UNIVERSITY OF BIRMINGHAM

Human-Computer Interaction Project: Improving Recycling Rates of Young Adults

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Abstract

This project aims to increase recycling behaviours in young adults. To do this we reviewed relevant literature from the field of psychology to better understand how we can change the behavioural patterns of our target demographic so that they make more environmentally friendly decisions. Using this understanding as the foundations for which to build our system we looked at three existing systems which have been seen to influence and change behaviour, or include features that could be used in a recycling application. Insights gained from the literature review and review of existing systems lead to the design of three personas, each representing a different segment of user from our proposed user base. Different scenarios in which the user might want to use our system were created for each persona. Taking what we learned, we went on to create three different prototypes, one focused on gamification elements, another focused on the social aspect of behaviour change. The last prototype focused on giving people functional tools that may aid them when it comes to recycling. Each prototype was heuristically evaluated as well as being evaluated for how well it solved the problems presented by our scenarios. From these evaluations a second generation prototype was designed. It was decided that the second generation prototype should primarily focus on giving individuals a functional tool that can help them to correctly identify what to recycle and where to recycle. A reward system was also included. A critical evaluation of the second generation prototype is given and suggestions for future development are put forward.

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Chapter 1

Introduction

1.1 Importance of Recycling

The scientific consensus that humans are contributing towards climate change has been demonstrated time and time again. The position is expressed by the Intergovernmental Panel on Climate Change (IPCC) statement that "human influence has been the dominant cause of the observed warming since the mid-20th century"[1]. Furthermore, according to NASA, most of the leading scientific organisations worldwide have issued public statements endorsing this position [2]. The dangers of climate change include life threatening food and water shortages, rising sea-levels and higher frequency of natural disasters. Since climate change is influenced by human behaviour these impacts can be lessened by reducing our contribution to the problem.

1.2 Outline

This project will first define the specific issue we are trying to solve. Once we have a firm grasp on *what* the problem is, we will review the current literature to better understand *how* the problem can be solved. This will involve studying existing theories on human behaviour which will serve as a solid scientific foundation with which we can build a new system designed change behaviour. The project then goes on to examine and critically evaluate existing systems that have been seen to influence the behaviour of their users. By looking at already-existing popular systems, we can assess both their strengths - for replication, as well as their weaknesses, which can be built upon and improved in our own application.

To gain a deeper understanding of the users we will be focusing on, a series of personas will be generated. These personas will each represent a final user of the application, and have unique qualities and characteristics. An analysis of these personas will provide a list of common traits and problems that our application could solve, ensuring user-driven development. With this information, prototype generations will commence. We will create a series of first-generation prototypes and evaluate their relative strengths and weaknesses against our personas and scenarios. Taking what we have learned from each section, a final second-generation prototype will be designed. This will be much more in-depth then the previous prototypes and acts as a final product that should be whole and complete if translated to a real-world application.

1.3 Definition of Problem

We have identified that the global-warming trends displayed over the past century are almost certainly the result of human activities. Scientists warn that unless action is taken soon we could face irreversible damage to the natural world [3]. In 2008 the Department for Environment, Food and Rural Affairs (DEFRA) considered a wide range of possible interventions for individuals to reduce their carbon footprint including adopting a lower impact diet, avoiding air travel, buying energy efficient products, and recycling. They concluded that while radical lifestyle changes are unlikely, "There are small and painless steps that people can take for the sake of the environment" [4]. They looked into the motivators and barriers for each of these interventions and identified recycling as a behaviour that people would be both willing and able to do.

However, In 2017 the Waste and Resources Action Programme conducted a large survey of 3329 people which indicated that among 18-34 year olds 42% are "not confident they are getting it right." 28% are "not sure what they put in the recycling bin is recyclable" 19% admitted "not putting much thought into what they throw in the bin" and 19% don't check what their local recycling guidelines are [5]. The report claims that 18-34 year olds in the UK have the lowest rates of recycling. This is worrisome as poor recycling habits could be transferred to future generations as well, where recycling will be even more important due to growing populations.

The ultimate aim of this project is to help protect and improve the environment by getting more young adults to recycle and to make recycling a part of their daily lives. Technology deeply intertwines with the everyday activities of this particular demographic, with mobile phones being ubiquitous. This presents a great opportunity for the change of behaviour and the development of positive habits through the use of software.

Chapter 2

Review of Related Work

2.1 Literature Review

In order to design a piece of technology which could get people to recycle more it is important to understand the individual differences as to why some people recycle and others do not. To do this we look at the current thoughts and theories as to why humans behave the way they do, and examine the factors that go into promoting behavioural changes. Unfortunately, there is no universal theory or model for how individuals behave. This comes as no surprise given the complexity of human psychology. Although our understanding in this area is limited, the fields of psychology, economics, marketing, and others have developed theories and frameworks on how we can influence people and change their behaviour.

Many theories and frameworks have been proposed, developed and studied to help us understand human behaviour. While all of these theories can be applied to help explain and understand why some people recycle and others do not, this literature review is concerned with only two such models. First the Theory of planned behaviour is discussed, as it has been studied extensively in the context of environmentalism. Secondly the value-belief-norm model is outlined. This model has also been found to explain people's pro-environmental behaviour. Furthermore, the model has been adapted specifically for environmentalism using the New Environmental Paradigm, which is also discussed below. Both models make the case that our behaviour is thought out and rational, however we argue that the disposal of rubbish is such a common place occurrence in everyday life that it is likely that recycling has a large habitual component. As such this literature review goes on to discuss the relevant literature in how habits are formed, maintained and changed. We conclude with a discussion of how these theories can help us to develop new technology aimed at getting people to recycle more.

2.1.1 Theory of Planned Behaviour

The Theory of Planned Behaviour (TPB), which is visualised in figure 2.1 [6], argues that behaviours can be directly predicted by a person's intentions which are in turn predicted by a combination of attitudes, subjective norms, and perceived behavioural control [7]. Thus, according to the theory, individuals will be more likely to recycle when they:

- Hold positive attitudes towards the idea of recycling

- Perceive social pressure from those whose opinions they value
- Feel capable of doing so

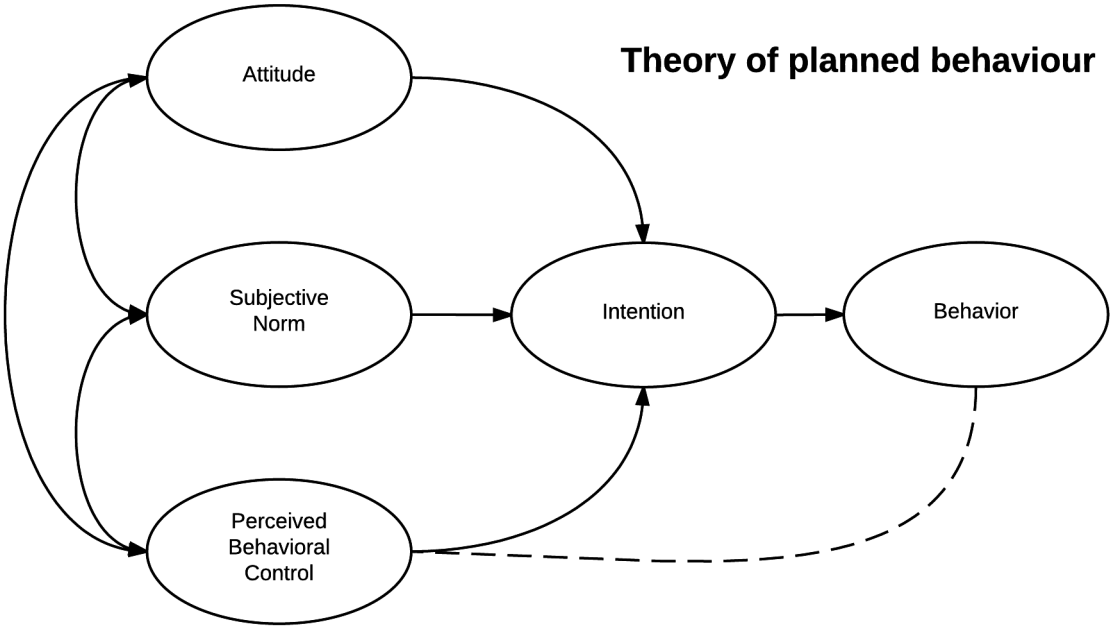

Figure 2.1: Theory of planned behaviour

The TPB has proven to be successful in explaining various types of pro-environmental behaviour, including travel choices [8], buying energy-saving light bulbs [9], and general pro-environmental behaviour [10]. In 2016, Morren and Grinstein undertook a meta-analysis on 81 studies on environmental behaviours, and found that a person's attitudes towards the environment is the best predictor of all their environmental behaviours [11].

The TPB argues that our attitudes are a strong antecedent to behaviour. In 2008 the EU released a report investigating the General attitudes of European citizens towards the environment [12]. The report found that while almost all Europeans have environmentally friendly attitudes those that have had more concrete experiences of environmental problems show a higher likelihood of taking actions in order to protect the environment. Which suggests that the more experience they have with environmental issues the stronger their attitudes will be, which in turn will lead to an increase in pro-environmental behaviours.

With respect to recycling, Davis and Morgan (2015) surveyed 294 individuals to investigate how TPB can be used to determine recycling behaviours [13]. They assessed participants attitudes towards recycling by asking them how strongly they relate to statements like, 'If I recycle my household waste I will be helping to conserve natural resources' and 'if I recycle my household waste I will be helping to protect the environment' [13]. The survey revealed that a person's attitude towards recycling is the strongest predictor of them actually doing so [13]. Similarly, In 2017, Lakhan measured attitudes to recycling by asking people questions such as whether they thought recycling was sensible, hygienic, a waste of time, or rewarding and also found that positive attitudes towards recycling was

the strongest indicator to engaging in recycling behaviours [14].

The TPB goes on to argue that subjective norms, which is to say the influence of social pressures from others, such as friends and family or role models plays a big role in the way in which individuals behave. These social pressures have been shown to influence a wide variety of behaviours from what we wear [15] to drug use [16]. Thomas and Sharpe (2013) conducted a literature review into how social norms contribute to recycling behaviours and concluded that because recycling is largely a visible activity (for example, people can see that whether or not their neighbours are recycling) that this created a 'social pressure' and has had a positive effect on peoples recycling behaviour [17].

It is not just our immediate social circle that can have an impact on an individual's pro-environmental behaviours. Mobley et al. studied what effect being exposed to environmental literature such as National Geographic had on peoples' behaviour, and found that the more exposure people have, the more people behave in environmentally responsible ways [18]. Furthermore, according to a recent report conducted by supermarket chain Waitrose (2019) 88% of people who watched the TV series 'Blue Planet II' claim that they have significantly changed their behaviour regarding their use of plastics, furthermore Waitrose report that they have seen an 800% increase in questions about plastics and packaging from its customers [19]. This research suggests that recycling is becoming the new social norm for the majority of people. DEFRA(2008) argue that people want to be 'part' of something, with over half responding that they agree with the statement "with so many people making a difference, it's worth being environmentally friendly as it can make a difference" [4]. Which is in line with the TPB assertion that subjective norms are a strong predictor of behaviour.

The final predicate the TPB states as being key to a person's behaviour is their perceived behavioural control (PBC) over that behaviour, that is to say how simple or difficult they perceive that behaviour is to carry out. Research has shown this to be a significant factor in many arenas from losing weight [20] to uptake in online banking [21]. The general idea is that if people feel confident in their ability to perform a task they are more likely are to perform that task. DEFRA suggest that one of the main reasons people don't recycle more is that they are not confident about what can be recycled and where it should go [4]. Similar findings have been found in the scientific literature, Kaiser and Gutscher showed PBC to be the most significant predictor of whether a person recycled glass or not when compared against the other two antecedents to behaviour proposed by TPB namely, attitudes and subjective norms [22]. This makes sense - if people don't know how to recycle, how can they be expected to do it? Before people can do something, they must know how. In a survey of 981 UK homes in 2003, Barr found that knowledge of local and national recycling policy increased the likelihood of a home recycling by 24% [23].

2.1.2 Value-Belief-Norm

While the TPB places emphasis on a person's attitudes to the behaviour in question. The value-belief-norm theory argues that an individual's behaviour is determined by their own moral and personal values [24]. Values can be defined as "stable constructs that serve as evaluative criteria for judging and responding to the world" [25]. Thus, our behaviour is said to be driven by our values. The value-belief-norm (VBN) argues that personal norms

are activated when a person assumes some responsibility for their actions. That is to say, the more strongly a person feels responsible for how their actions (or lack of actions) affect others is strongly correlated with how they behave. For example, the theory argues that the more people subscribe to the idea that climate change poses a threat to themselves or others, the more likely they are to engage in environmentally friendly behaviours.

The core element of the VBN is that how we view ourselves and how we perceive others to view us are both strong predictors to how we behave. The values individuals hold play an integral part of their identity. This makes sense conceptually, if a person exhibits strong personal values that climate change is important and that they feel like they should be behaving in a more environmentally friendly way, then it makes sense that they will think of themselves as environmentally friendly. Several studies have shown support for the value-belief-norm theory as a means of predicting behaviour change. Whitmash and O'Neill (2010) found that those who think of themselves to be environmentally conscious engage in more environmentally friendly behaviour [26]. Similarly, Markowitz et al. (2012) found a strong positive relationship between those who have a strong appreciation for the beauty of nature with pro-environmental behaviours [27].

The VBN has shown to be most successful at explaining behaviour change that when the behavioural cost is low and requires only little effort. For example, Onel and Mukherjee (2017) found it to be well suited at explaining pro-environmental behaviour such as recycling or purchasing energy efficient light bulbs [28]. However there appears to be a disconnect for behaviour that requires a high amount of effort. Bamberg and Schmidt, (2003) found the theory to be unsuccessful in explaining behaviour changes that come as a high behavioural cost, such as adopting a low impact diet, reducing car use or avoiding air travel [8]. This is in line with the report by DEFRA which concluded that expecting individuals to make radical lifestyle changes is extremely unlikely [4].

Dunlap et al, (2000) built on the VBN in the context of examining pro-environmental behaviour, and developed the New Ecological Paradigm (NEP) scale to determine an individual's values regarding the environment which is said to be their environmental worldview [29]. The authors argue that a person's environmental worldview acts as a lens as to how they view environment-related information. It is argued that individuals scoring highly on the NEP are more aware of the negative impact their behaviour may have on the environment or on other people. A persons awareness of what consequence their behaviour is having along with their acknowledgement of responsibility are said to activate personal and moral values and as such people behave in a way to try and mitigate their impact. Thus, according to the VBN, a person's future pro-environmental behaviour can be predicted by the extent to which they subscribe to the idea that they are personally responsible for negatively impacting the environment.

The NEP has been widely accepted in the field of environmental psychology and sociology. Cordano and Frieze, (2003) Have shown the NEP to predict a variety of environmental attitudes and behaviours such as using water more responsibly, buying energy efficient products, and increases in recycling [30]. In a literature review looking at the NEP Mesmer-Magnus et al. (2012) concluded that people who score highly on the NEP are likely to incorporate environmentalism into their personal identities and exhibit what they called an environmental commitment, which they defined as "the extent to which

an individual is dedicated to environmental sustainability and is willing to engage in pro-environmental behaviours" [31]. This is thought to be extremely important to behaviour change in the context of environmentalism as we are trying to create a lifestyle change which is a long term process rather than a single event.

2.1.3 Habits

The two theoretical frameworks described above both assume that people make reasoned and rational choices when deciding how to behave. However, some behaviours are much more habitual than others. For example, it is not hard to imagine that a person might not recycle simply because they automatically throw everything in the same bin. Throwing away waste is such a common part of everyday life, happening so frequently and automatically that we must explore the theory behind how habits are formed, maintained and ultimately changed.

Marechal (2010) states that habits have three main qualities: a low degree of involvement, a low degree of complexity, and a low degree of constraint [32]. They are said to be learnt patterns of behaviour that happen automatically in response to relevant cues. Habits develop through "context-dependent repetition" [33]. The behaviour is repeated in a particular context and reinforces the cue-behaviour association - the more we do it the more that behaviour becomes automatic and alternative behaviours become less likely. In a survey conducted by Verplanken (2012) it was found that 1 in 3 people agreed that the effort to overcome habitual behaviours in waste disposal was a significant barrier to change [34]. Danner et al. (2007) argue that an individual's habitual behaviour begins automatically in response to encountering the relevant cues [35].

Research into how habits can be modified or changed suggests that people need to put in conscious effort, and it is dependent upon people remembering to perform the new behaviour on as many occasions as possible [36], therefore we can confidently assert that memory processes will play a vital role in the formation and maintenance on new habits. Memory retrieval cues are a far more effective way to get somebody to remember something rather than us having to think about it ourselves [37].

2.1.4 Behaviour Change and Technology

Given that our ultimate aim is to change behaviour through the use of technology, it is important to examine what technologies already exist with the same goal. Fogg (2003) argues that "we have entered an era of persuasive technology", and has put forward what he calls the 'functional triad' to illustrate the different roles computers can play and how they can be used to influence people [38]. According to Fogg computers act in three basic ways:

1. As functional tools. They can help guide people through a process or transform data into in to understandable knowledge that can motivate people.

2. As social tools. They can connect people to other people.

3. As media. They can provide people with vicarious experiences that serve as motivation.

The functional triad is in line with the psychological theories outlined above. It emphasises how individuals are influenced by their social circle and that computers can be used to connect us with each other. It also emphasises that computers can help people to better understand information which can help them to learn new behaviours and to motivate. Fogg proposed this model in 2003 and although the world of technology moves quickly we can see how it is still relevant today. The rise of many successful social media companies shows just how important the social aspect of computing is. Similarly, the rise of sensor-rich smart phones and wearable technology has also seen a dramatic rise in the amount of technologies that can track and provide information about ourselves. Using the theories outlined in the literature review above as well as Fogg's functional triad outlined we have identified that the social and functional aspects of computers are important to behaviour change. Both of which are discussed below

Social Networks

Social Networking sites and applications are an area of technology that has emerged only recently, yet they are becoming an increasingly ubiquitous part of our everyday lives and the impact on its users reaches far and wide. A report by the Social media Examiner (2015) found that 96% of businesses use social media to help drive sales and raise brand awareness. This indicates the power social media has at influencing behaviour [39]. Indeed, as users can typically like, share, and comment on posts which then gets propagated in to the news feeds of those they are connected with is clearly a powerful tool, especially given that the impact of social influence was emphasised in both the TPB and VBN, and that studies show that individuals show a much greater tendency of adopting behaviours that they see in displayed in their social circles or by role models [39]. Furthermore, several studies have shown that social network integration has proved to be a reliable tool for improving the retention rate of an application. For example, Tong et al. (2018) found that applications with a social network feature were found to retain over 80% of their users, whereas in applications without this feature were shown to have a retention rate below 50% [40].

With respect to the theories above we can examine the role social media plays in influencing a person's behaviour. Both the TPB and the VBN both make the case that our behaviour is influenced by those around us. When investigating social movements Liu et al. (2017) found that for young adults (16-25 year olds) exposure to social media helped shape and influence a person's self-identity and attitudes towards that a social movement [41]. Johnstone and Lindh (2018) have attempted to incorporate the role of social media plays in the TPB [42]. They found a significant relationship between age and attitudes towards sustainable products when examining the impact that their social media has. They also found a correlation between age and the impact social media had on environmental awareness. This suggests that younger generations may lack the knowledge about the ideas surrounding sustainability and therefore turn to social role models for their ideas. This is useful for the current project as young adults are the chosen demographic.

Personal Informatics and Gamification

The rise of sensor-rich phones and wearable technology has seen a similarly dramatic rise in the amount of technologies that are said to track and provide information about ourselves. These apps are designed not just to collect data but to create self-reflection

and behaviour change via the idea of "self-knowledge through numbers" [43]. This makes sense, given the importance the TPB and VBN place on perceived behavioural control and personal norms. We argue that people use self-tracking applications not just to change their future behaviour, but also to record their past behaviour. Consolva et al (2008) interviewed people who used these applications and found that they boosted the self-efficacy of participants. For example, one participant said, "And I could see the feedback and think, I did it last week, you can do it again this time" [44]. Again, this is in line with the literature review above as self-efficacy is thought to be one of the greatest antecedents to behaviour change according to the TBP .

The current project is particularly interested in how the use of personal data can be intertwined with elements of gamification to help facilitate behaviour change. By gamification we mean implementing certain features found in video game design into our app designed to increase recycling behaviours. Typical features of gamification include social engagement through leader boards, collection of points and badges as well as completion of challenges [45]. Gamification has been shown to be a powerful tool in behaviour change and user retention, it primarily focuses on motivation through reinforcement and emotions [46]. The idea behind using personal data to create leaderboards or give rewards can be found in many apps aimed at changing behaviour. Strava is an exercise app that lets you compete against your friends. Hackerrank gives users stars when they have completed enough challenges. MyFitnessPal which can be used to track your diet helps users stay motivated by earning badges or connecting with friends for support or competitions. We believe that this could be a good way to change habitual nature of waste removal as it makes the user more likely to use our app as they want to collect the rewards and compete with their friends. Furthermore, the application of gamification in driving more people to recycle could be particularly beneficial when targeting young adults, as the effectiveness of gamification has been researched with regards to age and the results suggest that the effectiveness declines with older individuals [47].

Broadly speaking there are two different types of technology that can track our data. The first is active where users must actively engage with the technology. For instance, users of MyFitnessPal must open the app and scan their food to add it to their data. The second is passive, where the data is gathered automatically. For example, users of Fitbit simply wear the technology and data is automatically gathered. We argue that the active type poses a possible solution to a problem of habitual behaviour outlined above. People need to change their automatic behaviour and be reminded to make more effortful choices when it comes to what they throw away and where they throw it. If users wish to log their recycling behaviours they must engage with the system which serves as a helpful reminder that they are trying to recycle more. This will also serve as a way to reinforce the new behaviour, as the more often people recycle, the more often they will recycle in the future.

2.1.5 Conclusion of Literature Review

People's reasons for doing what they do are complex and difficult to explain, and using technology to change people's behaviour would be easy if we had a full understanding of what motivates and influences us. This literature review set out to help us better understand human behaviour and behaviour change in the general context of pro-environmental

behaviour and in the more specific context of peoples recycling behaviours.

Increasing recycling behaviours was selected for a number of reasons. Firstly, because it is thought to be a growing concern as the production of plastic continues to climb. Secondly, research shows that while most people are aware of the environmental problems being caused by climate change and that their behaviour is a contributing factor, they often claim that they don't have a proper understanding about how they can make a difference. The authors of this project believe that recycling presents a good opportunity for behaviour change as it is already widely understood, easy to learn and requires relatively little effort. This is in line with the findings presented in the literature review, that behaviour change is most likely when behavioural costs are low.

The target demographic of young adults was chosen because research findings suggest that younger generations recycle less than older generations. This is particularly troublesome as it is those as well as even younger generations that will inherit the problem unless something is done about it now. Furthermore, we argue that this generation would be more likely to use a mobile application designed to encourage and enable recycling behaviour than older generations.

With the behaviour we wanted to change identified and the demographic we wanted to impact chosen, the psychological underpinnings to behaviour and behaviour change were examined. There are dozens of theories regarding behaviour change, and while they can all help us to better understand where there is scope to influence peoples behaviour this literature review was only concerned with two of them. The theory of planned behaviour model and the value-belief-norm model. Both of these models were chosen because they have both been studied extensively and have been found to help explain many pro-environmental behaviours. While, both of these models are helpful to the current project, they are both limited when it comes to explaining behaviour that could be seen as habitual. We argue that disposing of rubbish happens so frequently that it is very likely to have a habitual component, to better understand how habits are formed, maintained, and changed. The literature surrounding habits was reviewed.

Research into the TPB emphasised the importance of attitudes, subjective norms, and perceived behavioural control. Each on these have been shown to be strong predictors of to behaviour. Attitudes towards a certain behaviour is often thought to be the strongest antecedent to behaviour. Being made aware of the recycling behaviours of others has also shown to increase recycling behaviours. People want to be seen doing their part. We could use this knowledge to try and incorporate a social aspect to recycling. Seeing what others are doing, and showing off what we ourselves are doing and try to shape attitudes through communication, fostering new social norms. The final antecedent to behaviour as described by the TPB suggests that for people to accomplish a certain task they must perceive themselves capable. This is particularly important to the current project as 'not knowing how' is often given as a main reason why people don't recycle. Giving people the appropriate knowledge as to how to recycle correctly has been identified as a major importance for our technology.

The VBN has also proved successful at explaining pro-environmental behaviour suggesting that there is a moral component to our behaviour and that our underlying personal values

are powerful predictors of behaviour. The main point of overlap between the TPB and VBN is that both emphasise the importance of attitudes and values to how we behave. However, the VBN demonstrates that more general values can be important to predict behaviour. Using this knowledge, we could design an application that tries to increase personal values towards the environment in a more general sense. The VBN argues that if a person is aware of the consequences their actions are having on the environment and the more personal responsibility they feel for their actions, the more likely they are to behave in ways to mitigate their actions. This is important to this project because one of the main reasons people claim for not recycling is that they often feel a disconnect between the size of the problem and what they are able to do. We could use this understanding for our application to show people what affect their recycling is having through some concrete real-world example like trees saved.

The idea that disposing of waste is such a commonplace occurrence that we argue it is often habitual, therefore we could not ignore the literature surrounding how habits are formed, maintained, and changed. Research shows that attempts to change long endured habits are often met with disappointment, this is true even after people adopt new intentions. However, one of the key findings that this literature review exposed was that habits are formed by repetitive actions. We could incorporate the use self-tracking and gamification to encourage repeat uses. This may help to interrupt people's automatic behaviours, so that they make more considered choices rather than 'easy' choices.

The importance of understanding the underlying processes that go in to behaviour and behaviour change are vital as we move ahead.By examining these underlying processes we are able to draw upon the existing literature to create hypotheses that we can use to drive behaviour change and design our application. From the research, it is clear that we have to encourage people to recycle by improving their values and attitudes, we have to help enable people to recycle by informing them and giving them the tools, they need for change. We need to make people feel good about recycling and show them that they can make a difference, we want to make it so people are seen recycling so that the social pressure to recycle grows. The literature review has given us a firm foundation from how to build our prototypes. A summary of our hypotheses and what it means for the current project are outlined in table 2.1 below.

Theory	Hypothesis	What it means to us
TPB	There is a positive relationship between peoples attitudes towards recycling and their recycling behaviours.	We need to increase people's attitudes towards recycling. Maybe we could educate people and make it fun.
TPB	There is a positive relationship between a person's subjective norms and their recycling behaviours.	We need to raise awareness of the importance of recycling within social groups. Can we make recycling more social?
TPB	There is a positive relationship between a person's perceived behavioural control and their recycling behaviours.	People need to know how to recycle and they need to believe that they can do it. Can we teach people how to recycle, show them what goes where?
VBN	There is a positive relationship between a person's awareness of undesirable consequences and their intention to recycle.	People need to know what effect not recycling is going to have. Can we inform people of the consequences that a lack of recycling has?
VBN	There is a positive relationship between how responsible a person feels for how their recycling behaviour affects the environment and other people.	People need to feel more responsible for how their recycling behaviours affect others. Can we make people feel more responsible or guilty for not recycling?
VBN	There is a positive relationship between a person's pro-environment personal norms and their intentions to recycle.	We need to instil people with pro-environmental values. Can we raise awareness of environmental issues in general?
Habits	People's waste disposal behavior is habitual.	We need to change a person's waste disposal. Can we encourage them away from the 'easy' option towards a more 'effortful' option? Can we remind people to recycle?

