will have at least 3 columns that are typically named “To Do”, “Doing” and “Done”

(Figure 2.1). At first, all tasks are written onto a card and then placed into the “To Do” column. Each developer then selects one card to complete and must move the into the “Doing” section. The card will be moved into the “Done” section once completed or back to the “To Do” pile if an issue occurred. New tasks may be added at any time to the “To Do” pile as this allows the development team to adapt to new requirements or issues that might occur.

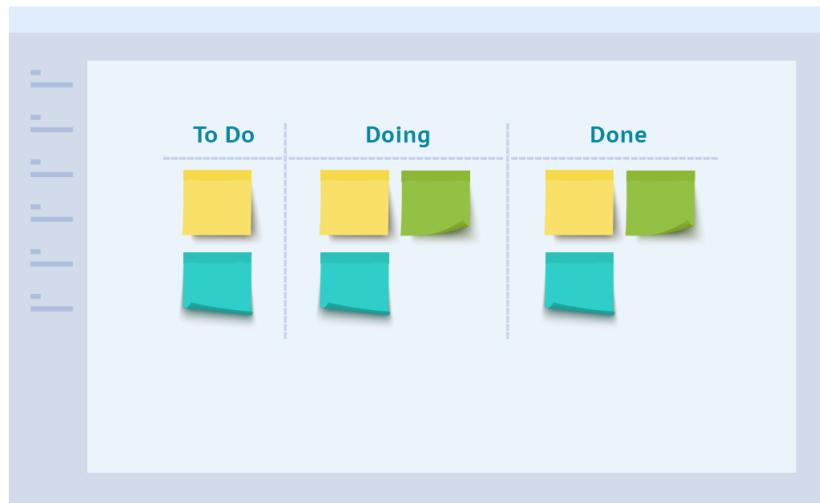


Figure 2.1: Example Kanban Board (digite.com - 2020)

One benefit of Kanban is that it flushes out issues early on that would normally cause a blockage in the development flow. This helps to maintain a steady workflow and improves how accurately the completion time of tasks can be estimated (Anderson, 2010). Kanban’s ability to flush out issues early on is understandable when looking at the causes of most IT project failures. The study by Al Neimat (2005) found that some primary causes of IT project failure were “poor planning”, “Unclear goals and objectives” and a “Failure to communicate”. Kanban effectively challenges all 3 of these reasons as it leads to clearly planned objectives that are well communicated and spread out amongst the team.

Most issues of Kanban come from people misusing the board. For example Kanban boards are sometimes made to be over-complicated or outdated, which ends up hindering the teams work flow instead of benefitting it. Another issue with Kanban is that it is harder to set milestone deadlines. In larger corporations that have dedicated testing teams, development teams would typically book in a test date in advance. Therefore, the difficulty of

estimating a testing deadline would be an issue for larger companies.

### **2.1.2 Extreme Programming**

XP (Extreme Programming) is a light weight software development methodology that is most suitable for smaller sized teams. Unlike Kanban or Scrum, XP's methods focus directly on improving the quality of the code by encouraging its followers to do regular code reviews, automated testing and constant integration testing whenever possible (Beck, 2000). It is a perfect methodology for small projects that have vague or rapidly changing requirements and requires the customer to be involved in every development stage. (Beck & Fowler, 2001).

One large benefit of XP comes from the high amount of testing. Due to the automated testing and peer reviewing, XP teams typically produce stable software. Since these teams also work closely with the customer there is a higher chance that this stable software will actually fulfill the user's desires.

On the other hand, there are some limitations to XP. One of which comes from the need to regularly communicate and get feedback from the customer. Often the customers for a project are busy people and do not have the time to meet up regularly to review each small change in the software. This means that XP projects require customers who have enough time to provide feedback. Extreme Programming is also not suitable for programming projects with only 1 member as multiple people are needed for Code reviews Paired Programming.

### **2.1.3 Test Driven Development**

The Test Driven Methodology is a software development process that focuses on developing code that will meet some previously determined test cases. These test cases are created before the programming begins and each test case is based on a key project requirement. The main idea is that testing is the first process to be prepared and it should be done regularly throughout development.

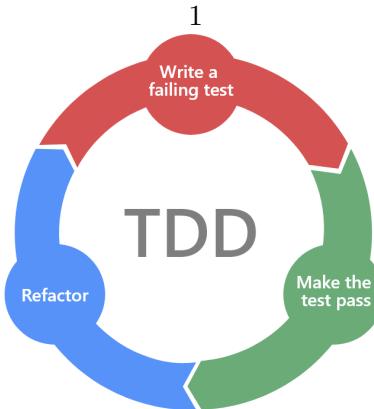


Figure 2.2: Example of the TDD process (marsner.com - 2019)

The main benefit of this is that in theory the end product will be of a higher quality, containing less unexpected errors. As all of the test cases are built directly from the requirements it also helps the project to stay on track with meeting the client's needs. As the tests are all created before development, the process becomes quicker as it is only the code tests need to be run after any change.

Following this method also has downfalls. Firstly, creating a large amount of tests that cover project requirements is a time consuming job, which can create a large delay during the start of development. Another issue with creating effective testing is that it takes a lot of careful planning as it is easy to create practically useless tests that end up wasting time. Finally, the method struggles when projects have designs that change often. This is because with changing design, all relevant tests must be rewrote to match these new plans. This can waste a large amount of time.

#### 2.1.4 Selected Practise

For this project, the practise that will be used is the Kanban Methodology with some aspects of Test Driven Development being employed. The reasons for this are as listed:

1. Using a Kanban board will allow for the requirements to be split up and broken into small planned pieces, making the development process more understandable.
2. Kanban was chosen over XP as it is a more suitable methodology for

a single programmer based project. For example it does not require code reviews with multiple members that would not be possible for this project.

3. Kanban was chosen over TDD as it is more suited for a project that has designs which are likely to change often.
4. Some aspects of TDD like regular Unit Testing will be used within the project as they will help catch simple errors throughout the development.

## 2.2 Development Tools

### 2.2.1 Task Management

#### Trello



Figure 2.3: Trello Logo (2020)

Trello is a Kanban style list management tool that encourages its users to breakdown their objectives into more manageable tasks and with the use of task alarms, helps to keep the developer on track (Figure 2.4). Trello can be accessed through their website or by using their mobile app, which is rated 4.7 on the Apple App Store. The phone app allows its users to track the progress of their work at any place or time.



Figure 2.4: Trello Apple App Store Review (2020)

One small downfall for this service is that the web version requires internet access, however the mobile application will work in offline mode which is useful for working whilst travelling. Due to this tool being an Atlassian product, it also has access to Jira. Jira is a service commonly used in large software organisations that becomes a hub for a project, allowing its consumers to track bugs, handle project deadlines and store relevant documentation. When Trello is connected to this service reported bugs are automatically added to the Trello board and kept in sync with the whole project, therefore improving the functionality of the tool. This service is free to use with a paid version that offers some improved business functionality.

Table 2.1: Trello Summary

Trello	
Positives	Negatives
<ul style="list-style-type: none"> <li>1. Has a full free version.</li> <li>2. Highly intuitive design.</li> <li>3. Task deadline features.</li> <li>4. Has some offline mode support.</li> <li>5. Connects with Jira services.</li> </ul>	<ul style="list-style-type: none"> <li>1. Difficult to move multiple cards at once.</li> <li>2. Doesn't show which cards depend on others to be completed.</li> </ul>

## Monday.com



Figure 2.5: Monday.com Logo (2020)

Similar to the aforementioned Trello, Monday.com is also a Kanban style list management tool. It has similar functionality with the ability to separate tasks into list items, set time deadlines for these tasks and has different organisational columns to mark the tasks as “in progress” or “completed”. This tool has a mobile application (with a rating of 4 on the Apple App Store) that allows mobile access to their services on the go, however some users have reviewed the app stating that the website version is better (Figure Monday.com Apple App Store Review (2020)).

This service will currently not work without a constant internet connection which is an issue as it limits the productivity of the developer whilst they are travelling. Monday.com offers some extra functionality over Trello which includes Budget Management and a Client portal, however this comes at an added cost as Monday.com requires a payment of £7 a month per user for the basic package, with a limited time free trial.

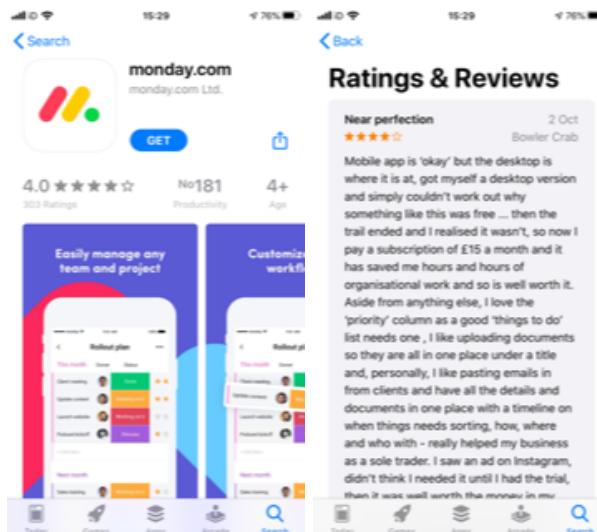


Figure 2.6: Monday.com Apple App Store Review (2020)

Table 2.2: Monday.com Summary

Monday.com	
Positives	Negatives
<ul style="list-style-type: none"><li>1. Visually displays current tasks.</li><li>2. Task alarm feature.</li><li>3. Budget Management feature.</li><li>4. Good task assigning feature.</li></ul>	<ul style="list-style-type: none"><li>1. No offline mode.</li><li>2. App has a paywall of £7.</li></ul>

### 2.2.2 File Storage

#### Google Drive



Figure 2.7: Google Drive Logo (2020)

Google drive is a free popular file sharing system that allows people store and access their files on the cloud. When accessing the site the user simply needs to register for a Google account, which allows them to access all of their connected resources. Once signed in, the service works similar to the windows File Explorer as it provides the ability to create folders, new files and simply drag and drop documents from a PC into the cloud hosted folders. Once a file is stored in Google Drive it can be accessed from anywhere.

Google Drive also offers an offline mode that allows files to be accessed with no internet connection. It also provides team working functionalities as multiple users can be given access to a single drive and through its connection to Google Docs, multiple people can edit one document at the same time. However, this multi access feature only works with file types that are supported by Google Docs.

Table 2.3: Google Drive Summary

Google Drive	
Positives	Negatives
<ol style="list-style-type: none"><li>1. Free Cloud Storage.</li><li>2. Google Docs connection allowing live file editing.</li><li>3. Team access to files.</li><li>4. Offline Sync feature.</li><li>5. Intuitive UI.</li></ol>	<ol style="list-style-type: none"><li>1. No file history service.</li><li>2. No file merging feature.</li></ol>

## GitHub



Figure 2.8: Github Logo (2020)

GitHub is a web based version control service that allows developers to store and backup their projects to cloud storage as they are being developed. GitHub includes a range of tools which allow its users to review code changes, merge code and view previous versions of their software as discussed on [Github.com](https://github.com) Nat (2008). A large benefit with this tool is that the programmer's code will be protected from data loss as GitHub provides free cloud storage for developers. With their service, any previous version of a program can be retrieved when required. It is also useful for team development as GitHub provides all necessary tools for merging different versions of code together from different branches.

To use GitHub, a Git client should be used which has both benefits and limitations. With the use of a Git client an experienced developer can quickly

pull and push code from a Github repository which typically increases the efficiency of development. However, both Git and Github have relatively steep learning curves, especially when dealing with code merging. If a developer is struggling to use Github, this would take their time away from the actual development of the project, meaning that the tool would instead be a hindrance to development.

Table 2.4: Github Summary

Google Drive	
Positives	Negatives
<ul style="list-style-type: none"> <li>1. Free Cloud Storage.</li> <li>2. Supports file merging.</li> <li>3. Provides Version control.</li> <li>4. Offline Sync feature.</li> <li>5. Prevents file loss.</li> </ul>	<ul style="list-style-type: none"> <li>1. Has a steep learning curve.</li> <li>2. Github UI not intuitive for new users.</li> </ul>

### 2.2.3 Which are Suitable?

From these reviewed tools Trello, Google Drive and Github will be used in development.

Trello will be used rather than Monday.com because:

1. It has better free version than Monday.com which is useful as this project has a limited budget.
2. Unlike Monday.com, Trello has an Offline mode which will be useful when travelling
3. It works directly with Jira services unlike Monday.com
4. Trello will be used as it can manage the project in a Kanban based method.

Both Github and Google Drive will be used because:

1. Google Drive allows for live editing of documents whilst Github is better with project files.
2. They are both free to use services so no reason to only select one.
3. These two tools can be used in unison to provide file storage for every area of the project.

## 2.3 Further Research

### 2.3.1 Gamification Theory

With the vast amount of mobile applications on offer throughout, trying to keep users coming back to one app has become increasingly difficult. The Gamification theory believes that if an app uses aspects of game mechanics it can help to keep users returning to it. As discussed by (Brigham, 2015) some typical elements that can be added include reward badges, points systems and a leaderboard feature. Using these tools has been suggested to leave users of the app “more engaged and more productive” Brigham (2015) and encourages the users to “keep coming back” Zichermann and Cunningham (2011). The phone app Duolingo is a great example of how effective Gamification can be in an educational app. It uses many Gamification elements including a points system, leaderboards, in app rewards and progressive challenges. Using this, the app currently has 300 million users world wide (Figure 2.9)



Figure 2.9: Duolingo homescreen (2020)

### 2.3.2 Self Determination Theory

The Self Determination Theory believes that when people have autonomous motivations for completing a task rather than feeling forced, they are more likely to keep doing a task. After Reeve (2002) studied research into student motivation, they found that students who had their own self-motivations for working were able to thrive more and maintain their motivations.

This idea can also be applied to mobile development. If a user feels compelled to use an app, rather than having the self-motivation to use it, they will begin to avoid using the app or just uninstall it. To avoid this, implementing features that reward users for good actions would be more successful than a feature that alerts users they need to “log your rubbish today!”. Telling a user that they “have” to do something will have the opposite effect of the app feeling like a chore, rather than motivating them.

### 2.3.3 Using Images for Persuasion

As discussed by Joffe (2008), it is shown that using images to inform and persuade people is more effective than just using text, due to “visual material’s ability to arouse emotion” Joffe (2008). Using images was found to be especially useful when explaining something to users that they do not experience often. So, for an app that is trying to help users to reduce the amount of waste that they produce, showing them the plastic waste actually filling the oceans would be more effective than just saying it with text.



Figure 2.10: Waste Site in Nicaragua

### 2.3.4 Summary

From these researched theories some useful information can be taken and applied to this project. The following list will now summarise the useful techniques that can be taken from these theories.

#### 1. Gamification Theory

- (a) Reward badges could be implemented to increase user involvement within the app.

- (b) A point system could be included within the app to give users a sense of achievement with their recycling progress.
- (c) A system could be added to reward users when they have a “streak” of using the app for multiple days in a row. This would motivate users to keep returning to the app.

2. Self Determination Theory.

- (a) Avoid language in the app that may seem like the direct commands to the user. If the user is instead informed when they do something well, they will keep themselves more motivated with using the app regularly.
- (b) It suggests that some aspects of the Gamification theory should be avoided as it may leave the user feeling too controlled. For example a daily “streak” system may have this negative side effect.

3. Images for Persuasion.

- (a) Images related to the damaging side affects of waste could be shown throughout the app to remind the user of the real impacts.
- (b) When the user throws away some waste, an image of that item in a waste site can be shown to help the user see the real results of their actions.

## 2.4 Similar Applications

### 2.4.1 WeRecycle

The WeRecycle app is a multi platform phone application created by the The On-Pack Recycling Label Ltd (OPRL) organisation. They released this app on both the Android and Apple app store however it was very recently removed from both of the stores. More information on OPRL can be found at [www.oprl.org.uk](http://www.oprl.org.uk)

#### Features

The main functionality of the WeRecycle Phone app is the ability for a user to track the items that they have recycled. The user can log an item on the app by scanning the barcode of the product and if the product is registered on their system, the product data will be added to the users Recycled waste history.

As shown in Figure 2.11, the app analyses the Recycled history and calculates a “recycling points” score for the user. This score is then compared with other people locally or nationally and displayed on a leaderboard to give the user a sense of competition. Finally the app has achievements which the user gains from completing certain tasks. This helps to keep the consumer motivated with recycling and helps to draw them back to the app as discussed in the Gamification Theory section.

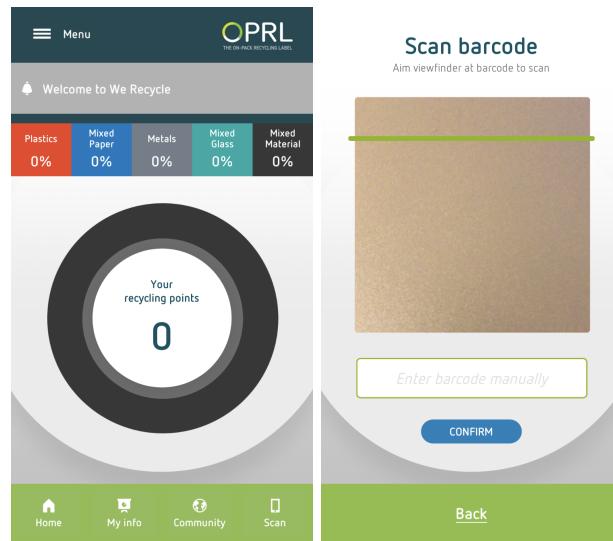


Figure 2.11: We Recycle Home Screen

## UI Design

The design of the UI for this app also has some interesting factors. These include:

1. Green Grey colour scheme that links the app to having an environmental feel.
2. Very receptive and nicely designed home page that displays material percentages.
3. The bottom navigation bar is clear and easy to operate, which improves the usability of the app.

## 2.4.2 RecycleAcademy

RecycleAcademy is a mobile application that is released on the Apple App Store. It was created by a Developer based in Slovakia named Milan Gladiš and its illustrations were created by the designer Alica Sevcikova.

### Features

This app's sole functionality is to show which type of bin each specific material type goes in (Figure 2.12). It achieves this by having one simple screen that the user can swipe left or right through to see the next material in the list. This app does not take the users location into account which means that it only works for people living in a specific area of Europe. This is because each country and region often have a different bin colour systems.

