Deliverable D – Conceptual Design

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1.0 Introduction

Climate change has become a major concern for every nation across the world. To combat this, multiple strategies are being implemented such as the use of renewable energy, the adoption of electric vehicles, the promotion of consuming local goods and recycling. Local municipalities and counties across the world have implemented such recycling programs to help reduce landfill waste as well as the need for new raw and synthetic materials, such as plastics. Unfortunately, the client has stated that recycling programs today, specifically in Ontario, are not as efficient as they could be. Recyclable materials are being contaminated which leads to their disposal in landfills, thus invalidating the entire recycling process. To help combat this issue, the client believes that the problem of contamination should be addressed at its source: the sorting of items in individual households. The recycling process starts at each individual's home, where members of the household must choose whether the item they wish to dispose of is recyclable and in which bin they should deposit it into. Regrettably, this task is not always done successfully which leads to items being sorted into its incorrect bin. This in turn leads to contamination of the recyclable material at the processing plant, which can then cause the material to be diverted to landfills. To avoid this issue, design engineering must be employed to conceptualize a solution to aid individuals in sorting their recyclable items at home. Based upon the client's needs and requirements, design criteria were determined and will be used to analyze and evaluate multiple different possible solutions. Once the evaluation process has been completed, the most optimal solution can be selected and the first stage of prototyping can begin.

2.0 Client Needs, Constraints & Requirements

The client requires a solution to make recycling a simpler task so it can be done responsibly. The misplacement of recyclable materials creates larger amounts of landfill, which releases high amounts of methane gas and carbon dioxide into the atmosphere. The client specified that ease for the users is critical, meaning that simpler ideas are ideal. Therefore, for the solution to attract more consumers, user-friendliness holds a great significance. The client also emphasized for the product to have a 90% rate of accuracy. In addition, for the design of the product to be an effective solution, the needs of the users must be considered. The user expects the product to be easy to use, to effectively resolve the issue that the user has in a short period of time. An attraction that the product should implement is to be more engaging and to educate the users. When the solution can teach the consumers, they will become more captivated and intrigued, pushing them towards using the product more often.

There are certain limitations the client specifically accentuated. One constraint is the cost of the product; the end goal of this product is for it to be able to adapt to different circumstances, regions, climates, and situations. For the product to be of this scale, it must be cost effective. The solution must only have an error margin of 10% for it to be adequate enough for a wide scale usage. The product, required to be user friendly, must be limited in complexity.