Table 2.1: Overview of hypotheses

2.2 Review of Existing Systems

2.2.1 Introduction

This section explores existing systems that have the intention of changing human habits, motivation and attitude. Based on the application features and the services provided to their users, we decided these applications were the most appropriate to study as a broad overview of applications that have the ability to transform human behaviour through online interactivity, easy access to information and giving users the ability to track personal goals. Another element that is significant in studying these applications is the habit of using these services. In order to create a successful application we must look at how applications reinforce habit on their users. This will be done through critically analysing different aspects of the applications, including user demographics, main application features, user experience and problems associated with the application.

2.2.2 Instagram

Figure 2.2: Instagram

Instagram is a social media platform created by Kevin Systrom and Mike Krieger, where individuals can share photos, videos, follow their friends and send private messages. It was launched in October 2010 and since then, billions of media files have been posted to the platform. Instagram is one of the most popular and influential social network services worldwide, as it is used by more than 800 million people [48]. The reason we chose Instagram as one of our three existing application case studies is that social media has the power to change human behaviour through online social connections, therefore it is important to assess a prominent example, such as Instagram.

2.2.3 MyFitnessPal

Figure 2.3: MyFitnessPal

MyFitnessPal is a smartphone application and website created by Albert Lee and Mark Lee, where individuals track their daily diet and exercise routines. It uses personal informatics and gamification elements to motivate users by tracking calories, breaking down ingredients and logging activities. It was launched in September 2015 and since then, has been used by 140 million people to achieve their health and fitness goals [49]. The digital audience have become increasingly interested in tracking their health digitally through the popularity of health and fitness trends [50]. According to City University London, the posting of pictures of food on Instagram has had a positive impact on regulating healthy foods. Seeing foods that are organised and appetising triggers gustatory sensations in our brains which activate our desire to consume. This equates that a user's feed influences their behaviour to eat healthier [51]. The reason we chose MyFitnessPal as our second existing system case study is because self-logging through the documentation of our activities have become leading trends in the change of human behaviour.

2.2.4 WeRecycle

Figure 2.4: WeRecycle

WeRecycle is a prototype application created by UX designer Kedar Joyner launched in March 2019 that allows individuals to scan the barcodes of their packaging and find out where the nearest recycling point is. It also provides interactive learning opportunities to understand how their actions make a difference. [52]. The reason we chose WeRecycle as our final case study is that convenient accessibility to information is a leading trend in

breaking habits of human behaviour when it comes to recycling. [52].

2.2.5 Demographics

Across the globe, 18 to 29 year-olds account for 60% of the active Instagram population [53]. This demographic skew towards teenagers and young adults is seen even clearer when younger teenagers are included in the statistics. For example. in Taiwan, over 70% of individuals between the ages of 12 and 24 use Instagram [53]. Lessons in targeting this specific demographic can be learned by looking at how Instagram manages to capture its user base. The main reasons for Instagram use by university students include surveillance (being up to date with activities of friends and influencers), documentation (capturing and sharing important moments), coolness (being popular or accepted among peers) and creativity (displaying personal creations or finding others that share similar interests). [54]. Another factor contributing to the platform's popularity is its availability, as it is usable as an app on smartphones, ubiquitous devices in many parts of the world.

MyFitnessPal's demographics include people who are trying to lose weight. According to the UK parliament 28.7% of adults are obese and a further 35.6% are overweight but not obese [55] and according to the NHS 2/3 of adults population in England are obese [56]. There is a market of people who want to lose weight and contribute to their own self-improvement. MyFitnessPal allows its users to insert their goals, provides a community forum and motivates its user through daily reminders allowing for consistent use of the application. Another factor contributing to the platforms popularity is its availability, as it is usable as an app on smartphones, ubiquitous devices in many parts of the world.

In 2015 an estimate of 55% of global plastic waste was discarded, 25% was incinerated and 20% was recycled. According to Science Advances, packaging was the dominant use of primary plastics with 42% of plastics entering use phase [57]. If this behaviour continues to occur, Geyer predicts that there will be over 13 billion tons of plastic in our landfills and in our environment by 2050 [57]. It is believed that another 13 billion tons will have to be incinerated by this time and only 9.9 billion tons will be recycled [58]. This behaviour is resulting in putting human health at risk, endangers our wildlife, our oceans and littering our landfills. Many know the repercussions of their attitude yet why don't they recycle? It is stated in the introduction that there are obvious barriers preventing them from taking the right action when it comes to recycling. The demographic for WeRecycle target those who are passionate about reducing waste and want to improve their recycling ability and those who are interested yet feel they lack the time and education to build sustainable habits [59].

2.2.6 Social Connection

A major benefit of MyFitnessPal and Instagram is the community it provides. In the MyFitnessPal application, a forum is available where fellow users of the app exchange tips and advice as well as create relationships through sharing personal experiences and struggles. This connection builds an environment where people can grow together to achieve their goals. Similarly, users of Instagram use hashtags to attract followers to view their posts. Other people can leave comments and tag their friends in posts. This builds

a community where users can constantly engage with each other using content provided by other users of the application.

2.2.7 Information Accessibility

There is a strong correlation between human effort and changing habits [60]. If information is not accessible, people find it more difficult to incorporate change into their everyday environment. Instagram incorporated an algorithm to help filter the best and most relevant content to each user every-time they check their social media feed [61]. The three main factors that determine what you see on your feed include: Interest, relationship and timeliness along with three additional criteria that play a smaller role in influencing your feed such as frequency, following and usage [61]. The interest factor determines the order of photos and videos in your feed will be based on the likelihood you'll be interested in the content, your relationship with the person posting and the timeliness of the post i.e. how recent the post is. As previously discussed, our feed influences our everyday activity. Therefore if a user decided that they wanted to change their interest to recycling or environmental awareness, their feed would automatically update and a natural integration would occur where recycling content would be incorporated. Additionally, if a post is 'liked' among social circles the outreach of a post can improve. [61] This can lead to this post reaching a wider audience allowing for the spread of information to occur naturally.

MyFitnessPal has a databases of nutritional information and a collection of exercise routines. It also collects data from users through a smartphone's inbuilt tools, such as the Global Positioning System, accelerometer, microphone, speaker, and camera, to measure health and fitness parameters. The application then analyses this data and summarizes it, allowing the creation of individualised plans based on users' goals. It can also provide frequent feedback, personalized coaching, and additional motivation by allowing milestones to be shared on social media [62]. This information makes it easy for the user to stay motivated due to accessibility of information.

WeRecycle has a map feature so that users can find their nearest recycling centre. It is illustrated so that a user can enter their current location and material they are using and the map feature will redirect them to their closest recycling bin of that materials type. The option to search, add and get details of bins of recycling centres is available. This creates easy user flow so that all the user has to do grant to application access to their current location, search what type of bin they wish to locate and the map will direct them to the recycling bin they wish to go. This eliminates any confusion about what material goes in what bin when the map can clearly label what bins accept what material in the jurisdiction of the user. This enforces user accessibility to information leading for an easier transition to a waste-free existence.

2.2.8 Self-Logging

Instagram, MyFitnessPal and WeRecycle all show different variations of self-logging (i.e. the presence of a diary component). We see self-logging in the form of a users profile on Instagram where photographs are shared by the user. These photographs can consist of memories, experiences, achievements, awareness posts and, as discussed previously,

progress posts. MyFitnessPal shows logging through its most famous feature of the scanner also known as the 'calorie counter', which logs a food diary for its user. It monitors its users food intake giving the user ability to creates lists of foods eaten at breakfast, lunch, dinner and snacks through scanning the bar code of your items. It allows its user to group foods together to prepare meals, make recipes and search for foods if you do not have access to its bar code. It also gives the option to search restaurants and request their menu via email. An impressive feature of the app is that if the camera does not recognise the bar code, its gives the user an option to input it manually. This gives its users an alternative way to use the feature and is a good example of error prevention. All of these qualities make it easy for a user to access information and monitor their progress through self-logging giving the user satisfactory use of the application.

Similarly in WeRecycle, the scanner feature and the recycle log allows you to monitor your progress. The scanner feature allows you to scan the barcode of your packaging so that you know what parts of the packaging you can recycle. The items you have recycled goes into a history section where a user can reflect on what they can recycled. Next, the recycle log feature which contains an education system where you can do various learning modules under the categories titled plastic, glass, paper, organics and metals. In your log section you have an achievements section which shows your progression in the form of badges. These qualities make it easy for a user to access information and monitor their progress through self-documentation.

2.2.9 Reward System

WeRecycle, Instagram and MyFitness application share commonalities such as a reward system. According to Trevor Hayes, when you get a social media notification your brain sends a chemical messenger called dopamine along a reward pathway which makes you feel satisfied [52]. Dopamine is associated with food, exercise, love, sex, gambling, drugs and now social media. This adds to the addiction of the application. Gamification techniques are applied in WeRecycle in the form of badges and points which are received whenever milestones are reached. MyFitnessPal also takes this approach by storing a reward system based on the goals a user wishes to accomplish. MyFitnessPal provides a path for self-improvement through reminders and badges giving the user a sense of accomplishment [63].

The effectiveness of MyFitnessPal as a behaviour change tool is questionable. Various fitness applications for changing behaviour are available but little is known about their effectiveness. Taking from a study by Laign et al. it was concluded that after six months, weight change was minimal, with no difference between groups [64]. In contrast according to Customer Reports, MyFitnessPal was rated the best free weight loss application with 83 points in overall customer satisfaction relative to maintenance, calorie awareness and food variety [64]. In conclusion, it is important to note that smartphone applications for weight loss may be useful for people who are ready to self-monitor calories, but introducing a smartphone app is unlikely to produce substantial weight change for most patients. Taken from this study, self-motivation is an important attribute to consider when choosing the target audience for future applications, as if a person is not driven by internal rewards to improve on themselves in the category specific to the application, the application will not force change upon that person.

2.2.10 User Experience

In terms of interaction between users and the software, Instagram does a lot of things very well. It is an image-intensive platform which takes advantage of the fact that the majority of the general population (65%) are visual learners [65]. In addition, the fast processing within the human brain in response to visual stimuli is exploited [65]. As a social network service, it is very streamlined and is not overloaded with several unnecessary features. The user interface of the mobile app is mapped very intuitively. Since it is primarily a photo-sharing service, the main feature of adding photos is positioned in the bottom centre of the screen, within close reach of a user's thumb. Constant feedback is also provided by the application to the user. For example, when a page is loading, there is a bar that indicates how close the loading process is to completion. Instagram also seamlessly teaches features with short messages on how to perform certain actions, such as replying to comments. Recently, Instagram introduced automatically generated alternative text for images, as well as the ability to write your own alternative text. This allows visually impaired users to use text-to-speech in order to receive a description of what particular pictures are showing.

From interacting with MyFitnessPal it seems that the main function is hidden away on the secondary screen, the search functionality and scanning foods can often be quite complex and the multi-add feature is often forgotten about the users. Low priority is given to primary function of the application. For example, in a recent analysis performed by UX designer Luke O'Sullivan, it was found that the food logging and macros sections were of high priority, exercise, weight and exercise were given medium priority and the other features were given low priority [66]. From this study is it clear that the primary reason people use this application is to log their food and read their macros. Despite this, on opening the application, the user enters the home screen where a brief overview of the calories consumed versus remaining. Although this feature is nice to have, it is used less frequently. Users were very clear that they wanted immediate access to logging food or checking their macros. The current flow of the application means that an extra step is added to the process of logging food and as a direct result decreases efficiency while also proceeding to waste users time. It would be beneficial to prioritize the key features highlighted in the application. Many users who did not use the scanner feature struggled to find where the option to enter a bar code was. This can be noted and used in the integration of our first generation prototype. Finally the multi-add functionality of the application is a section in the application where users can add food items to each meal individually. It is not obvious that there is a multi-add feature in the 'Diary' section.[63] It would be useful if this feature was added to the main page to allow users the opportunity to view further detail on each food item. It is understandable that not every user would be interested this feature, however efficiency could be improved by prioritizing the feature as it would allow the user an easier and faster way to add foods.

Taken from WeRecycle user testing carried out by Joyner, the three features that were reviewed were the image search feature, button labels and recycle log feature [52]. It would take a user a number of minutes to know if their item was recyclable or not. A prevention error that could be incorporated into our prototypes is letting the user know automatically if the item can be recyclable or not after they scan their object. Secondly, buttons in the application looked like labels. Users found it unclear what to press to bring them to the page they wanted to go to [52]. Having clear and obvious labels should

be mandatory in the creation of future prototypes. Lastly, many users said they did not understand the Recycle Log feature screen [52]. Packing too many features into one screen can lead to confusion and ultimately make it unclear to the user in how each part connects. It is crucial that the human interaction element of the application places focus on one thing at a time while giving them flexibility in the application.

2.2.11 Takeaways

The takeaways of these application include reducing the perceived effort or any other potential barriers that may hinder a person from using the application to help them achieve their goals. An example of this is the Instagram user interface. The search tool in particular does not provide a comprehensive way of narrowing queries. It does tailor the search results to the user's typically preferred content, but it is quite difficult to find specific images or videos efficiently. It is impossible to sort search results in order of popularity or date. There is also no way of successfully limiting search results by adding additional keywords.

Instagram's large young adult user base is an excellent source for potential users of recycling software. Implementation of an Instagram feed in our application would be highly beneficial as users would be able to stay motivated through interaction with media from like-minded people. The limited search functionality could be overcome by filtering the feed to show posts from specific pages and hashtags. There are also a lot of great user interface decisions that will be applied in our software.

Taken from this we will do a similar implementation but combine aspects from Instagram's behavioural change strategy into our first generation prototype so that the behavioural change element is improved on and exceeds the questionable outcomes of MyFitnessPal.

Similarly, according to Luke O'Sullivan user testing evaluation of MyFitnessPal, often users expressed confusion when searching for and attempting to add food items to their diary [66]. We also discovered the primary function of the application was located on a secondary screen, over a blog page that the majority of users do not use. It would be beneficial for this application to reduce the number of steps needed for a user to accomplish their primary goal using MyFitnessPal, and to minimise confusion surrounding the main purpose of the application. Where the home page and navigation bar leads is something to consider when designing our prototype with the aim to optimise the user flow.

In saying this, it is important to note that internal motivation is a critical component in someone using the application. An example of this would be if someone using MyFitnessPal app was to scan their foods barcode before throwing it away, the same would apply to using the WeRecycle application i.e. before throwing their rubbish away they would scan the bar code to find out what bin the item is going in. This requirement of having to scan your packaging could act as a helpful reminder to recycle and encourage the formation of new habits.

2.2.12 Conclusion of Existing Systems

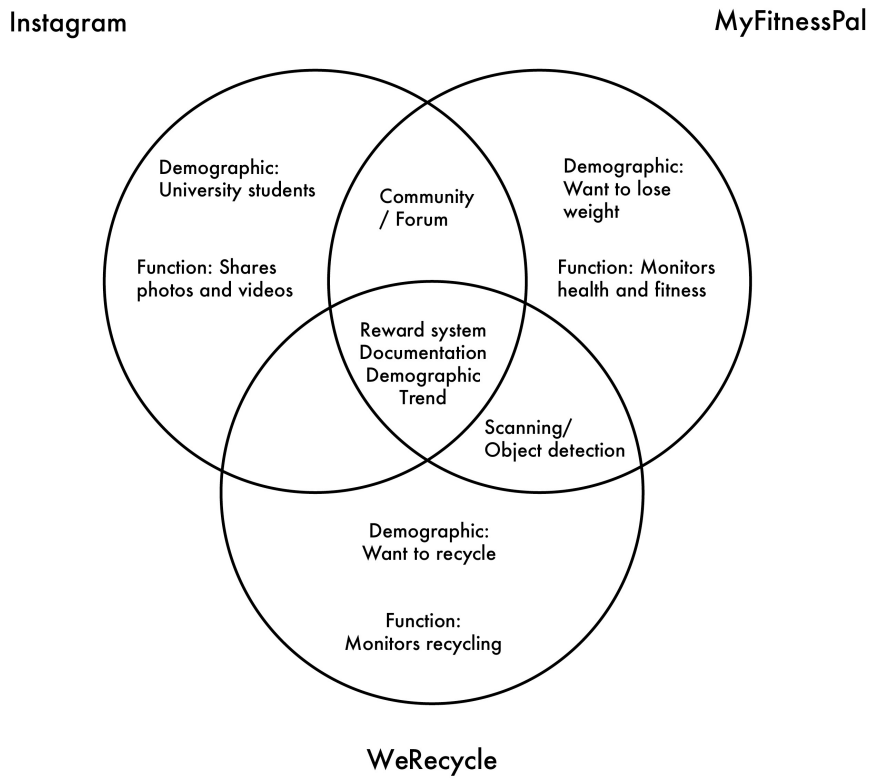

Figure 2.5: Venn diagram of the existing systems

As shown on the Venn diagram (figure 2.5), despite choosing a broad variety of applications to study, there seems to be a number of commonalities shared between each system. These commonalities include demographics, the habit of self-documentation (logging and diaries), rewards systems and easy access to information. Although there are similarities between these applications, each application shows these features in a different way relative to the theme of the application e.g. recycling, fitness or social. This is shown in the following:

Firstly, how a user accesses information is a driver for changing ongoing user behaviour. It is shown that Instagram can play a part in natural integration of content to occur through their feed if the user consciously decides to change their online interests to environmental interests. Additionally on studying MyFitnessPal, plans based on the user goals are incorporated, along with regular feedback, personalized coaching and photo sharing on social media when milestones are reached allow for a sense of community to be built linking MyFitnessPal and Instagram. Finally WeRecycling removes confusion by giving the user accessible information relative to their daily waste consumption. These three features can lead a user to feel satisfied which ultimately leads to a good user experience.

Secondly Instagram, MyFitnessPal and WeRecycle all have self-documentation but in distinctive forms. Instagram displays a profile where users can share moments in their life, MyFitnessPal through logging past meals and WeRecycle contains an educational system

where progression is recorded through learning exercises.

Thirdly reward systems are incorporated in the three applications. Instagram's form of rewards is shown through "likes" while MyFitnessPal and WeRecycle use badges. Instagram, MyFitnessPal and WeRecycle have a clear demographic, helping people connect online as well as anyone over the age of 18 reach their goals through fitness and recycling. All applications bar WeRecycle can be found on Android and iOS. WeRecycle is the first application to try and tackle the problem of segregating packaging into specific bins dedicated to help people recycle. By creating an application that is simple in both design and aesthetic and purely aimed at people who want to recycle, the WeRecycle application will be the only application in the market that provides a product for all people who want to recycle.

2.3 Conclusion of Review of Related Work

Drawing on information gathered during the literature review we have looked at three existing systems that have been shown to change a person's behaviours and habits. The literature review highlighted the importance that our social circle has on human behaviour. It also demonstrated that having easy access to relevant information can both serve to form our attitudes and influence future behaviour. Instagram was chosen for the power it has in socially influencing our target demographic, and for how it offers an easy way for users to share information with each other. MyFitnessPal was chosen for its ability to increase self-efficacy through self-reflection, for its ability to engage users through the use of gamification, and for the way it needs to be actively used to track behaviour which will lead to the breaking of automatic habitual behaviours. WeRecycle was chosen as it was the closest design of an application that is attempting to target recycling behaviour. We want our users to share information and to consciously log and monitor their waste disposal habits. Repeated use of our system will lead to the formation of new habits and an increased attitude towards the environment and added confident in their abilities to recycle. Through studying existing systems, we found that in order for a user to feel that they are capable, it is important for information to be easily accessible and for there to be a reward system to help retain users and reinforce the habit. Humans are creatures of habit and we want our users to get in to the habit of using our application as a life-long educational tool which will help people gain confidence and to be more conscious about their daily decision of recycling. The overall goal of our app is to engage, educate, and empower our users to have more positive attitudes towards the environment and recycling. To do this we will develop three different prototypes aimed at doing just that through the lessons we have learnt so far.

Chapter 3

Analysis of User Requirements

3.1 Introduction

When designing any application, it is imperative to have a clear understanding of user needs. To aid in generating an extensive list of requirements, personas are often created - each representing a final end-user of the product being created. It is important to understand the mindset of users in niche being targeted by an app idea as it can then be better-tailored towards the consumer, resulting in a better user experience and more successful application. Each persona also contains several scenarios in which they experience some issue or problem that the end-product attempts to solve. These scenarios can be useful in fine-tuning functionalities within the app as the scenarios are often very specific. The combination of these two methodologies results in an application that, during development, is consistently focused on the needs of the user - and benefits from this.

George Angelos was chosen to represent those individuals coming from a background of very little knowledge in regards to recycling. Our app should be simple and clear, keeping the barrier to entry as low as possible to reflect this need. George is also the only student of the 3 personas, and was partly chosen for this reason as students make up a large portion of the target demographic for our app. Finally, being from Greece, English is a second language for George and the development of the UI/UX for the app needs to bear this in mind.

Naomi Thompson was chosen as a user class since she represents a key demographic for our app. She is at the younger end of our target age demographic and therefore has distinct needs and thoughts regarding not only the environment but her relationship with technology. For example she is more tech-savvy than Emma. Outside of her age she also represents users from more rural areas who have different access to recycling and may have differing motivations for protecting the environment. This contrasts her with both George and Emma who live in urban environments where access to recycling is convenient. On top of this Naomi was selected because of position to improve the fortunes of her family business using the marketing power that lies behind being outwardly environmentally sustainable which is a motivation entirely absent from George and Emma.

Emma Vickers was chosen to represent individuals from the upper range of our age demographic. With age, typically comes more responsibilities which is seen in the case of Emma with her demanding job and family life. It was important to have a use case where

recycling wasn't a top priority for the user as they will have different needs and motivations to use such an app to those younger individuals with less commitments. Emma also lives in London, a very distinct location to those in previous user classes which aids in broadening our perspectives on end-users. Finally, Emma was chosen as she is in the position of raising young children which many users in this age range may also be in.

With these three users in mind, scenarios could be generated to evaluate the use cases for our application. The creation of these 3 distinct personas meant that a broad range of situations could be analysed. By considering the problems that our users face, we can better create an application that at every stage in the development process, aims to solve at least one of these issues. In doing so, our app will be extremely fit for purpose, targeted for our niche demographic, and streamlined.

3.2 Personas

3.2.1 Student

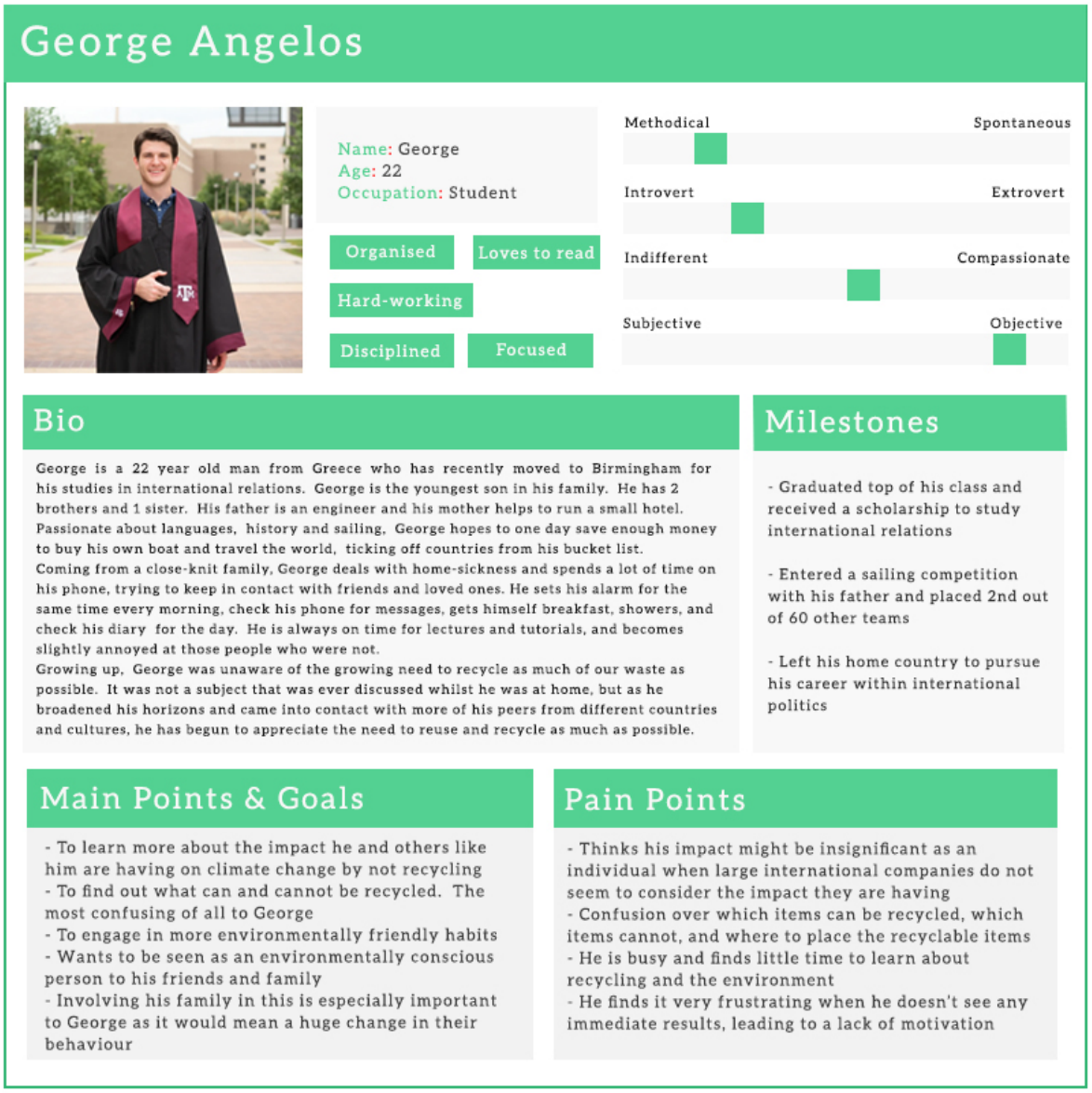

Figure 3.1: George

3.2.2 George: Scenarios

Scenario 1: George was born and raised in Greece. Knowledge of the impact modern day living has on the environment was lacking when he was growing up. Even today, when George goes back to Greece his family still fail to acknowledge the huge impact that not recycling has on the world today. He gets disheartened and struggles to educate his family about this issue when George himself often struggles to understand the specifics of recycling. George still gets confused about which bins should be used for the different parts of the packaging he tries to dispose and needs a way to make this clearer.