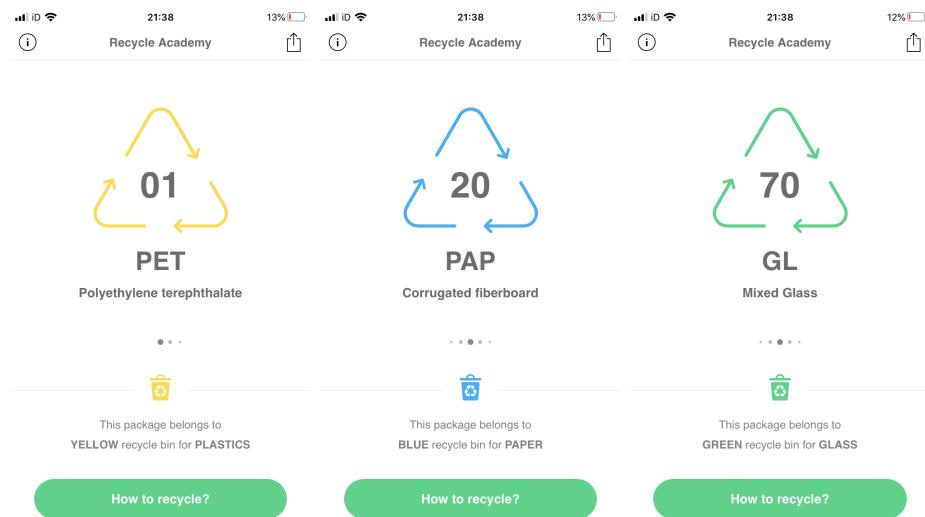


Figure 2.12: Recycle Academy (2020)

### UI Design

From this app some useful UI designs are implemented. These include:

1. The app has a great use of animations paired with the striking use of colours. This makes the app more aesthetically appealing to the user.
2. The main swiping feature comes natural to the user and gives the app a very low learning curve.

- The changing colour feature makes the app visually stimulating and allows the user to quickly understand which bin each material type belongs in.

### 2.4.3 Recycle Now

RecycleNow.com is a UK based website that hosts a vast amount of recycling information. The site was created by the UK Charity WRAP (“The Waste and Resource Action Programme”) and is funded by the UK government and used locally by 90% of UK Authorities.

#### Features

One of the main functions of this site is to allow users to find the nearest location at which they can recycle a specific material. For example if the user wanted to dispose of some plastic containers, they can select this on the site and it will find all suitable recycle points near their real location (shown in Figure 2.13). The site also provides information explaining how certain items are recycled and lots of information on how to understand different product recycling labels.

As RecycleNow is a website, it has a strong support for a range of device screen sizes. This makes the site very accessible as nearly any device and user with basic web access can use it.

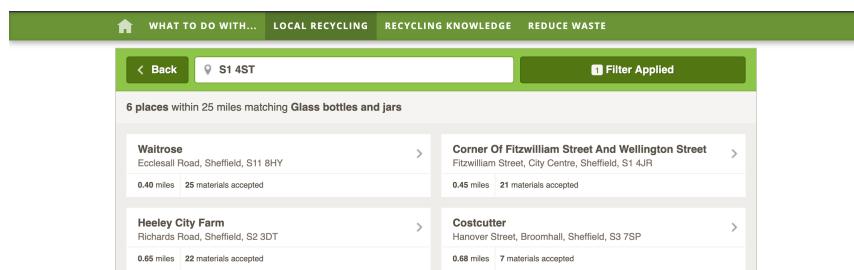


Figure 2.13: RecycleNow Search Screen :2020

#### UI Design

From this app some useful UI designs are implemented. These include:

- Its colour scheme consists of a mixture of green shades. This colour

scheme matches the typical recycling environmental theme.

2. Detailed navigation bar makes the app straightforward to use and is easy for new users to learn.
3. A lot of imagery is used, which helps to hold the users attention.

## 2.5 Conclusion of Research

From these existing applications, some aspects may also be useful for this project. These useful factors include:

1. From the “We Recycle” app the clear and aesthetically pleasing home page can be used for this project. This design clearly displays the useful data in a way that can be instantly understood.
2. From the “We Recycle” app and the “Recycle Now” website, some aspects of the navigation bars can be applied in this project. This project should also aim for a similar Nav bar style so that any new users feel confident to navigate the app, even when they have little experience with it. This would help to stop new users getting frustrated and uninstalling the app.
3. As this project also has an environmental theme, it would be useful to use the green colour scheme. This would help to remind the user of the environmental aims of the app, which may increase how engaged they are.

There are also some negative factors to the existing applications that this project such avoid. These factors are;

1. “WeRecycle” has a weak use of animations which makes the app feel slow and sluggish to use. This may dissuade busy users from using the app further .
2. The “Recycle Academy” app has a design issue with the swiping material list feature. If the user wants information on a Mixed Glass material they have to manually swipe right many times until they see the materials information. This wastes a lot of the user’s time and is inconvenient. This project should always consider the time it takes for a user to complete an action, as they often won’t have long to log an item of waste.

3. As “recycleNow” is a normal website it requires a constant internet connection. It is important for this project’s deliverable to be accessible as possible and therefore this issue should be avoided.

# Chapter 3

## Design

### 3.1 Mobile Application Frameworks

#### 3.1.1 Ionic framework



Figure 3.1: Ionic framework Logo (2020)

As mentioned by Yusuf (2016), Ionic is a mobile development framework that lets developers build mobile applications using web languages like HTML5 and JavaScript. Ionic is built on top of the Apache Cordova which is a framework used to create hybrid applications. In this scenario the term hybrid means a web application that can also access native functionality of a mobile device. With this Hybrid-Web method, Ionic applications are able to work on practically any platform from a single code base. Ionic builds on top of the functionality of Apache Cordova by adding a range of native-like components that help to make web based apps get the usability feel of a native mobile application. These Components include Modals, Popups and Slides as listed on their official documentation web page.

Ionic focuses on the front end UI section of an app and typically uses a

back end framework such as Angular to handle core functionality. Apache Cordova is then used to access native functionality when required.

Table 3.1: Ionic Framework Summary

Ionic Framework	
Positives	Negatives
<ol style="list-style-type: none"><li>1. One code base for all mobile platforms.</li><li>2. High amount of native-like components.</li><li>3. Average app size smaller than average native apps.</li><li>4. Web Developers experience will pass over to Ionic.</li><li>5. Very Detailed Documentation.</li></ol>	<ol style="list-style-type: none"><li>1. Slower performance than a full native app.</li><li>2. Requires the learning of multiple frameworks to use it.</li><li>3. No hot reloading.</li></ol>

### 3.1.2 PWA



Figure 3.2: PWA Symbol (2020)

A PWA (Progressive Web App) is a phone application which at its core, is just a web application with some extra functionality that makes it appear and act like a native mobile app. To be precise, a PWA is typically created like a normal website with HTML, CSS and JavaScript. Then with the use of concepts such as Service Workers; a technology allowing the programmer to change how network requests are handled by the web browser, the website will instead act like a native app with offline mode functionality (Grigsby, n.d.). As PWAs are not actual applications, it is difficult to add them to a native App Store like Apple's App Store. Instead, PWAs are added to a device's home screen by accessing the PWA's web page through a web

browser and clicking an “add page to home screen” button. As Google are pushing for PWAs, Android has increasingly good support for them, however Apple based devices offer limited support and stop PWAs from accessing most native features.

Table 3.2: PWA Summary

PWA	
Positives	Negatives
<ol style="list-style-type: none"><li>1. One code base for all mobile platforms.</li><li>2. High amount of native-like components.</li><li>3. Average app size smaller than average native apps.</li><li>4. Web Developers experience will pass over to Ionic.</li><li>5. Very Detailed Documentation.</li></ol>	<ol style="list-style-type: none"><li>1. Slower performance than a full native app.</li><li>2. Requires the learning of multiple frameworks to use it.</li><li>3. No hot reloading.</li></ol>

### 3.1.3 React Native



Figure 3.3: React Logo (2020)

React Native is a JavaScript based Hybrid-Native framework that can be used to create Native mobile phone applications. Just like Ionic, React has a range of built in Native components that can be used in an application and can create an app for both iOS and Android with one code base (Novick, 2017). React Native is very similar to React (React is a popular web development language), meaning that React developers will find it very easy to adapt to this framework. Also due to its growing popularity, this framework has a lot of support documentation online, which helps developers during

the learning process. To summarise, React Native is a increasingly popular Hybrid Native framework that is used to create highly responsive mobile apps for Android and iOS.

Table 3.3: React Native Summary

React Native	
Positives	Negatives
<ol style="list-style-type: none"><li>1. A lot of learning materials and documentation online.</li><li>2. Can create highly efficient apps due to Native functionality.</li><li>3. Supports hot loading.</li><li>4. All native functionality of a device can be accessed.</li></ol>	<ol style="list-style-type: none"><li>1. Often has large file size for apps as most components come in large packages.</li><li>2. Learning the React Routing can be complicated for new learners.</li><li>3. Sometimes requires extra code to make the app fully cross platform.</li></ol>

### 3.1.4 Selected Framework

After researching the different possible frameworks, the Ionic framework was chosen for this project. The Ionic framework was selected because of the following reasons:

1. The Ionic framework provides the best cross platform compatibility than compared to PWA's and React Native.
2. The PWA support for IOS was too poor for it to be used over the other frameworks.
3. Ionic Framework apps typically have a smaller file size than React Apps. This is important as having free phone storage is something many smart phone users struggle with.

## 3.2 Methods of Data Storage

### 3.2.1 Server Storage

#### Explanation

One method of handling the users data would be to store it onto an online server. To do this, server storage providers like MongoDB Atlas or Amazon's AWS would be used. Although some of these providers offer a free version of their service, most have a regular fee in order to use the service. If server storage is used, a secure log in system would have to be created in order to protect the user's data and to allow them to access the files.

#### Pros & Cons

Table 3.4: Server Storage Summary

Server Storage	
Positives	Negatives
<ol style="list-style-type: none"><li>1. The users data syncs to any device.</li><li>2. Uses less of the user's smart phone storage.</li><li>3. User files are protected from data loss.</li></ol>	<ol style="list-style-type: none"><li>1. A secure log in system is required for the user to securely access their data.</li><li>2. A lot of data protection GDPR rules must be taken into consideration.</li><li>3. Accessing the files requires internet access.</li></ol>

### 3.2.2 Local Storage

#### Explanation

Storing the users data locally is another method that can be used. This would be done by using a native storage plugin within Ionic which allows applications to permanently store data within the local device. Therefore, all of the users private information will remain on their device and not require online password secured accounts for storage. Two possible plugins to handle the storage would be Ionic Storage (Weigert, 2020) and SQLite native (Ionic, 2020).

## Pros & Cons

Table 3.5: Local Storage Summary

Local Storage	
Positives	Negatives
<ol style="list-style-type: none"><li>1. User data is secure as it never leaves their device.</li><li>2. Data can be accessed with or without an internet connection.</li><li>3. A secure log in system not required which saves a lot of time.</li></ol>	<ol style="list-style-type: none"><li>1. The user's smartphone data gets used up.</li><li>2. Data can't be synced between multiple devices.</li><li>3. Data not backed up.</li></ol>

### 3.2.3 Choice of Storage

After weighing up the two options for this project, local storage will be used to handle the user data. The local storage method was chosen because of the following reasons.

1. By keeping all of the data on the users smartphone, it is more secure and has less chance of GDPR rules being broken.
2. It is important that the user can use the app, even when they don't have an internet connection.

## 3.3 Emulators

When deciding on which Emulation software to use during development, it must also be decided which platform the deliverable will mainly be tested on (Android or iOS). Therefore, two popular tools will be evaluated whilst taking the OS of these emulators into account. As the selected framework, Ionic will still generate the app for both platforms, only one platform will be used for debugging. These two candidates are being reviewed as they were the software suggested within Ionic's official documentation (Brandy Scarney, 2020).

### 3.3.1 Android Studios



Figure 3.4: Android Studio Logo (2020)

Android Studios is the first option to host the emulator. This software supports the emulation of nearly any android device and any screen size. This software was partly developed by Google who are the main contributors to Android and the software is also what Ionic's official documentation suggests should be used (Brandy Scarney, 2020). This increases the integrity of the tool. Android studios also has a very positive review of 9 out of 10 on the independent review site TrustRadius. It has been reviewed as having an intuitive and easy to use interface (*Trust Radius, Android Studios review, n.d.*).

The Android Studios software handles the install of the ADB (Android Debug Bridge) tool. Using ADB, it would be possible to emulate the deliverable on a real device. An android device would simply need plugging into the development computer and with a few simple commands, ADB can get the deliverable running on the real device. This is very useful for debugging as it would provide a realistic testing environment.

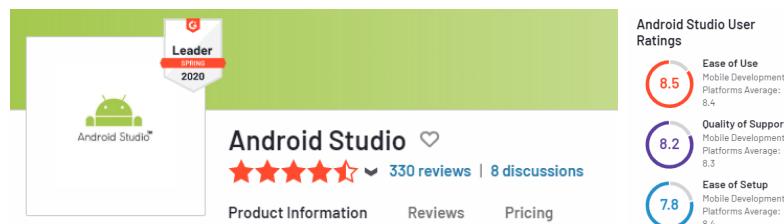


Figure 3.5: Android Studio Reviews (G2 Review - 2020)

### 3.3.2 XCode



Figure 3.6: XCode Logo (2020)

XCode is a software created by Apple that provides a development IDE and most importantly for this project, handles the creation of iOS emulators. Since this software was created by Apple, it can only be legally installed onto a system that is running macOS. For this project, a Windows based computer will be used during development. Therefore, to run XCode a macOS virtual system would have to be used, which takes up a lot of computer resources and makes the emulating process a lot more complicated. On the independent G2 review site XCode is rated 4.1 out of 5 with a usability score of 7.6 out of 10 (Figure 3.7)

XCode supports the ability to run the deliverable on an actual Apple device. However to use this feature a \$100 developer license is required to do this.

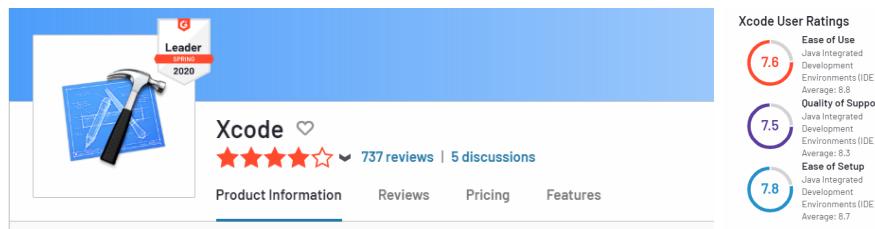


Figure 3.7: Android Studio Reviews (G2 Review - 2020)

### 3.3.3 Selected Software

Android Studio was chosen as the main platform for testing. The reasons for this are as follows.

1. Android Studio has better support on Windows than XCode.

2. Android Studio allows the deliverable to be run on a real device for free, unlike XCode.
3. Android Studio has a better overall rating than XCode ( $4.5 > 4.1$ ).

### 3.4 UI Design Patterns

Within mobile development there are a wide variety of UX design patterns that improve the usability of the applications. With the high range of mobile applications currently available to smartphone users, one badly designed UI page is enough to push a user to uninstall an app. Therefore it is important to research into the design patterns that smartphone users are commonly used to.

The guide book written by Perea and Giner (2017) discusses a wide selection of these mobile UX design patterns. By reading through these options it was easy to evaluate each pattern and decide which are applicable to this projects deliverable. The list below will name some of these applicable designs. The Ionic framework also has a range of components that provide a native feel to the app that users would be comfortable with.

- Bottom Nav Bar.
- Back Button.
- Swipe down to refresh.
- Dialogs.
- Alert Popup.
- Modals.

### 3.5 Wireframe Flow Design

To get a deeper plan of the deliverable a wireframe was created. A wireframe is typically a quick sketch of the different screens that an application will have. It also shows how the different pages of the app flow and the direction of the page navigation. This is explained in Chapter 4 of the guide book by Klimczak (2013).

A wireframe was used for this project as it is quick to make, cheap and helps to iron out any navigational flaws in the design. For the wireframe shown below the service named Moqups was used.



Figure 3.8: Wireframe of main pages (Joe Barton - 2019)

## **Chapter 4**

# **Development**

### **4.1 Using Organisational Tools**

Before the development process could begin, the tools chosen in subsection 2.2.3 had to be set up. The first step was to prepare the Trello board as this would help to create a detailed development road map. The Trello site was easy to become acquainted with and a basic plan was quickly set up (Figure 4.1). As development progressed, the Trello board was regularly updated as it was a key tool in keeping on track with the deliverable's deadlines. This means that the Kanban methodology mentioned in subsection 2.1.1 was used consistently throughout this project.

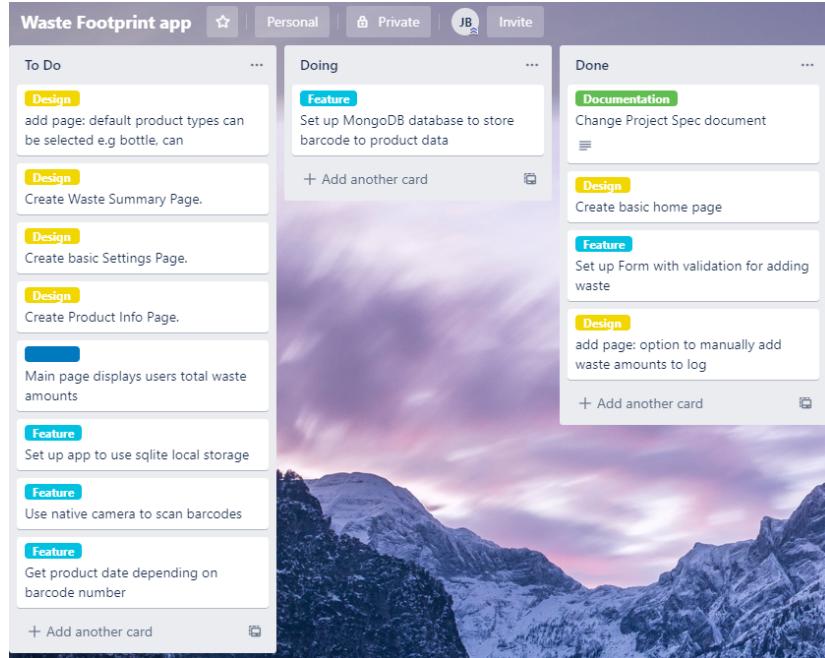


Figure 4.1: Trello in use (2020)

Git and Github were also prepared and used during the development of the project. In order to use these tools correctly, the tutorial created by (Nelson, 2015) was the perfect resource. The guide covers all the main processes of using Git and the Github site. A Github repository was then created for the deliverable (Figure 4.2). Throughout development, the deliverable was regularly pushed to the repository and branches were used to handle the creation of separate functionality. This kept the code base well organised and protected the deliverable from any form of data loss.

Commit	Description	Date
JoeBarton Merge pull request #1 from JoeBarton/SQLiteLog	Latest commit f7e28d4 on 5 Feb	
e2e	Initial commit	4 months ago
src	Changed how the SQLite handles dates now.	3 months ago
.gitignore	Initial commit	4 months ago
angular.json	Set up SQLite storage with basic data types. Can now add to the log a...	4 months ago
browserslist	Initial commit	4 months ago
README.md	Custom CO2 calculator with basic data source. Can now add to the log a...	4 months ago

Figure 4.2: WasteFootprint Github Repository (2020)

## 4.2 Setting Up Development Environment

After completing the planning, the first step was to prepare an emulator so that it is possible to debug the application throughout development.