3.0 Problem Statement

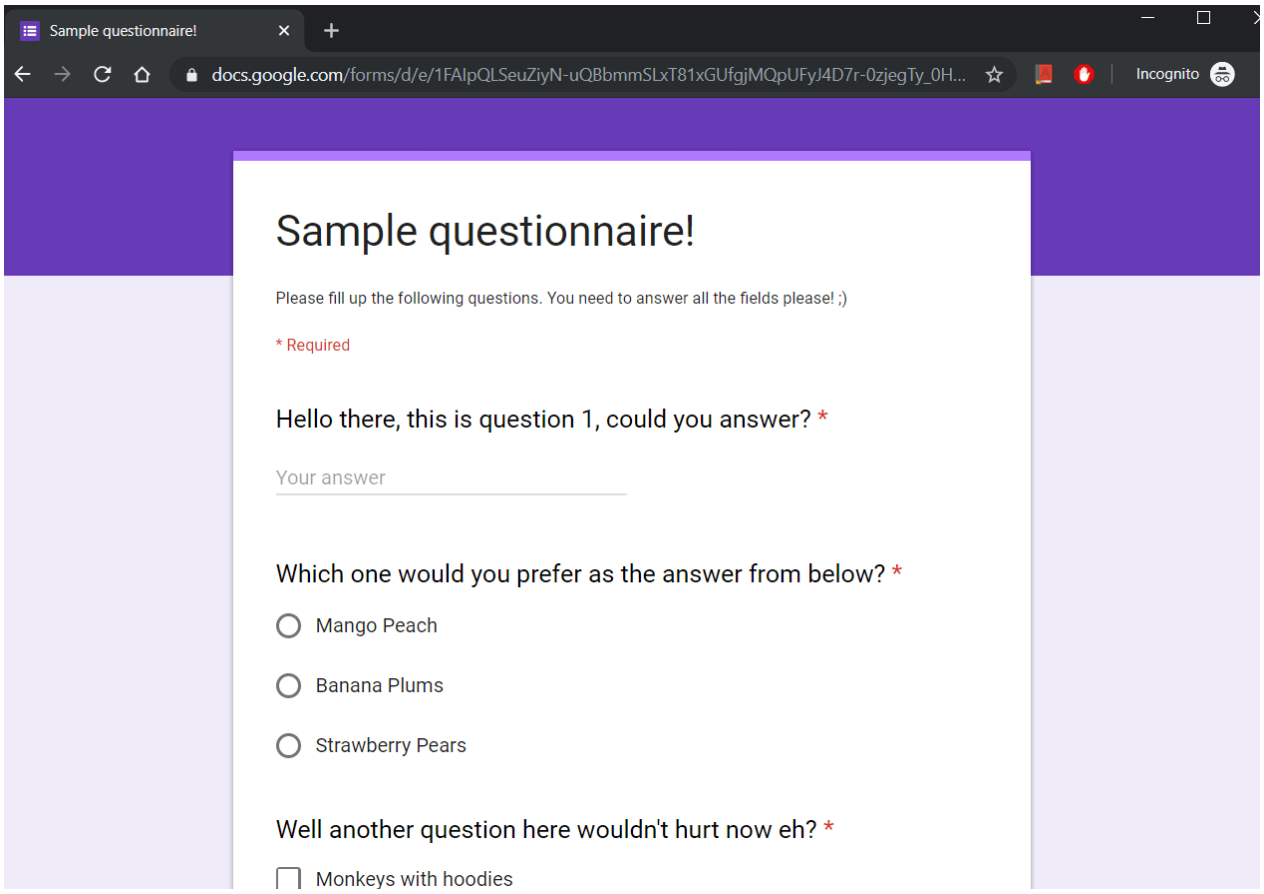
The final product needs to be a functional solution to the issue of non-efficient, confusing recycling practices. Any potential solution needs to be user-friendly, as well as easy to use above all else. The medium through which this solution can be achieved has essentially no limitation, so long as it is able to effectively maintain the users interest enough to use it regularly.