Scenario 2: George lives off campus and has to commute daily to attend his lectures and seminars. This combined with the social events that are also often held on campus means that George doesn't spend a lot of time at home. Whilst he knows the campus itself has great facilities for recycling everyday items, George is looking to find similar recycling facilities nearer to his home.

Scenario 3: Being an international student, George came to the UK not knowing a single person. To meet new people, he has joined several societies, including the sailing society, and loves how connected he feels to these people due to their shared interests. Not only does he enjoy the social aspect, but he feels the sense of community motivates him to attend and participate on days where otherwise he would bail. There is a small environmental society at his university, but it is quite inactive, and they only meet once a fortnight. George is wondering if there are more people like him who want to make an impact on the environment outside of the university.

3.2.3 Young Professional

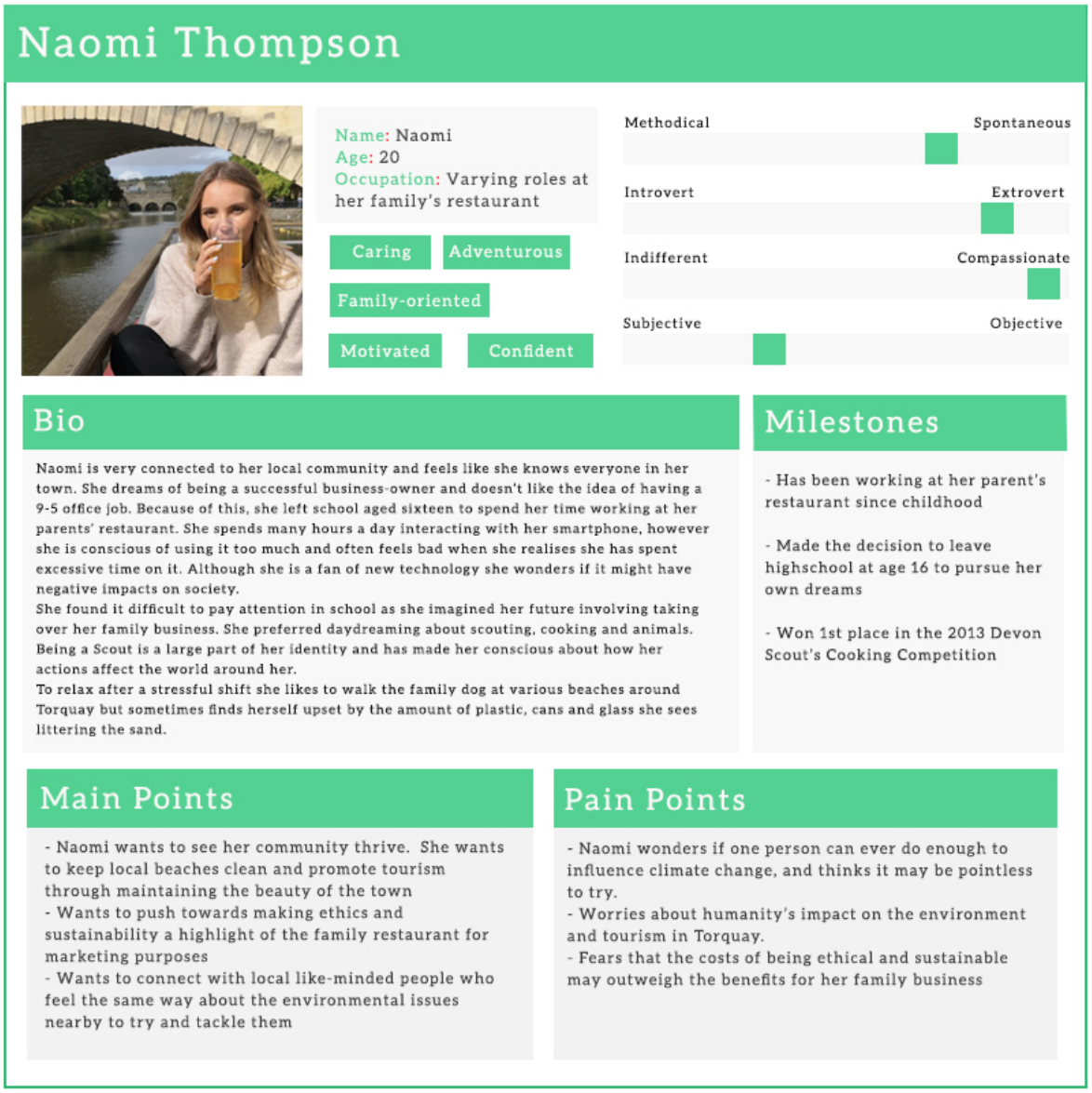

Figure 3.2: Naomi

3.2.4 Naomi: Scenarios

Scenario 1: Naomi attends a local scouting group, and has done for many years. She loves learning about biodiversity, and teaching new members about the environment. Recently Naomi has been getting into playful competitions with her group mates on various tasks, and this week, the focus is on who can recycle the most. Naomi needs a way for her and her friends to track exactly how much each person is recycling over the course of the next week.

Scenario 2: Naomi is already very environmentally conscious and recycles regularly. However, working for her family can consume a lot of time and the nature of the work is quite stressful. Naomi has noticed that she is becoming less and less consistent with her recycling habits during the busy holiday period and is becoming disappointed in herself. Naomi is now looking for a way to set recycling goals to keep on top of this so she can hold herself accountable.

Scenario 3: As an individual, Naomi is environmentally conscious and does her best to reduce her contribution to waste, however she can't help but feel as though she isn't having a big impact on the local environment. She finds it quite disheartening walking around her town park sometimes, noticing the amount of litter and wonders how people can be so disrespectful to nature. Whilst Naomi would happily attempt a park clean up by herself, it is practically unfeasible, and it would be much more beneficial to attempt something like this as part of a group effort.

3.2.5 Working Parent

Figure 3.3: Emma

3.2.6 Emma: Scenarios

Scenario 1: Emma is always trying to set a good example for her children as they are growing up fast. When Emma was young, the environment was seldom discussed, and she believes that everyone should be knowledgeable and responsible for its care. To be an environmental role model for her children, Emma has decided to raise the bar in her household, and make recycling more of a priority. However, constantly using google to determine which items can be recycled is very time consuming, and Emma is typically running on a very tight schedule. Emma is looking for a central location where she can get all the information she requires with regards to recycling in a fast manner.

Scenario 2: Emma's office has become much more environmentally aware over the past 6 months after attending a green party event. Many of the break-room conversations are now leaning towards these affairs, and Emma feels a little isolated. Whilst she does read the news when she has spare time, very rarely does she encounter environmental issues being discussed. Emma wants to feel more in-sync with her team members, but doesn't have much time to spend researching current events.

Scenario 3: Emma's children now have recently been given smart phones and use them to play games and watch their favourite TV shows. Emma monitors the apps and websites they visit fairly closely. She realises that they are still very young, and wants them to have fun, but isn't comfortable with the idea of them watching TV for the majority of the day. To try and get them involved in the green movement Emma wants to move her family in, she is looking to find an app that encourages them to recycle in a fun and interactive way.

3.3 Conclusive Remarks

3.3.1 Personas

The personas provided a framework for the psychology of the potential users of our application. Getting inside the minds of George Angelos, Naomi Thompson, and Emma Vickers allowed for easier visualisation of general application functionality that would resonate with their character profiles. Analysis of the personas via a Venn diagram (figure 3.4) allowed insight into the key shared traits between our end-users - attitudes towards recycling, technical ability, and age. This provided a clear and concise set of characteristics that our prototypes could focus development upon.

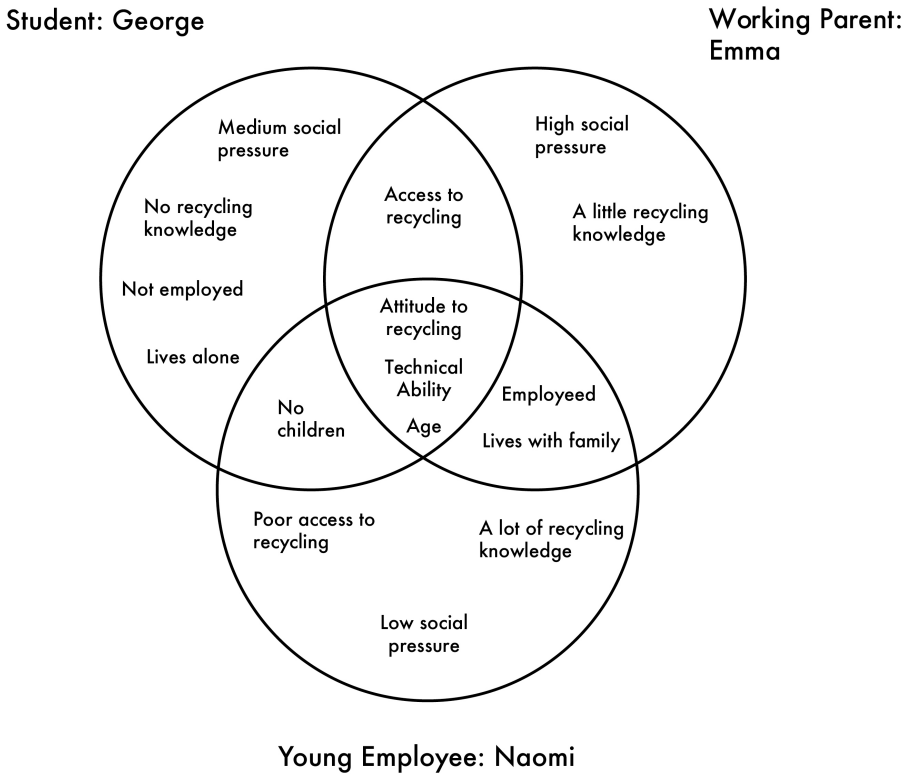

Figure 3.4: Venn diagram of user personas

3.3.2 Scenarios

The scenarios honed in on more specific situations in which potential users may look for an application such as this to solve their problems. The unique scenarios faced by our three users will be used to evaluate the first-generation prototypes created in the next stage of our development process. This will allow us to score each prototype based on their utility, allowing for direct and objective comparisons to be made about specific app features.

Chapter 4

First Generation Prototypes

Three prototypes were designed for potential mobile applications that could be used to develop the recycling habits of the user. The advantage of prototyping is that it allows us to create a visual representation of ideas, as well as prompt the generation of new ideas. By having prototypes, certain aspects of the design can be evaluated. This allows for the identification of poor design choices which can be discarded, as well as good design choices, which can be implemented and further developed in the next generation prototype. The prototypes also give other team members a better understanding of certain ideas, allowing for more effective collaboration.

4.1 Design Process

Several methods of prototype design were considered. The idea of pen and paper design was discarded quickly, as the readability and clarity of such prototypes did not seem appropriate. Balsamiq mockups were considered, but the cartoon-like aesthetic felt limiting in expressing ideas. A choice was made that the first generation prototypes were to be designed using the online prototyping platform Proto.io. Use of this prototyping tool throughout all three prototypes allowed for the presentation of varying concepts in a consistent format. In addition to this, Adobe InDesign was used to supplement prototype design. For annotations of the screens, LibreOffice Impress was used.

The aim of these first generation prototypes was to attempt to provide potential designs for mobile applications which could improve recycling habits. In addition to this, solutions to the specific issues presented in the user requirements were presented. The designs were created with the goal of targeting the recycling problem using specific approaches that were discerned in the review of relevant literature and existing systems. While some aspects of the prototypes overlapped, the main foci were distinct. The prototypes were centred around the ideas of:

1. Gamification
2. Social Networking
3. Tools to Assist Recycling

The prototypes were evaluated against the scenarios presented by our personas as well as the usability heuristics outlined by Jakob Nielsen in his book from 1994 [67]. The heuristics are:

1. Visibility of system status
2. Match between system and the real world
3. User control and freedom
4. Consistency and standards
5. Error prevention
6. Recognition rather than recall
7. Flexibility and efficiency of use
8. Aesthetic and minimalist design
9. Help users recognise, diagnose and recover from errors
10. Help and Documentation

A scoring of -2 to 2 was applied to the prototypes with respect to both the individual usability heuristics and each of the user scenarios. The scores were assigned under the following reasoning:

- -2: a strong fail, design will definitely not be used in the second generation prototype.
- -1: a fail, design will not be used in second generation, but some aspects of the design could be applied if heavy changes were made.
- 0: borderline cases, meaning significant changes would have to be made, but the design still has potential to be used in the next generation prototype.
- 1: a pass, meaning some changes would have to be made, but the design should be considered in the second generation prototype.
- 2: strong pass, which indicates that the prototype fulfills a certain criterion very well and that a similar design should be strongly considered in the second generation prototype.

4.2 Prototype A: Gamification

4.2.1 Rationale

This prototype focuses on the gamification of recycling in order to improve recycling habits. This decision is based on the literature review, where the effects of gamification on development of habits and on changing people's behaviour were explored and it was concluded that the technique is more effective on younger individuals (our target demographic). In addition to this, review of related systems showed that popular software such as MyFitnessPal incorporate aspects of gamification in their features.

The main features include logging daily recycling efforts, learning about recycling by way of a daily quiz, collecting points and badges for taking part in these activities and comparing your progress with your friends by way of the leaderboard.

4.2.2 Sign up

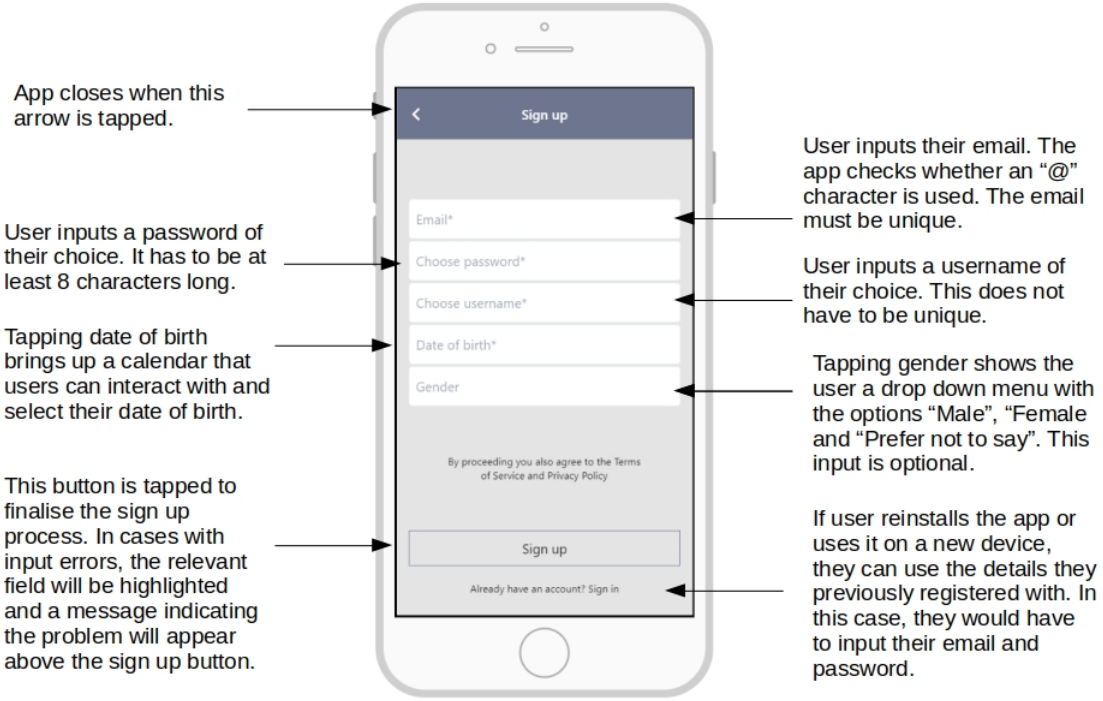

Figure 4.1: The sign up screen of Prototype A

First time users of the application will be greeted with a sign up screen, shown in figure 4.1. Here, the main pieces of information they have to input are their email, as well as a password and username of their choice. An email is required because it allows users to search for other users. It also lets users log in on different devices and continue with their progress. The users also input their date of birth and gender, which is only used to determine the demographics of the user base. The calendar which lets users select their birthday is limited to the range of years 1900-2010.

4.2.3 Home Screen

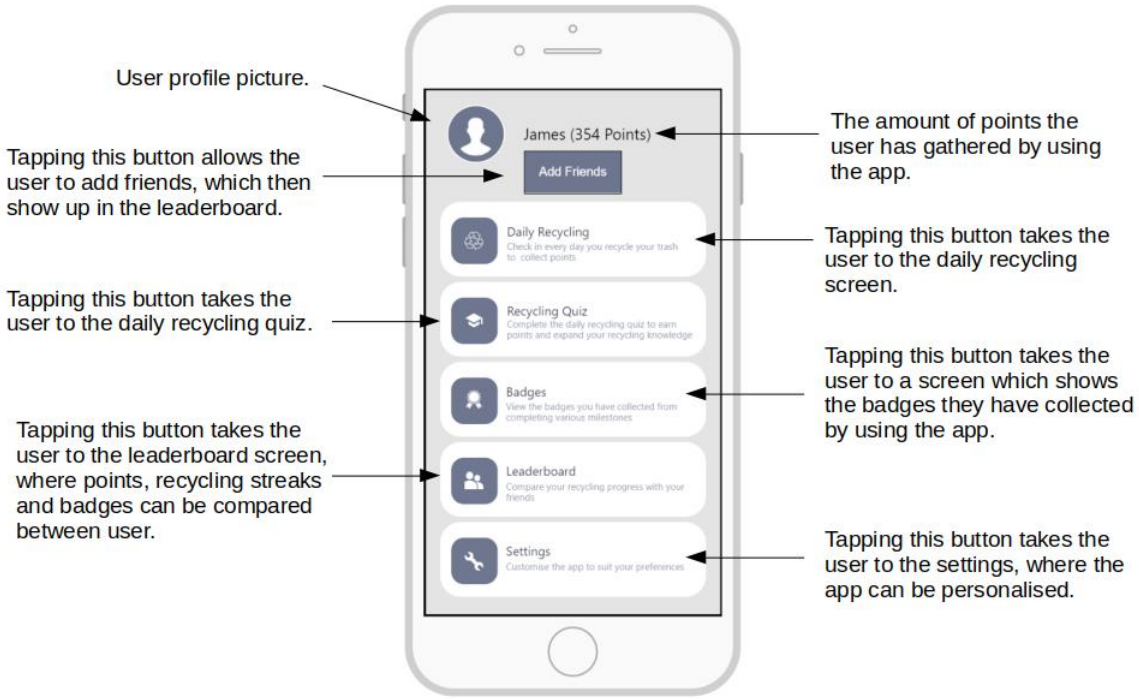

Figure 4.2: The home screen of Prototype A

Every subsequent use of the application will direct the user to the home screen upon launch. The home screen, shown in figure 4.2, contains an overview of all of the features of the application in a single place. The top of the screen shows the user's photo, username and the amount of points they have accumulated through usage of the application. The photo can be changed by tapping on the current photo (as well as in the settings). When changing the photo the user is allowed to access their camera (if they have given the application permission) to take a new photo. Alternatively, they can access their stored pictures and select a photo they would like to use (permission has to be given to the application for this as well).

The "Add Friends" button just below the user details is used to connect with other users. If the individual knows that their friends have the application installed, they can add them as in-app friends by inputting their email. A friend request will appear as a notification within the application (an exclamation mark in the top right corner of the "Add Friends" button). Adding friends enhances the user experience by allowing the use of the leaderboard feature (figure 4.6).

By pressing settings, the user is given options to personalise the application. Language options are available to make the application accessible across many countries. A toggle for dark mode is present to allow the user a better visual experience when using the application in poor lighting. There are also notification options, which let the user select how intrusive they would like the application to be. Notification options can be selected to send the user messages while they do not have the application turned on. Reminders can be set which will inform the user if they have forgotten to complete the daily recycling and daily quiz. In addition, preferences can be set for certain things in the application,

such as how the recycling streak is tracked (more on this in the leaderboard section). Finally, the user can change their personal details in the settings.

4.2.4 Daily Recycling

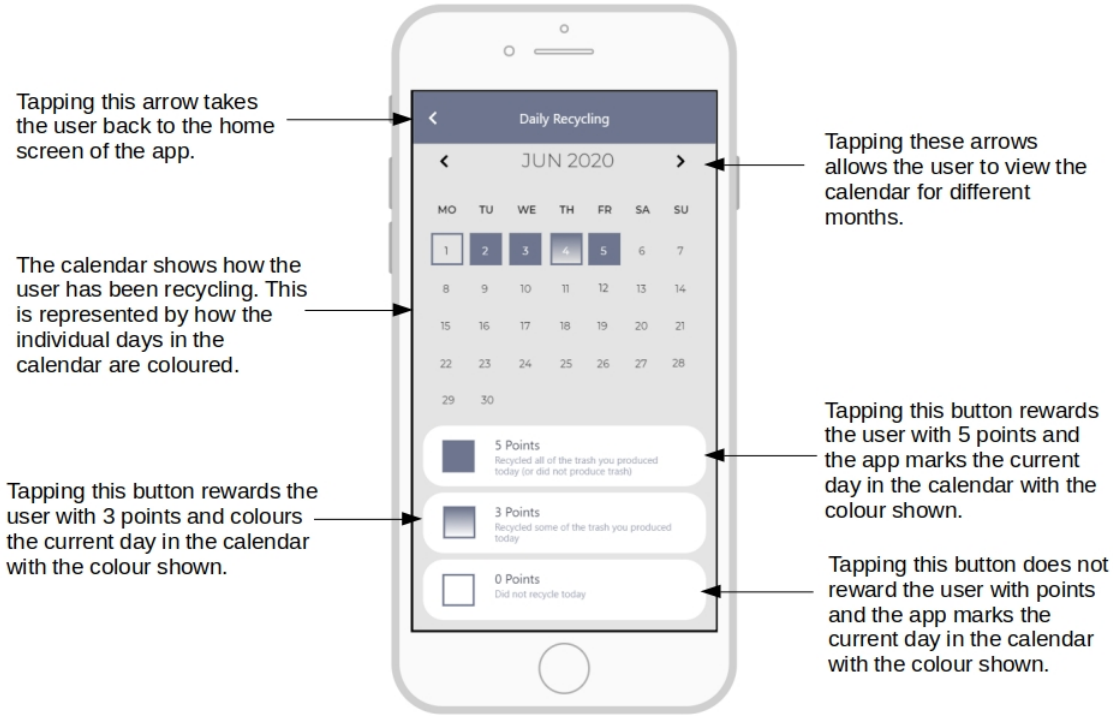

Figure 4.3: The daily recycling screen of Prototype A

The "Daily Recycling" feature can be accessed with a single button press from the home screen (figure 4.2). This feature, shown in figure 4.3, allows the user to track their recycling. At the end of every day, a user can select amongst the 3 options in the bottom of the screen. If they discarded their trash appropriately, and recycled all of the recyclables, they click the button which gives them five points. This button also applies for users who did not throw away any trash that day. If only some of the recyclables were discarded appropriately that day, the user should press the three point button. If the user did not recycle their recyclables, the 0 point button should be selected. The user also gets 0 points if they forget to select an option on the daily recycling screen that day. Depending on their actions that day, the user will notice that the calendar will be filled in with the matching square. The user can go back to previous months to observe their previous recycling habits. In order to go back to the home screen, the user has to press the arrow on the left of "Daily Recycling".

4.2.5 Quiz

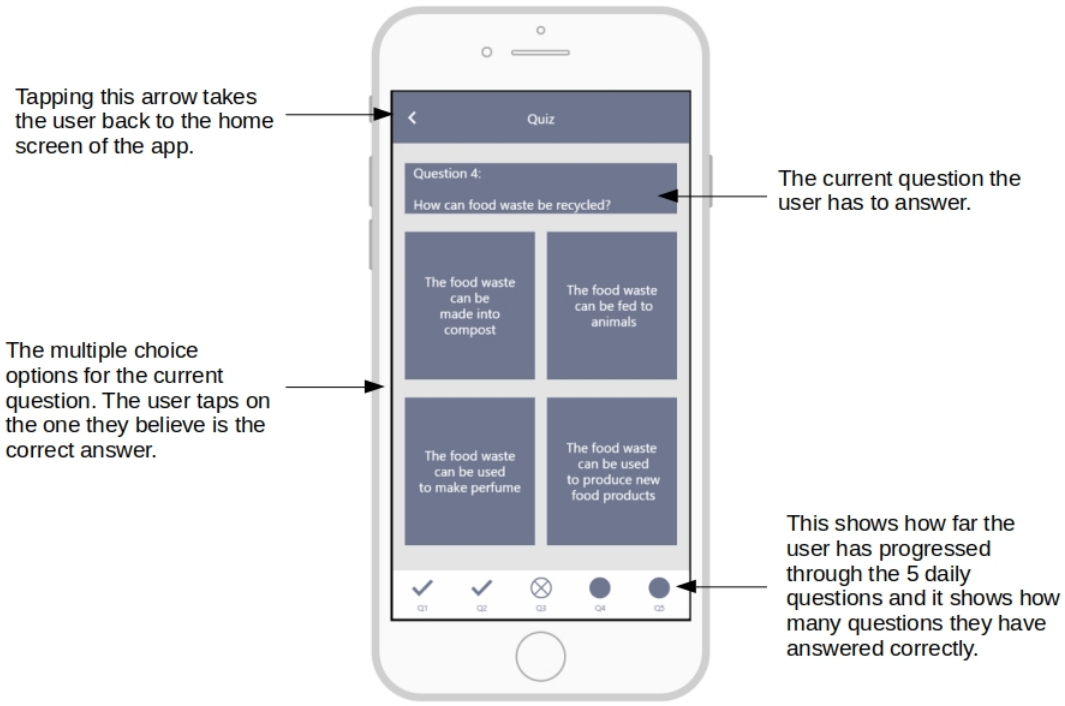

Figure 4.4: The recycling quiz of Prototype A

By clicking on the "Recycling Quiz" button on the home screen (figure 4.2), the user enters the screen shown in figure 4.4. This is a quiz which a user is allowed to complete once every day, with new questions every time they play. An exception to this is if a user gets a question wrong, in which case that question will reappear in a future quiz. The quiz consists of five multiple choice questions, with four options to pick from. Figure 4.4 shows a user towards the end of the quiz, interacting with the penultimate question. The bottom of the screen informs the user whether they answered their previous questions correctly (represented by a tick) or incorrectly (shown by a cross). For every correct answer, the user adds a point to their total score. The user can pause the quiz at any time by clicking the arrow in the top left corner, which will take them back to the home screen. If the quiz is completed, the user will also be brought back to the home screen.