As suggested in section 3.3, the software Android Studio was used to handle the emulators. To help with the setup of the emulators, the book Smyth (2016) was read, which is an instructional book that explains how to use Android Studio. After reading chapter 2 of the book, the setup of the emulator was fairly simple and a Google Pixel XL emulator was set up successfully in a short time. (Figure 4.3).

Now a basic version of an Ionic project had to be created to ensure it would run on the emulator as expected. Due to Ionic having a good amount of documentation, setting up a basic project was straightforward. After installing required dependencies, it only took two commands to create an example ionic project and run it onto the emulator.

See the following command:

---

```
1 $ ionic start myApp tabs  
2 $ ionic cordova run android -l
```

---

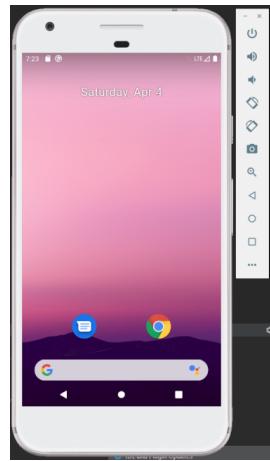


Figure 4.3: First time running the Emulator

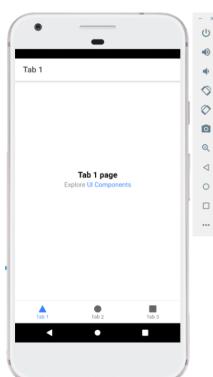


Figure 4.4: Running basic project on emulator

## 4.3 Programming in Ionic 4

As mentioned in subsection 3.1.1, the Ionic framework is built on top of the Angular framework. Because of this, all page routing and data handling is done using Angular. This framework can be complicated to use and so a lot of learning resources were required during development. To use the full capabilities of Ionic, a developer would also need to understand how Ionic, Angular and Cordova all work together.

### 4.3.1 Page Routing

In Ionic each screen in an application's UI that a user would see, is represented by a component called a Page. So the Home Page and Full Log Page (which are planned in section 3.5) would both be represented by their own Page component. To create a page the Ionic CLI command is used:

---

```
1 $ ionic g page pages/nameofthepage
```

---

A Page component in Ionic is made of 5 independent files. These files are explained in Figure 4.5.

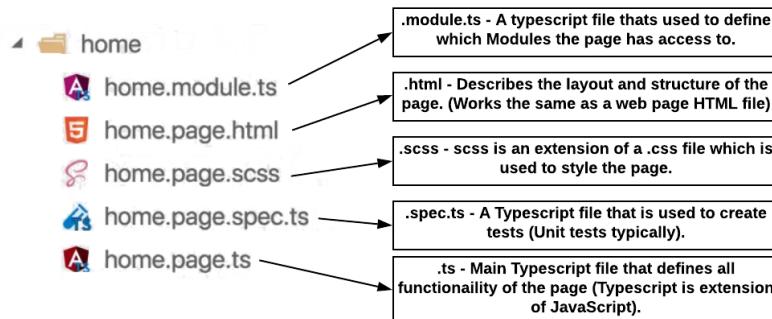


Figure 4.5: Format of Ionic Page (Joe Barton - 2020)

With this understanding of how a Page works, a range of pages were created as designed in the wireframe. However, these pages are still not accessible to the user until the page routing has been set up.

For this application Angular routing was used, which works in a similar way to web routing. So to navigate to the Full Log page, the user would

be redirected to the “/Fulllog” address. Before the routing will work, the router needs to know which Ionic Page should be shown for each particular address path. Most routes are defined in the “app-routing.module.ts” file. In this file it is a simple process to define where each route leads.

During the design of this project a Navbar was chosen to handle app navigation. To do this, another routing file had to be created. Inside this newly created file, the paths that the Navbar can navigate to were defined (Figure 4.6). So to navigate to the Full Log page, the user will now be directed to the “tabs/fulllog” address which was defined in the new Tabs routing page. It is important to navigate to the Navbar version of a page as this tells Ionic to add the designed Navbar to the bottom of the particular page.

```
const routes: Routes = [
  {
    path: 'tabs',
    component: TabsPage,
    children: [
      {
        path: 'Waste-Home',
        children: [
          {
            path: '',
            loadChildren: () => import('../waste-home/waste-home.module').then( m => m.WasteHomePageModule)
          }
        ]
      },
      {
        path: 'Full-Log',
        children: [
          {
            path: '',
            loadChildren: () => import('../full-log/full-log.module').then( m => m.FullLogPageModule)
          }
        ]
      },
      {
        path: 'Map',
        children: [
          {
            path: ''
          }
        ]
      }
    ]
  }
]
```

Figure 4.6: Nav Bar Navigation snippet (2020)

With this set up, the flow of the program was created and further functionality could be worked on.

## 4.4 Local Data Storage

In subsection 3.2.3, the final decision was that all user data should be saved on the user’s local device so that passwords and protected server storage are not required. To implement this, a method of local data storage had to be chosen so that the user’s waste history could be saved. On Ionic’s official documentation site, they have two main suggestions for local data storage on a device. The methods are “Ionic Storage” which stores data using JSON objects and the “SQLite” plugin that is a Cordova tool. Ionic

Storage is a good tool for storing smaller amounts of data that should stay saved even after restarting the application (Weigert, 2020). The “SQLite” plugin is similar to Ionic Storage, however it is more suitable for storing large amounts of data in a table format (Ionic, 2020). Since the Waste history was to be stored in a table format, Cordova SQLite was chosen as it was the most suitable plugin.

#### 4.4.1 SQLite

To use the SQLite tool, a new Ionic Service had to be added to the project. An Ionic Service is a type of component that is similar to a Page (The Ionic Page was discussed in subsection 4.3.1). The main difference is that a Service doesn’t include a HTML or SCSS file as they don’t create any visual components that a user would see. Instead they are used to handle data based functionality that is called repeatedly like API communication or data storage commands. The command below was used to create the database Ionic Service:

---

```
1 $ ionic g service services/database
```

---

Inside the new database service file, specific functions were created to allow the Mobile App to access and save data within the SQLite database. The book written by Feiler (n.d.) proved to be a very useful resource as it provided guidance in using SQLite commands. Functions like “openOrCreate()” (Shown in Listing 4.1) and “addWasteLog()” were created which provided basic functionality for adding to a local database.

---

```
1
2 openOrCreate(){
3     //Creates the database if not existed yet then opens the database
4
5     return this.sqlite.create({
6         name: 'wasteLog.db',
7         location: 'default'
8     }).then((db: SQLiteObject) => {
9         this.db = db;
10        return this.db.executeSql('CREATE TABLE IF NOT EXISTS log(
11            id INTEGER PRIMARY KEY AUTOINCREMENT, waste_name
12            VARHCHAR(32), waste_amount SMALLINT, waste_type VARHCHAR(15), +
13            waste_material VARCHAR(15), was_recycled BOOLEAN, is_necessary
14            VARCHAR(1), waste_notes VARHCHAR(100), log_date VARHCHAR(27)
15            )', [])
16        .then(data => {
17            this.databaseReady.next(true);
18        })
19    })
20}
```

---

```

15         return data;
16     }).catch(() => {
17
18     })
19   );
20 }

```

Listing 4.1: Create Database function

#### 4.4.2 Observable

Within the application, multiple Pages need access to the waste history logs that the user has saved in their local storage. To get this information from the SQLite database the loadWasteLogs() function can be called as it will query through the entire SQLite database and translate all waste log rows into an array of Log items. If multiple Pages want to regularly check whether they are still up to date with the stored Waste Logs, they would have to constantly call the loadWasteLogs() query function. The issue with this is that the “loadWasteLogs” function is heavy and inefficient when called often as it reads everything from the local database. In response to this an Observable object was used.

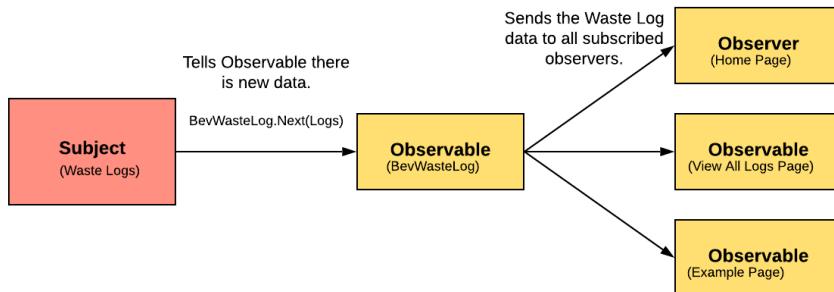


Figure 4.7: Observable Diagram (Joe Barton 2020)

An Observable is an object type in Angular that represents some data that your application wants to observe. The data that wishes to be observed is called the ‘subject’ and functions that are watching this data are called ‘observers’. To be become an observer the function simply needs to subscribe to an observable object. Then any time the subject is updated with new data, the observable will send the updated data to every observer. This is clearly shown in figure 4.7. By using this data structure, any pages that

required Waste Log information were able to remain up to date, without slowing the performance of the application.

## 4.5 Waste Log Table

One of the main features of the mobile application was to show users a log of all the waste that they have thrown away. To do this some sort of table component should be used so that the users can clearly see all of their logs in a list. In the book by (Siegle, 2018) which gives people advice on how to reduce their plastic footprint, an example of a 'Plastic Diary Grid' (Figure 4.8) is shown that people could use to log their waste (Siegle, 2018, p. 124).

Plastic / product	Source	Status: A = avoidable U = useful N = necessary	Number of uses: S = single-use M = multiple-use	U = uninvited P = purchase (or given with product) F = free	Features	End: B = general bin (landfill or incineration) R = recycling	Number
Wrapper: packet pack balsam tissues	High street chemist	U	6 individual tissues in pack	P	Thin plastic LDPE, 6 month use-by date	B	12 (Multipack but ALL individually wrapped)
Wrapper: car magazine	Post	A	No use (straight to bin)	U (no interest in cars)	Thin plastic, heavily inked	B (can't be recycled)	1
Drinks bottle for bio-smoothie	Health food shop	A	S	P	Thick white plastic	R	1
Plastic toothbrush	Supermarket	N	M (as long as battery lasts)	P	Contains battery	B	1

Figure 4.8: Plastic Diary Grid (Lucy Siegle - 2018)

Since people may be familiar with this graph style already, it was decided that the View All Logs Page of the app should have a similar table. To achieve this the Material Angular mat-table component was used. This was chosen as it creates well formatted tables quickly with a range of useful plugins like a Paginator and row sorting. After some trial and error, the table became ready for use.

One piece of information that a waste log holds is a Boolean, representing whether the rubbish was recycled. To help the user visualise this, one of the two symbols that are shown in figure 4.9 were used to represent if the item was recycled. Due to the size of mobile phone screen being limited, instead of squeezing the full row of data onto the view all logs page, the user can click on a row to view all of the logs details. This is also shown in figure 4.9. To improve the usability of the table, sorting functionality was added that allows the user to order the logs by the logged date.

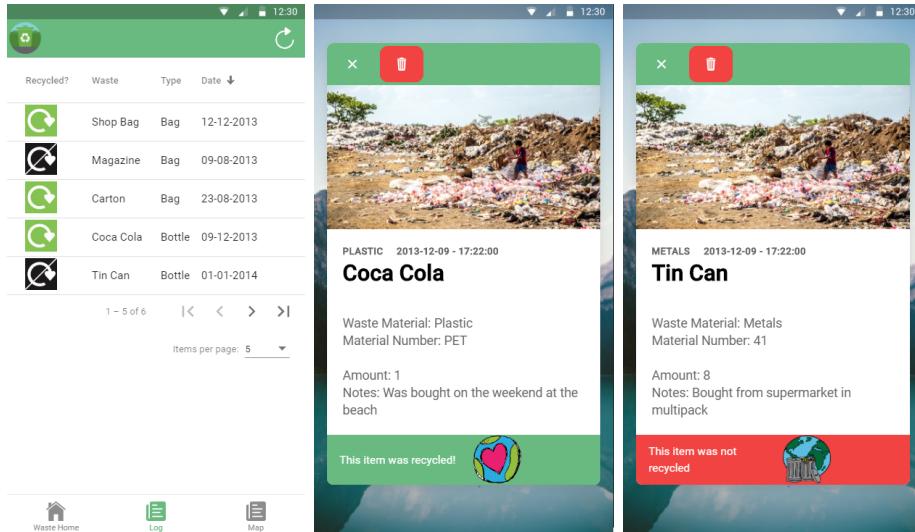


Figure 4.9: Full Waste Log page (Joe Barton - 2020)

## 4.6 Custom Images for Waste

As mentioned in the previous section, when a user clicks on a specific row in the Waste log table a page will appear, allowing the user to view all details about a specific log (Figure 4.9). In addition to showing all the details of a specific log, this page also displays an image at the top of the Card Component. As talked about in subsection 2.3.3, visually seeing something is more impactful than viewing a written summary. So, if the user had thrown a plastic bottle into the landfill bin instead of recycling, this could be represented with text by simply reading “This item was not recycled”. Telling the user this in plain text lacks any emotional connection and it would be unlikely for them to understand any impact their actions may have had. Therefore, to ensure more meaningful information, custom images were used in this project so the user can visualise where their waste has gone.

To implement this a switch statement was used along with some custom images of waste. This switch statement looks at the material of the waste thrown away and whether it was recycled. The code for this is shown in Listing 4.2. The code in action is shown in Figure 4.10.

---

```

1  switch(this.log.wastetype.toLocaleLowerCase()){
2      case "plastic": {
3          this.headImage = "/wastePic/plasticGood.png" ;
4          if(this.log.wasrecycled == false){
5

```

```

6         this.headImage = "/wastePic/PlasticBottleBad.png" ;
7     }
8     break;
9 }
10 case "mixedpaper":{
11     this.headImage = "/wastePic/cardboardGood.png"
12     if(this.log.wasrecycled == false){
13         this.headImage = "/wastePic/MixedBad.jpg" ;
14     }
15     break;
16 }
17 case "glass":{
18     this.headImage = "/wastePic/GlassGood.jpg"
19     if(this.log.wasrecycled == false){
20         this.headImage = "/wastePic/GlassBad.png" ;
21     }
22     break;
23 }
24 case "metals":{
25     this.headImage = "/wastePic/metalGood.png"
26     if(this.log.wasrecycled == false){
27         if(this.log.wastename.toLowerCase().includes("can")){
28             this.headImage = "/wastePic/MetalCanBad.png" ;
29         }
30         this.headImage = "/wastePic/metalBad.png" ;
31     }
32     break;
33 }
34 }

```

Listing 4.2: Create Database function

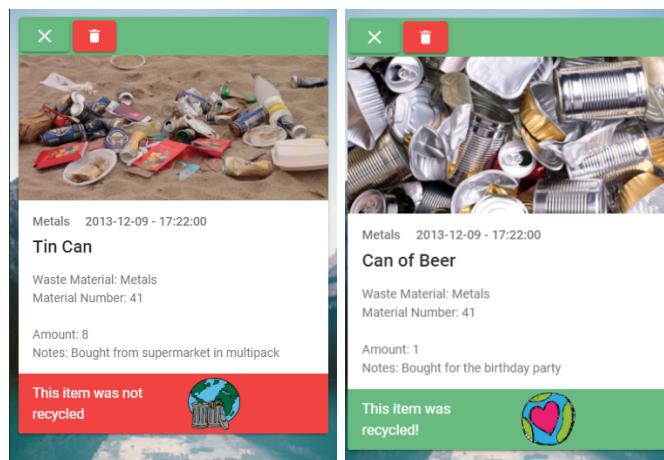


Figure 4.10: Detailed Log Page Images (Joe Barton - 2020)

## 4.7 User Interfaces

Throughout the development of the application, a range of user friendly components and design patterns were employed. Most of these design patterns came from the table listed in section 3.4, however some additional UI Components were used to further improve the app's ease of use.

- Drag down to refresh - Full Log View Page.
- Slides - Log Waste Page.
- Toasts - Log Waste Page.
- Searchbar - Log Waste Page.
- Refresher - Full Log View Page.
- Popover - Log Waste Page.
- Date Time Picker - Log Waste Page.
- Modals - View a Log Modal.
- Back Buttons - Log Waste Page.
- Bottom Navbar - Most Pages.

### 4.7.1 Examples of Components in use

One page that has a high amount of components in use is the “Log Waste” page. This page allows the user to record waste that they have discarded. On this page there are three methods for adding waste to the waste log. These include quick adding predefined waste, scanning a product’s barcode or completing a detailed log form.

One design that changed from the original wireframe, was how the user navigates between the three methods of logging waste. It was originally designed that there would be buttons in the header bar that can navigate to the other pages when clicked (in chapter 3.5). However, during development it was decided that this just creates confusion as it is not an action users would feel naturally comfortable with. Instead of this, a Slide component was used which provided a gesture-based method of navigation. If the user wishes to go to the next page with a Slide component, they simply swipe the screen in the direction that they wish to navigate. This is a very natural movement that most smart phone owners will do instinctively (Shown below

in Figure 4.11).

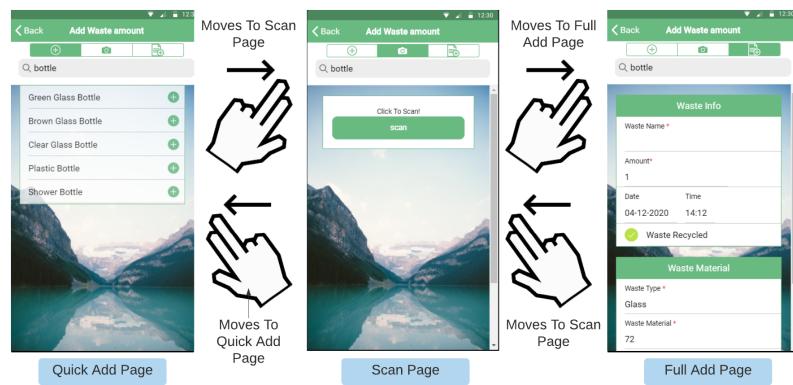


Figure 4.11: Navigating Log Waste Page (Joe Barton - 2020)

The “Quick Logging” functionality was implemented by using the Searchbar component which allows the users to quickly filter through a list of items. If for example, a person throws away a green beer bottle and wanted to log this on the app, they could enter “bottle” into the search bar. The search bar would then filter all of the registered item types and return the possible options of “Green Glass Bottle”, “Brown Glass Bottle”, “Plastic bottle” and so on (shown in Figure 4.12). These options are displayed onto an Ionic List component that automatically updates with the search results as the user is typing. To add the item to the waste log the user clicks on the row that contains their item. A Popover will then appear, asking the user to confirm they wish to log a certain item. Since this is a quick process even for people who have limited time, they will be able to record waste which is important for retaining users.