4.0 Initial Concepts

4.1 Abera's Ideas

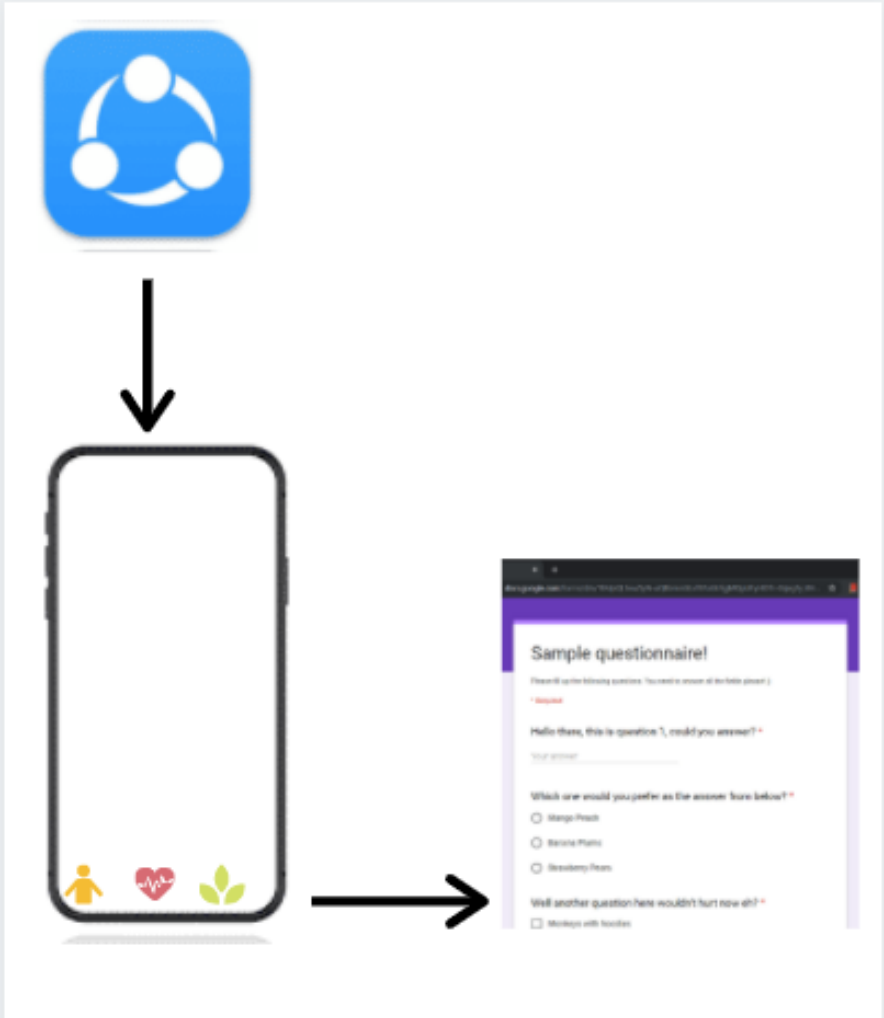
4.1.1 Questionnaire

The first idea is for a URL link to be posted onto the recycling bins, which users can type into their browser for access to the questionnaire.



4.1.2 App + Questionnaire

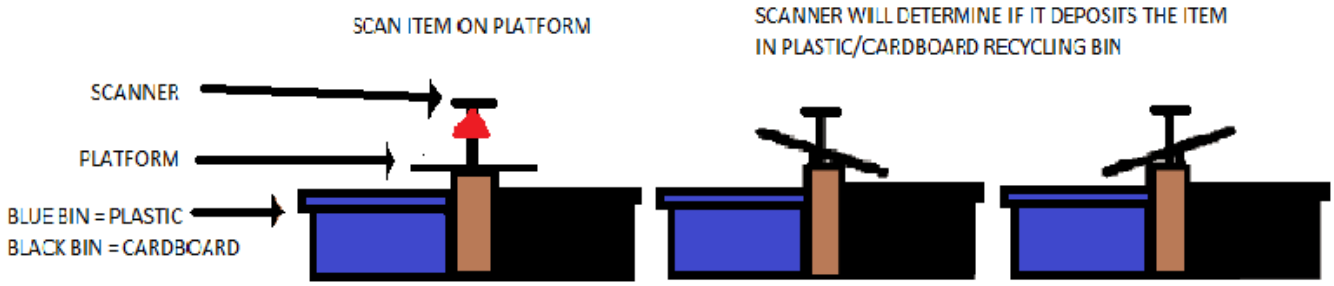
The second idea is an app that opens up a questionnaire. The app also consists of incentive points which can be earned when people use it more often. There will be another section for links the consumer can click on for more information on the significance of recycling.



4.2 John's Ideas

4.2.1 Automatic Recycler Using AR Scanner

The recyclable item is put on a platform, then the AR scanner scans the item and using a library of picture data determines if the item is cardboard or plastic. Then it prompts a hydraulic arm to tilt the platform and depositing the item in the proper bin.

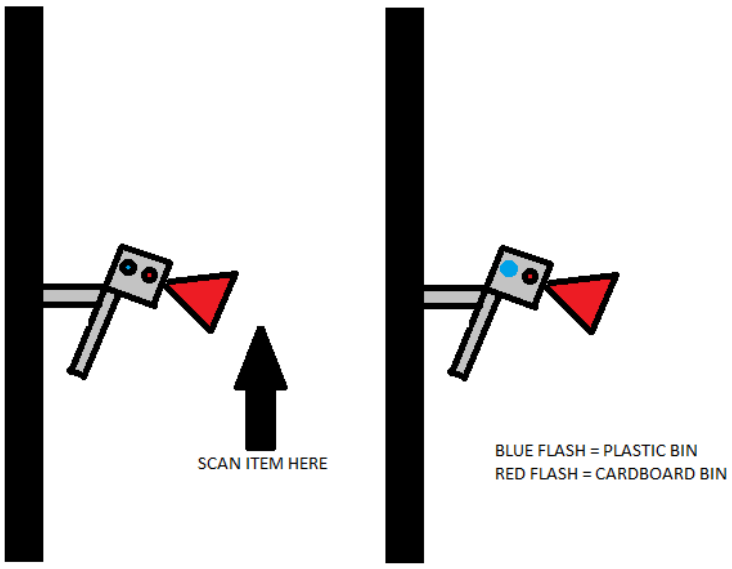


4.2.1 Barcode Scanner App

This App relies on scanning the barcode of the item. It then uses its database to find what the item is and ultimately what it is made from. A message then appears instructing the user on where to deposit the item.