4.2.6 Badges

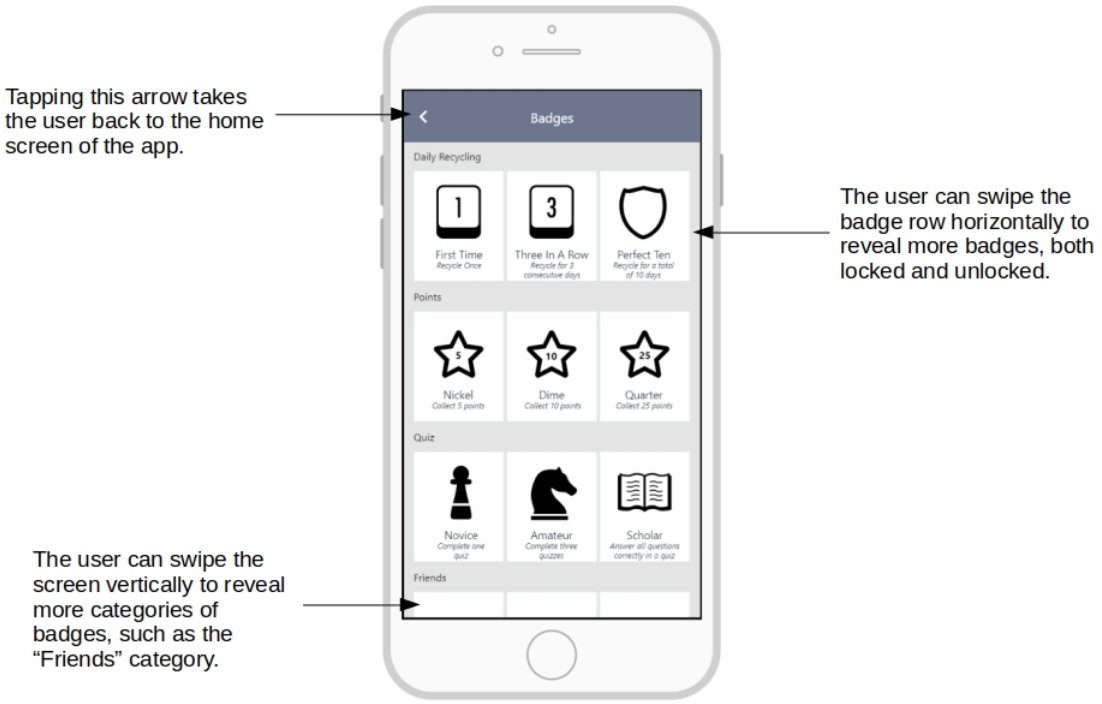

Figure 4.5: The badge screen of Prototype A

By using the application consistently, the user will obtain badges for achieving various milestones. The user can access the badge screen, shown in figure 4.5, by clicking on the ”Badges” button in the home screen (figure 4.2). The various badges are split into categories related to the main parts of the application. These categories include daily recycling, the daily quiz, points and friends. By accomplishing certain streaks and goals, the user will unlock the relevant badge. An example of this can be seen in figure 4.5, where the badge ”Novice” was unlocked when the user completed their first daily quiz. The user can view all of the obtained, as well as locked badges by dragging their finger across the row of interest. The locked badges will give users tasks to work towards. Locked badges can be identified as they are greyed out. The arrow in the top left corner brings the user back to the home screen.

4.2.7 Leaderboard

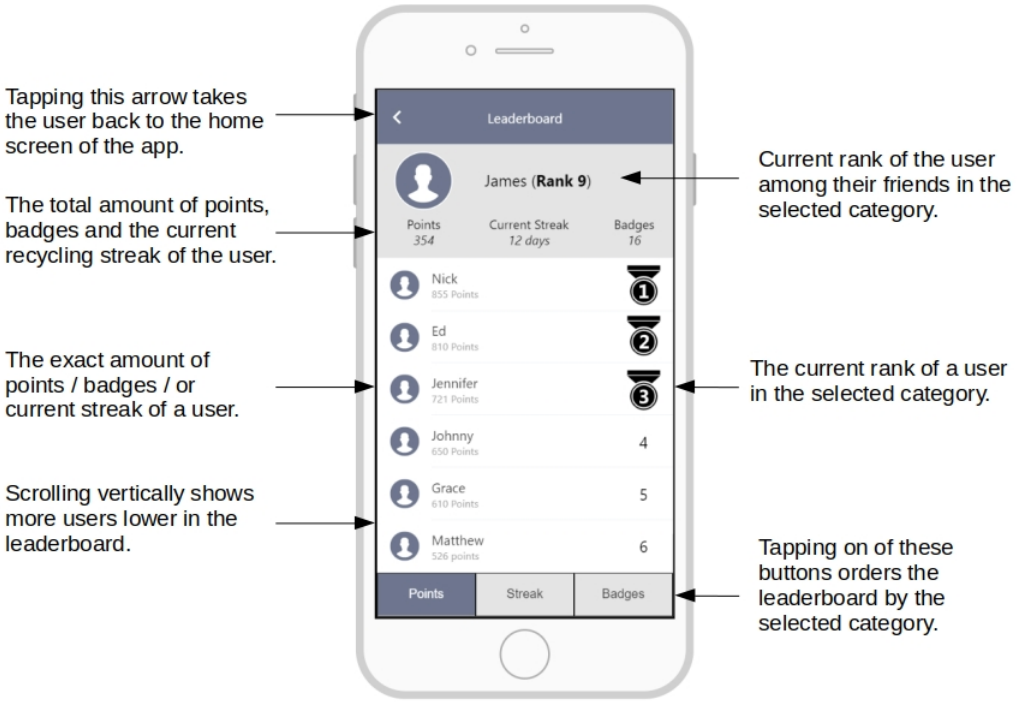

Figure 4.6: The leaderboard screen of Prototype A

Another feature that can be accessed from the home screen (figure 4.2) is the leaderboard, shown in figure 4.6. Here the user can see how they are ranked compared to their friends. In the top of the screen, the user can see their total points, the number of days they have recycled (fully or partially - calculation of the streak can be adjusted in the settings), and the amount of badges they have collected. The user can scroll through the list of friends by dragging their finger vertically across the screen, which shows what their friends' ranks are in a particular area. The ranking can be sorted at the bottom of the screen, with the choices of points, streak or badges. The arrow in the top left corner of the screen takes the user back to the home screen.

4.2.8 Heuristic Evaluation

Heuristic	Score	Reasoning
Visibility of system status	1	Throughout the prototype, the top of the screen shows the user which section of the app they currently are in. The user also receives feedback from the app in the quiz, where they can see how far they have progressed (figure 4.4).
Match between system and the real world	1	The prototype explains menu options with accompanying text, such as in the daily recycling (figure 4.3) and home screens (figure 4.2). Familiar features are used such as a calendar (figure 4.3).
User control and freedom	-1	Freedom in navigating the prototype is restricted, all features must be accessed from the home menu (figure 4.2) and the app does not support alternatives to registering by email (figure 4.1).
Consistency and standards	1	The prototype has mostly consistent features, such as the option to return to the home screen from any other screen (figure 4.6) and use of similar icons throughout the application. However, the daily recycling calendar uses a different font from the rest of the prototype (figure 4.3).
Error prevention	0	Error consideration in this prototype are present with signing up, where a user would be informed if they have entered invalid details (4.1). The limited features of the prototype make it difficult to encounter errors.
Recognition rather than recall	2	Intuitive iconography used throughout the application, very few menus to navigate and every part of the application is accessible from the home menu (figure 4.2).
Flexibility and efficiency of use	2	The prototype provides settings that can be adjusted to suit the requirements of different users. There are no unnecessary button presses (e.g. single press to select a choice on the quiz, figure 4.4), therefore the prototype is designed efficiently.
Aesthetic and minimalist design	0	Overall, the application only shows the most important information to the user, however, additional information is included at times, such as the descriptions of the sections in the home screen (figure 4.2).
Help users recognise, diagnose and recover from errors	0	During sign up (figure 4.1, the user will be given a message if they have entered one of the forms incorrectly, for example, an email which does not contain the "@" character.
Help and Documentation	-2	This heuristic was not considered in this prototype

Table 4.1: Heuristic evaluation of Prototype A

4.2.9 Evaluation against Scenarios

Scenario	Score	Reasoning
George 1	0	George can better his understanding of recycling through the daily quiz available in this prototype (figure 4.4), however, it might not always have questions relevant to what he's recycling.
George 2	-2	This prototype would not be able to assist George with finding recycling points.
George 3	1	George could feel part of a community of people dedicated to recycling by using the app as it features the option of adding friends and viewing their recycling progress in terms of a leaderboard (figure 4.6).
Naomi 1	2	Naomi and her friends would be able to successfully track their recycling habits with the daily recycling feature in this prototype (figure 4.3), as it shows a calendar with days that the person did and did not recycle.
Naomi 2	2	Naomi would would be able to set daily recycling reminders on this app (figure 4.2), which can help her develop a proper recycling habit even though she is busy.
Naomi 3	-2	While Naomi can add friends, communication through the application is limited, therefore group activities would have to be arranged in other ways.
Emma 1	-2	The prototype does not directly tell Emma how to recycle waste she has at a particular time, however, it could educate her through repeated use.
Emma 2	-2	Emma could learn about certain facts through the daily quiz, however, current events would be outside of the scope of this prototype.
Emma 3	1	Emma's children could enjoy collecting points and badges (figure 4.5) and Emma would be happy if her children used an application such as this. However, the limited features could cause the children to get bored of the application over time.

Table 4.2: Evaluation of Prototype A against user scenarios

4.2.10 Conclusive Remarks for Prototype A

After analysis, this prototype was found to have successfully used elements of gamification and personal informatics identified in the literature review and analysis of existing apps to tackle some of the key issues identified by our user profiles.

More specifically, this app showed to be capable of increasing the users' understanding of how they can recycle although this was limited by the breadth of information contained in the app. It also had the quality of being able to help users develop a habit of recycling more regularly. However, whether or not the application could entice users to maintain this on a long-term basis was less clear, particularly due to the lack of features overall.

A flaw associated with this prototype is the fact that the daily recycling logging is entirely dependant on user honesty. This is the case for a lot of productivity applications and it is expected that dishonest logging of recycling habits will most likely lead to the user uninstalling the application.

The design of the prototype had consistency throughout the different screens, however, there was a lack of help and documentation. This is something that should be improved. However, since the desired user base is young adults, they would be expected to be quite competent with technology and most of the individuals would therefore likely be able to interact with the application without further information.

4.3 Prototype B: Social Media

4.3.1 Rationale

Prototype B was inspired by the review of how social networks systems change behaviour, which revealed that belonging to a community, having like minded people and seeing other people do certain things can indeed affect behaviour. It was concluded that our target demographic, young adults, are heavy users of the social network platform Instagram, therefore the development of software which implements this system would allow users to have a familiar feeling.

This prototype, which shows an application named "VisionRecycle", focuses on implementing social media features to help assist in the recycling process. The main features include connecting with the users local community, being informed through top worldwide environmental blogs and connecting with environmental influencers on Instagram.

4.3.2 Sign up

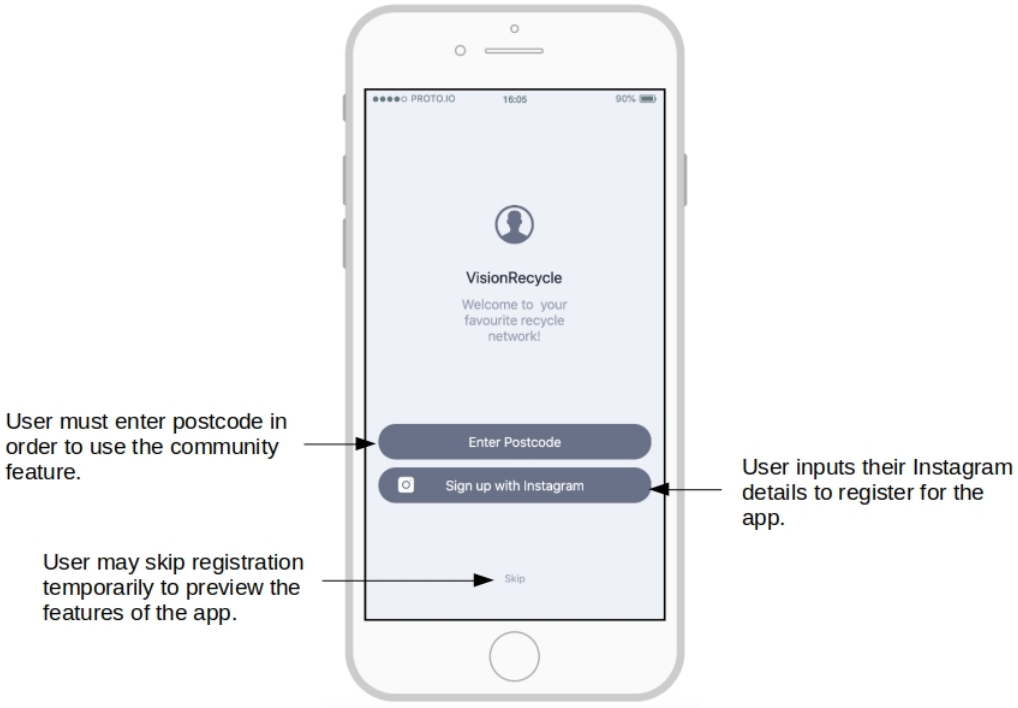

Figure 4.7: The sign up screen of Prototype B

When the application is launched for the first time, the user is greeted with the screen shown in figure 4.7. The user must enter their postcode to access the Community section of the application. This allows for the user to connect with their local community which is a prime feature of the application. The user is required to have an Instagram account to log in to this application. This allows the user to have quick log in access and enables the interaction with the Instagram integration. The user may choose to initially skip registration, however, this will limit functionality of the application greatly. The user will be able to see some of the features, but they will be informed that they must be logged in

in order to continue. If initial registration is skipped, the user will see the sign up screen the next time they open the application. Once signed in, further use of the application will direct the user to the home screen upon launch (figure 4.8).

4.3.3 Home Screen

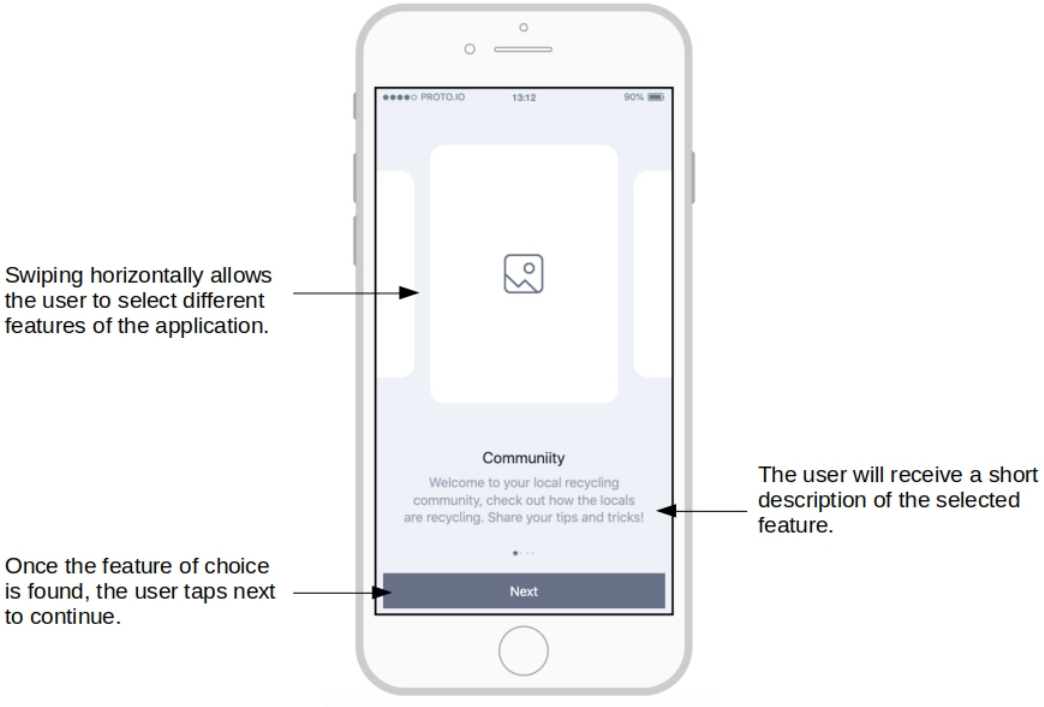

Figure 4.8: The home screen of Prototype B

This prototype has three sections: Community, Blog and Instagram. Once the viewer has logged into the application, they are brought to the home screen, shown in figure 4.8. The user can swipe across, by dragging their finger horizontally, to see the community section, the blog section and the Instagram section. Each section on the home menu has has an image as well as an associated name and short description. Once the user selects the feature they would like to use, the "next" button at the bottom of the screen is pressed in order to use the feature.

4.3.4 Community

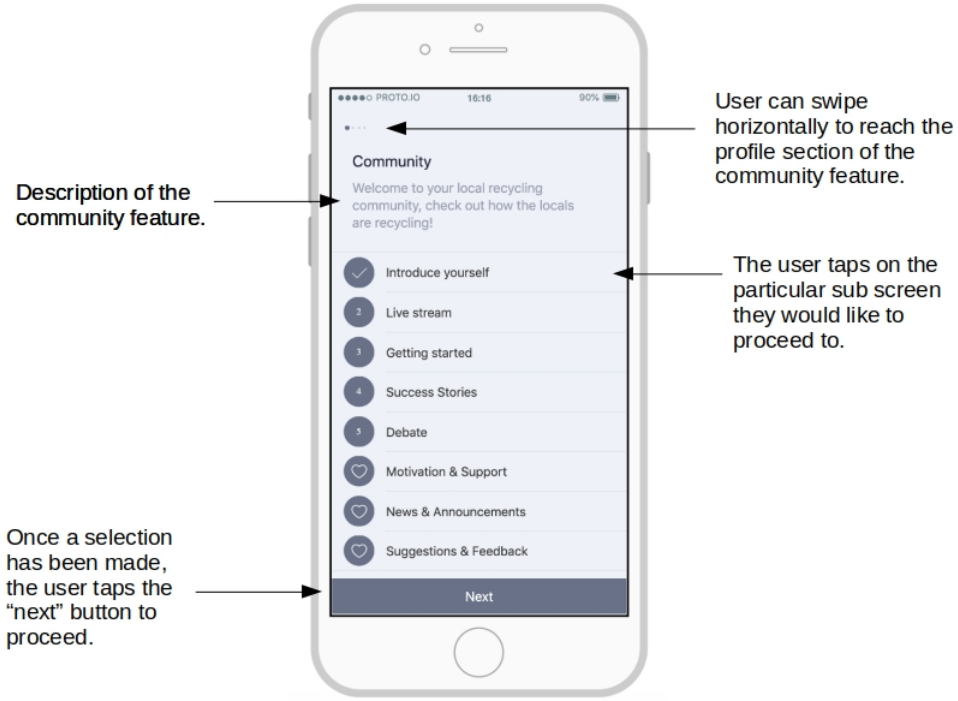

Figure 4.9: The Community forum of Prototype B

Once the user selects the Community feature from the Home screen, they are brought to the Community screen. The Community screen is divided into two sections: Forum and Profile. The Forum section is shown by default and the user can swipe horizontally by dragging their finger across the screen to reach the Profile section. The Forum section allows the users to connect with their local community and see how people in their community are responding to prevent climate change. The user can therefore participate in or organise recycling events within the community. The Community feature allows users to introduce themselves to their local community, to get started with making small differences in their daily lives that contribute to preventing climate change, to read and write success stories about how human effort can make a difference, to participate in debates on environmentalism, to receive motivation and support from the community, to read news and announcements in the community relevant to environmental action and to provide suggestions and feedback. In order to select one of these subsections, the user must tap on the subsection of their choice. The application gives feedback if a selection is tapped, as a tick appears on the left side of the screen (as shown with "Introduce yourself" in figure 4.9). The user must then tap the "next" button to proceed.

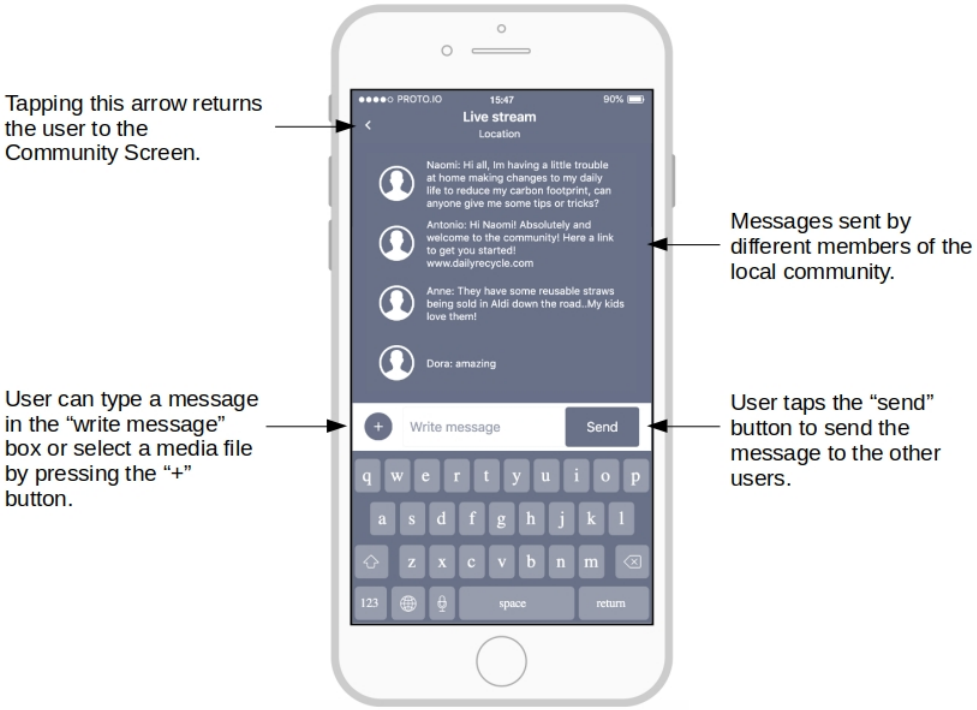

Figure 4.10: The Community forum live stream of Prototype B

By clicking "Live Stream" from the previous section, the user is brought to the live stream of their local community, shown in figure 4.10. This particular community is assigned to the user when they sign up, as they are required to enter their postcode (figure 4.7). The live stream feature allows the user to communicate with their local community through sharing links, files (limited to 5 megabytes) or through an online chat. The user can type their thoughts and questions into the chat and receive responses. There is also an option to follow different chat threads allowing for organisation in conversation interests. The user also has the choice to personalise the intrusiveness of the application by muting the conversation or enabling notifications. The user can return to the previous Community screen by tapping the arrow in the top left corner of the screen.

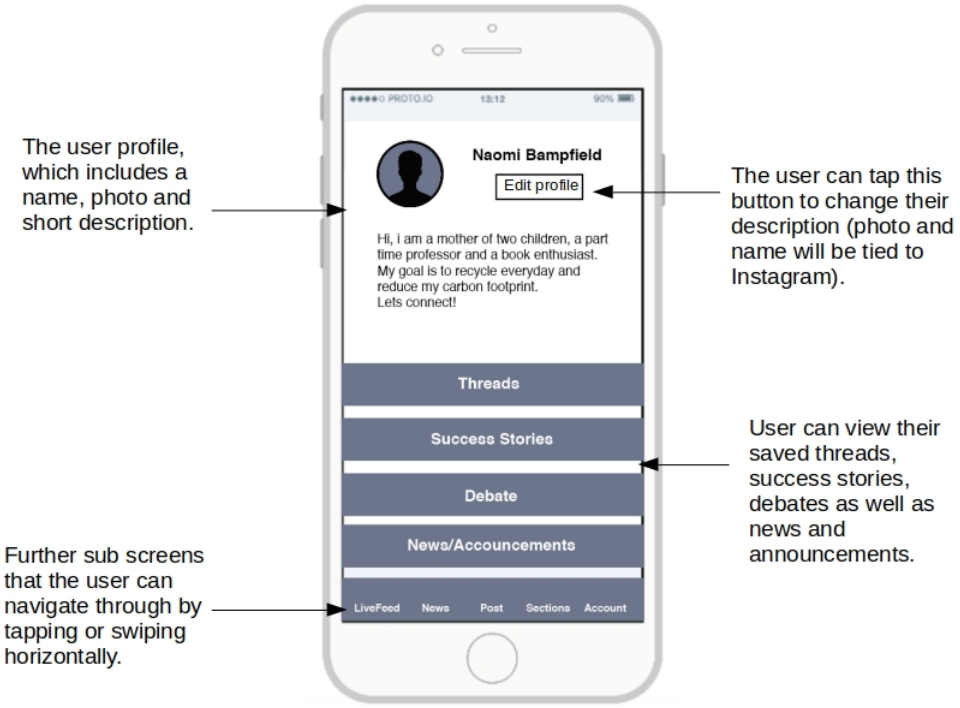

Figure 4.11: The Community profile of Prototype B

By swiping horizontally from the Community forum screen (figure 4.9), the user is brought to the Community Profile screen, shown in figure 4.11. This screen allows the user to view their own profile and their saved articles, threads, success stories, debates, news and announcements as well as events that they discovered while interacting with the Community Forum. At the top of the screen the user will see their name and photo which have been transferred from their Instagram profile, as they used Instagram to log into the application (figure 4.7). The user can write a short description about themselves. This description can be changed any time by tapping the "Edit profile" button, which will bring up the previously inputted text which can then be edited. Users can follow each other and be inspired by each others saved posts and threads. This gives users the choice to read articles immediately or at a later time. It also gives the user the opportunity to make their own online persona to express themselves. A navigation bar at the bottom of the screen is introduced to give the user the opportunity to go to and from the various subsections in the application.