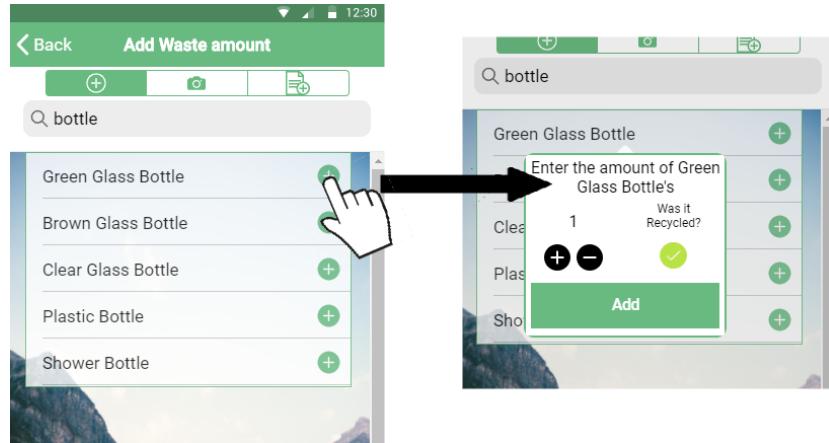


Figure 4.12: Quick adding waste (Joe Barton - 2020)

## 4.8 Phone Barcode Scanning

Right from the initial planning stages of the project, it was decided that the app should have the ability to scan the barcode of a product. This is then added to the user's waste log automatically.

The first step of implementation involved finding an Ionic plugin that provides camera scanning functionality. Ionic's documentation site was useful as it suggested the "Barcode Scanner" plugin by Apache Cordova. This plugin was chosen as it is compatible with any modern smartphone brand, which supports the project objective; creating an app that works on most modern mobile platforms (mentioned in section 1.2). The plugin also had clear documentation which made it a straightforward process to use.

To use this plugin, the first step was to install the plugin package.

---

```

1 $ ionic cordova plugin add phonegap-plugin-barcodescanner
2 $ npm install @ionic-native/barcode-scanner

```

---

This was then imported onto the Add Waste page. Using the functionality of this plugin is a simple process. The barcode scanner comes with a function named "scan". When called, this function will activate the user's camera on their screen. It will then stay open until a barcode is scanned or the user cancels the action. If a barcode is detected, the barcode number values will be returned by the function (the code for this is shown in Listing 4.3). The next step is to take the barcode number and find which product it represents by using an API.

---

```

1  scanBarcode(){
2      this.barcodeScanner.scan().then(barcodeData => {
3          //After scanning a barcode value it will check the database for a
4          matching product
5          this.result =
6              this.productService.searchData(+barcodeData.text).subscribe(result
7                  => {
8                      let product: any = result;
9                      if(product['found'] == true){
10                          //if a matching product is found it will be displayed on the form
11
12                          this.quickAdd.get('wasteName').setValue(product.product.productName);
13                          this.quickAdd.get('wasteType').setValue(product.product.productType);
14                          this.quickAdd.get('wasteMaterial').setValue(product.product.material);
15                          this.quickAdd.get('wasteNotes').setValue(this.quickAdd.get('wasteNotes').value
16                                  + "Barcode: " + product.product.barcodeid);e
17
18                  }
19              }).catch(err => {
20                  console.log('Error', err);
21              });
22      });

```

---

Listing 4.3: Barcode Scan Function

#### 4.8.1 Barcode Product Api Issue

As the barcode number of a product could be collected, it then had to be submitted to a product API so that the product's material information could be gathered. After some research the most suitable API was found to be Open Product Data's barcode API. However, when using this API, some issues arose. For a few weeks starting on 18/01/2020, the API's site went down and showed a database issue command.

When the site finally came back online, it became apparent that the database did not contain the required data. Firstly, the database mainly contained American product information which meant that most UK products were not recognised. Secondly, for most of the products it did not contain the necessary amount of packaging information that this project requires. This was a big set back at the time and was due to the lack of research done into this area.

After looking into other possible API's, it was found they either had a large paywall or did not contain the product material information. At this point a workaround had to be decided. Instead of using an outside API, the workaround of creating a new API was chosen as it would provide the specific product data that was needed.

## **API Workaround**

To create an API that holds product information, Node.js combined with MongoDB was chosen. Node.js is a lightweight and scalable JavaScript based development framework. Due to this framework being built on Google's V8 JavaScript engine, it has fast performance. As it is also has a simple setup process, it doesn't take long to create an active server. These factors, along with the fact that it is well suited for creating RESTful endpoints, meant it was a good tool to use. Therefore, in this case, Node.js is the middleman between the mobile application and the back-end database that contains the product information. The book by Dayley (2014) supports this idea of using Node.js and was a useful guide for setting the system up.

To handle the actual product data, a MongoDB database was chosen. MongoDB is a NoSQL database program that boasts high performance and high scalability. The other option that could have been used for the above, was an SQL database. MongoDB was chosen over this mainly because it has faster performance and an easier setup process. SQL is a more suitable Database language when there is relational data that needs to be stored (relational data is where rows in one table need to be linked to rows in another table to show a relationship). In this case, there will be no relational data as it will be one table that contains the various product data. This suggests that MongoDB is the most suitable database to use in this scenario.

## **Hosting the API**

To host both the Node.js server and MongoDB database, two separate hosting services were required. To host the MongoDB database, the MongoDB developers offer free hosting on their website through the use of Atlas (Ittycheria, 2009). This service comes with a large amount of free storage and simple setup instructions which made it a suitable choice to host the solution. This database was then filled with some sample data (shown in Figure 4.13).

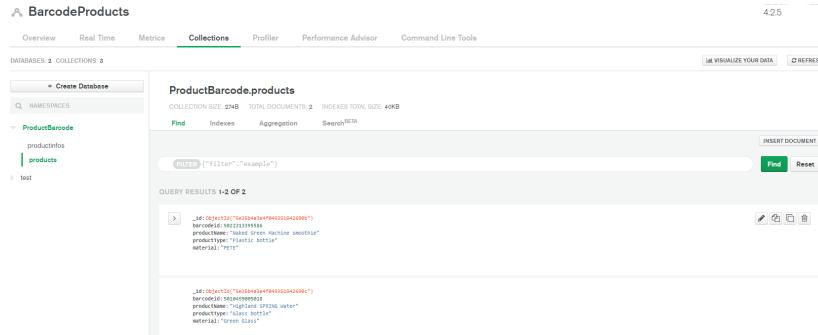


Figure 4.13: MongoDB Hosted Database (Joe Barton - 2020)

After searching through a range of Node.js hosts, Glitch.com was found (Dash, 2017). Glitch.com was a good choice as it provides a fully free service with high limits on the amount it can be used. It also has a built-in development service that allows the programmer to edit the hosted Node.js code and see the results of the changes within seconds. Only two RESTful endpoints were set up on the server. This first end point returned all stored products in the database when requested. The other end point retrieved a single product's data by searching the MongoDB for a specified barcode number (shown in Listing 4.4).

---

```

1 productRoutes.route('/:_barcode').get((req,res) => {
2     let id=req.params.barcode;
3     MyProduct.findOne({barcodeid: id}, function (err, product) {
4         product= {product, "found": true}
5         if(product){
6             res.header("Access-Control-Allow-Origin", "*");
7             res.json(product);
8
9         }else{
10             res.header("Access-Control-Allow-Origin", "*");
11             res.json({"found":false});
12         }
13
14     });
15 })

```

---

Listing 4.4: Node.js RESTful endpoint

## Connecting the app to the server

As the workaround API had been set up, the frontend application had to ping the API to get the product material information that it required from

the barcode number. To handle the HTTP calls to the API, another service was created named Productapi. In the service there is a function named “searchData” that takes in a barcode number and then sends a http get request to the Node.js server with the barcode included. If the product is in the database, the function will then return the product information. It is shown in Listing 4.3 how the code breaks down the JSON object and extracts the relevant information.

## 4.9 Recycling Locator Issue

Previously in subsection 2.4.3 the site named “Recycle Now” was reviewed and was found to have a widget called the “Recycling Locator widget”. Developers are allowed to include this widget into their application and it maps out all of the nearest recycle points near a user. The user can even supply a specific material to find where it can be recycled (Figure 4.14).

The screenshot shows the MongoDB Compass interface. At the top, there are tabs for Overview, Real Time, Metrics, Collections (which is selected), Profiler, Performance Advisor, and Command Line Tools. Below the tabs, it says 'Databases: 2 COLLECTIONS: 3'. Under 'Collections', there is a list with 'ProductBarcode' expanded, showing 'products' and 'test'. The 'products' entry has a green bar under it. The 'Find' tab is selected in the 'ProductBarcode.products' section. A search bar contains the query '("filter": "example")'. The results section shows two documents:

```

_id: "6f051152c7a1234567890123456789012"
barcode: "12345678901234567890123456789012"
productname: "nested aerosol machine smoothie"
producttype: "plastic bottle"
material: "reusable"

_id: "6f051152c7a1234567890123456789023"
barcode: "12345678901234567890123456789023"
productname: "nested aerosol machine smoothie"
producttype: "plastic bottle"
material: "green glass"

```

Figure 4.14: Recycling Locator search (2020)

### 4.9.1 What was the Issue?

To use this widget, permission needs to be given by Wrap.org.uk. It is explained that they will provide the widget to anyone for free, as long as no profit is being made from the application. After contacting the Wrap team, it became apparent that there were some issues with the application for the widget.

In the application it is required that the applicant provides the url at which their application will be hosted. This is because the widget is typically used on websites. However since the deliverable is a mobile phone application, there will be no web address to access it. This means that this project was

not given permission to use the widget.

#### 4.9.2 Google Maps Workaround

As a replacement for the Recycle widget the Google Maps API has been used. This was chosen because of its fast responsive API service and free usage up to certain amounts. Although Google maps does not provide detailed locations of recycling points like the Recycling Locator widget, it still has a moderate amount of data on recycling facilities. Therefore as a replacement, Google Maps was the best solution.

After creating an account on the Google API site, the Google Maps JavaScript plugin was added to the application. Unlike most Ionic Components, Google Maps does not have a Cordova plugin that can be directly installed. Instead, a JavaScript package needs to be included directly inside the project at run time. Since the Ionic framework is a web based language this was still possible by adding one line into the projects index file (Listing 4.5). Then with one further div tag the map was displaying on the screen.

---

```
1 <script async defer src="https://maps.googleapis.com/maps/api/" +
2   "js?key=AIzaSyAQAt9rYP8sm5Hbj2iv779N9q321sL95zc&libraries=places"
3 type="text/javascript"></script>
```

---

Listing 4.5: Google Maps API JavaScript

## Geolocation

To enable a user to view local recycling points in their area, the app has to read the phone's location. This was implemented using a Geo location Cordova plugin that can find the latitude and longitude of the device with one function call. To avoid any GDPR issues of handling sensitive user data, the user's location is only ever temporarily saved on their device and is only used by the Google Maps API. The plugin also requires the user to grant permission before it will track their position.

---

```
1 updateUserPosition(){
2   let latLng = new google.maps.LatLng(53.3766,-1.4668);
3
4   this.geoLocation.getCurrentPosition().then(resp => {
5
6     latLng = new
7       google.maps.LatLng(resp.coords.latitude,resp.coords.longitude);
8     this.storage.set('latlng',latLng);
```

---

```

8
9     }).catch((err) => {
10         this.storage.get('latlng').then((result) => {
11             if(result === undefined){
12                 this.storage.set('latlng',latLng);
13             }
14         })
15         console.log(err);
16     })
17
18     return latLng;
19 }

```

Listing 4.6: Geolocation Plugin in use

Using the location of the user, the app is able to find any recycling points in that particular area and marks them on the map with a map pin. The user can click on the pin to find out information about the recycling point (shown in Figure 4.15). Unlike the originally planned widget, the Google Maps API lacks in recycling point information meaning the user cannot search where a specific material can be recycled. Despite this, the API was shown to be a suitable replacement for the widget as it manages to guide users to recycling centres, which was the original objective of the Recycling Locator.

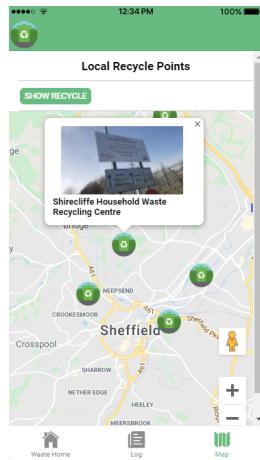


Figure 4.15: Recycle Locator Map (2020)

## 4.10 Data Summary Display

A few of this project's objectives involve processing the data that a user has provided and displaying it in summaries. To meet these objectives, the

Home Screen was set up as a data summary page. The first objective that would be met on the homepage is objective 11 “Create a Graphic summary of waste the user has disposed”, which is listed in section 1.2.

Before displaying any data, all of the logged information that the user had created needed to be filtered by a business logic algorithm. To begin, the algorithm had to receive all of the user’s current logged data. To achieve this it subscribed to the observable object inside of the Database service (This process was explained previously in subsection 4.4.2). It then runs the logs through a business logic layer that counts and totals the data that is inputted. It specifically records which type of items have been thrown away by the user (shown in Listing 4.7) and then calculates the percentage of waste that was recycled.

---

```

1 for(let log of logs){
2     this.wasteTotal += log.wasteamount;
3     if(log.wastetype.search("Plastic")){
4         this.wasteAmounts[0] += log.wasteamount;
5     }
6     if(log.wastetype.toLocaleLowerCase() == "mixedpaper"){
7         this.wasteAmounts[1] += log.wasteamount;
8     }
9     if(log.wastetype.toLocaleLowerCase() == "glass"){
10        this.wasteAmounts[2] += log.wasteamount;
11    }
12    if(log.wastetype.toLocaleLowerCase() == "metals"){
13        this.wasteAmounts[3] += log.wasteamount;
14    }
15    if(log.wastetype.toLocaleLowerCase() == "others"){
16        this.wasteAmounts[4] += log.wasteamount;
17    }
18    //Check if recycled
19    if(Boolean(String(log.wasrecycled) == "true")){
20        this.wasteRecycled += log.wasteamount;
21    }
22 }
23 }
```

---

Listing 4.7: Summarises the material types of each log

For displaying the raw summary data of what the user had thrown away, inspiration was taken from the previously reviewed “We Recycle” application (Figure 2.11). Using some CSS objects and Angular variable binding, a similar version of the data display was created. This design was chosen as the strong use of colour representation helps the user to visualise and understand the data quickly. The colour scheme also matches the colours on the Piechart that was displayed, which helps to further visualise the information.

For the graphical representation of the data, it was decided that a colour based chart should be chosen as it is an impactful way of summarising data. As discussed in the previous paragraph, this is more effective than simply displaying raw data. There were two possible libraries that could have been used to create this summary chart. There were CanvasJS (fenopix, 2013) or Chart.js (ChartJS, 2013). Both of these libraries provide free and varied graphical displays that can be used in any web-based application. Chart.js was chosen to be used in this project as it provided better customisation for the desired “doughnut” pie chart and operated with smoother animations.



Figure 4.16: Home Page Summary (Joe Barton - 2020)

The final part of the data summary page was a comparison between the total amount of waste that the user has recycled compared to the UK average. This feature helps to give the user a sense of competitiveness and achievement as they are striving to be better than the average of their country. As discussed in subsection 2.3.1, when the user feels like they are competing it helps to keep them driven with using the application, as it invokes a gamified motivation to win. This feature also achieves objective 9 (as listed in section 1.2) as they get a sense of achievement when they have a better recycling rate than the average. The average amount that people in the UK recycle was collected from an official report from the department for Environment & Rural Affairs (2019). This is shown working in Figure 4.17.

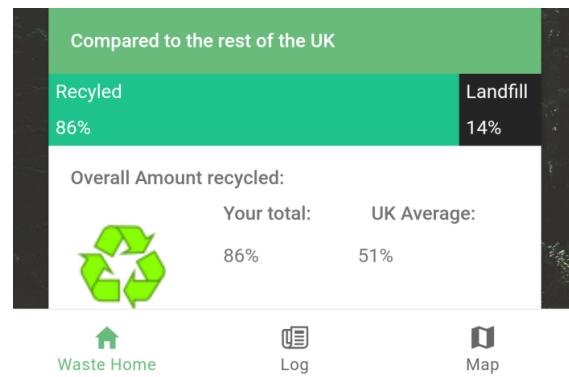


Figure 4.17: Average Recycle Rate Comparison (Joe Barton - 2020)

# **Chapter 5**

## **Testing**

Throughout the development of this project, forms of regular testing were carried out. This was done as regular testing helps to remove obvious defects from new features that are developed. This regular testing also achieves objective 12 of the project that aimed to “Employ a regular testing process during development”. Three forms of testing were done for this project which will now be discussed in this section.

### **5.1 Unit Testing**

The earliest form of testing that was prepared during development was a range of unit tests. As explained in subsection 4.3.1, when Ionic Pages and Services are created, Ionic automatically creates a “.Spec.ts” file. This file is a Unit test file that Ionic set up by default. All of the “.spec.ts” files are automatically set up to test whether the Page can be generated without any compilation issues. The files are set up using Jasmine (A common Unit test framework), which means that they can be changed to test whatever you like.

One unit test that was customised, was the spec.ts file for the application’s Home Page. The business logic function mentioned in section 4.10 will benefit from Unit testing as it helps to quickly detect bugs in its calculations. To run this business logic unit testing, some sample data was input into the calculateDataTotals() function. With this sample data the expected results of the calculations were known, which means that the Unit test can compare the results of the calculateDataTotals() function to the expected values. The code for this is shown in Listing 5.1.

---

```

1  beforeEach(async(() => {
2    TestBed.configureTestingModule({
3      declarations: [ WasteHomePage ],
4      providers: [{provide: DatabaseService, useClass: MockDbService}],
5      imports: [IonicModule.forRoot(),
6        RouterTestingModule,
7        HttpClientTestingModule,
8      ]).compileComponents();
9      //creates a mock version of the Home Page so that dataa can be
10     inputted
11   fixture = TestBed.createComponent(WasteHomePage);
12   component = fixture.componentInstance;
13
14   //A spy is used to watch if the create bar chart is called as expected
15   spyOn(component, 'createBarChart')
16   fixture.detectChanges();
17   component.calculateDataTotals(testData)
18 });
19
20 it('should create', () => {
21   expect(component).toBeTruthy();
22 });
23 it('should total data correctly', () => {
24   expect(component.wasteTotal).toEqual(13);
25 });
26 it('should calculate amount of waste recycled', () => {
27   expect(component.wasteRecycled).toEqual(3);
28 });
29 it('should calualte percetage of none recycled waste', () => {
30   expect(component.totalnotRecycled).toEqual(77);
31 });
32 it('should calualte percetage of recycled waste', () => {
33   expect(component.totalPerRec).toEqual(23);
34 });
35 it('Expect Create a Bar chart to have been called', () => {
36   expect(component.createBarChart).toHaveBeenCalled();
37 });
38
39
40
41

```

---

Listing 5.1: Unit Test code for the Home Page

Once the unit tests are running in a Command Prompt window, all of the tests will compile and run every time a code change is done. This means it is easy to check if any new code has caused a fatal error or unexpected outputs. The test script will display all of the testing results on a Google Chrome page that is run by the Karma framework (Shown in Figure 5.1). To run all of the Unit tests one command needs to be entered:

```
1 $ npm test
```

Listing 5.2: Command to run Unit Tests

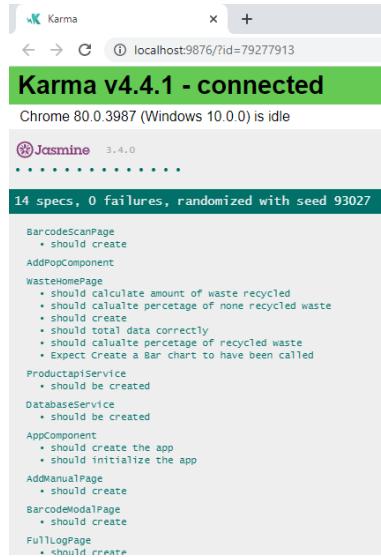


Figure 5.1: Karma Unit Test Screen (2020)

## 5.2 Postman Testing

In section 4.8.1, it is explained that this project required an API to be created using Node.js. When the API was under development, testing had to be done to check that the API's endpoints were returning the expected product data. To do this, the Postman software was used. This tool allows its users to send HTML requests to an API or web address and then tracks the response that it receives. This tool was chosen as its sleek, easy to use design allows for the testing of RESTful APIs to be done quickly. One example of this tool in use is when the API was checked that it returns the information for the “Naked Green Machine smoothie” when barcode 5022313395586 is submitted. The testing is shown in Figure 5.2 and Figure 5.3.

The screenshot shows the Postman interface with a GET request to <https://secretive-paper-rhvxx3gher.glitch.me/product/5022313395586>. The 'Params' tab is selected, showing a single query parameter 'Key' with value 'Value'. The 'Body' tab is selected, showing a JSON response:

```

1  {
2    "product": {
3      "_id": "5e35b4a3e4f049351842690b",
4      "barcodeid": 5022313395586,
5      "productName": "Naked Green Machine smoothie",
6      "productType": "Plastic bottle",
7      "material": "PETE"
8    },
9    "found": true
10 }

```

Figure 5.2: Postman Testing example (2020)

The screenshot shows the Postman interface with a GET request to <https://secretive-paper-rhvxx3gher.glitch.me/product/1234>. The 'Params' tab is selected, showing a single query parameter 'Key' with value 'Value'. The 'Body' tab is selected, showing a JSON response:

```

1  {
2    "found": false
3  }

```

Figure 5.3: Postman Testing example with Wrong Barcode(2020)

### 5.3 User Testing

The final form of testing that was done on the deliverable was user testing. User based usability testing is a “qualitative way of gauging, how effective an interface is at helping a user complete specific goals” (McAleer, 2015). This form of testing was completed as it is a good way of finding any major

UI issues and seeing if the mobile app achieved objective 8 of creating “UIs that all have high amounts of usability”.

### **5.3.1 How was the testing done?**

After the user had read all of the GDPR documents (Appendix B) and signed the consent form (Appendix C), they were asked to complete some preset tasks as seen in appendix D. After the user had finished the set tasks, they were asked to fill in 2 forms.

The first form asked for the user’s opinions on the app and retrieved qualitative information, such as which UI features the user had a problem with and what they think can be improved.

The second form was a System Usability Score (SUS) test. To do a SUS test, users are given a SUS form to fill in that consists of 10 pre set questions that are answered on a scale of 1 to 5. After multiple users complete the SUS form, the total scores are put through some calculations that generate a Usability score. This score can be compared with the scores of other apps to help highlight how usable the deliverable is. This information was gathered from the detailed book written by Klug (2017). This test was chosen for this project as it quickly rates the app with a valid and reliable quantitative rating. This will be useful whilst evaluating the application.

### **5.3.2 Who did the testing?**

Since this app is aimed at helping users improve their ecological footprint, the main target audience will be people with an interest in the environment and sustainability. After some research into local environmental groups, the SHU Sustainability Network were found. They agreed to take part in testing the Waste Log phone app. This testing took place in the Sheffield Hallam Students’ Union building on the 4th of March 2020. Five people completed the testing process. Testing with further users was planned to take place again after a few weeks but Covid-19 related issues prevented this.

### 5.3.3 Results of the testing

#### Opinion Form

The testing surveys were found to be a useful source of feedback as they highlighted some issues within the application and summarised how usable the target users found the app. From the first Survey, it was found that 80% of users stated that they would use the app in the future and that users found the app fairly aesthetically pleasing. These summarised results can be found in appendix F.



Figure 5.4: Would you use the app? (Opinion Form - 2020)

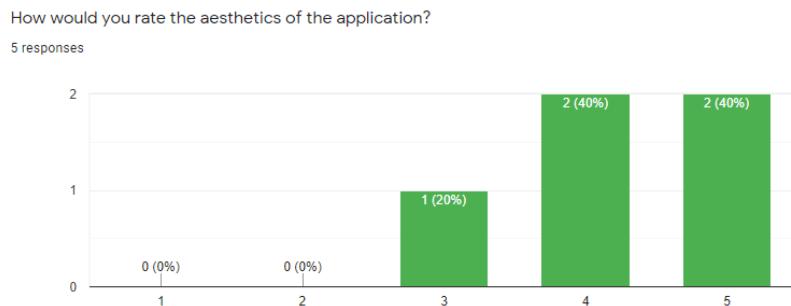


Figure 5.5: Aesthetics rating of the app (Opinion Form - 2020)

In the Opinion Form the participants also listed the issues they found when completing the set tasks. These issues and improvements are as listed:

1. “Add” Navigation button not easy to find.
2. After scanning a barcode the app does not redirect to add page.
3. Home page graph didn’t instantly update new data after adding a log.

4. Could be more data summary on the Home Page.
5. Information on the Data Summary page is too clumped together.
6. Could provide directions to the recycle points on the map.
7. Ability to edit an existing log.

Some of these issues were easy to fix and provided quick improvement to the app. The features that were fixed include making the barcode scanner redirect to the add page correctly, making the “add” button more obvious through adding text and by making the data correctly update on the home screen.

The other design improvements could not be completed at the time as they would take the project past its set deadlines. Overall, this testing proved useful as it caught out these major bugs and led to instant app improvements.

## SUS Form

After collecting the SUS surveys, a SUS score was given by using the score calculation Excel document. Overall, the app scored a SUS score of 89. This score gives the app a high passing grade that is in the top 10% of SUS scores. It is therefore clear that the app has a high level of usability and is visually appealing for users. The score calculation is shown below in Figure 5.6 and the SUS results summary can be found in appendix H.

Participant	q1	q2	q3	q4	q5	q6	q7	q8	q9	q10	SUS Score
p1	5	1	4	1	4	1	5	1	5	1	95.0
p2	5	3	5	1	3	2	4	2	4	1	80.0
p3	5	1	4	1	4	1	5	1	5	1	95.0
p4	5	2	4	1	3	2	4	1	4	1	82.5
p5	4	2	5	1	4	1	5	1	5	1	92.5
											89.0

Figure 5.6: SUS score generator (2020)

# **Chapter 6**

## **Critical Evaluation**

This project is aimed at creating a deliverable that assists users with improving their environmental footprint, by simplifying the process of managing their rubbish waste. The final outcome successfully meets most of the original requirements of the project; however, it is clear that there are some areas of possible further improvement.

### **6.1 Evaluating the Project**

After researching, designing and developing a Waste Footprint tracking app, a final product was created. In order to rate the overall success of this product, user testing was completed that provided some qualitative and quantitative results. The results will now be processed in order to properly evaluate the project and the deliverable.

#### **6.1.1 Critical Review**

One major objective of this project was to create an app that users would turn to regularly. To achieve this, a large proportion of research went into creating user friendly designs and other methods for keeping users encouraged and motivated. The research has shown positive results as 80% of the test participants stated that they would use the app regularly for logging their waste (section 5.3). These statistics suggest that the deliverable was successful in meeting this main aim, and that the research was beneficial to the project.

Another objective for the project was that the deliverable had high amounts of usability. From the results of the testing, 60% of users stated that they found it easy to navigate the app and the other 40% found navigation fairly easy. (Figure 6.1). Navigation is a large factor when measuring the usability of an application and so the results suggest a success in this area.

These results are also supported by the SUS survey. This project's SUS survey generated a SUS score of 89. A score of 89 is in the top 10% of SUS scores, meaning it can be interpreted as an A grade. This quantifies score supports the conclusion that the deliverable has high amounts of usability.

Did you find navigating the app to be complicated or easy?

5 responses

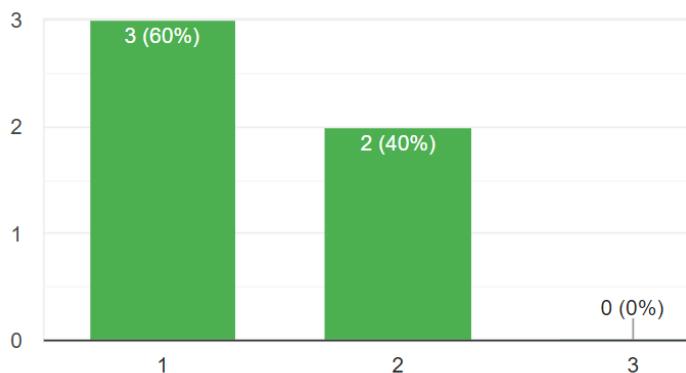


Figure 6.1: Opinion Form navigation score (2020)

For the project to be successful it also had to meet the previously decided deadlines that were listed within the project specification document (Appendix A). For most of the deadlines, the project was completed on time with a few exceptions. This success can be largely accredited to the Kanban methodology and Trello tool that were necessary in keeping all tasks on target. Therefore the research into the time management tools and methodologies achieved effective results and was a positive aid to the outcome of the whole project. However not all deadlines were met on time.

As development progressed, some issues like the barcode API issue and the Recycle Map issue became apparent and led to certain deadlines being missed. These unexpected issues were partially due to a lack of research in certain areas. If with the Product API, further research had been done in the early stages, the problems discussed in section 4.8.1 could have been fully avoided, which would have helped to keep the development on schedule.

As the project was behind schedule at that point, some areas of development had to be sped up which led to a few bugs in the code. This was shown during testing when users ran into a few app breaking issues. Although this suggests that the research section of this project was not fully successful, it also highlights the success in the testing section of the project.

## 6.2 Ethical Concerns

From the beginning of the creation of the project ethical concerns and data protection regulations have been regularly considered. One important regulation is the General Data Protection Regulation (GDPR) act. This is a European legal framework that states how user data should be collected and stored. Its basic aim is to protect user data from misuse and any individual who fails to follow the GDPR will face large fines and legal action.

In multiple parts of this project the GDPR act affected development. For example, when deciding whether the user's data should be stored locally or on a server, it was decided that any user data should only be stored on their own device (section 3.2). Also only necessary data was ever requested from the user. These two actions greatly reduced the chance of any GDPR rules being broken.

Similarly, for user-testing which is discussed in section 5.3, GDPR and ethical concerns were considered. It was eventually decided that any no personal identifying information about the participant should be taken or stored. All results were stored securely in the Google form service with no connection to the identity of the participant. Also as mentioned in section 5.3, test participants were required to read an information sheet and sign a consent form. Along with some other small considerations this ensured that the user testing correctly followed all data protection rules.

## 6.3 Future Development

### 6.3.1 Improved Map Services

The first future improvement that could be made is improving the “find local recycling locations” functionality. Due to issues mentioned previously, a Google Maps replacement is currently being used to allow users to find local recycling points. In the future this would be replaced by the Recycling Locator widget that was mentioned in section 4.9. This would add more

depth to the functionality of the app as the widget contains more information on recycling points than Google Maps and allows for specific materials to be searched.

### 6.3.2 Achievements and scoring system

Another future improvement to the app is to include achievements within the app and a user score. This would use some aspects of the Gamification theory as discussed in subsection 2.3.1 to improve user engagement within the app. This idea came from the user feedback form, where a user asked for a more in depth data summary for their waste. A recycling points system would achieve this.

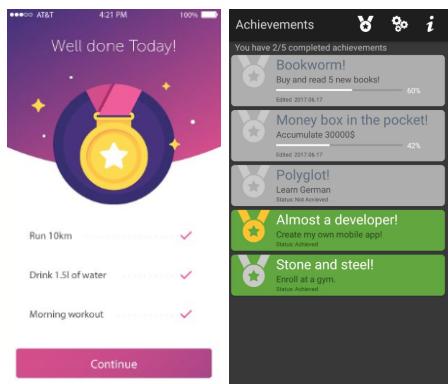


Figure 6.2: Examples of app achievements

### 6.3.3 More Information on Recycling

One final improvement that could be made is to include a recycling information section to the app. This section would allow the user to learn about the different labels on packaging and the likelihood that different materials actually get recycled. This idea is inspired from the Recycle Academy app that is evaluated in Figure 2.12. In this app the user can see information on different material numbers and has links to further information for each material. This would help the user to continue using this project's app correctly as they would have a more accurate understanding of the full recycling process.

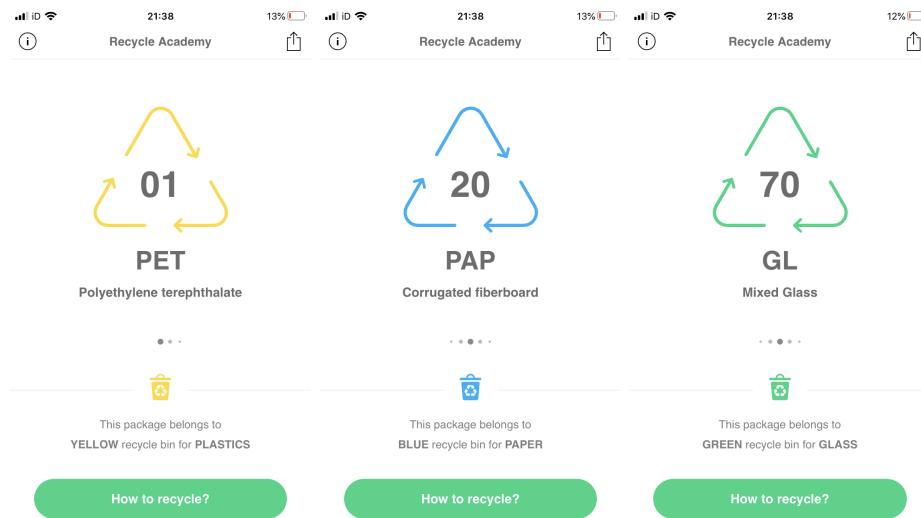


Figure 6.3: Recycle Academy example (2020)

## 6.4 Individual Development

From the very start, this project has provided a vast range of learning opportunities. These skills involve a range of different areas like project management, mobile application development and application testing.

Smartphone app development is a skill that I have always wanted to acquire. However, before this project I had no experience in the field or with running mobile emulations.

Now that the project has been completed, my knowledge and ability has improved greatly. From the research into mobile development frameworks and the reviewing of existing mobile apps my understanding of the sector has greatened. As a result of this I can now listen to app ideas and critically decide which frameworks would be most suitable for them. This is important as clients with little programming experience will often come to developers with their ideas to ask how plausible their design is.

Along with improved understanding of the sector, I now have practical experience with developing a full mobile app using the Ionic framework. This skill now gives me access to one of the largest software engineering job sectors, that as shown in the revenue growth forecast by Clement (2019), is set to keep growing for the foreseeable future. The final deliverable can also be used as physical proof of my ability which would help during the job

application process.

Finally some further important skills were learnt during the testing period. Multiple forms of testing were used during development like unit testing, user testing and SUS testing. From using these testing methods I have learnt how to properly test a program that is being developed and why the testing is important. Being able to test is a general skill used throughout the whole of software engineering. This makes it a necessary tool in a developer's toolbox.

Along with these technical skills many of my personal skills have improved also; time management through using task tracking tools, communication skills from talking to test participants and my ability to work under pressure with set deadlines.

# Chapter 7

## Conclusion

This project initially set out to benefit the environment through increasing the amount people recycle. To do this, a mobile application was developed that can track a user's rubbish waste, scan barcodes of products to quickly add them to a waste log, be simple to use and include features to keep the user engaged.

Throughout the project, research into app development, creating app design plans, developing additional app features and application testing were conducted.

The app was developed through firstly researching different selected practises. From these practises, the Kanban methodology with some aspects of Test Driven Development were chosen. This was due to its suitability for this project and its ability to support constantly changing designs.

Research into Gamification, self-determination theory and development tools also strengthened the final outcome of the project, as using image persuasion and allowing the user to decide things of their own accord, fuels a more popular app.

Through the critical analysis of similar products such as WeRecycle and Recycle Academy, all successful UI designs were analysed and then influenced the design of this project. These include the benefits of a swiping gesture feature and aesthetically pleasing colour layouts. A wireframe was also used early on in the project. This tool proved useful as it helped to avoid any navigational issues and UI design mistakes.

Another major choice in this project was the selection of a mobile development framework. Ionic was chosen as it had the best cross platform

compatibility and used the smallest storage capacity, which helped meet the aims of this project.

Analysing different methods of storage and emulators allowed for the most suitable to be selected. This enabled the app to keep within GDPR guidelines. Prior to the critical evaluation, testing was crucial. Different forms of testing such as Postman testing, user testing and unit testing were investigated, and a SUS form was used to gain feedback. The application got an SUS rating of 89, which suggests it has very user friendly UI screens.

The critical evaluation of the project's development process, ethical concerns and future development highlighted both positives and negatives. Overall, the results of the testing suggest that the project was successful as the delivered phone application met most of the project's requirements. However, it was not totally successful as some features like in-app achievements and awards were not properly implemented, so future improvements to correct this will be required. These improvements include adding more Gamification functionality and improving the recycle facility locator.

In final summary, this project was successful in meeting its main aim and objectives. From this, a user friendly, aesthetically pleasing application was created that should reduce many user's waste footprints and benefit the environment for many years to come.