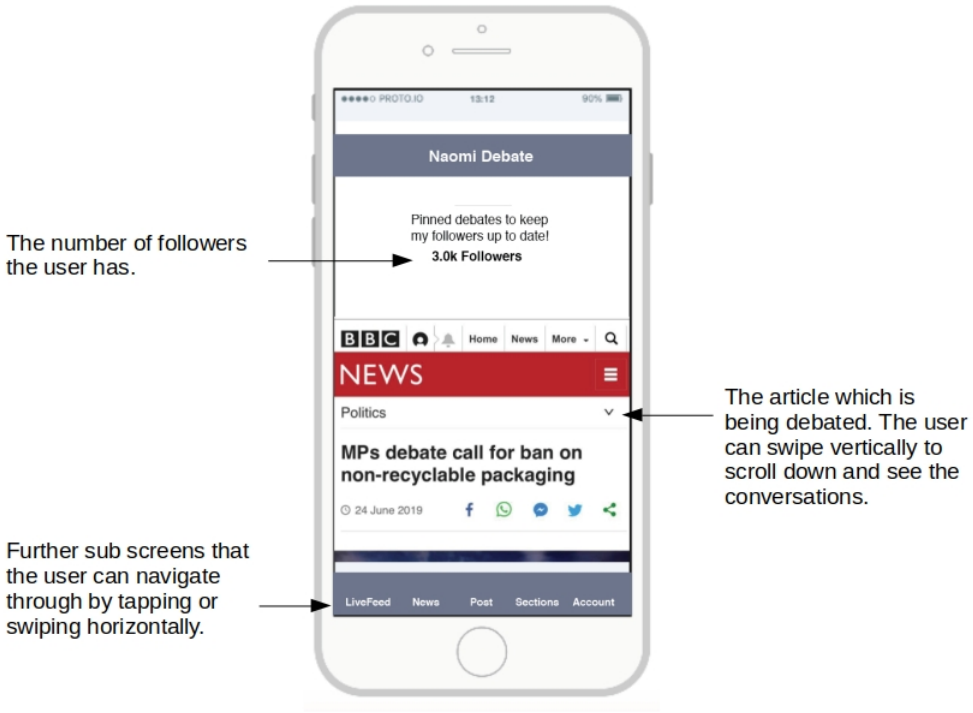

Figure 4.12: The debate screen of Prototype B

The user can navigate to the saved debate screen from the previous Community Profile screen (figure 4.11) by tapping on the "Debate" section. In the saved debate section, shown in figure 4.12, the user will notice at the top of the screen, the number of followers that they have for their saved debates. The user can swipe vertically by dragging their finger across the screen to scroll down and view different debates that they have saved previously. In addition to viewing debates, the user can participate by posting and replying to comments. In figure 4.12, the user has has saved the post named "MPs debate call for ban on non-recyclable packaging". If the user scrolled down, the in-app comments related to this article would be visible. Once again, at bottom of the screen, the user can navigate to other subsections of the Community section of the application.

4.3.5 Blog

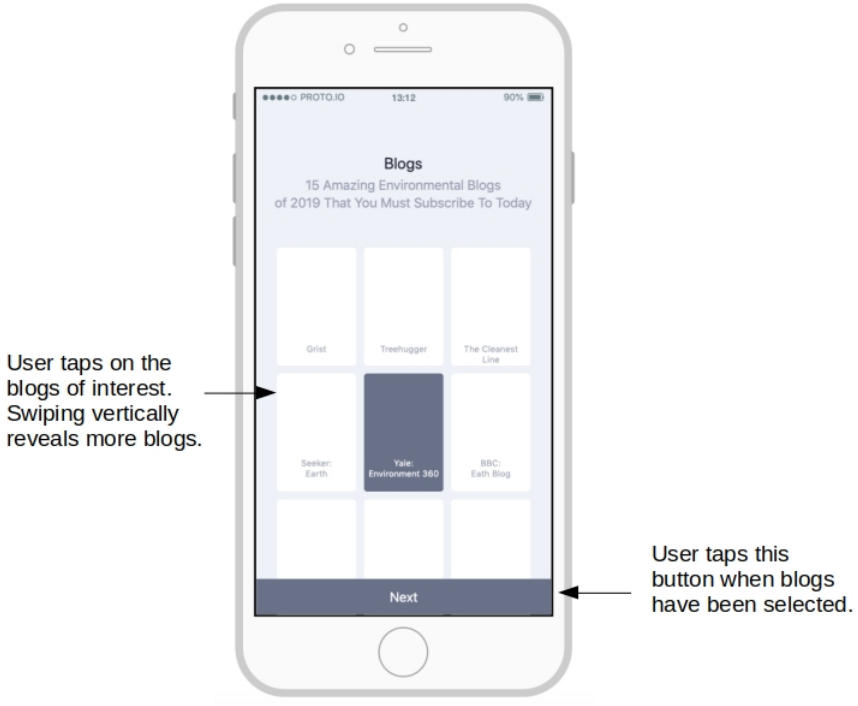

Figure 4.13: The Blog screen of Prototype B

From the Home screen (figure 4.8), the user can swipe horizontally until they see the Blog feature. By tapping "next", the user arrives at the screen shown in figure 4.13. This is the Blog section of the application. The user will see different blogs which might interest them and they will proceed to tap on the ones that do. More blogs will become visible if the user swipes vertically to scroll down the screen. Once the blogs of interest have been selected the user will tap "next" at the bottom of the screen, which will bring them to a simple screen which lists the blogs they have selected. The user can then tap on a particular blog and they will be redirected to the website which the blog is hosted on, opening the default browser of the device and minimising the application.

4.3.6 Instagram

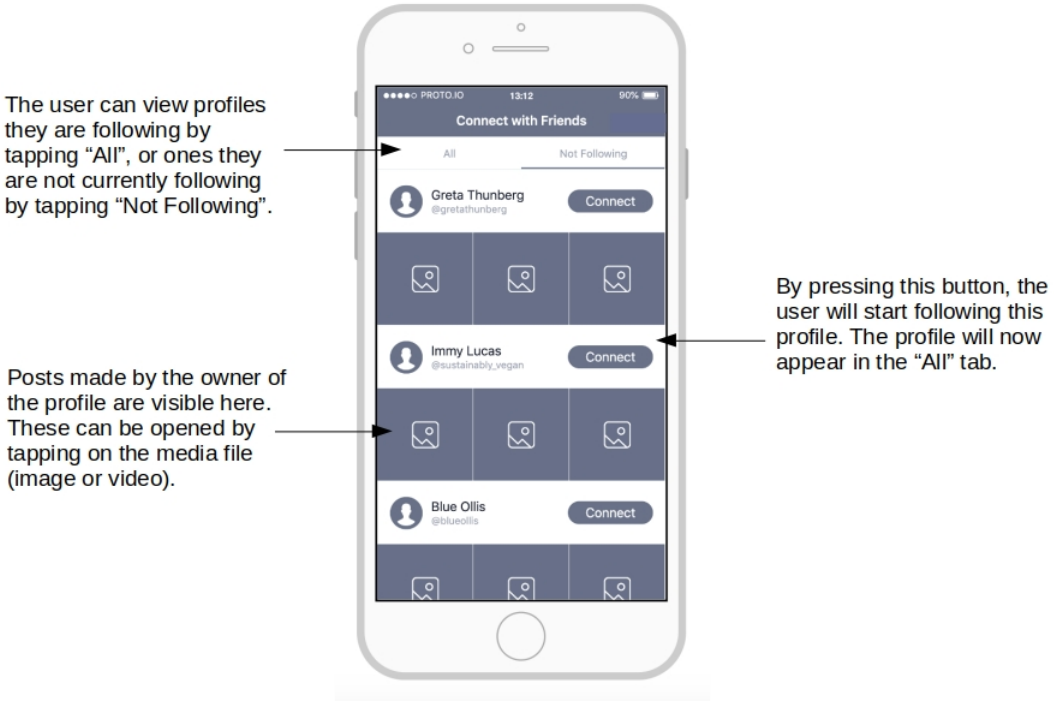

Figure 4.14: The Instagram screen of Prototype B

From the Home screen (figure 4.8), the user can swipe horizontally until they see the Instagram feature. They then have to tap ”next” to arrive at the screen shown in figure 4.14. The user will then see a list of Instagram profiles that belong to environmentalists, along with the posts these individuals have made on the social network platform. These posts can be opened by tapping on a picture or video of interest. Doing this will enlarge the post, and the associated description and comments will be visible. In order to see more posts, the user can swipe a row of picture and videos horizontally. In order to see more profiles, a vertical swipe is required. The user can press the ”connect” button for influencers that post content which is of greatest interest. These profiles will then appear in the ”All” tab, which can be accessed with a simple tap. This allows the user to filter out profiles that they are not interested in.

4.3.7 Heuristic Evaluation

Heuristic	Score	Reasoning
Visibility of system status	1	If the user sends a message in the community group chat (figure 4.10), they will receive feedback from the app, with the message appearing among the messages of other individuals.
Match between system and the real world	0	There are some poor choices of names in the features, for example, "Live Stream" would make young adults think of a video stream, not a group chat. On the other hand, the presence of Instagram integration (figure 4.14) would be familiar to the users.
User control & Freedom in navigating	-1	a navigation bar is present only in some areas of the application (figure 4.11). The prototype makes it mandatory that you need an Instagram to sign in along with a postcode.
Consistency and standards	-1	The main sections of the prototype, Community (figure 4.9), Blog (figure 4.13) and Instagram (figure 4.14) have very different layouts, so the consistency is lacking.
Error prevention	0	User must enter valid Instagram details and a valid post code when signing up (figure 4.7). In the community chat (figure 4.10), the app will inform the user if a media file being uploaded is too large.
Recognition rather than recall	-2	There are a lot of menus to navigate, particularly in the community section (figure 4.9), which could intimidate users. The presence of a profile subsection is not clear and the user might not think to swipe horizontally to reach it.
Flexibility and efficiency of use	-2	Often throughout the app, the user is required to tap on a certain feature, followed by tapping on the "next" button (figure 4.8), reducing efficiency. Each main section (Community, Blog, Instagram) can only be accessed from the Home screen.
Aesthetic and minimalist design	-2	The design is inconsistent throughout the prototype, so users could find this jarring. In addition, there is often a lot of content on a single screen.
Help users recognise, diagnose and recover from errors	-2	This heuristic was not considered for this prototype.
Help and Documentation	-2	This heuristic was not considered for this prototype.

Table 4.3: Heuristic evaluation of Prototype B

4.3.8 Evaluation against Scenarios

Scenario	Score	Reasoning
George 1	0	This prototype would not be able to directly help George learn certain facts about recycling a particular item. However, he could potentially send a message to his local community through the app and ask (figure 4.10), but he might feel that it would require too much effort.
George 2	0	Once again, George has the option of asking his local community through the app, but the prototype does not include an efficient way for George to receive this information, such as through a map.
George 3	2	Using this app would definitely make George feel part of a community of environmentally conscious people. Reading blogs (figure 4.13), following environmentalists on Instagram (figure 4.14) and interacting with his local community would all contribute towards this.
Naomi 1	-2	There are no tracking features in this prototype. While users can make posts, it is unlikely that this will accurately represent recycling habits.
Naomi 2	0	Naomi would not be able to use the application to set goals, however, she would be exposed to people who are environmentally conscious (figure 4.9), which could make recycling something she thinks about more often.
Naomi 3	1	Naomi could make a thread about wanting to organise an event (figure 4.9), and / or post in the community live stream (figure 4.10) about the event However, the prototype does not have a feature which is explicitly for creating events.
Emma 1	-1	Since Emma requires a quick way getting information, this prototype will not be her best option, as it would take time to go through various social media posts and her busy schedule might not afford her that time.
Emma 2	2	Emma could use this prototype read articles, news, blogs, Instagram posts, community discussion and debates to keep up to date with environmental issues.
Emma 3	-2	Emma's children are too young to for online social networks and Emma might have privacy concerns, therefore she would not want her children using this application.

Table 4.4: Evaluation of Prototype B against user scenarios

4.3.9 Conclusive Remarks for Prototype B

Valuable lessons were learned in the design and subsequent evaluation of prototype B. Primarily that social media is a powerful tool which can be applied to solving real world problems users might face. However, it might not be the quickest or most effective way of improving recycling habits and knowledge for individuals.

The persona scenario evaluations showed that users could potentially find the application very useful for certain specific wants relating to working as a community. Despite this it was unclear whether this warranted an application all of its own. It is highly likely that an individual would prefer to simply use Instagram than an embedded version of Instagram available in this prototype.

In terms of taking features from this application for use in further prototypes, it was concluded that integrating a social network into one of the other prototypes would over-complicate them. However, implementation of some limited community related aspects from this app may prove useful for a future prototype.

A lot of the design choices were poor and the evaluation of the prototype showed the importance of having a consistent layout, which would make the users less likely to encounter confusion while using the application. The lack of documentation magnified the issues associated with having an abundance of features. This showed the importance streamlining the features and design of future prototypes.

4.4 Prototype C: Tools to Assist Recycling

4.4.1 Rationale

The final first generation prototype, Prototype C, focuses on on tools that would assist users in the recycling process. This prototype shows an application named "Greenscanner". The tools selected for getting people to recycle more include a barcode scanner which allows the user to scan an item that they would like to recycle (and subsequently providing the user information about how to recycle this item) as well as a map feature which would show the user nearby locations where items of certain types can be recycled. The main feature, the barcode scanner, was inspired by the review of MyFitnessPal, where the scanner is used for a different purpose (obtaining nutritional information on the scanned item), and WeRecycle, where it is used for a similar purpose (identifying recyclables).

4.4.2 Home Screen

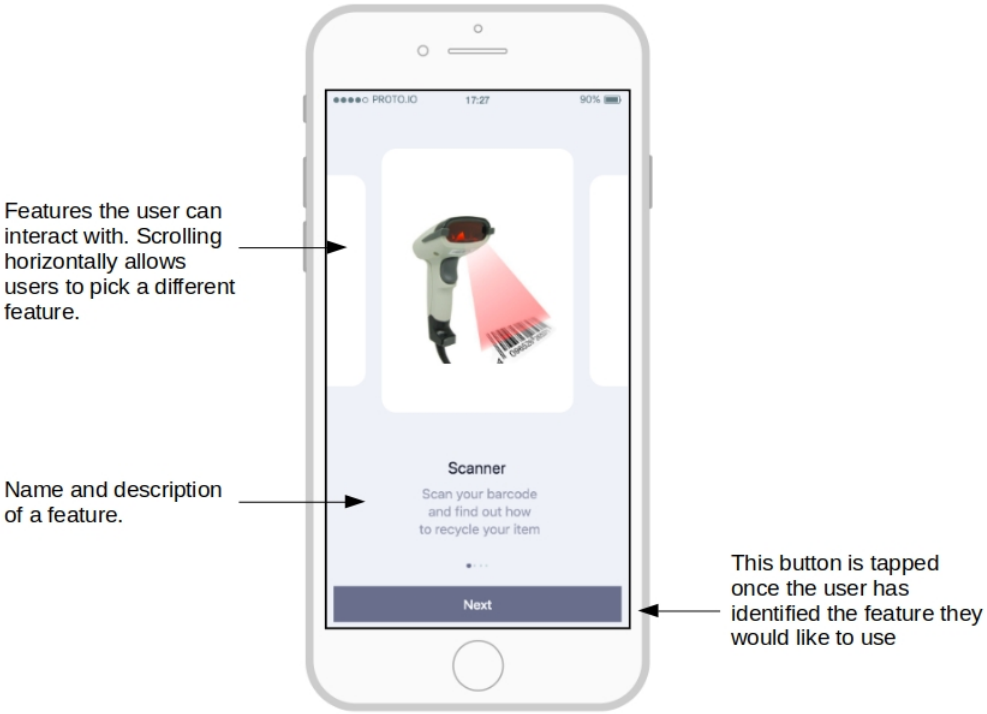

Figure 4.15: The home screen of Prototype C

Figure 4.15 shows the home screen of the prototype, which is what the user will see as soon as they launch the application. There is no sign up screen for this prototype, as there is no interaction with other users. The user can drag their finger horizontally left or right. This will present the user the following options: Scanner, Map and Settings. Each button has a large picture representing the option and a brief description of what each option does underneath. Once the user has swiped to a feature they would like to use, the "next" button is pressed and the user is taken to the appropriate screen. The settings screen simply allows the user to change the language and adjust permissions, such as location, camera and storage, therefore there is no separate figure for this section.

4.4.3 Scanner

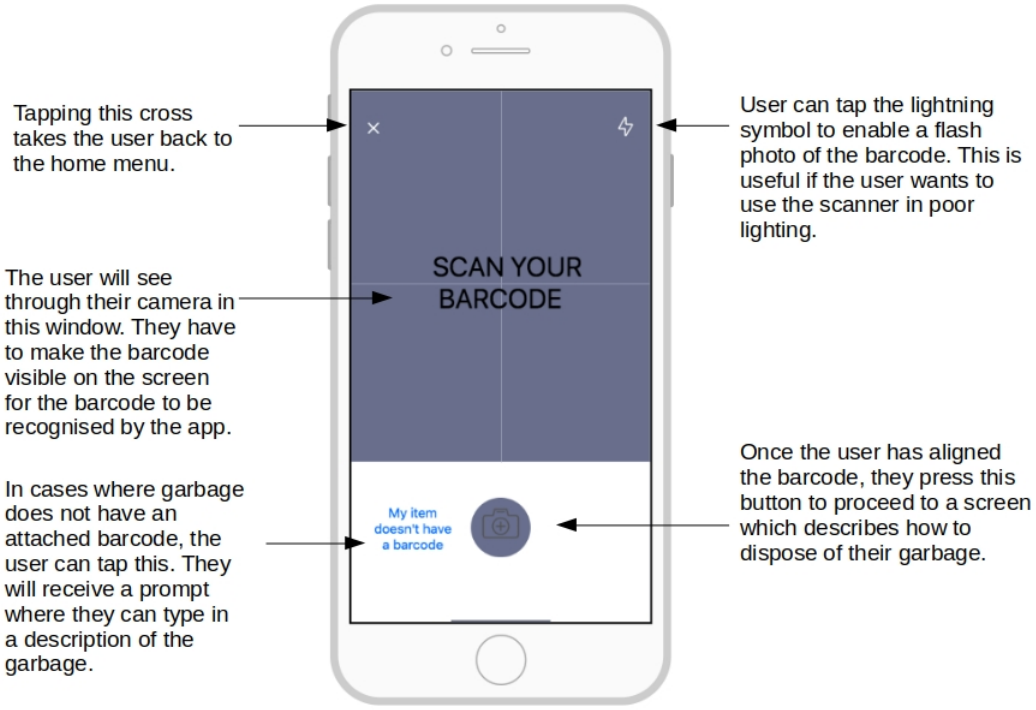

Figure 4.16: The scanner of Prototype C

The scanner feature of this is displayed in figure 4.16 The scanner enables the user to scan a barcode of a product. The barcode must be align so that it is visible on the screen through the camera. A photo of the barcode must be taken (which is only stored temporarily until the barcode is recognised, then subsequently deleted). If the photo was not taken properly, the user will receive an error message which will prompt them to attempt to take the photo once more. If the photo is successful, the user will be taken to a separate screen. Here they will be provided with information on what that product's packaging is made of and how/if those materials can be recycled. The user can follow a link to the map page from here, matching their scanned item to the closest locations where they can dispose their garbage (figures 4.17 and 4.18). If the item does not have a barcode, the user must press on the "My item doesn't have a barcode" text. This will allow the details of the item to be selected from a drop down menu to provide the same information. The drop-down menu is long and can therefore be filtered by typing certain keywords. In order to use the scanner, the user will be prompted with a request from the application to use the camera of the device. The user must accept to proceed with using the scanner itself, however, there is the option for getting information about garbage recycling with using the drop-down menu.

4.4.4 Map

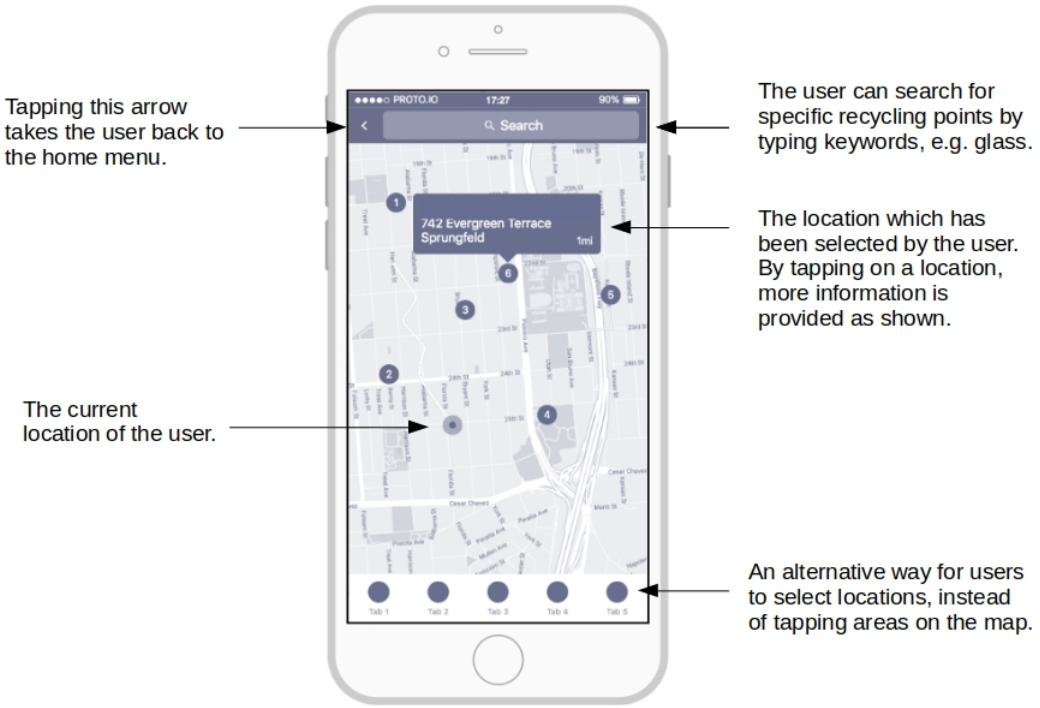

Figure 4.17: The map feature of Prototype C, which shows nearby recycling locations

The map feature is shown in figure 4.17, can be accessed from the home menu, or from the scanner after an item has been scanned. In order to ease the user experience, the user will be prompted with a permission request from the application. If permitted, the application to acquire information about the current location of the user. This page shows the user a map which indicates where the nearest recycling points are and what they can recycle there. The user can use the search bar at the top to type in keywords for a specific type of garbage they may want to recycle. For example, if the user types in clothes, the map will show locations where clothes can be taken for recycling. If the user reaches the map by following a link from the scanner page it will show where their scanned item can be recycled. The map screen allows for users to select locations either by tapping on parts of the map or by tapping through the circular buttons at the bottom of the screen, each of which will highlight the area of the map with the matching number. Once a location is highlighted, a further tap on the highlighted location will give the user directions to the recycling point (figure 4.18).

Directions

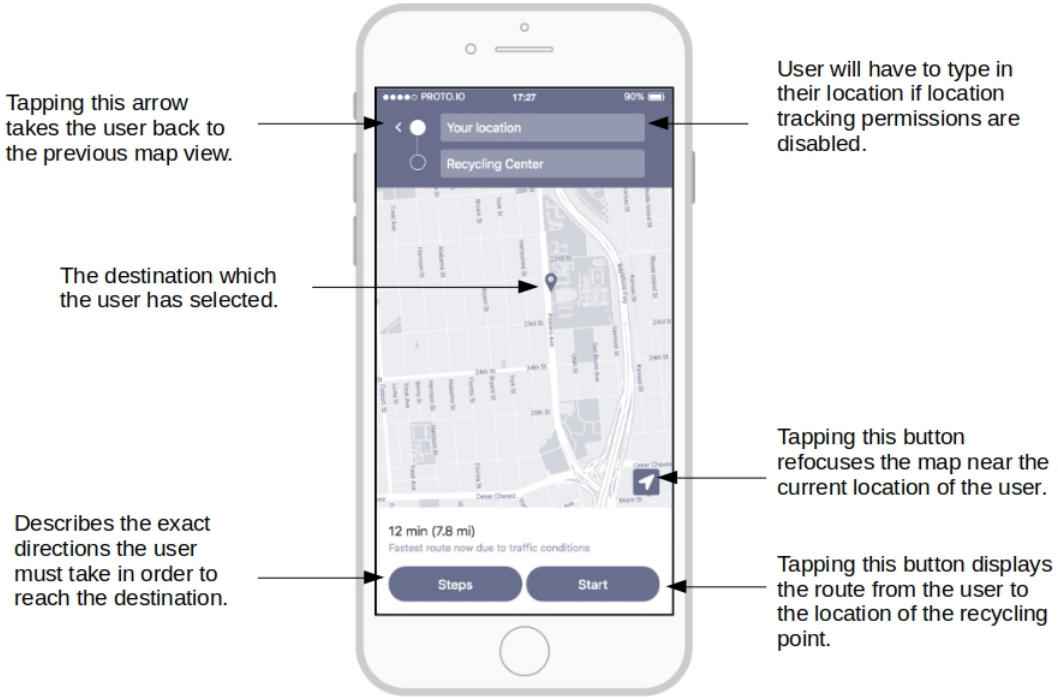

Figure 4.18: The map feature of Prototype C, which shows directions to a recycling location

Based on the previous screen this page, as displayed in figure 4.18, shows the user how to get to the selected recycling point. If the user has enabled permission for the application to know their location, the user simply needs to press start to receive directions. Otherwise, the user must press the bar at the top of the screen and type in their current location. Once the user pressed start, they can swap between different methods of transport including car, bicycle, pubic transport or on foot. By pressing the steps button, the user will see a more detailed description of how to arrive at their destination.

4.4.5 Heuristic Evaluation

Heuristic	Score	Reasoning
Visibility of system status	2	The user is given good feedback from the app. The user can see what they are scanning through the camera (figure 4.16) and directions on the map (figure 4.18) adjust according the current location of the user.
Match between system and the real world	2	The prototype displays recycling guidance with real world recycling symbology and the map features a map that the user will be familiar with from other areas of life.
User control and freedom	2	The user is given the freedom to manually type in a product code rather than using the scanner (figure 4.16), the map can be accessed from the scanner or from the home menu (figure 4.15).
Consistency and standards	-2	The prototype design has inconsistencies such as varied fonts, button sizes and somewhat mismatched layout.
Error prevention	1	The utilisation of the smartphone camera to enable the camera scanner feature of the app has a potential for errors. This is mitigated by the ability to manually input a product code. In addition to this, items without a barcode can also be searched for (figure 4.16).
Recognition rather than recall	2	the Home menu (figure 4.15) shows clear pictures of the features, which will allow users to quickly identify the feature they would like to select. The small number of features reduces the amount of recall necessary.
Flexibility and efficiency of use	-1	The are some unnecessary button taps on both the map and the scanner. The scanner requires the user to take a photo rather than identifying the barcode directly through the camera, creating an extra step and reducing efficiency.
Aesthetic and minimalist design	1	The prototype is mostly minimalist as the application only consist of a few different screens. The map features contains a lot of necessary information which reduces the overall minimalism (figure 4.17).
Help users recognise, diagnose and recover from errors	-1	Some error messages are in place for common issues such as the scanner failing to identify an item however these are not comprehensive or as user-friendly as they could be.
Help and Documentation	-2	This heuristic was not considered for this prototype.

Table 4.5: Heuristic evaluation of Prototype C

4.4.6 Evaluation against Scenarios

Scenario	Score	Reasoning
George 1	2	The app would help George immensely in finding out how to recycle certain items. George could scan an item he would like to recycle and the app could inform him of which bin to use (figure 4.16).
George 2	2	The map feature would show George the closest locations for recycling a certain item. The app would also provide directions to the recycling point (figure 4.18).
George 3	-1	The app does not directly contain any community features, however, the simplicity of the scanner could be something that George's friends would quickly grow to enjoy using. Other people can be introduced to this application very easily.
Naomi 1	-2	The prototype does not contain tracking and community features, therefore Naomi would not be able to use the app for this purpose.
Naomi 2	-1	Naomi has good recycling knowledge, so the scanner may not be particularly useful to her, but the map feature might show Naomi convenient locations for recycling which could improve her habits (as she currently does not have good access to recycling facilities).
Naomi 3	0	Naomi would not be able to organise events using the features found in this prototype, however the app could be very useful during such an event, as people lacking knowledge of recycling could use the scanner to identify how to dispose of the litter correctly.
Emma 1	2	Emma would find the scanner very convenient for working out how to recycle items in a fast and efficient manner. She would also be able to use the map for identifying recycling locations in unfamiliar areas if she goes on business trips.
Emma 2	-2	The prototype does not contain features which could help Emma keep up with current environmental news.
Emma 3	2	Emma would be happy to let her children use the scanner, and the children would most likely find this feature very fun and informative, which could help them develop a good knowledge of recycling at a young age.