# Appendices

## **Appendix A**

# **Project Specification**

# PROJECT SPECIFICATION - Project (Technical Computing) 2019/20

<b>Student:</b>	<b>Joe Matthew Barton</b>
<b>Date:</b>	<b>14/10/2019</b>
<b>Supervisor:</b>	<b>Jamie Hufford</b>
<b>Degree Course:</b>	<b>Software Engineering</b>
<b>Title of Project:</b>	<b>A mobile application that tracks the rubbish produced and recycled by a user to help them reduce their waste footprint.</b>

## Elaboration/Aim

With the increase of awareness towards environmental issues, many people are trying to change their lifestyles to help reduce their negative impact on the environment. Increasing the amount that we recycle is one common change that people attempt.

Although this seems simple enough, understanding which items can be recycled and which waste points to use can be very confusing; this may lead to loss of motivation to recycle.

My project will attempt to simplify this process through the creation of a Waste Footprint app for smartphones. Firstly, the user will scan the barcode of a common supermarket item and the app will identify the material information of this product. Using this information, the app will find if the product can be recycled and if so, will search for the nearest recycling locations. This will help to give the user an idea of how sustainable the product's packaging is.

The user will then get the option of adding this product to their waste record. The waste record is a log that keeps track of all materials the users has thrown away and recycled.

An additional feature will be a graphical representation of the amount of waste that the user has thrown away, compared with their weekly goal. Research will be done on this first, but the idea is that this gives the user a sense of achievement and encourages them to continue using the app. This is due to the competitive feeling of the user wanting to meet their goals.

It will also have a section that informs users about recycling information, explaining what the different recycling themed symbols mean on packaging and the likelihood that it is recycled.

To keep users regularly using the app and updating their waste record, every feature on the app needs to be simple and quick to use. This includes things like first time set up of the app and the process of adding a product to the user's waste record. I will achieve this by designing highly usable UIs and following relevant UI design patterns.

The previously described functionality intends to simplify and encourage the act of reducing the users waste footprint.

## Project Objectives

- Research into application platforms that are designed for smartphones
- Research into the process of User Experience (UX) design
- Research into an existing Barcode to product API.
- Search into behavioural gamification theory.
- Find suitable agile task management programs.
- Design app to work with existing APIs
- Enable usage of the smart phone camera to scan barcodes.
- Develop UIs that all have high amounts of usability.

- Implement features that give the user a sense of achievement whilst doing repetitive tasks.
- Develop an app that works on most modern smartphones.
- Create a Graphic summary of waste the user has disposed
- Employ a regular testing process during development.
- Test my app with participants to ensure:
  - App is straightforward and easy to use.
  - Works on different Smartphone brands.

### **Project deliverable(s)**

Using aspects of the agile methodology, I will create a mobile application that will:

- Scan the barcode of common supermarket products and find local recycling points for the scanned product.
- Give the option of adding the scanned product to the user's waste record.
- Allow users to manually add waste to their waste record (e.g. 50g of tin recycled).
- Allow users to set targets for waste and amount recycled.
- Display Daily/weekly summary of the amount of waste they have disposed of.
- Compare the waste footprint of the user to the UK average waste footprint.
- Create Graphic summary of waste the user has disposed
- Give users virtual medals/reward for meeting goals.

### **Action plan**

<b>Task</b>	<b>Milestone Deadline</b>
<b>Find project supervisor</b>	11/10/2019
<b>Submit project specification for moderation</b>	25/10/2019
<b>Complete research into:</b> <ul style="list-style-type: none"> <li>▪ Progressive web apps</li> <li>▪ Password-less email log in system</li> <li>▪ Existing Barcode to product APIs</li> <li>▪ Touch optimised web framework</li> <li>▪ Behavioural gamification theory</li> </ul>	24/11/2019 <ul style="list-style-type: none"> <li>▪ 01/11/2019</li> <li>▪ 08/11/2019</li> <li>▪ 10/11/2019</li> <li>▪ 15/11/2019</li> <li>▪ 24/11/2019</li> </ul>
<b>Find a suitable agile task management program</b>	24/11/2019
<b>The Information review</b>	06/12/2019
<b>Complete Development:</b> <ul style="list-style-type: none"> <li>▪ Basic version of app that allows user to manually add waste amount.</li> <li>▪ Add barcode scanning feature.</li> <li>▪ Add additional features</li> </ul>	14/02/2020 <ul style="list-style-type: none"> <li>▪ 20/12/2019</li> <li>-</li> <li>▪ 03/01/2020</li> <li>▪ 20/01/2020</li> </ul>
<b>Test app with sample of users</b>	31/01/2020
<b>Fix issues found in user testing</b>	14/02/2020
<b>Agree contents page with supervisor</b>	21/02/2020
<b>Sections of Draft Report</b>	27/03/2020
<b>Draft critical evaluation</b>	27/03/2020
<b>Turnitin submission</b>	22/04/2020
<b>Submit electronic version</b>	23/04/2020
<b>Demo to supervision</b>	12/05/2020



**BCS Code of Conduct**

I confirm that I have successfully completed the BCS code of conduct on-line test with a mark of 70% or above. This is a condition of completing the Project (Technical Computing) module.

**Signature:** 

**Publication of Work**

I confirm that I understand the "Guidance on Publication Procedures" as described on the Bb site for the module.

**Signature:** 

**GDPR**

I confirm that I will use the "Participant Information Sheet" as a basis for any survey, questionnaire or participant testing materials. This form is available on the Bb site for the module.

**Signature:** 

**Ethics**

Complete the SHUREC 7 (research ethics checklist for students) form below. If you think that your project may include ethical issues that need resolving (working with vulnerable people, testing procedures etc.) then discuss this with your supervisor as soon as possible and comment further here.

Both you and your supervisor need to sign the completed SHUREC 7 form.

Please contact the project co-ordinator if further advice is needed.

## **RESEARCH ETHICS CHECKLIST FOR STUDENTS (SHUREC 7)**

This form is designed to help students and their supervisors to complete an ethical scrutiny of proposed research. The SHU [Research Ethics Policy](#) should be consulted before completing the form.

Answering the questions below will help you decide whether your proposed research requires ethical review by a Designated Research Ethics Working Group.

The final responsibility for ensuring that ethical research practices are followed rests with the supervisor for student research.

Note that students and staff are responsible for making suitable arrangements for keeping data secure and, if relevant, for keeping the identity of participants anonymous. They are also responsible for following SHU guidelines about data encryption and research data management.

The form also enables the University and Faculty to keep a record confirming that research conducted has been subjected to ethical scrutiny.

For student projects, the form may be completed by the student and the supervisor and/or module leader (as applicable). In all cases, it should be counter-signed by the supervisor and/or module leader, and kept as a record showing that ethical scrutiny has occurred. Students should retain a copy for inclusion in their research projects, and staff should keep a copy in the student file.

Please note if it may be necessary to conduct a health and safety risk assessment for the proposed research. Further information can be obtained from the Faculty Safety Co-ordinator.

### **General Details**

Name of student	Joe Barton
SHU email address	<a href="mailto:B6012490@my.shu.ac.uk">B6012490@my.shu.ac.uk</a>
Course or qualification (student)	Software Engineering
Name of supervisor	Jamie Hufford
email address	<a href="mailto:joemattbarton@hotmail.com">joemattbarton@hotmail.com</a>
Title of proposed research	Participant's doing test run of the waste footprint app.
Proposed start date	20/01/2020
Proposed end date	31/01/2020
Brief outline of research to include, rationale & aims (250-500 words).	<p>My research will be done after I have developed a working version of my app.</p> <p>I will be asking a small range of participants who all have different smartphone brands to complete a set of use case scenarios. I will be doing this to ensure that my app is simple enough for Participant's to complete basic tasks without any support and to ensure that it works as expected on different Smartphone brands.</p> <p>The user test scenarios will be designed around the main functionalities of the app. For example, scan and add a set product to their waste record.</p>

	<p>After the Participant has completed these test case scenarios, they will answer a few questions which will provide me with their feedback on the app.</p> <p>The questions asked will be getting information on these topics:</p> <ul style="list-style-type: none"> <li>• What phone model do they have?</li> <li>• Were they able to complete all set tasks?</li> <li>• Did they have any difficulties?</li> <li>• Which tasks did they find easiest to complete?</li> <li>• Any additional features they think the app should have.</li> <li>• Any features they dislike.</li> </ul> <p>With the Participant's permission I will <b>overtly</b> watch them as they use the app. This is to ensure there are no unexpected errors like graphical display issues due to them using a different smartphone device. If I see one of these issues occur, I will note down the type of device it occurred on so that it can be fixed at a later date.</p> <p>This testing will be done to provide me with an approximation to how usable the app is. The participants can also highlight specific features they had issues with. I can use this information to improve on existing functionality and to decide on any future updates that will come to the app. Also as mentioned above, it will help to find issues that occur from using different brands of smartphone.</p>
Where data is collected from individuals, outline the nature of data, details of anonymisation, storage and disposal procedures if required (250-500 words).	<p>The only information that I will store from the user are their questionnaire answers and basic error information if an unexpected bug occurs in the app whilst they complete the set scenarios.</p> <p>This questionnaire will only ask for the participants phone model and opinions on the app. There will be no stored information that could uniquely identify the Participant.</p> <p>I will be using the Google Forms service (link below) to create and complete the server. Google Forms is a GDPR compliant service that stores all the responses securely. The transmission of any survey data will be sent using SSL to encrypt the data.</p> <p>All responses from the survey can only be accessed by a private google account that I will have. I will be the only person who knows the password to access this information.</p> <p>After creating the questionnaire, the Google Forms service will provide me with a link that each Participant can access. This link will take them to a questionnaire page where they can fill in their answers. Whilst they are doing the questionnaire, I will be in a different room unable to see any responses that they are giving.</p> <p>The only other time that I will collect information is if the participant has a graphical issues or unexpected error on their smartphone whilst completing the scenarios. If this occurs, I will note down the phone model and short description of the issue. These notes will be stored on a secure Google Document that only I can access.</p> <p>Before participants begin the study, they will be asked to read and sign the "Participant Consent Form" as provided by Sheffield Hallam University.</p> <p>At any time, participants will be able withdraw from the testing.</p>

I will also follow the advice provided by Sheffield Hallam University in the document linked on this page =

<https://www.shu.ac.uk/research/quality/ethics-and-integrity/ethics-approval-procedures>

Google Forms information = <https://www.google.com/forms/about/>

**1. Health Related Research Involving the NHS or Social Care / Community Care or the Criminal Justice Service or with research participants unable to provide informed consent**

Question	Yes/No
<p>1. Does the research involve?</p> <ul style="list-style-type: none"> <li>• Patients recruited because of their past or present use of the NHS or Social Care</li> <li>• Relatives/carers of patients recruited because of their past or present use of the NHS or Social Care</li> <li>• Access to data, organs or other bodily material of past or present NHS patients</li> <li>• Foetal material and IVF involving NHS patients</li> <li>• The recently dead in NHS premises</li> <li>• Prisoners or others within the criminal justice system recruited for health-related research*</li> <li>• Police, court officials, prisoners or others within the criminal justice system*</li> <li>• Participants who are unable to provide informed consent due to their incapacity even if the project is not health related</li> </ul>	NO
<p>2. Is this a research project as opposed to service evaluation or audit?</p> <p><i>For NHS definitions please see the following website</i>  <a href="http://www.hra.nhs.uk/documents/2013/09/defining-research.pdf">http://www.hra.nhs.uk/documents/2013/09/defining-research.pdf</a></p>	

If you have answered **YES** to questions **1 & 2** then you **must** seek the appropriate external approvals from the NHS, Social Care or the National Offender Management Service (NOMS) under their independent Research Governance schemes. Further information is provided below.

NHS <https://www.myresearchproject.org.uk/Signin.aspx>

\* All prison projects also need National Offender Management Service (NOMS) Approval and Governor's Approval and may need Ministry of Justice approval. Further guidance at:  
<http://www.hra.nhs.uk/research-community/applying-for-approvals/national-offender-management-service-noms/>

**NB** FRECs provide Independent Scientific Review for NHS or SC research and initial scrutiny for ethics applications as required for university sponsorship of the research. Applicants can use the NHS pro-forma and submit this initially to their FREC.

**2. Research with Human Participants**

Question	Yes/No
Does the research involve human participants? This includes surveys, questionnaires, observing behaviour etc.	Yes
Question	Yes/No
<p>1. Note If YES, then please answer questions 2 to 10  <i>If NO, please go to Section 3</i></p> <p>2. Will any of the participants be vulnerable?</p> <p><i>Note: Vulnerable' people include children and young people, people with learning disabilities, people who may be limited by age or sickness, etc. See definition on website</i></p>	NO

3. Are drugs, placebos or other substances (e.g. food substances, vitamins) to be administered to the study participants or will the study involve invasive, intrusive or potentially harmful procedures of any kind?	NO
4. Will tissue samples (including blood) be obtained from participants?	NO
5. Is pain or more than mild discomfort likely to result from the study?	NO
6. Will the study involve prolonged or repetitive testing?	NO
7. Is there any reasonable and foreseeable risk of physical or emotional harm to any of the participants?	NO
<i>Note: Harm may be caused by distressing or intrusive interview questions, uncomfortable procedures involving the participant, invasion of privacy, topics relating to highly personal information, topics relating to illegal activity, etc.</i>	
8. Will anyone be taking part without giving their informed consent?	NO
9. Is it covert research?	NO
<i>Note: 'Covert research' refers to research that is conducted without the knowledge of participants.</i>	
10. Will the research output allow identification of any individual who has not given their express consent to be identified?	NO

If you answered **YES only** to question **1**, the checklist should be saved and any course procedures for submission followed. If you have answered **YES** to any of the other questions you are **required** to submit a SHUREC8A (or 8B) to the FREC. If you answered **YES** to question **8** and participants cannot provide informed consent due to their incapacity you must obtain the appropriate approvals from the NHS research governance system. Your supervisor will advise.

### 3. Research in Organisations

Question	Yes/No
1. Will the research involve working with/within an organisation (e.g. school, business, charity, museum, government department, international agency, etc.)?	NO
2. If you answered YES to question 1, do you have granted access to conduct the research?	
<i>If YES, students please show evidence to your supervisor. PI should retain safely.</i>	
3. If you answered NO to question 2, is it because: <ol style="list-style-type: none"> <li>you have not yet asked</li> <li>you have asked and not yet received an answer</li> <li>you have asked and been refused access.</li> </ol>	
<i>Note: You will only be able to start the research when you have been granted access.</i>	

### 4. Research with Products and Artefacts

Question	Yes/No
1. Will the research involve working with copyrighted documents, films, broadcasts, photographs, artworks, designs, products, programmes, databases, networks, processes, existing datasets or secure data?	Yes

<p>2. If you answered YES to question 1, are the materials you intend to use in the public domain?</p> <p><i>Notes: 'In the public domain' does not mean the same thing as 'publicly accessible'.</i></p> <ul style="list-style-type: none"> <li>• <i>Information which is 'in the public domain' is no longer protected by copyright (i.e. copyright has either expired or been waived) and can be used without permission.</i></li> <li>• <i>Information which is 'publicly accessible' (e.g. TV broadcasts, websites, artworks, newspapers) is available for anyone to consult/view. It is still protected by copyright even if there is no copyright notice. In UK law, copyright protection is automatic and does not require a copyright statement, although it is always good practice to provide one. It is necessary to check the terms and conditions of use to find out exactly how the material may be reused etc.</i></li> </ul> <p><i>If you answered YES to question 1, be aware that you may need to consider other ethics codes. For example, when conducting Internet research, consult the code of the Association of Internet Researchers; for educational research, consult the Code of Ethics of the British Educational Research Association.</i></p>	yes
<p>3. If you answered NO to question 2, do you have explicit permission to use these materials as data?</p> <p><i>If YES, please show evidence to your supervisor.</i></p>	
<p>4. If you answered NO to question 3, is it because:</p> <ul style="list-style-type: none"> <li>A. you have not yet asked permission</li> <li>B. you have asked and not yet received and answer</li> <li>C. you have asked and been refused access.</li> </ul> <p><i>Note: You will only be able to start the research when you have been granted permission</i></p>	A/B/C

### Adherence to SHU policy and procedures

<b>Personal statement</b>	
I can confirm that:	
<ul style="list-style-type: none"> <li>— I have read the Sheffield Hallam University Research Ethics Policy and Procedures</li> <li>— I agree to abide by its principles.</li> </ul>	
<b>Student</b>	
Name: Joe Barton	Date: 22/10/2019
<b>Signature:</b> 	
<b>Supervisor or other person giving ethical sign-off</b>	
I can confirm that completion of this form has not identified the need for ethical approval by the FREC or an NHS, Social Care or other external REC. The research will not commence until any approvals required under Sections 3 & 4 have been received.	
Name: Jamie Hufford	Date: 23/10/2019
<b>Signature:</b> 	

## **Appendix B**

# **Project Information Sheet**

## “Waste Tracker” Mobile Application Testing

As part of my final dissertation project, I would like you to take part in the testing and evaluation of the “Waste Tracker” mobile application that has been created. The “Waste Tracker” is a mobile application that tracks the rubbish produced and recycled by a user to help them reduce their waste footprint. I would like to get your feedback on how well that app works and any improvements that you feel that app would benefit with having.

You have been selected to take part in this research simply because you were available at the correct time and place. It is up to you to decide if you want to take part. A copy of the information provided here is yours to keep, along with the consent form if you do decide to take part. You can still decide to withdraw at any time without giving a reason, or you can decide not to answer a particular question.

For this testing you will be given a smart phone device that has the Waste Tracker app loaded onto it. You will then be asked to complete a few straightforward tasks. After completing these tasks, you will be asked to complete 2 surveys. This first survey will ask for you feedback on the application and will ask you to outline any issues you had with it. The second survey will be a SUS survey. This survey will ask for some of your opinions on the app by rating certain features from 0 to 10. The only data that will be recorded from you will be your answers to the surveys. The process will take place In a nearby, quiet area and will take approximately 20 minutes.

There are no risks to this study and you will get my thanks for supporting my final project dissertation after completing the testing. The data will be securely stored on a google server that only I (Joe Barton) will have access to. The results of the study may be summarised and included in my final project report, however no information connecting to you will ever be stored or mentioned in either the google storage or dissertation report. After the completion of the final project, the raw data stored in the Google Drive will be deleted. Only summaries of the data will be left inside of the dissertation. The actual study will be on for a couple of days until a decent number of people have tested the app.

The University undertakes research as part of its function for the community under its legal status. Data protection allows us to use personal data for research with appropriate safeguards in place under the legal basis of public tasks that are in the public interest. A full statement of your rights can be found at <https://www.shu.ac.uk/about-this-website/privacy-policy/privacy-notices/privacy-notice-for-research>. However, all University research is reviewed to ensure that participants are treated appropriately and their rights respected. Further information at <https://www.shu.ac.uk/research/ethics-integrity-and-practice>.

As a closing message, details of whom you may contact are provided below, should you have any concerns, or if adverse effects occur after the study:

**You can contact me by email and I shall get back to you as soon as possible to answer any questions that you have:**

My email address: b6012490@my.shu.ac.uk

Details of who to contact if you have any concerns or if adverse effects occur after the study are given below.

### **Researcher/ Research Team Details:**

<p><b>You should contact the Data Protection Officer if:</b></p> <ul style="list-style-type: none"> <li>• you have a query about how your data is used by the University</li> <li>• you would like to report a data security breach (e.g. if you think your personal data has been lost or disclosed inappropriately)</li> <li>• you would like to complain about how the University has used your personal data</li> </ul> <p style="text-align: center;"><a href="mailto:DPO@shu.ac.uk"><u>DPO@shu.ac.uk</u></a></p>	<p><b>You should contact the Head of Research Ethics (Professor Ann Macaskill) if:</b></p> <ul style="list-style-type: none"> <li>• you have concerns with how the research was undertaken or how you were treated</li> </ul> <p style="text-align: center;"><a href="mailto:a.macaskill@shu.ac.uk"><u>a.macaskill@shu.ac.uk</u></a></p>
<p>Postal address: Sheffield Hallam University, Howard Street, Sheffield S1 1WBT Telephone: 0114 225 5555</p>	

## **Appendix C**

### **User Consent Form**

## **PARTICIPANT CONSENT FORM**

### **Waste Log Mobile Application Testing**

*Please answer the following questions by ticking the response that applies*

	<b>YES</b>	<b>NO</b>
1. I have read the Information Sheet for this study and have had details of the study explained to me.	<input type="checkbox"/>	<input type="checkbox"/>
2. My questions about the study have been answered to my satisfaction and I understand that I may ask further questions at any point.	<input type="checkbox"/>	<input type="checkbox"/>
3. I understand that I am free to withdraw from the study within the time limits outlined in the Information Sheet, without giving a reason for my withdrawal or to decline to answer any particular questions in the study without any consequences to my future treatment by the researcher.	<input type="checkbox"/>	<input type="checkbox"/>
4. I agree to provide information to the researchers under the conditions of confidentiality set out in the Information Sheet.	<input type="checkbox"/>	<input type="checkbox"/>
5. I wish to participate in the study under the conditions set out in the Information Sheet.	<input type="checkbox"/>	<input type="checkbox"/>
6. I consent to the information collected for the purposes of this research study, once anonymised (so that I cannot be identified), to be used for any other research purposes.	<input type="checkbox"/>	<input type="checkbox"/>

**Participant's Signature:** \_\_\_\_\_ **Date:** \_\_\_\_\_

**Participant's Name (Printed):** \_\_\_\_\_

**Contact details:** \_\_\_\_\_

**Researcher's Name (Printed):** \_\_\_\_\_ Joe Barton

**Researcher's Signature:** \_\_\_\_\_ Joe Barton

**Researcher's contact details:**

**Address:** Flat A432 Room B, The Anvil, 109 Clough Rd, Highfield, Sheffield S2 4TB

**Email:** b6012490@my.shu.ac.uk

**Please keep your copy of the consent form and the information sheet together.**

## **Appendix D**

# **User Instruction Sheet**



## Participant Instruction Sheet

Thank you for agreeing to take part in the testing.

Please ensure that you have read and understood the consent form **before continuing**.

### Instructions

For the first part of the testing you will be asked to use the Waste Tracker app on the phone that will be given to you.

Try to complete these tasks on your own, however if you have an issue you can ask me for help at any time.

---

1. Logging Waste.
  - a. Quick add a Shower Bottle to the Waste Log and mark the item as recycled.
  - b. Add the provided drink bottle to the Waste Log by scanning the barcode. Mark it is not recycled.
  - c. Add a Can of Cola to the Waste Log using the Detailed Add page. Add a note of your choice to the log.
2. View All Logs
  - a. Navigate to the View All Logs Page
  - b. Check that the three items you added are displayed in the table.
3. View Log Details
  - a. Select the “Shower Bottle” log that you previously added.
  - b. Look at the details of this log.
  - c. Delete the “Shower Bottle” log.

4. Home Screen
    - a. Navigate to the Home Screen.
    - b. What percentage of the waste is Plastic?
    - c. What is the overall amount of waste that you have recycled?
  5. Map Locator
    - a. Navigate to the Map Screen.
    - b. Did the map locate your correct position?
    - c. Find the nearest recycling locations next to you.
- 

With the tasks completed, you should now have a better understanding of how the app works. There will now be 2 Forms that need to be completed.

Please can you now complete the first Google Form that will be provided to you.

## **Appendix E**

### **User Survey Example**

# Waste Log Questions

Now that you have completed the set tasks on the app, you will be asked a small range of questions to gather your opinion of the Mobile App.

\* Required

1. Did you find navigating the app to be complicated or easy? \*

*Mark only one oval.*

1      2      3      4      5

Easy                     Complicated

2. Did you have any issues when navigating to different pages? If so, please list them.

---

3. How did you find the process of adding the waste to the Waste Log (Task 1)? \*

*Mark only one oval.*

1      2      3      4      5

Straightforward                     Complicated

4. Did you have any issues with adding the waste to the waste log? If so, please list these issues.

---

5. Is there any further functionality that you think that app should have? If so, please list them.

---

---

---

---

---

6. How would you rate the aesthetics of the application? \*

*Mark only one oval.*

1      2      3      4      5

Ugly      Good Looking

---

---

---

---

---

7. What possible improvements do you think the app could have?

---

---

---

---

---

8. Did you have any issues when completing the tasks? If so please list them.

---

---

---

---

---

9. Would you regularly use this app for Logging your waste?

*Check all that apply.*

- Yes  
 No
- 

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Google Forms

## **Appendix F**

# **User Survey Results Summary**



# Waste Log Testing

Questions    Responses    5

## 5 responses



Accepting responses

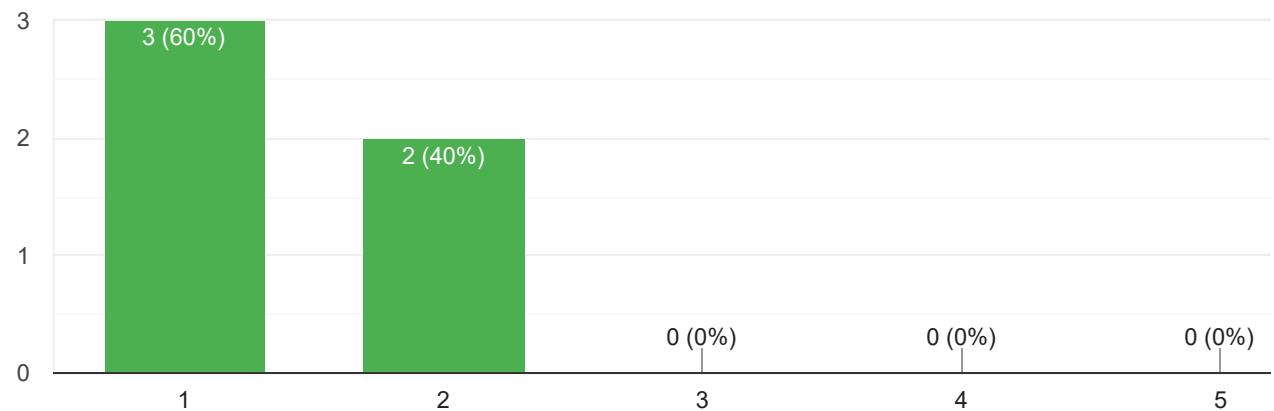
Summary

Question

Individual

Did you find navigating the app to be complicated or easy?

5 responses



Did you have any issues when navigating to different pages? If so, please list them.

3 responses

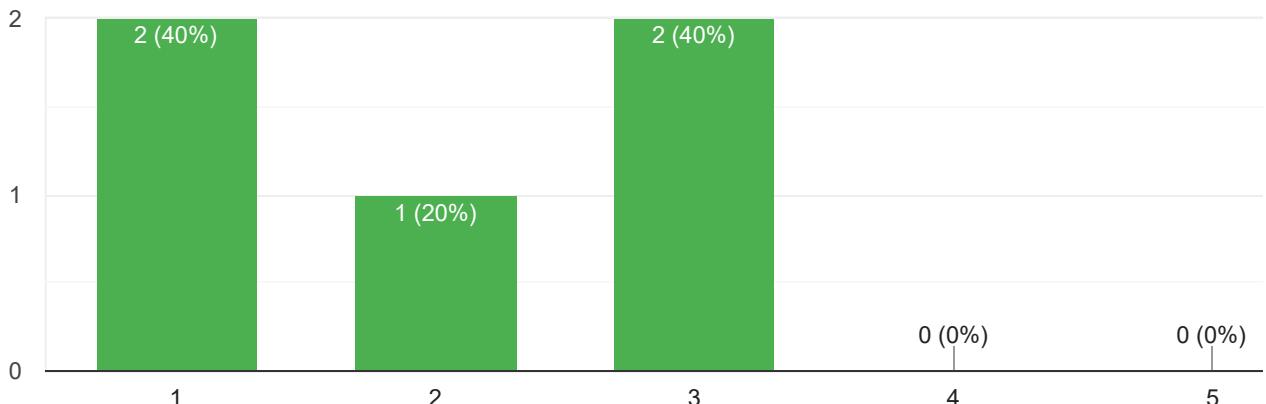
No.

Add item button is not clear to find

I struggled to find how to get to the add page. Maybe add text to say the button adds an item. Also after scanning the product I was not navigated to the correct screen.

## How did you find the process of adding the waste to the Waste Log (Task 1)?

5 responses



## Did you have any issues with adding the waste to the waste log? If so, please list these issues.

5 responses

after scanning the barcode of the bottle nothing happened. Had to find the detailed page by myself.

The wastehome graph didn't update my input waste and there was an issue with the barcode scanning

After scanning barcode should navigate to detailed add page

As said scanning the product did not re direct me anywhere . Needed the interviewer to direct me

Scanning barcode issue

## Is there any further functionality that you think that app should have? If so, please list them.

3 responses

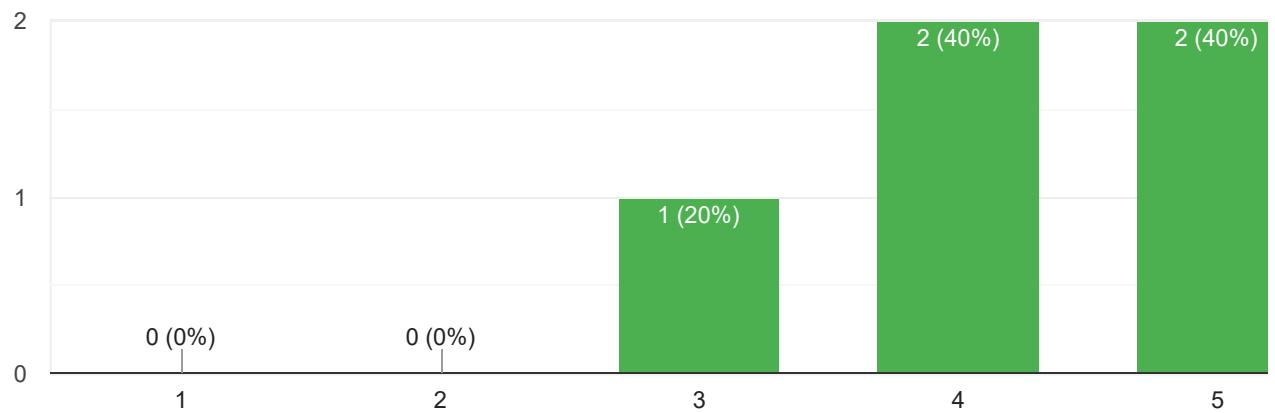
The image on the top left kept confusing me, thinking it was a shortcut to the homescreen.

Editing of the log should be an option

I did not see anyway of editing a log. Maybe an information on what each recycle symbol means

## How would you rate the aesthetics of the application?

5 responses



## What possible improvements do you think the app could have?

4 responses

On the view log information page there is the name of the image used displayed. Maybe delete this as it's not pretty.

The + on the top right to add a new item should be clearer to find, maybe with an additional text to it

Homescreen bit confusing, maybe separate the two graphs sections

Most data summary in the Home screen. Make the map do more so that I can see more details of the local recycle points. Fix obvious issues mentioned before

## Did you have any issues when completing the tasks? If so please list them.

3 responses

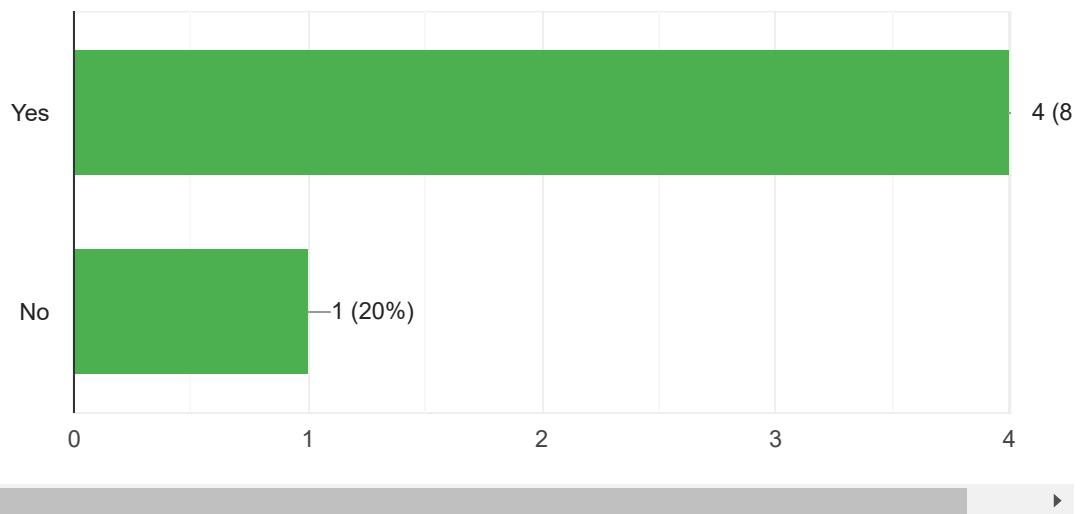
No.

Scan barcode issue that was mentioned before. I don't think that the home screen data updated when I added the new product.

Scanning barcode issue

## Would you regularly use this app for Logging your waste?

5 responses



## **Appendix G**

### **User Survey Reponses**

# SUS Form

1. 1. I think that I would like to use this App frequently.

*Mark only one oval.*

1      2      3      4      5

---

Strongly Disagree      Strongly Agree

---

2. 2. I found the App unnecessarily complex.

*Mark only one oval.*

1      2      3      4      5

---

Strongly Agree      Strongly Disagree

---

3. 3. I thought the App was easy to use.

*Mark only one oval.*

1      2      3      4      5

---

Strongly Disagree      Strongly Agree

---

4. 4. I think that I would need the support of a technical person to be able to use this App.

*Mark only one oval.*

1      2      3      4      5

---

Strongly Agree      Strongly Disagree

---

5. 5. I found the various functions in this App were well integrated.

*Mark only one oval.*

1      2      3      4      5

---

Strongly Disagree      Strongly Agree

---

6. 6. I thought there was too much inconsistency in this App.

*Mark only one oval.*

1      2      3      4      5

---

Strongly Agree      Strongly Disagree

---

7. 7. I would imagine that most people would learn to use this App very quickly.

*Mark only one oval.*

1      2      3      4      5

---

Strongly Disagree      Strongly Agree

---

8. 8. I found the system very cumbersome to use.

*Mark only one oval.*

1      2      3      4      5

---

Strongly Agree      Strongly Disagree

---

9. I felt very confident using the App.

*Mark only one oval.*

1      2      3      4      5

---

Strongly Disagree      Strongly Agree

---

10. I needed to learn a lot of things before I could get going with this App.

*Mark only one oval.*

1      2      3      4      5

---

Strongly Agree      Strongly Disagree

---

---

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## **Appendix H**

### **SUS Survey Results**



# SUS Form

Questions    Responses    5

## 5 responses



Accepting responses

Summary

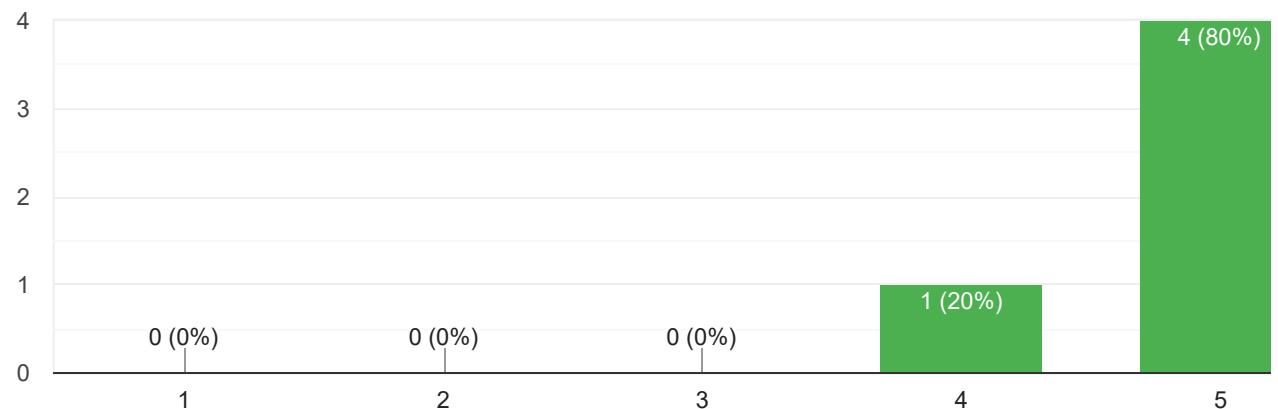
Question

Individual

1. I think that I would like to use this App frequently.

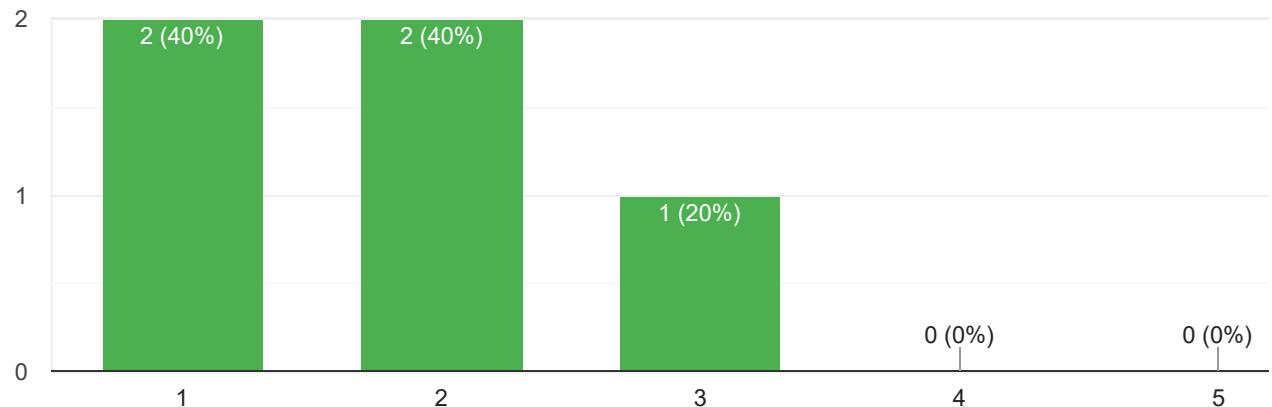


5 responses



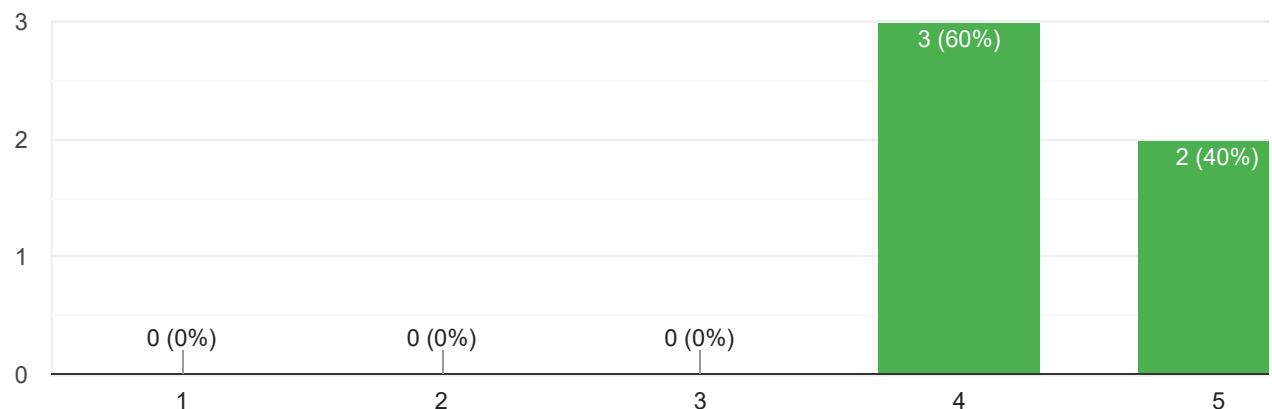
## 2. I found the App unnecessarily complex.