Table 4.6: Evaluation of Prototype C against user scenarios

4.4.7 Conclusive Remarks for Prototype C

Evaluation of this prototype has shown that it could potentially be used in many of the user scenarios. This is mainly due to the simplicity of the application and its effectiveness in tackling significant reasons why young adults do not recycle: lack of knowledge and lack of confidence in recycling (solved with the scanner) as well as a lack of immediate access (solved with the map).

The features in this prototype create a good starting point for a future prototype to build upon, as it contains useful functionality but does not particularly entice long term use. The prototype could be improved by adding some of the features of primarily prototype A, which could help in making the user develop habits for recycling, as they would be able to track their recycling and further their sense of accomplishment.

The design of the prototype is quite minimalist and there are not many screens to navigate through, however, there are improvements to be made. The application could being made more visually appealing by adding greater consistency to the design and the user experience could be improved by including help and documentation.

4.5 Conclusive Remarks

As outlined in the design process we produced three prototypes using proto.io since it allowed us to create the type of professional designs we felt the user cases would expect and appreciate the clarity of. This resulted in three prototypes designs with overall clear and readable features however some improvements were identified due to the subsequent analysis of the three designs.

The usability of each prototype was found to have some key areas which could be improved. Prototype A (Gamification) the user was never more than one click away from the home screen where all other parts of the app could be accessed. In Prototype C (Tools to Assist Recycling) if the user was on the second step of the maps screen (figure 4.18) they would be two clicks away from the home screen and could be a further swipe from whichever part of the app they sought to access next. This is a lesson which can be taken into account when making the second generation prototype where each screen should be accessible at the touch of a button.

All three prototypes were lacking in comprehensive error prevention, error recovery and documentation. Some error messages were in place for more obvious limitations such as in Prototype C's scanner when an item did not have a bar-code, as seen in figure 4.16 and sign-up errors in Prototype A whereby a user would see an error message if they provided a invalid e-mail address for example. This heuristic was not considered for Prototype B as explained in it's evaluation. Help and documentation heuristics in particular will receive greater attention and will be woven into the design process for the second generation prototype.

The three prototypes have provided information about how the different approaches fare in solving the problems posed by the user scenarios. The limited features in prototype A made it a relatively poor choice on it's own, particularly in terms of immediately telling individuals how to recycle a specific item. The community section of prototype B was able to successfully tackle a few of the user scenarios, however, the prototype overall was overly complex and faced too many design issues. Prototype C has a scanner for packaging, which could help a lot of users identify how to recycle particular waste, as well as a map, which could show users locations for recycling if they do not have immediate access to these facilities. These features make prototype C a good starting point to build upon.

The lessons learned from evaluating the advantages and drawbacks of each of these three prototypes led to a decision on how a second generation prototype should be developed. A decision was made to develop a new prototype which is centred around the scanner feature of prototype C since it provided a viable solution to one of a the key issues facing our carefully selected user cases. As well as this we decided that the map feature will be an appropriate extra feature since if designed with the lessons we have learned in mind it can link seamlessly from scanned items. Furthermore, these central features will be supplemented by the inclusion of gamification techniques used in prototype A, as those will be simple to tie in without bloating the application.

Some features from the prototypes were shown to be effective and useful for tackling user issues but nevertheless will not be included in the second generation prototype. The ratio-

nale for this decision was that the second generation prototype should have a clear focus where each and every part leads on from and adds to the overall user experience. Overloading the app with too many features of potentially low relevance was determined to be a mistake which we should avoid moving forward. As a result, features of prototype B will not be considered in the second generation prototype, as these features would require an entirely different approach which does not seem feasible. Although these features will not be included this does not mean that we would not consider finding a suitable path to including these features in another iteration of the app.

Chapter 5

Second Generation Prototype

Gathering information from the literature review, existing systems, personas and first generation prototypes, we have combined the aspects that were deemed to be the most necessary in changing human recycling behaviour and that would produce the best user experience into our second generation prototype, the application GreenScanner. The intention was to have the prototype provide a design that can help more people recycle by making the recycling process more accessible to its users. We considered user personas throughout the design and, as a result, have centred our design around solving their problems. Our goal was to target the issue of recycling using specific approaches relative to the relevant literature. The focus on our application, GreenScanner, is primarily centred on tools that assist in the recycling process, gamification rewards systems and connecting and competing with friends - aspects that were concluded to be the most effective from evaluation of the first generation prototypes.

5.1 Design Process

A variety of tools were considered for the design of the second generation prototype. This includes hand drawn illustrations, LibreOffice Impress, Balsamiq, Proto.io, Adobe Suite Illustrator and Adobe Suite Photoshop. For hand-drawn prototyping, we discovered the accessibility and convenience of drawing our ideas by hand. Drawing our prototypes on paper was done naturally throughout our design process and it allowed for a very quick representation of ideas. As a result, the second generation screens were initially hand-drawn as a starting point. However, we felt that it might not be as visually stimulating or realistic to the user to have our second generation prototype be represented by hand drawing rather than to digital software.

LibreOffice Impress was considered for prototyping, but due to limitations in its design tools and that fact that it is primarily suited for creating slides for presentations rather than prototyping, it was not selected as the main software used for creating the screens of the application. Instead, it was selected as a tool for annotation, as it allowed an efficient way of inserting text and objects onto images of finished screens.

Balsamiq mockups is a free prototyping software that provides a combination of digital and hand drawn templates on creation of applications. This software is quick and highly accessible, and for this reason it was also considered during the creation of the first generation prototypes. However we felt that it was limiting in professionalism and the

potential designs did not accurately represent the ideas for the application. In addition, using Balsamiq would've resulted in designs that are of a lower fidelity than those in the first generation prototype.

Proto.io is a software that is not free. A user is allowed 15 days of access until subscriptions are implemented. The software provides realistic icons which give a digital feel to viewing the application. This software was successful in creating our first generation prototypes, however we found that on interacting with the software, it was difficult to select the areas of the application we wanted to edit. We felt it was the strongest software out of the options available however on discovering professional UX/UI designer application portfolios, we realised that many designer use professional software such as the Adobe Suite to create the design of their application. This gives the user a more creative range in what can be inserted into the application allowing for a unique brand identity of the product to be formed. This also contributes to the feeling the person who is interacting with the applications feel, it provides a successful user flow as this professional layout is familiar. As a result, Adobe Suite Illustrator, Adobe Suite Photoshop were used for designing the prototype screens and LibreOffice Impress was used to annotate these designs.
The second generation prototype screens are shown and described in the next sections. An evaluation is done to assess the prototype and to identify weaknesses. The details of the assessment criteria and the reasoning behind the selection of the particular evaluation methods are discussed in the evaluation section.

5.2 Greenscanner

5.2.1 Login

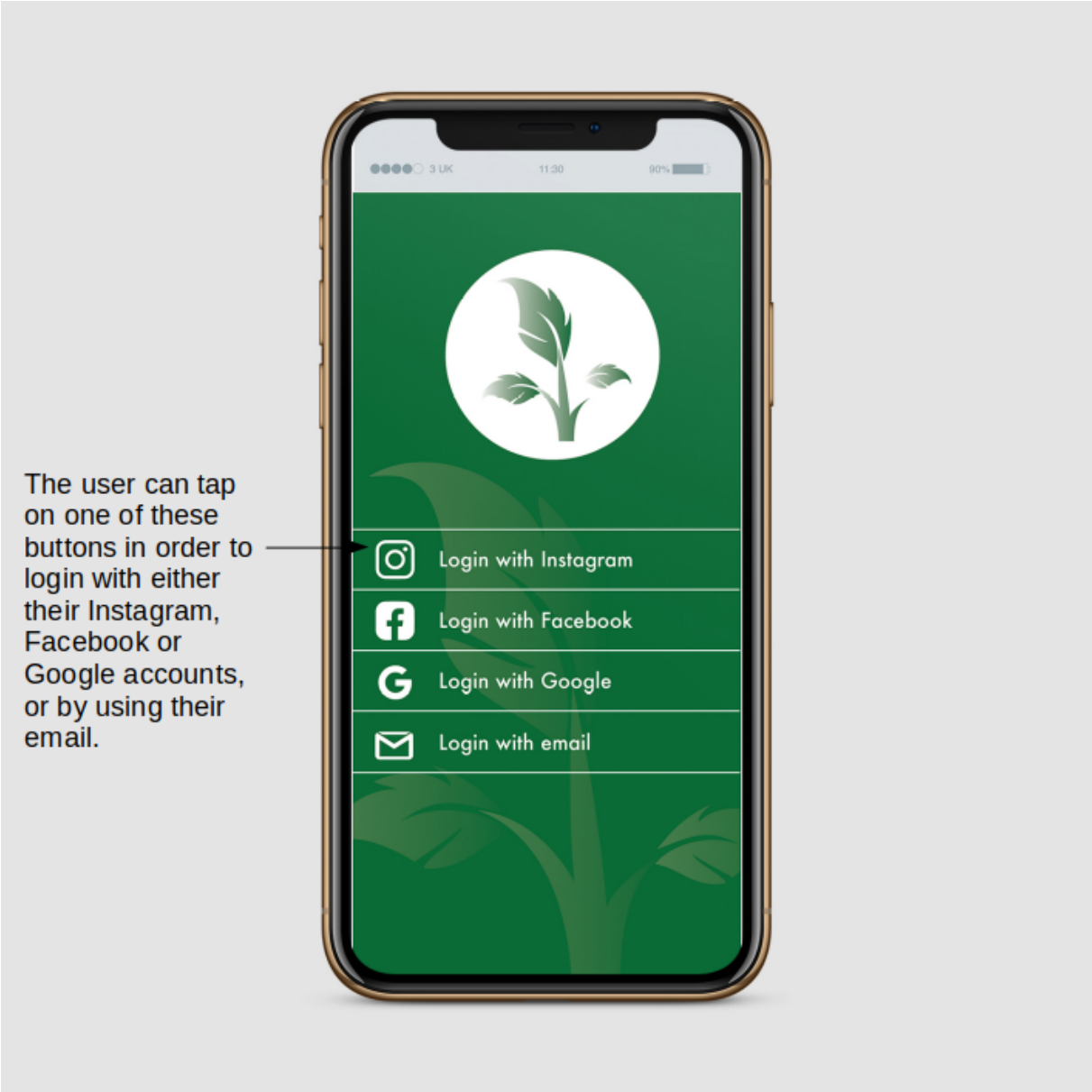

Figure 5.1: Login screen of the second generation prototype

When a user opens the app for the first time, they will be greeted by the Login screen shown in figure 5.1. From here they will have the choice between logging in via Instagram, Facebook, Google, and their personal email. The user presses one of these choices and they are taken to a screen where they have to input their details. For example, if the user selects "Login with Instagram", they will be taken to a screen which requires them to input their phone number, username or email address associated with their Instagram account, followed by the relevant password. The user will be informed with a message below the login details if the details provided were incorrect. On subsequent logins using the same device, the user will no longer see this screen, as their details will be remembered.

Instead, the application will launch and they will be brought to the Tree screen (figure 5.2).

5.2.2 Tree

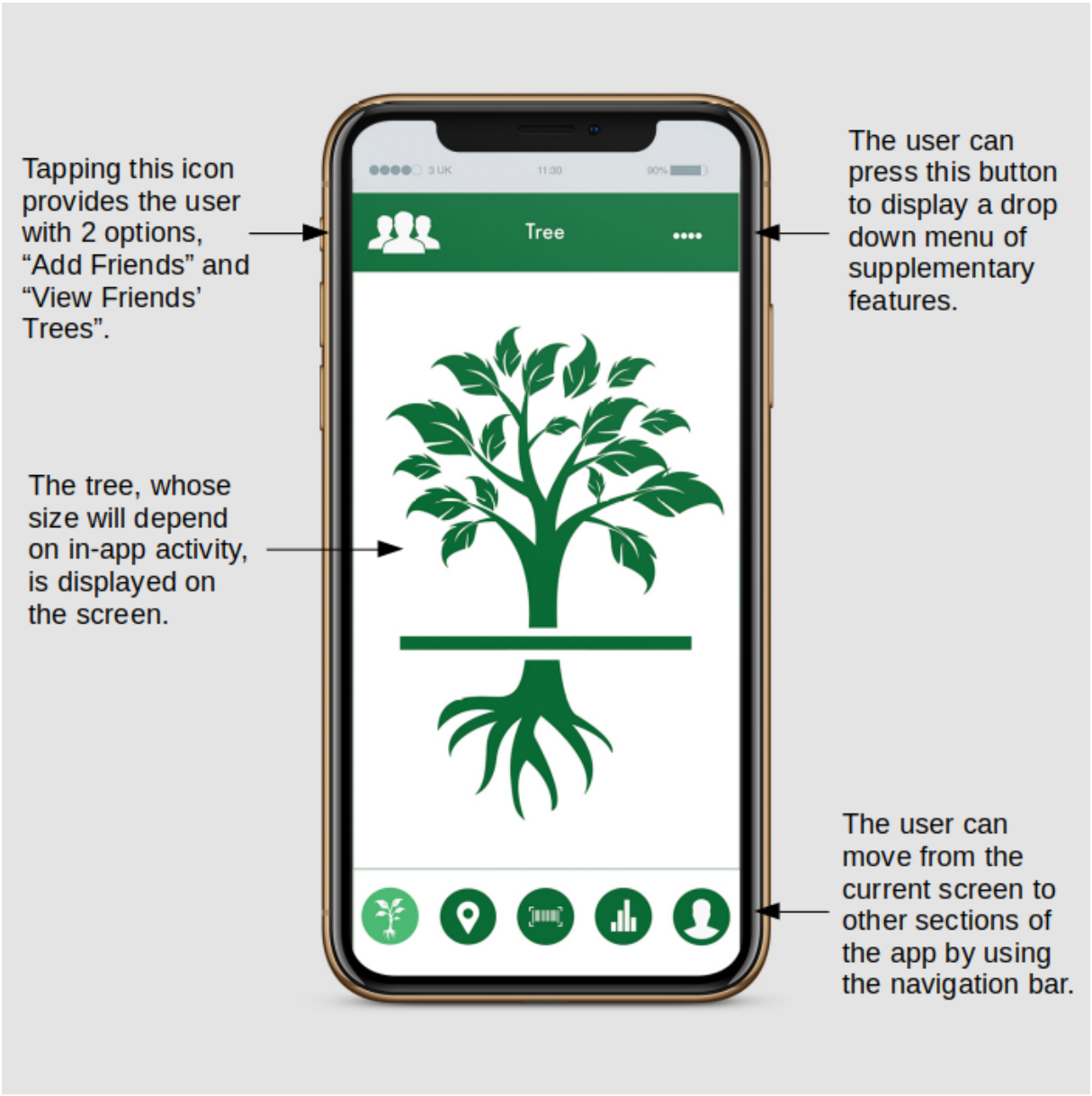

Figure 5.2: Tree screen of the second generation prototype

After logging in, the user will arrive at the home screen, which in this application is called the Tree screen, shown in figure 5.2. In the centre of the screen, a tree is displayed, whose size and healthiness depends on the user's recycling performance. The user logs their recycling in the progress section (figure 5.10), which can be accessed by tapping the bar chart icon in the navigation bar.

By tapping on the icon in the top left corner, the user can add friends, by searching for their email (which could be linked to their Instagram, Facebook or Google accounts).

Once the user has added some friends, they are able to select "View Friends' Trees", which allows them to select a particular friend and see how their tree currently looks.

On the top right of the screen, the user can tap the four dot icon to reveal a drop down menu which allows them to change the appearance of the tree, e.g. pine or willow (size and healthiness remain the same). The other option in the drop down menu is "Help", which the user can press to read the documentation on the current screen, explaining how the Tree feature works.

The navigation bar at the bottom of the screen can be used to move to different main sections of the app, each represented by an icon. An alternative to this is for a user to swipe the screen horizontally, which will change the screen. For example, if the user is on the Tree screen and they swipe from right to left, the will move to the map screen.

Figure 5.3: Tree screen of the second generation prototype

Figure 5.3 shows the progression of Tree screen as the user continues to use the application. The screen on the left is what the tree would look like early on in the usage of the software. The user would develop their tree into what is seen in screen on the right with a few weeks of consistent recycling. If the user's recycling habits deteriorate, so will the appearance of the tree, as it will start to lose leaves.

5.2.3 Scanner

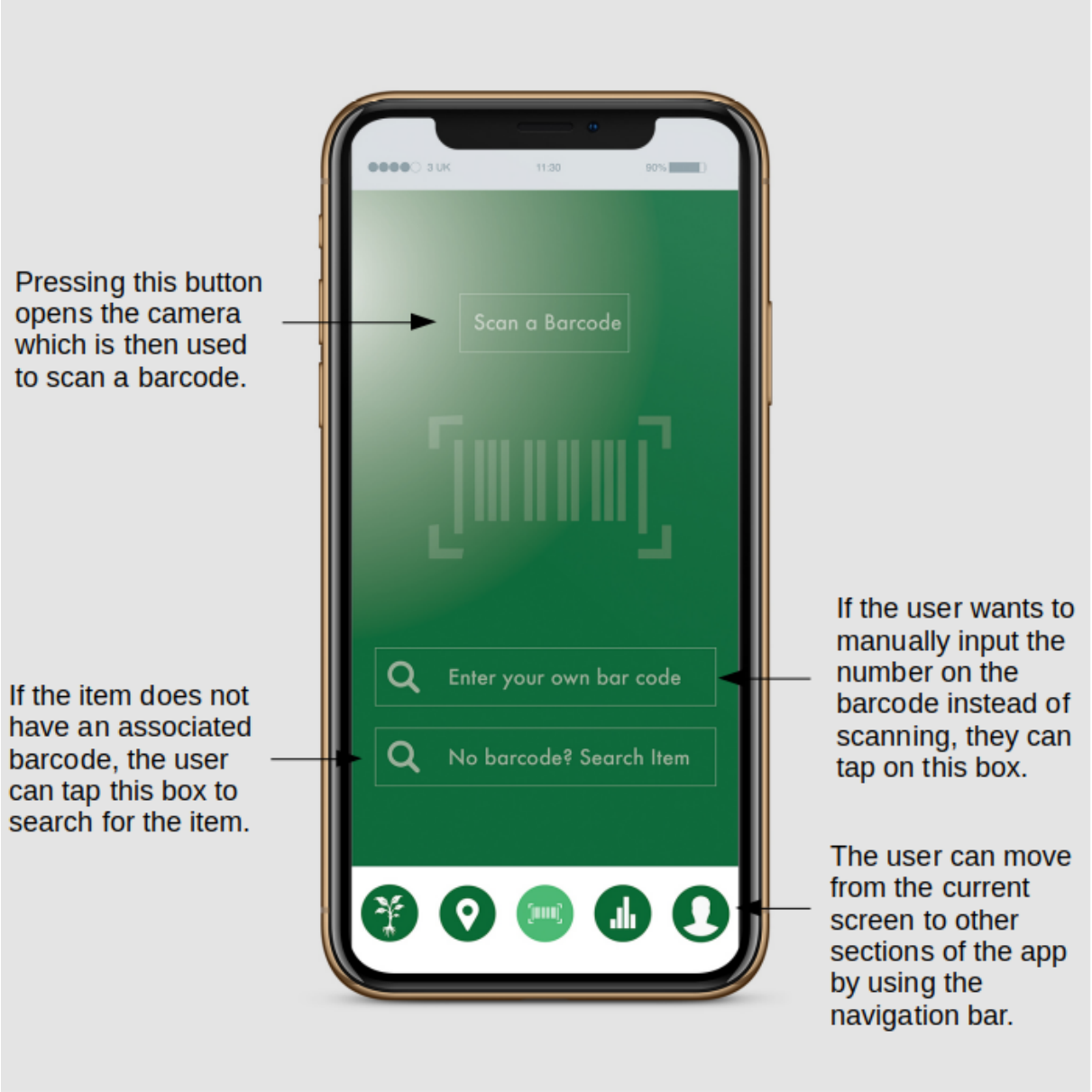

Figure 5.4: Main scanner screen of the second generation prototype

Pressing the barcode icon on the navigation bar at the bottom of the screen brings the user to the Scanner feature (figure 5.4). Here the user has a few options for identifying the item they would like to recycle. By tapping the "Scan a Barcode" button, the device camera will open (first in-app use of the camera will require permitting the application to use the camera). The camera can then be used to detect the barcode (demonstrated in figure 5.5). Another option is to simply type in the number associated with the barcode by tapping on the "Enter your own barcode" box. This will bring up the keyboard of the device, which will be set to showing numbers rather than letters as that is what the user will have to input. For items that do not have an associated barcode, the user can press the "No barcode? Search item" box, where they will be able to type in keywords which describe what they are trying to recycle. These keywords filter out items in the database and return a potential match for what the user is describing. The default keyboard is

used in this case, as the user will be typing words.

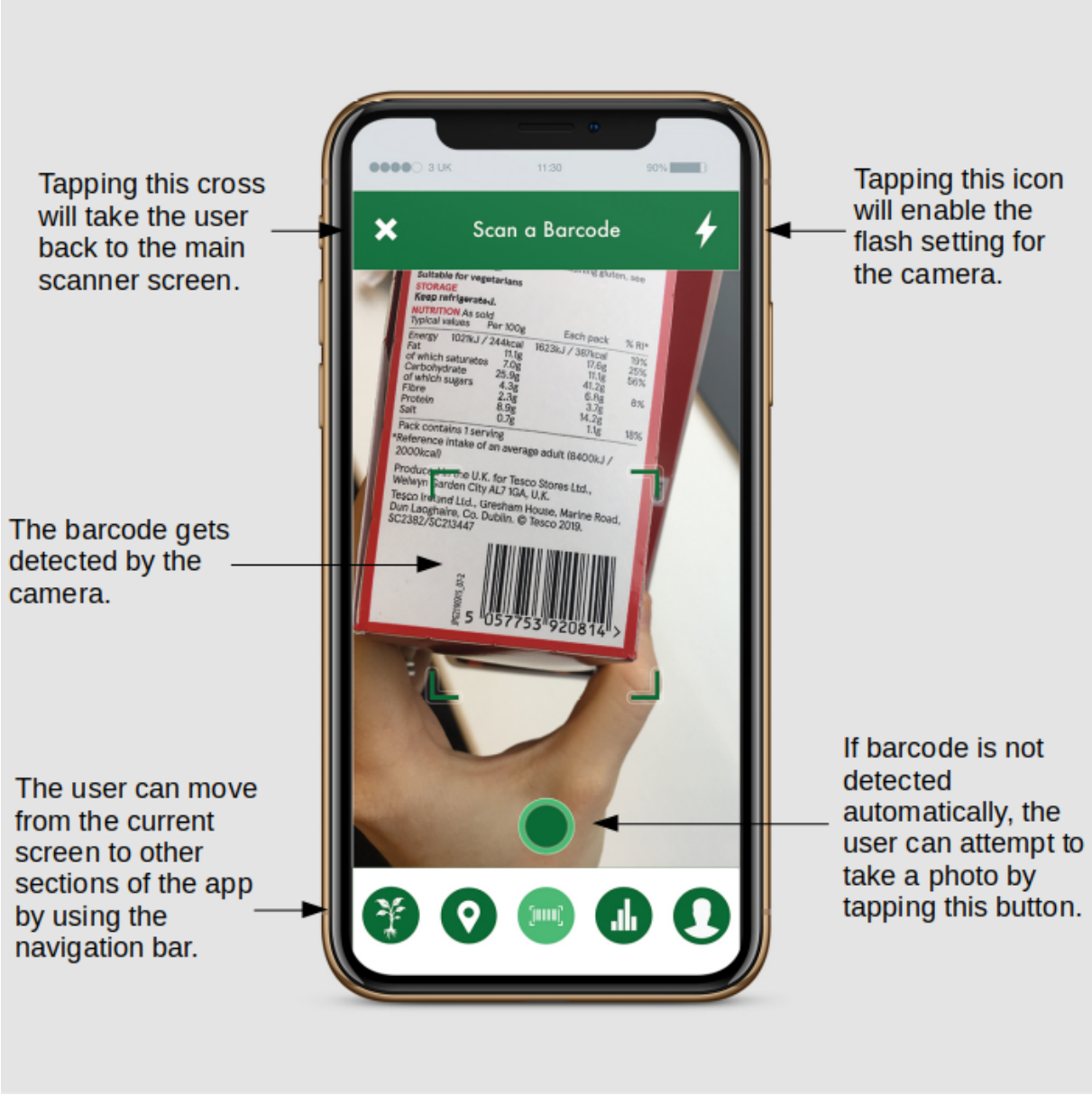

Figure 5.5: Scanner screen of the second generation prototype

Pressing the "Scan a Barcode" button on the previous screen brings up the screen shown in figure 5.5. The user will be able to see what their camera is showing on the screen. By focusing the camera on the barcode, the application will automatically detect it and take the user to the scan information screen (figure 5.6). If the camera does not detect the barcode automatically, this is most likely due to poor lighting. In this case, the user would tap the icon on the right corner of the screen to enable the camera flash setting and subsequently press the green button at the bottom of the camera display to take a photo of the scan using the flash. If this is unsuccesful, the user can type in the barcode manually from the main scanner screen (figure 5.4). They can return to this screen by tapping the cross in the top left corner of the screen.