5 responses



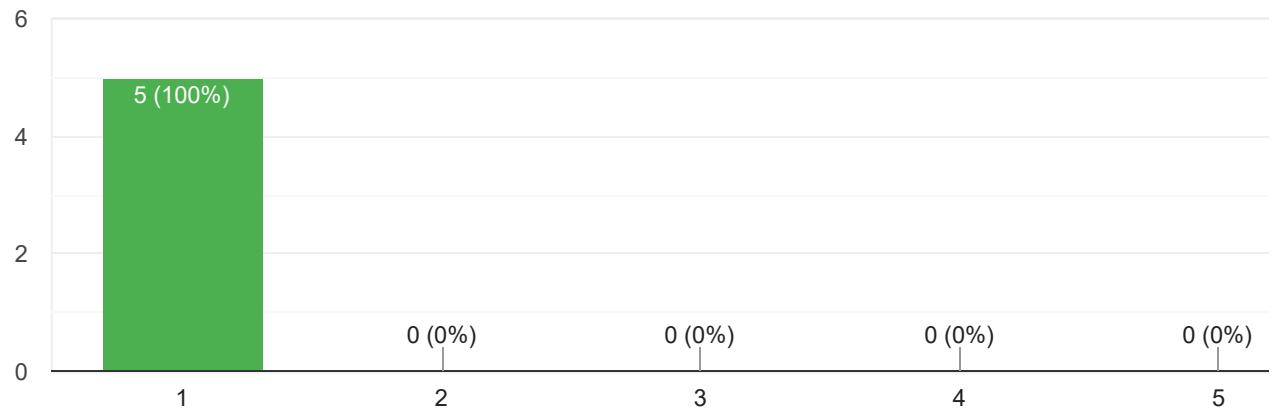
## 3. I thought the App was easy to use.

5 responses



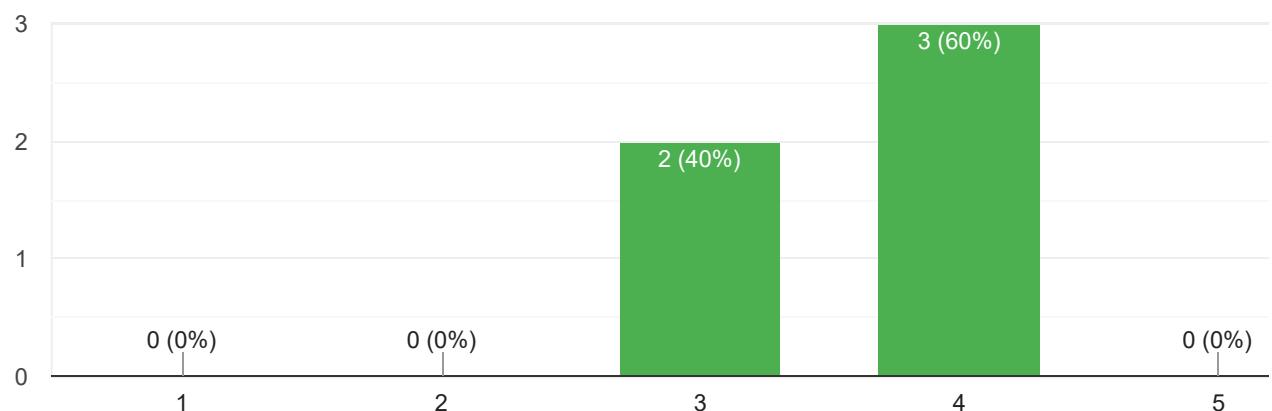
4. I think that I would need the support of a technical person to be able to use this App.

5 responses



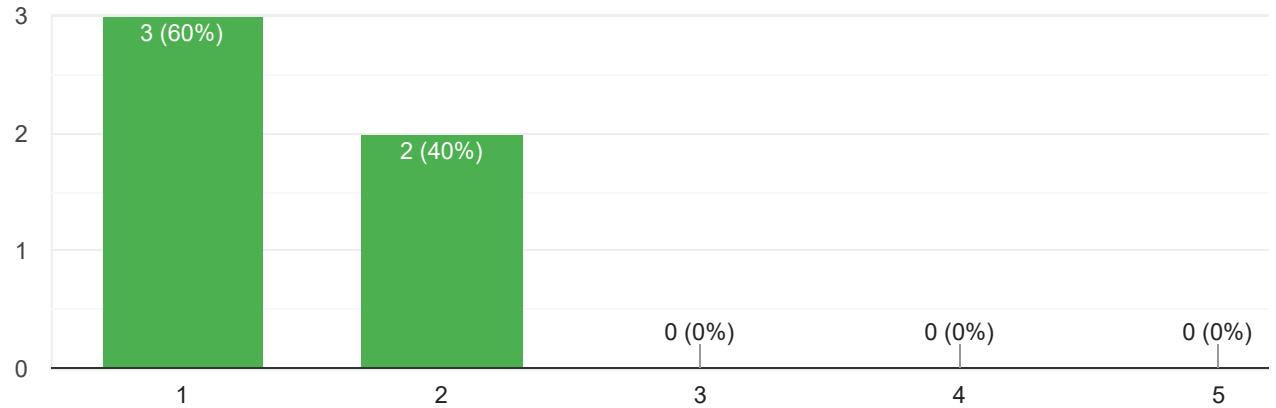
5. I found the various functions in this App were well integrated.

5 responses



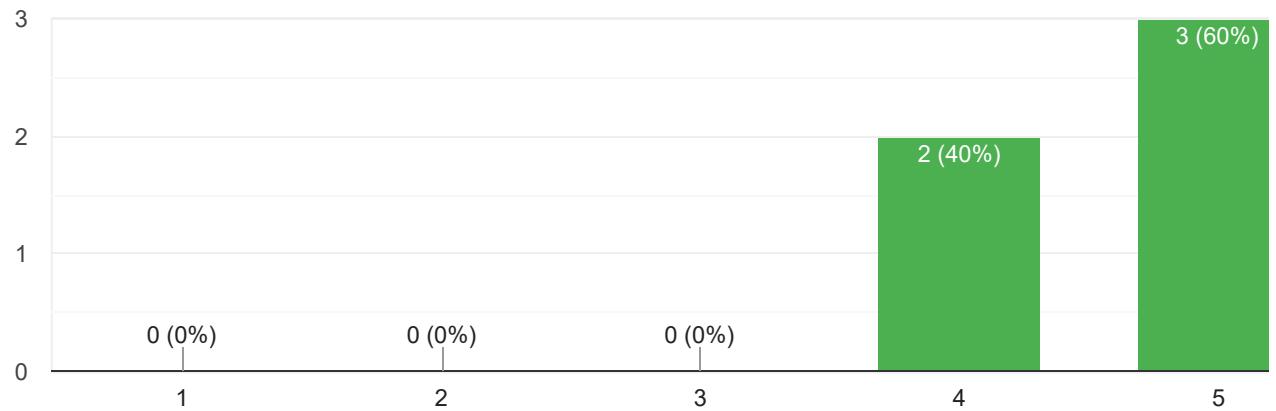
6. I thought there was too much inconsistency in this App.

5 responses



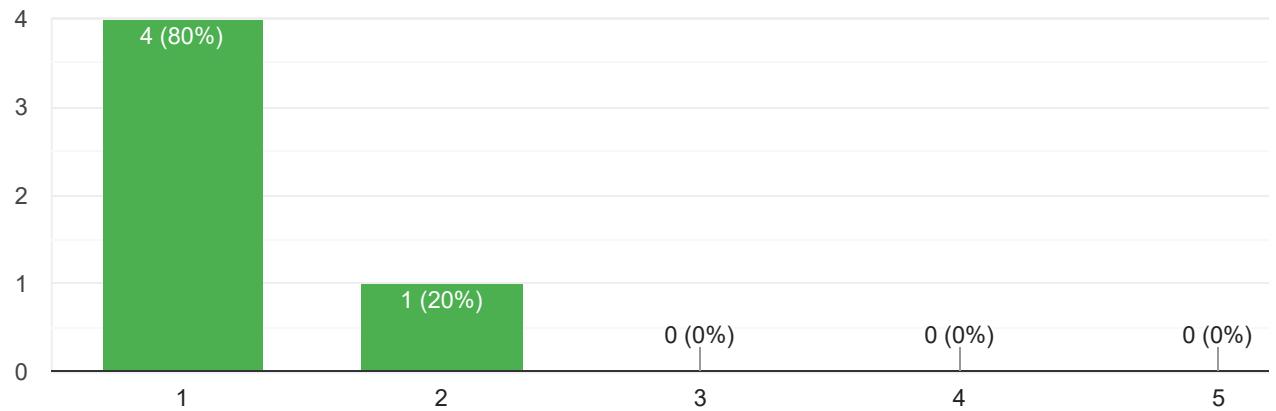
7. I would imagine that most people would learn to use this App very quickly.

5 responses

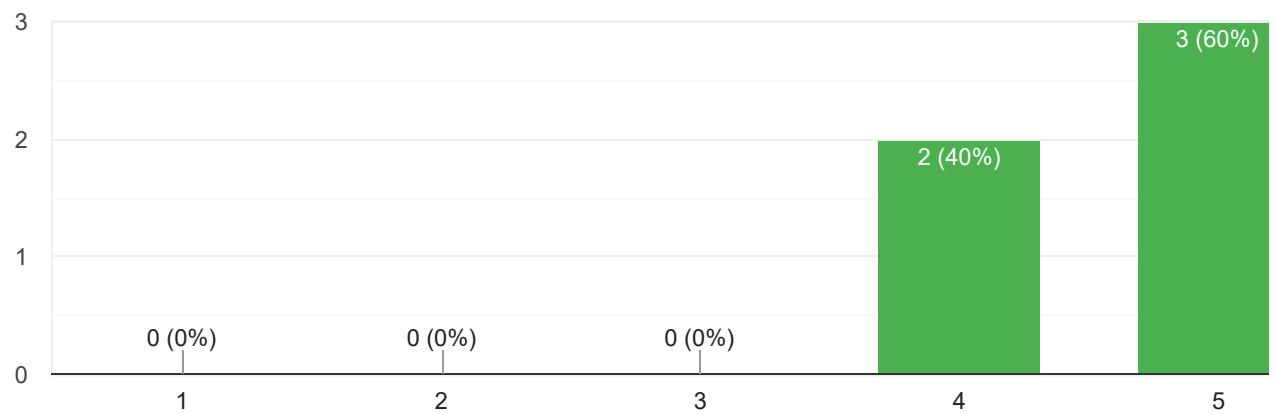


**8. I found the system very cumbersome to use.**

5 responses

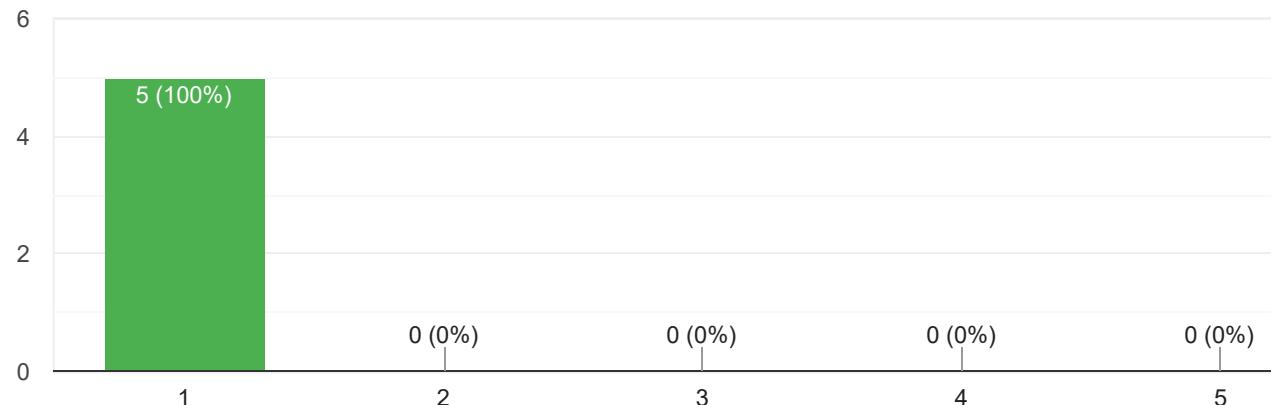
**9. I felt very confident using the App.**

5 responses



I needed to learn a lot of things before I could get going with this App.

5 responses



# References

- Al Neimat, T. (2005). Why it projects fail. *The project perfect white paper collection*, 1, 1–8.
- Anderson, D. J. (2010). *Kanban: successful evolutionary change for your technology business*. Blue Hole Press.
- Beck, K. (2000). *Extreme programming explained: embrace change*. addison-wesley professional.
- Beck, K., & Fowler, M. (2001). *Planning extreme programming*. Addison-Wesley Professional.
- Brandy Scarney, P. G. (2020, Apr 2,). *Android development*. Retrieved from <https://ionicframework.com/docs/developing/android>
- Brigham, T. J. (2015). An introduction to gamification: Adding game elements for engagement. *Medical Reference Services Quarterly*, 34(4), 471-480. Retrieved from <http://www.tandfonline.com/doi/abs/10.1080/02763869.2015.1082385>
- ChartJS. (2013, Mar 17). *Simple yet flexible javascript charting for designers & developers*. Retrieved from <https://www.chartjs.org/>
- Clement, J. (2019, June). Retrieved from <https://www.statista.com/statistics/269025/worldwide-mobile-app-revenue-forecast/>
- Dash, A. (2017). *Simple, powerful, free tools to create and use millions of apps*. Retrieved from <https://glitch.com/>
- Dayley, B. (2014). *Node.js, mongodb, and angularjs web development*. Addison-Wesley Professional.
- Feiler, J. (n.d.). *Introducing sqlite for mobile developers* (1st edition ed.). Apress.
- fenopix. (2013, Feb). *Simple & intuitive charting api in javascript. don't take our word for it. try out the api below !* Retrieved from <https://canvasjs.com/blog/>
- for Environment & Rural Affairs, D. (2019, Mar 7). *Uk statistics on waste*. Retrieved from [https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment\\_data/file/784263/UK\\_Statistics\\_on\\_Waste\\_statistical\\_notice\\_March\\_2019\\_rev\\_FINAL.pdf](https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/784263/UK_Statistics_on_Waste_statistical_notice_March_2019_rev_FINAL.pdf)

- Grigsby, J. (n.d.). *Progressive web app* (1st edition ed.). A Book Apart.
- Ionic. (2020, Mar 13,). *Sqlite*. Retrieved from <https://ionicframework.com/docs/native/sqlite>
- Ittycheria, D. (2009). *Mongodb is a cross-platform document-oriented database program. classified as a nosql database program, mongodb uses json-like documents with schema. mongodb is developed by mongodb inc. and licensed under the server side public license*. Retrieved from [www.mongodb.com](http://www.mongodb.com)
- Joffe, H. (2008, 02). The power of visual material: Persuasion, emotion and identification. *Diogenes*, 55, 84-93. doi: 10.1177/0392192107087919
- Klimczak, E. (2013). *Design for software: A playbook for developers*. John Wiley & Sons.
- Klug, B. (2017). An overview of the system usability scale in library website and system usability testing. *Weave: Journal of Library User Experience*, 1(6). Retrieved from <https://doaj.org/article/76e2f68e4e8647bab974b7051647e10a>
- McAleer, P. (2015). *Designing for mobile* (1st edition ed.). O'Reilly Media, Inc.
- Nat, F. (2008). *Github*. Retrieved from <https://github.com/features/project-management/>
- Nelson, M. (2015, Oct 1,). *An intro to git and github for beginners*. Retrieved from <https://product.hubspot.com/blog/git-and-github-tutorial-for-beginners>
- Novick, V. (2017). *React native-building mobile apps with javascript*. Packt Publishing Ltd.
- Perea, P., & Giner, P. (2017). *Ux design for mobile* (1st ed.). Packt Publishing. (ID: alma99313190602501)
- Reeve, J. (2002). Self-determination theory applied to educational settings.
- Siegle, L. (2018). *Turning the tide on plastic*. Trapeze.
- Smyth, N. (2016). *Android studio 2 development essentials*. EBookFrenzy.
- Trust radius, android studios review*. (n.d.). Retrieved from <https://www.trustradius.com/products/android-studio/reviews>
- Weigert, C. (2020, Apr 2,). *Ionic storage*. Retrieved from <https://ionicframework.com/docs/angular/storage>
- Yusuf, S. (2016). *Ionic framework by example*. Packt Publishing Ltd.
- Zichermann, G., & Cunningham, C. (2011). *Gamification by design: Implementing game mechanics in web and mobile apps*. ” O'Reilly Media, Inc.”.