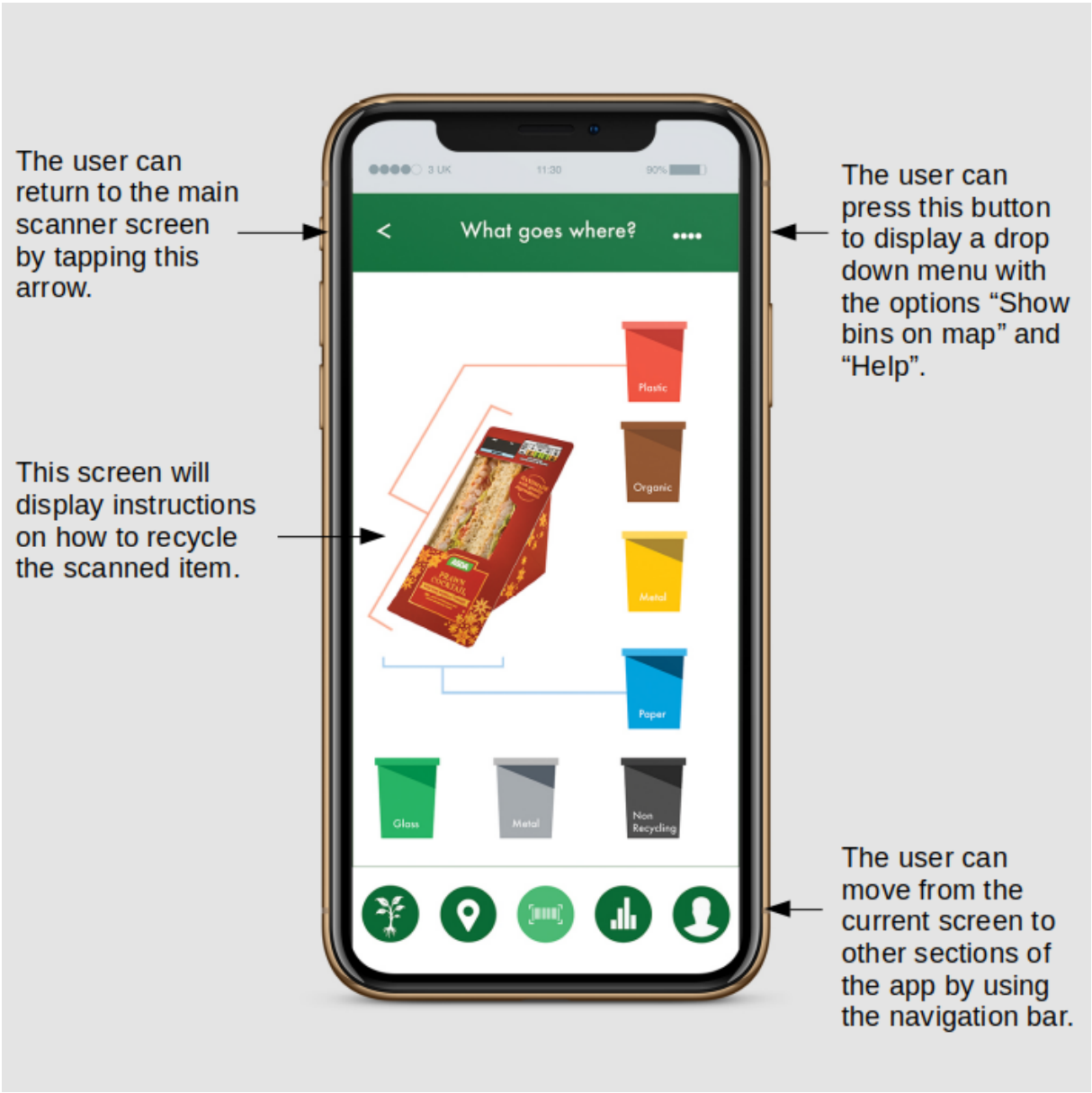

Figure 5.6: Scan information screen of the second generation prototype

After the item to be recycled has been identified by scanning or manual input, the scan information is displayed, as shown in figure 5.6. The application shows which bins the components of the scanned item are supposed to be placed into. The user can tap on the top right corner of the screen (the four dots) to bring up a drop down menu which consists of ”Show bins on map” and ”Help”. The latter documents what is shown on the screen in case the user is confused by the display. The former lets the user select which bins they would like to see the locations of on the map of their local area (the bin selection is shown in figure 5.8). The user can return to the main scanner screen (figure 5.4) by tapping the arrow in the top left corner of the screen.

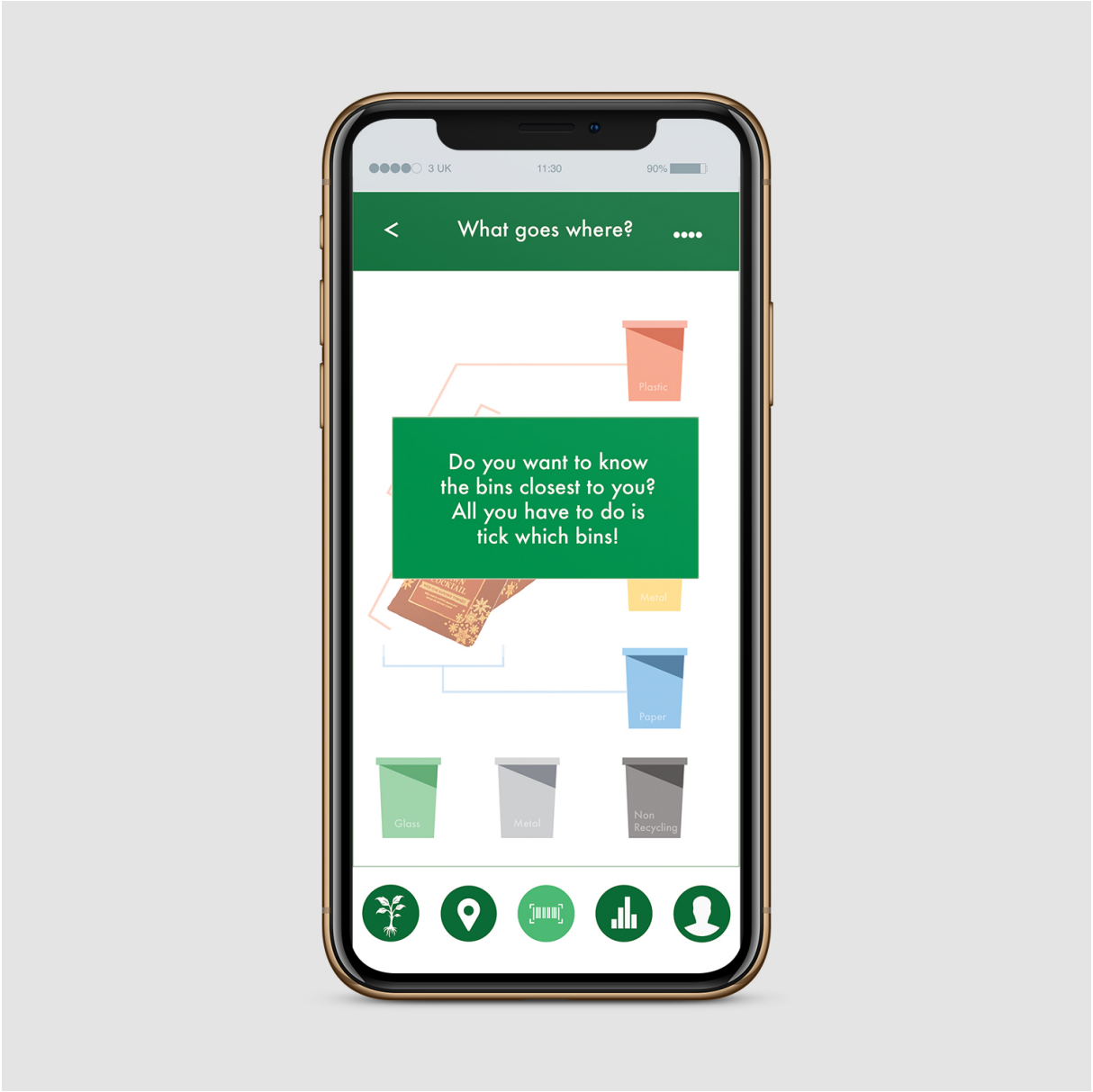

Figure 5.7: Scan information pop-up of the second generation prototype

The first time the user selects "Show bins on map", as described under figure 5.6, a pop-up message will appear, which explains what has to be done to proceed. To acknowledge this message as read and to proceed to the selection of the bins, the user simply taps anywhere on the screen and the pop-up message will disappear.

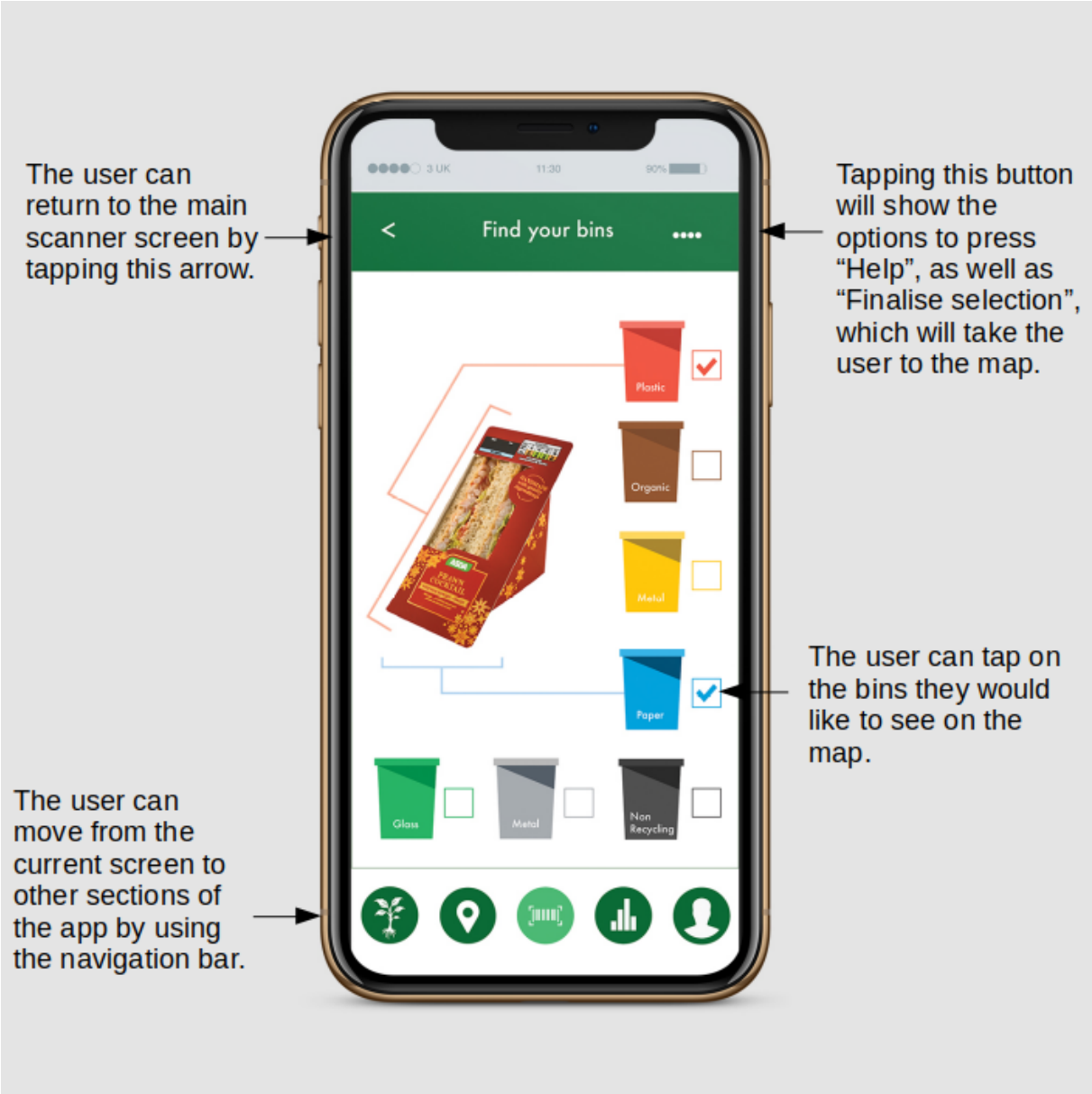

Figure 5.8: Scan information screen of the second generation prototype

After pressing "Show bins on map" the user arrives at the screen shown in figure 5.8. They then tap on the bins that they would like to see on the map, which will show the closest bins to their current location. Once the bins are selected, the user taps the four dot icon in the top right corner of the screen, which will show the drop down menu with the options "Help" and "Finalise selection". By pressing the latter, the user will be taken to the map screen (figure 5.9). By pressing the former, information about what is currently shown on the screen will be displayed.

The user is not limited to selecting the bins that are relevant to the item they have scanned. They can also tap the arrow in the top left corner to return to the main scanner screen at any point (figure 5.4), or use the navigation bar, to move to a different section in the application.

5.2.4 Map

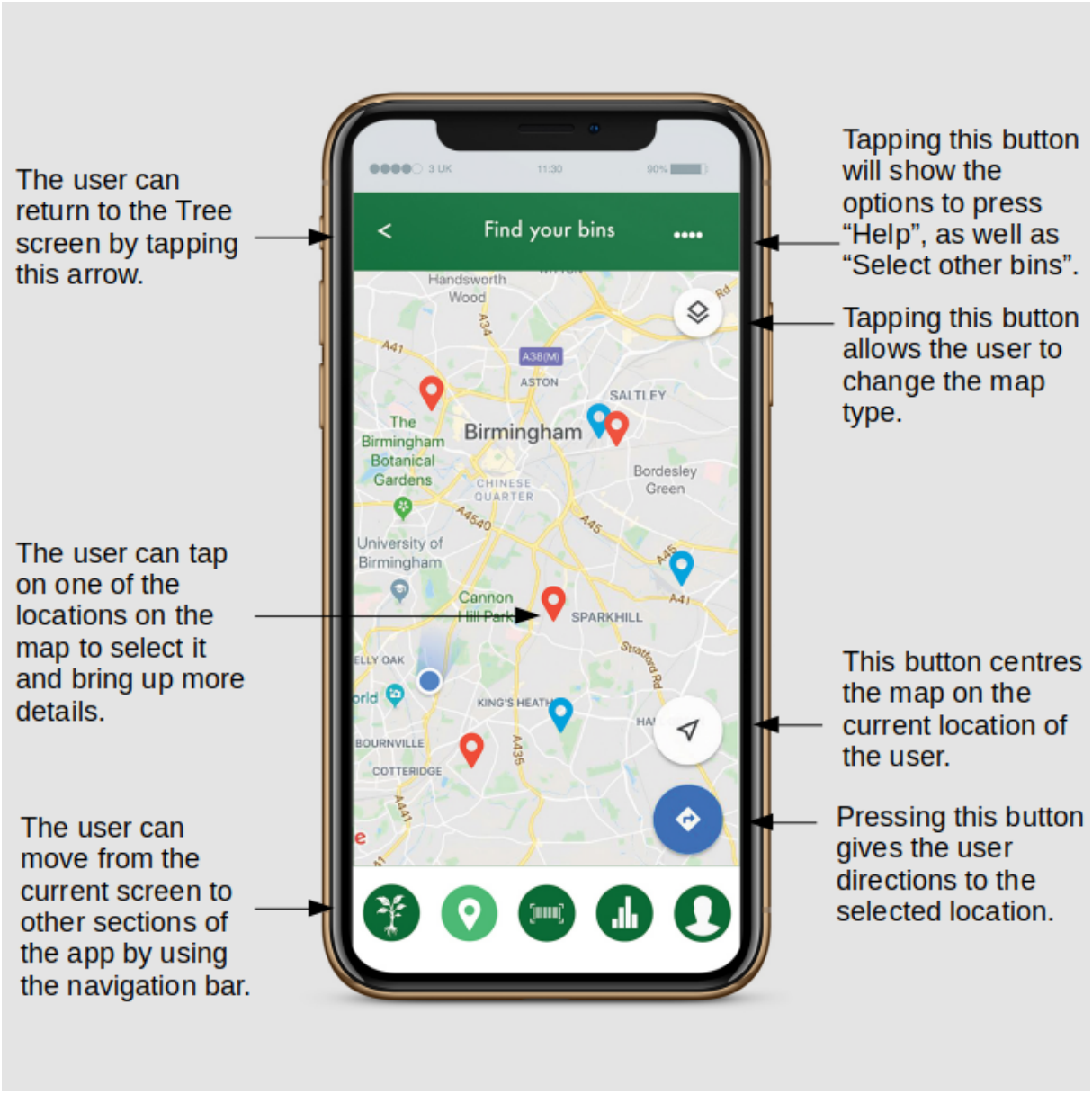

Figure 5.9: Map screen of the second generation prototype

The map screen, shown in figure 5.9, can be accessed anytime from the navigation bar at the bottom of the screen. It can also be accessed from the information screen of scan (figure 5.8), once bins have been selected. By tapping on a particular location, more details are shown, such as the opening times and phone number a given recycling centre. The user can press the four dot icon in the top right corner of the screen to select the "Help" option, which is the documentation of the map page, as well as "Select other bins" where the user can filter the type of recycling service they are searching for (similarly to figure 5.8).

Additionally, the user can select whether they want to see the default, satellite or terrain version of the map by pressing the icon on top right of the map. They can use the arrow at the bottom of the map to centre the view on their current location, or the blue directions

icon just below it to see detailed directions to their selected recycling centre alongside an estimation of the time it will take to travel there by car, public transport, bicycle or on foot.

5.2.5 Progress

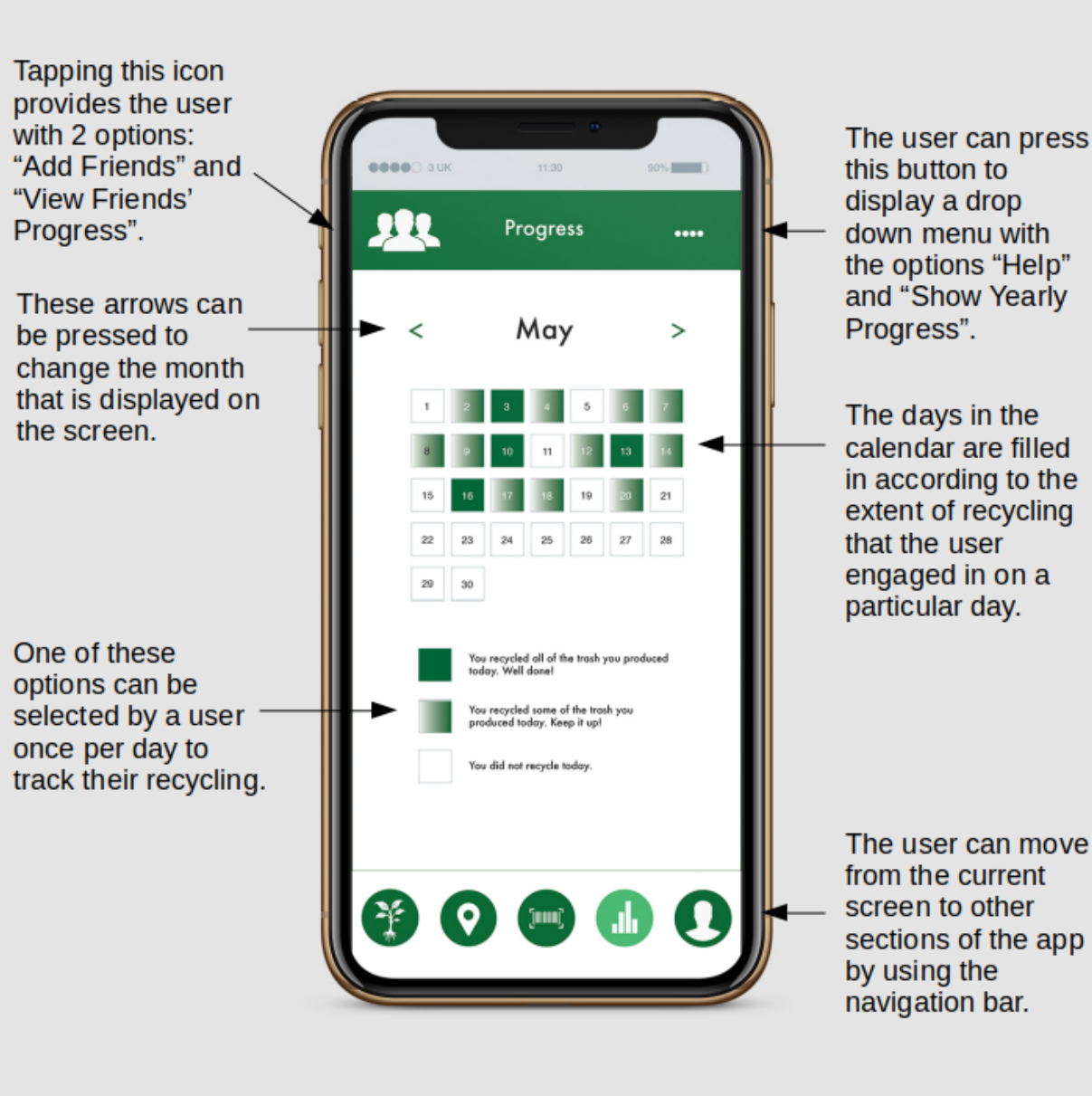

Figure 5.10: Monthly progress screen of the second generation prototype

In the Progress screen, shown in figure 5.10, which can be accessed any time for the navigation bar, the user can select whether they recycled all of their recyclables, some of their recyclables, or none of their recyclables by tapping on the appropriate button. This is limited to once a day, and the selection will be reflected in the calendar. The user can also navigate between months to see past recycling habits.

Similarly to the Tree screen (figure 5.2), the user has the option to add friends by tapping

on the icon in the top left corner of the screen. If the user has friends, they will also be able to view their progress in the same way they view their own. The icon in the top right corner of the screen provides a drop down menu with the options "Help", which provides a description on how to navigate the current screen, as well as "Show Yearly Progress", which, when tapped, takes the user to the yearly progress screen (figure 5.11). Alternatively, the user can reach that screen by swiping the screen horizontally.

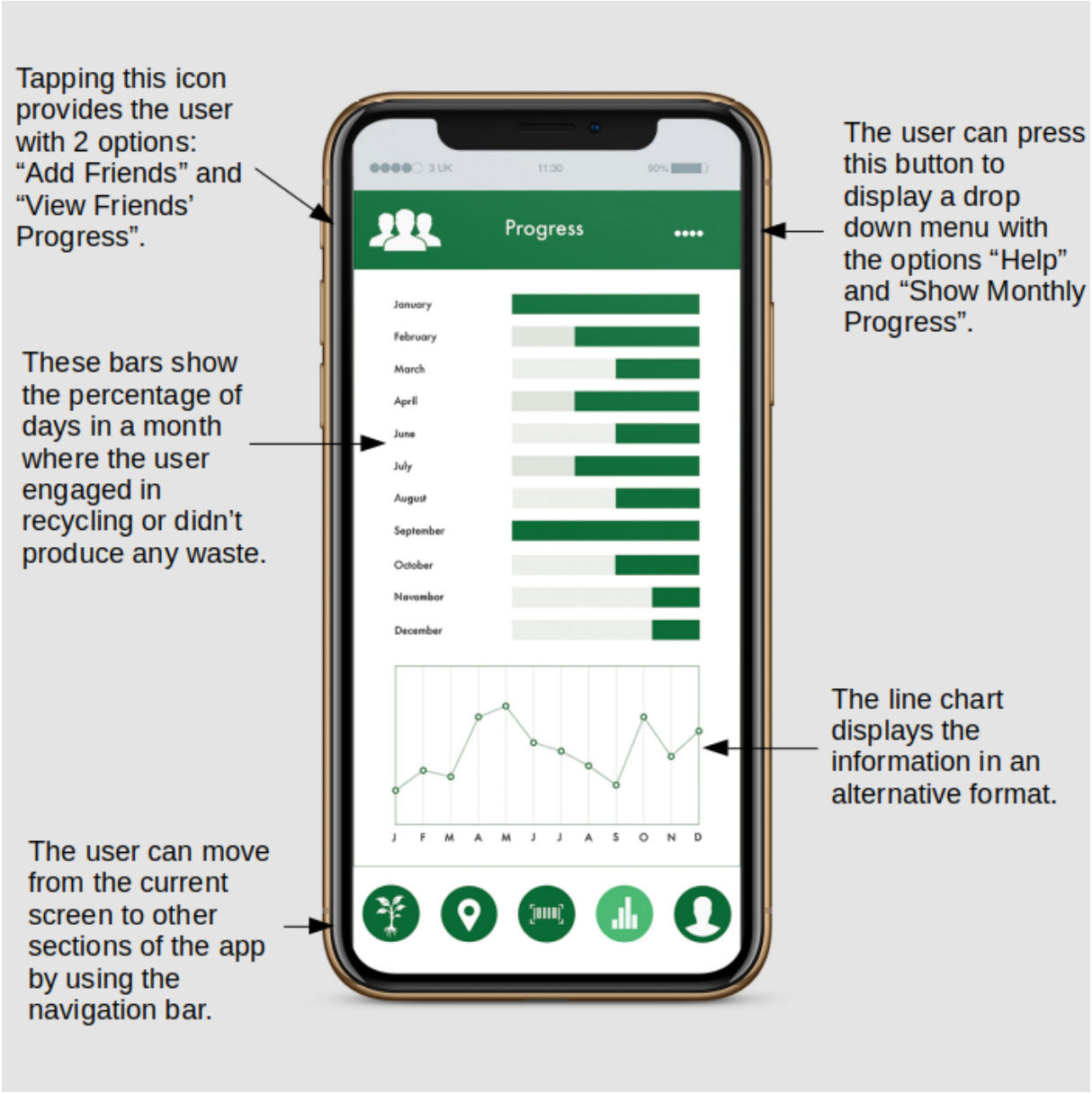

Figure 5.11: Yearly progress screen of the second generation prototype

The yearly progress screen, shown in figure 5.11, displays the user's recycling habits in the form of a vertical bar chart, which shows the percentage of days in a month that the user recycled all of their waste or did not produce any waste. This information is also displayed in a line chart below the bar chart.

The user can also view their friends' yearly progress in exactly the same way as in the monthly progress screen (figure 5.10). The icon in the top right has the same options as

the monthly progress screen as well. By swiping horizontally, the user can return to the previous screen, and the navigation bar can be used to move to any other section of the application at any time.

5.2.6 Settings

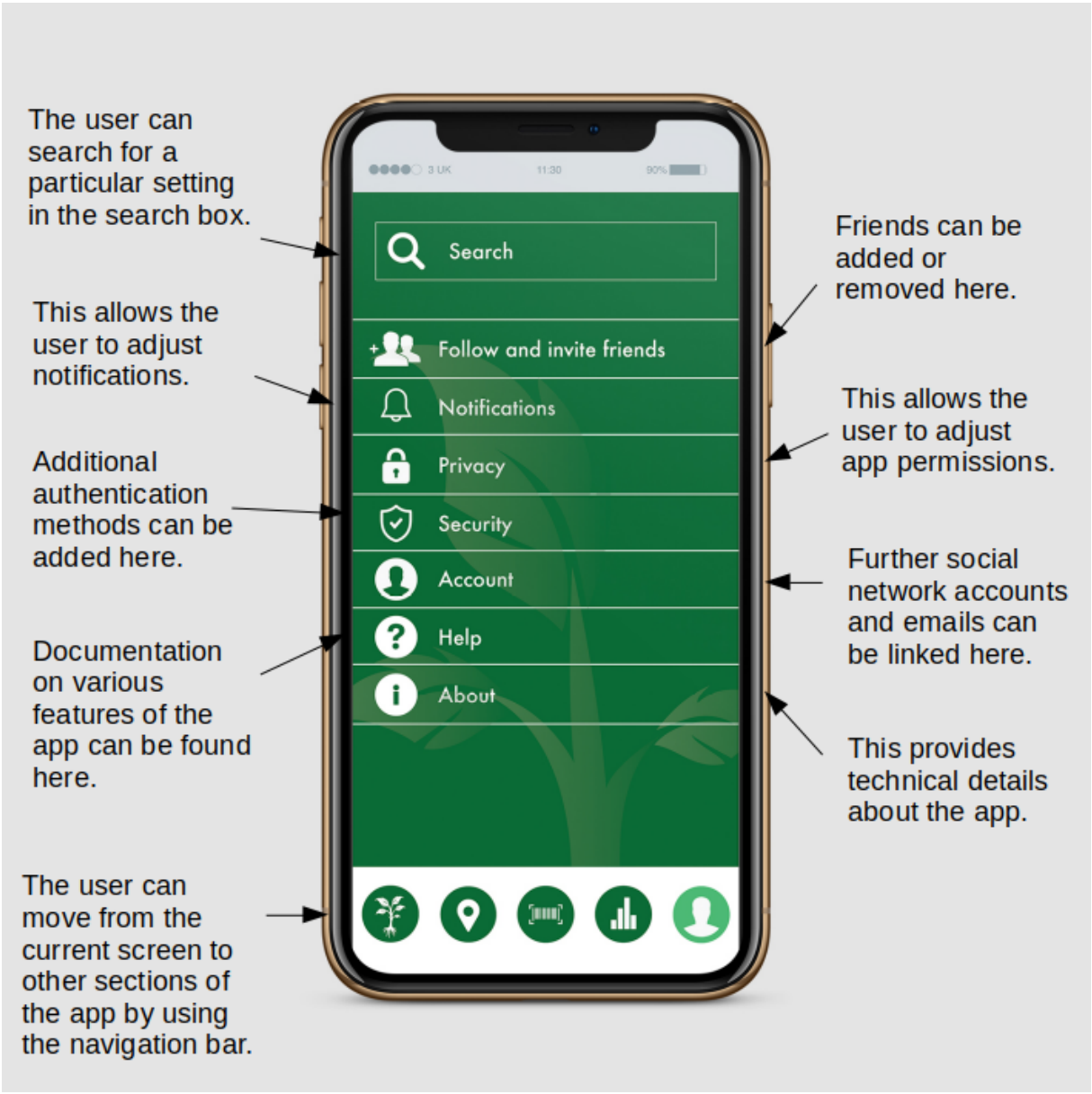

Figure 5.12: Settings of the second generation prototype

The final section of the application which can be accessed from the navigation bar is the settings menu, shown in figure 5.12. At the top of the screen, the user can type keywords for a setting they are looking to adjust, which will take them into the appropriate screen from the list below the search bar. "Follow and invite friends" allows the user to add friends in the same way as they were able to on other screens, but here they also have the option to remove friends. "Notifications" can be adjusted to include reminders for the user to log their daily recycling efforts, receive a weekly summary of the real-world

consequences of their recycling and getting informed about friend invites outside of the application. "Privacy" allows the user to adjust permissions given to the application, while "Security" provides the option of setting additional identification methods on launch of the application, such as two-factor authentication. Other social media accounts and emails can be linked in the "Account" section. "Help" provides documentation on the different screens in the application and "About" includes details about the technical details of the applications.

5.2.7 Notifications

Figure 5.13: Notification of the second generation prototype

At the end of every week, depending on how much the user recycled, the application will send them a notification, as shown in figure 5.13, informing them how many trees they saved through their efforts. In addition, similar messages will be sent to the user if they

have receive friend requests from other users of the application. These notification can be disabled in the options of the application.

5.2.8 Loading screen

Figure 5.14: Loading screen of the second generation prototype

Depending on the performance of the device, some of the features of the app, such as the map, may take some time to load. In these cases, a loading screen such as the one shown in figure 5.14 will appear. The spinning circular shape will inform the user that the application has not frozen and that the feature then have selected to use is loading.

5.3 Evaluation

It is important to assess the screens that were design for the second generation prototype in order to identify areas that can be improved in future versions. The evaluation of the prototype is split into two sections: the heuristic evaluation and the evaluation against persona scenarios. The reasons for choosing these methods and the evaluation criteria are discussed below.

Similarly to the first generation prototypes, Nielsen's heuristics for user interface design were selected for the heuristic evaluation [67]. The ten usability heuristics used were [67]:

1. Visibility of system status
2. Match between system and the real world
3. User control and freedom
4. Consistency and standards
5. Error prevention
6. Recognition rather than recall
7. Flexibility and efficiency of use
8. Aesthetic and minimalist design
9. Help users recognise, diagnose and recover from errors
10. Help and Documentation

The reason why this evaluation was picked specifically is because it appears to be the most commonly used set of heuristic criteria, as it appeared often when reviewing the assessment of several other user interface designs. The advantages of using a heuristic evaluation is that it allows for a cheap, quick and efficient identification of usability flaws in the prototype. The evaluation was carried out by looking through the screens and identifying usability problems relating to a particular heuristic.

In contrast to the first generation prototype, a different scoring system was used. For the second generation prototype, the heuristics were assessed in terms the severity of the problems related to that heuristic. The scores, as described by Nielsen, are [68]:

- 0: I don't agree that there are usability problems at all
- 1: Cosmetic problems only - need not be fixed unless extra time is available on project
- 2: Minor usability problems: fixing this should be given low priority
- 3: Major usability problems: important to fix, so should be given high priority
- 4: Usability catastrophe: imperative to fix this before product can be released

An evaluation against the scenarios of the personas is also used. This was chosen due to the fact that it provides information about how applicable the prototype is in solving potential problems that users could face in the real world. It provides an assessment of whether a particular class of user would find the application useful. For this reason, a simple Pass / Fail assessment with respect to a particular scenario was applied, as the features of the prototype would either assist in solving the problem detailed in the scenario, or they would be insufficient. A cognitive walkthrough was not incorporated into the evaluation, as we felt that the bias of individuals who developed the prototype would be too strong to accurately represent an actual user interacting with the application.

Other, more resource consuming methods of evaluation, such as a focus groups or interviews, were avoided due to limitations of the prototype developed. The prototype simply shows the different screens available to the user, but it does not act as an actual application which potential users could interact with. For this reason, results gathered from a focus group might not have been very reliable. In addition, these methods would require more time and money, which is outside the scope of the project.

5.3.1 Heuristic Evaluation

Heuristic	Score	Reasoning
Visibility of system status	0	The user is given feedback at several points throughout the application. When using the barcode scanner (figure 5.4), the screen displays what is seen through the camera. When the bins are being selected (figure 5.8), a tick appears after a selection is made. Loading screens also appear in cases where a device struggles to immediately launch a feature of the application (figure 5.14). The map feature (figure 5.9) shows the location of the user through GPS and directions update as the user moves.
Match between system and the real world	1	The central imagery of the app is the growth of tree (figure 5.2) which displays key information with a clear and universal real world example of progression. Similarly, the real-life image of bins, recycling symbols and their respective colours are used (figure 5.8). The user is expected to make use of navigation bar by identifying the clear and standard symbols chosen since they are commonly used in other apps we analysed. Technical language has been avoided for the most part. The screens being named “Tree”, “Scanner”, and “Progress” are all words which users are likely to be familiar with from the real world. There may be some confusion when choosing options in the settings screen (figure 5.12), as terms such as ”security” and ”privacy”, as well as ”help” and ”about” may be quite vague.
User control and freedom	0	If the user arrives at a section of the application by accident, they can easily move to the intended screen with the navigation bar, which is available throughout the screens. In some cases, such as when using the scanner (figure 5.4 the user has the option to return to the main screen by tapping the cross or arrow in the top left corner of the screen. The user should not feel as though they are stuck in any of the screens.

Table 5.1: Part 1 of the heuristic evaluation of the second generation prototype

Heuristic	Score	Reasoning
Consistency and standards	2	The placement of the navigation bar is consistent throughout different screens and is also located at the bottom of the screen which is seen in many other mobile applications. Icons represent what is expected, such as the bar chart icon for the progress section (figure 5.10). However, There is a lack of consistency in when the user taps on the four dot icon in the top right corner of some screens (for example, figure 5.2). While there is always a "Help" option, there is also a different option depending on what screen the user is currently on.
Error prevention	2	The technological requirements of the the scanner feature (figure 5.4) have a high potential for errors but these have been alleviated by allowing the user to take a picture (and optionally use the flash feature) if live scanning does not work. If this does not solve the issues, the user can opt to enter the product bar-code manually. In the bin selection screen, an incorrectly selected bin can be deselected by tapping on the bin once more (figure 5.8). There is little error prevention in the progress section (figure 5.10), where if the user presses the wrong selection for their daily recycling efforts, they are unable to undo this.
Recognition rather than recall	2	The navigation bar contains symbols which users should recognise are for particular features of the application. There are some features, such as the selection of bins (5.7), where the user is guided through the process, removing the need for recall. One exception, where recall is used is with the four dot icon on several screens (for example, figure 5.2). This icon, which appears in the top right corner of the display has some differences as to what it does on each screen, with it providing the user an option to change the type of tree being displayed on the tree screen. On the progress screen (figure 5.10, this button allows the user to move to a different screen). This could be amended with a potential cost to the minimalism of the app.

Table 5.2: Part 2 of the heuristic evaluation of the second generation prototype

Heuristic	Score	Reasoning
Flexibility and efficiency of use	0	There are several options associated with use of the scanner (figure 5.4). The user can type in a barcode manually, use the device camera to scan the barcode, and even look up items that do not have barcodes. Movement to different sections of the application can be achieved with either swiping the screen horizontally or using the navigation bar. The map can also be accessed directly from the navigation bar rather than through the scanner. It would be difficult to add more shortcuts as everything within the prototype is accessible with just a single of a few button taps.
Aesthetic and minimalist design	1	The screens overall have a high signal to noise ratio, as information on the screen is typically highly relevant to the user. Less important features for the immediate use of the application are stored away in the four dot icon in some of the screens. However, there is room for improvement, as the map feature (figure 5.9) has some non essential options, such as map type, which could be removed to make it easier to interact with.
Help users recognise, diagnose and recover from errors	1	Error messages such as "invalid email" appear on screen when the user inputs incorrect credentials when logging in (figure 5.1). If a user incorrectly enters a barcode while manually inputting the number (figure 5.4), the message "incorrect barcode" appears. The map feature (figure 5.9) recalculates direction if a user accidentally takes the wrong path. There is not much potential for error in other areas of the application.
Help and Documentation	2	the prototype is well documented, and information on a features is accessible both from a specific screen or from the settings menu (figure 5.12). However, the option to access "Help" is missing on some screens such as (figures 5.4 and 5.5). In addition, the information is hidden away in the drop down menu accessible from the four dot icon, which might not be immediately obvious.

Table 5.3: Part 3 of the heuristic evaluation of the second generation prototype

5.3.2 Evaluation against Scenarios

Scenario	Pass or Fail	Reasoning
George wants to learn which bins to use for different packaging materials	Pass	George would be able to use the scanner feature (figure 5.4) to identify whether items he wishes to discard are recyclable. The scanner information screen (figure 5.6) would show him exactly what kind of bin he would have to use.
George wants to find local recycling facilities	Pass	On the scan information screen (figure 5.6), there is an option to show local bins on the map. This shows very clearly where the nearest facilities are, as well as providing the option for directions.
George is looking for environmentally-aware individuals nearby to connect with	Fail	The application does contain features such as adding friends, viewing their progress in terms of their tree (figure 5.2) or their daily recycling (figure 5.10). However, these are features mainly for individuals who already have friends who recycle, whereas George is trying to meet new people.

Table 5.4: Evaluation of George's scenarios

Scenario	Pass or Fail	Reasoning
Naomi needs a way to track her, and her friends' recycling habits	Pass	The progress screen has two sections, which would allow Naomi to view her friends' monthly recycling in the form of a calendar (figure 5.10) as well as their yearly progress through a bar and line chart (figure 5.11). She could also observe the status of her friends' trees (figure 5.2), as this would show whether they are being consistent in their recycling effort.
Naomi wants to set recycling goals to help stay committed	Pass	Naomi would be able to use the screens described in her previous scenario to set her own goals and view her own progress by way of the calendar, bar chart and tree.
Naomi wants to attend group events to restore the local environment	Fail	The second generation prototype did not include features for hosting group events, therefore Naomi would not be able to use the application for this purpose. This was deliberate, as the features of the first generation prototype B were excluded in order to keep the application focused and streamlined.

Table 5.5: Evaluation of Naomi's scenarios

Scenario	Pass or Fail	Reasoning
Emma wants to reduce the time it takes to get the information she needs to recycle	Pass	The scanner (figure 5.4) would provide Emma with a very quick way of identifying whether she can recycle her waste and if so, how to dispose of it. She could also get quick access to a map with recycling locations (figure 5.9) which she could use on business trips.
Emma wants to have a central location to get news and updates regarding environmental issues	Fail	The prototype does not include a news feed, therefore Emma would not be able to use this application to assist her in this scenario. This issue was originally tackled by the first generation prototype B, however, the feature was not added to this prototype as it would have bloated the application.
Emma has young children who she wants to encourage to recycle	Pass	The easy-to-use scanner (figure 5.5) would be very accessible and fun for children to engage with. The highly digestible information provided (figure 5.6) would be perfect for introducing young people to recycling habits. The children would also enjoy seeing the tree develop over time (figure 5.2).

Table 5.6: Evaluation of Emma's scenarios

5.4 Conclusion

Using higher fidelity tools for the design of the second generation prototype, Greenscanner, has proved to be useful, as it allowed easier, more critical analysis. This is due to the fact that the visuals are simple to interpret and the screens represent designs that could be expected in actual, usable software. The prototype was evaluated through heuristics and personas. This has provided an indication of areas of the prototype that are lacking and could be improved in future designs.

5.4.1 Conclusion of Heuristic Evaluation

Overall, the prototype does not have any major design flaws that would severely inhibit the user experience. Most of the issues arise from the four dot icon in the top right corner of most screens, as the drop down menu that this button brings up is inconsistent between different screens. In addition, it adds to users having to recall what is in the drop down menu rather than immediately recognising a function they would like to use. Help being part of the drop down menu could also be improved by instead adding a question mark icon to screens. Error prevention could also be improved by allowing a user to undo their daily recycling choice, as an accidental press of the wrong button could lead to user frustration, since this will be reflected in their tree, calendar and statistics.

5.4.2 Conclusion of Persona-Driven Evaluation

In evaluating the three scenarios for each of the personas against the second generation prototype, we saw that the majority of cases passed. Those which did not pass were a result of a design choice to make our application focus solely upon providing utility-based features which users would objectively benefit from when trying to increase recycling habits. The community features - whilst interesting - did not fit the niche of our application, and would have added extra layers of complexity which would likely end up alienating users looking for a simpler experience. Scenarios which didn't focus upon social and community aspects all passed, and shows how our app breaks down the barriers to recycling through the inclusion of two main features: the scanner and the map. Overall, the scenarios covered every main feature of the prototype, therefore there weren't any functionalities that were unnecessary.

Chapter 6

Summary and Recommendations

6.1 Summary of the Work Done

As a group, we all have a strong interest in climate change. This is why we chose to focus on developing a system with the big picture idea of increasing environmentally friendly behaviour. Not only is this of interest to us it is also an important issue all over the world today. The consequences of global warming are often discussed in the media and are on the minds of many people. Since environmentalism is such a broad topic, our focus was specifically narrowed down to recycling. We highlighted recycling as a behaviour we could target as it is something a lot of people already have the means and ability to do. The aim of the project was to use technology to increase the rates of recycling among young adults. This demographic was targeted as statistics showed that these individuals do not recycle at the rates older people do.

A literature review was then carried out. This helped us to better understand the steps we could take to give our technology the best chance at influencing and changing the behaviour of our users. The review focused on the psychology of behaviour change. Specifically, the theory of planned behaviour, value-belief-norms and habits were reviewed. In addition to this, we explored the impact social networks have had at influencing the attitudes and behaviour of their users. Finally, we went on to explore how the rise of personal informatics technology and gamification have been used to facilitate behaviour change. This served as a strong, scientifically robust foundation with which we could develop our technology.

Based on the findings of the literature review, three relevant existing systems were reviewed and critically evaluated. This offered us insight into how different technology has been able to target a similar demographic and influence user behaviour. The systems were each evaluated with regard to how they can create a social connection between users, how easily they offer access to information, and how they use self-logging and reward systems to help promote behaviour change. Finally, each system was evaluated for its overall user experience.

Building upon the knowledge gained from the review of relevant literature and existing systems, we performed an analysis of user requirements. For this task, three distinct classes of user were identified, which included a student, a young professional as well as a young working parent. For each class, a persona was developed, and each persona had

associated scenarios where a potential application could be used to assist them in solving the related problem.

The first generation prototypes were inspired by the research done in the previous sections. Three prototypes were built with the proto.io software, and they were split into the categories of gamification, social networking, as well as functional tools to assist recycling. A heuristic and persona-driven evaluation allowed us to identify the strengths and weaknesses associated with each prototype. The prototypes were able to solve different problems in the user scenarios, therefore we decided that combining the prototypes would allow us to solve more problems with a single application. However, prototype B (the social networking prototype) was excluded, as we felt that it would require an application of its own and it would not mesh well with the simplicity of prototypes A and C.

The second generation prototype, Greenscanner, was based on the first generation prototypes A and C. It was presented in screens designed using Adobe Suite Illustrator and Photoshop, as well as LibreOffice Impress for annotation purposes. This prototype was of a higher fidelity and allowed for a more thorough evaluation, which once again consisted of Nielsen's heuristic evaluation and a persona-driven analysis. It was concluded that there were only minor design issues, specifically in the areas of consistency and standards, error prevention, recognition rather than recall as well as help and documentation. Most of the problems in the persona scenarios were tackled by the application. However, social requirements of the users were not met, as this did not seem feasible for a single application.

Overall, the second generation prototype would likely be something that individuals would find useful, as it provides an efficient way of identifying recyclables as well as supplying instructions for their disposal.

6.2 Lessons learned

Several improvements could be made to different aspects of the project. Although the literature review was extensive, it does not cover many of the possible variables that may influence a person's recycling behaviour. For example. one could argue that the decision to recycle is an ethical one, or that it has a large altruistic component, or that people recycle because it makes them feel good. While exploring all possible theories of behaviour would be far beyond the scope of this project the question as to whether or not there are theories better suited to explaining recycling remains. In the review of existing systems, WeRecycle, which is a prototype, was selected. This may have been a poor choice, as the prototype does not have the demonstrable success that can be observed in Instagram and MyFitnessPal.

The review of technology consisted of three mobile applications. This may have been short sighted, as we could have gained a wider view of the problem and possible solutions if we looked further afield for ideas and inspiration. For example, we could have looked into how real-world physical systems influence behaviour, or into the technology of embedded systems. This project's viewpoint is limited to mobile applications and it is possible that we did not have a comprehensive understanding of what other solutions were available.

This project set out to target young adults who were already interested in recycling and

three personas were created to represent different segments of this age group. However, there is no reason why this application could not be used by others, and we may have not done enough to specifically cater to the young adult demographic. This is not necessarily a negative, as improving the recycling rates of other age groups is ultimately good for the environment. It could also be that our personas were too similar to one another in pre-existing attitudes towards environmentalism. It is possible that we missed out on potential insights by not widening our focus when we were creating our personas.

A lot of time was spent on the first generation prototypes. These prototypes could have been lower fidelity and that would have still allowed us to identify the usability strengths and flaws of each. The time saved on the first generation prototypes could have been invested in a more thorough evaluation of the second generation prototype.

The removal of a significant social network component from the second generation prototype went against a lot of the initial research that was carried out. A decision to focus on developing a social network could have been made instead of what was chosen. However, the evaluation of the first generation social media prototype was poor, which led to the design of the scanner-based system.

6.3 Future Work

6.3.1 User Interface and Accessibility

The minor issues in the usability heuristics should be addressed in future prototypes. Replacing the drop down menu which contains inconsistent features depending on the screen should be replaced with icons, such as a question mark for instances when the user needs help on a particular screen. Subsequently, further thought and effort should be put into adapting the system for disabled users. The scanner could include audio which would announce the category of a scanned item (for example, plastic or paper). This would benefit users with visual impairments. With the implementation of greater accessibility options, an evaluation which involves potential users should be carried out to assess the effectiveness of these features.

6.3.2 Localisation

In order to make the application usable in different countries, a lot of work would have to be done. The method of waste separation as well as the colours and images used on recycling bins vary greatly between countries. Therefore, it would be insufficient to simply include language options - understanding and implementing regional recycling guidelines would be necessary.

6.3.3 Image Recognition

In future iterations of our application, the technology for image recognition may have advanced to the point where the scanner could also reliably identify items without barcodes. A common use case for this would be for users looking to recycle coffee cups or

packaging from small independent market stalls. This feature could also integrate with augmented reality, with real-time responses to images captured from the phone camera, providing information on which bins should be used for each item.

6.3.4 Introduction of More Social Features

While it was decided that the second generation prototype should not implement a robust social network component, as it would harm the simplicity of the application, the current friend system could be expanded slightly. The addition of a simple chat option could greatly enhance the sense of community, which is something we identified as important based on our analysis of the personas.

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Appendix A

Contributions

Abstract: **Aaron Chapman**
Introduction: **Aaron Chapman, Ignas Stakaitis, Sean McAuley and Daniel Cutter**
Importance of Recycling: **Aaron Chapman**
Definition of Problem: **Ignas Stakaitis, Aaron Chapman and Sean McAuley**
Review of Related Work: **Aaron Chapman**

Literature Review: **Aaron Chapman**
Theory of Planned Behaviour: **Aaron Chapman**
Value-belief-norms: **Aaron Chapman**
Habits: **Aaron Chapman**
Behaviour Change and Technology: **Aaron Chapman and Ignas Stakaitis**
Conclusion of Literature Review: **Aaron Chapman**

Review of Existing Systems: **Vivienne O'Brien**
Introduction: **Vivienne O'Brien**
Instagram: **Ignas Stakaitis and Vivienne O'Brien**
MyFitnessPal: **Vivienne O'Brien**
WeRecycle: **Vivienne O'Brien**
Conclusion of existing systems: **Vivienne O'Brien**
Conclusion of literature review and review of existing systems: **Aaron Chapman and Vivienne O'Brien**

Analysis of User Requirements: **Daniel Cutter**
Introduction: **Daniel Cutter**
George: **Aaron Chapman, Figure by Daniel Cutter**
Naomi: **Sean McAuley, Figure by Daniel Cutter**
Emma: **Daniel Cutter**
Conclusive Remarks:
Personas: **Daniel Cutter, Venn diagram by Vivienne O'Brien**
Scenarios: **Daniel Cutter**

First Generation Prototypes: **Ignas Stakaitis**
Design Process: **Ignas Stakaitis**

Prototype A: Gamification: **Ignas Stakaitis**
Rationale: **Ignas Stakaitis**
Sign up: **Ignas Stakaitis**
Home Screen: **Ignas Stakaitis**
Daily Recycling: **Ignas Stakaitis**
Quiz: **Ignas Stakaitis**
Badges: **Ignas Stakaitis**
Leaderboard: **Ignas Stakaitis**
Heuristic Evaluation: **Ignas Stakaitis**
Evaluation against Scenarios: **Ignas Stakaitis**
Conclusive Remarks for Prototype A: **Sean McAuley and Ignas Stakaitis**

Prototype B: Social Media: **Vivienne O'Brien**
Rationale: **Vivienne O'Brien**
Sign up: **Description by Ignas Stakaitis and Vivienne O'Brien, Image by Vivienne O'Brien, annotated by Ignas Stakaitis**
Home Screen: **Description by Ignas Stakaitis and Vivienne O'Brien, Image by Vivienne O'Brien, annotated by Ignas Stakaitis**
Community: **Description by Ignas Stakaitis and Vivienne O'Brien, Image by Vivienne O'Brien, annotated by Ignas Stakaitis**
Blog: **Description by Ignas Stakaitis and Vivienne O'Brien, Image by Vivienne O'Brien, annotated by Ignas Stakaitis**
Instagram: **Description by Ignas Stakaitis and Vivienne O'Brien, Image by Vivienne O'Brien, annotated by Ignas Stakaitis**
Heuristic Evaluation: **Ignas Stakaitis**
Evaluation against Scenarios: **Ignas Stakaitis**
Conclusive Remarks for Prototype B: **Sean McAuley and Ignas Stakaitis**

Prototype C: Tools to Assist Recycling: **Sean McAuley**
Rationale: **Sean McAuley**
Home Screen: **Description by Ignas Stakaitis and Sean McAuley, Image by Sean McAuley, annotated by Ignas Stakaitis**
Scanner: **Description by Ignas Stakaitis and Sean McAuley, Image by Sean McAuley, annotated by Ignas Stakaitis**
Map: **Description by Ignas Stakaitis and Sean McAuley, Image by Sean McAuley, annotated by Ignas Stakaitis**
Heuristic Evaluation: **Sean McAuley and Ignas Stakaitis**
Evaluation against Scenarios: **Sean McAuley and Ignas Stakaitis**
Conclusive Remarks for Prototype C:**Sean McAuley and Ignas Stakaitis**
Conclusive Remarks:**Sean McAuley and Ignas Stakaitis**

Second Generation Prototype
Design Process: **Vivienne O'Brien**
Login Screen: **Description by Ignas Stakaitis Image by Vivienne O'Brien, annotated by Ignas Stakaitis**
Tree Screen: **Description by Ignas Stakaitis Image by Vivienne O'Brien, annotated by Ignas Stakaitis**
Scanner Screen: **Description by Ignas Stakaitis Image by Vivienne O'Brien, an-**

notated by Ignas Stakaitis
Map Screen: **Description by Sean McAuley and Ignas Stakaitis, Image by Vivienne O'Brien, annotated by Ignas Stakaitis**
Progress Screen: **Description by Ignas Stakaitis Image by Vivienne O'Brien, annotated by Ignas Stakaitis**
Settings Screen: **Description by Ignas Stakaitis Image by Vivienne O'Brien, annotated by Ignas Stakaitis**
Notifications Screen: **Description by Ignas Stakaitis Image by Vivienne O'Brien, annotated by Ignas Stakaitis**
Loading Screen: **Description by Ignas Stakaitis Image by Vivienne O'Brien, annotated by Ignas Stakaitis**

Evaluation: **Ignas Stakaitis**
Heuristic Evaluation of 2nd Generation Prototype:**Ignas Stakaitis and Sean McAuley**
Evaluation against Scenarios: **Daniel Cutter and Ignas Stakaitis**
Conclusion of heuristic evaluation: **Ignas Stakaitis**
Conclusion of persona-driven evaluation: **Daniel Cutter and Ignas Stakaitis**

Summary and Recommendations: **Ignas Stakaitis and Aaron Chapman**
Summary of the work done:**Ignas Stakaitis and Aaron Chapman**
Lessons learned: **Ignas Stakaitis and Aaron Chapman**
Future work: **Ignas Stakaitis, Aaron Chapman and Daniel Cutter**