4.2.1 Physical AR Scanner

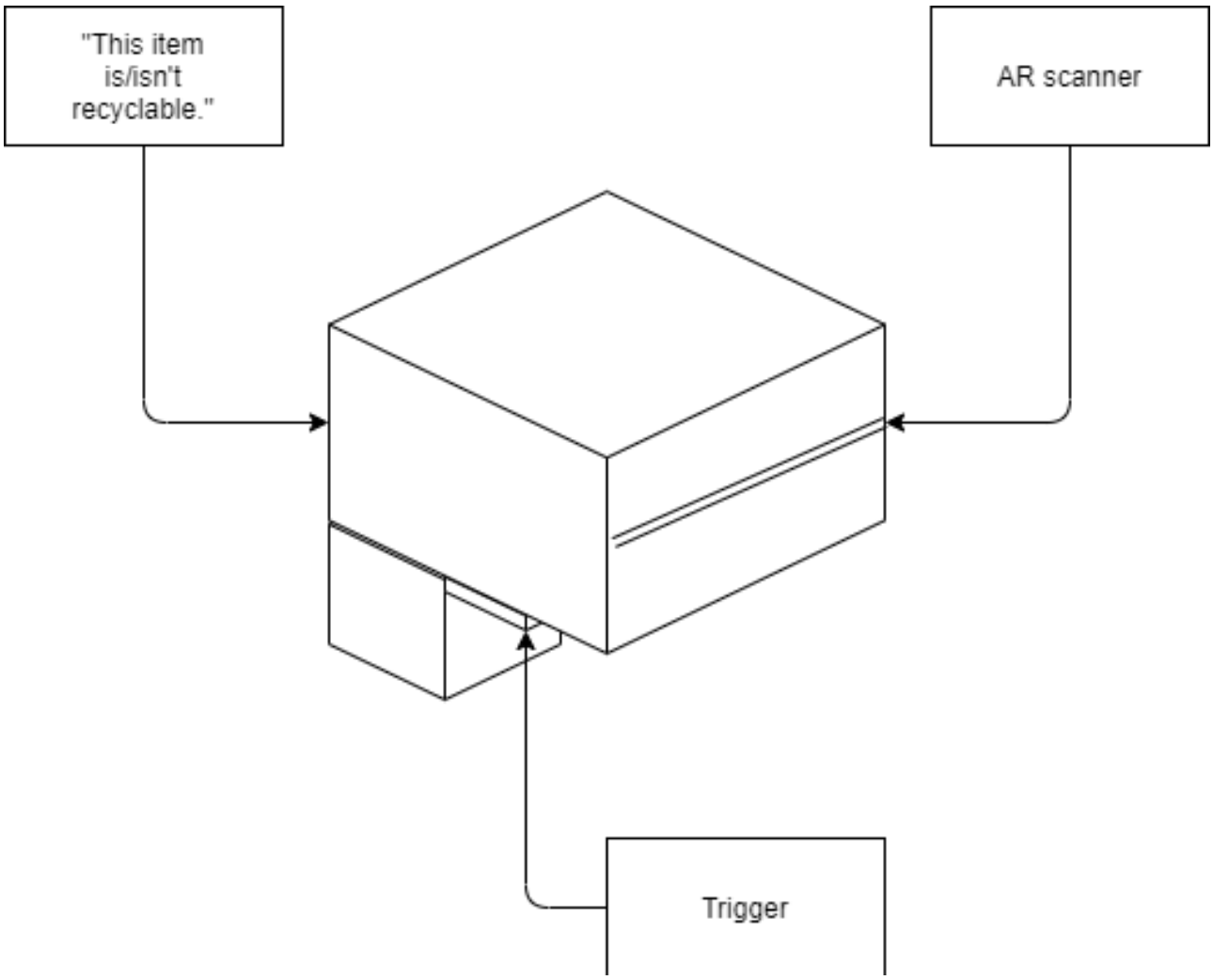
This method does not rely on using a phone. The scanner can be attached anywhere (ideally beside recycling area). The user scans the desired recyclable item as shown above, the scanner then uses its database to determine what the item is. The scanner then flashes one of two colors: red meaning deposit in cardboard bin, and blue meaning deposit in plastic bin.



4.3 David's Ideas

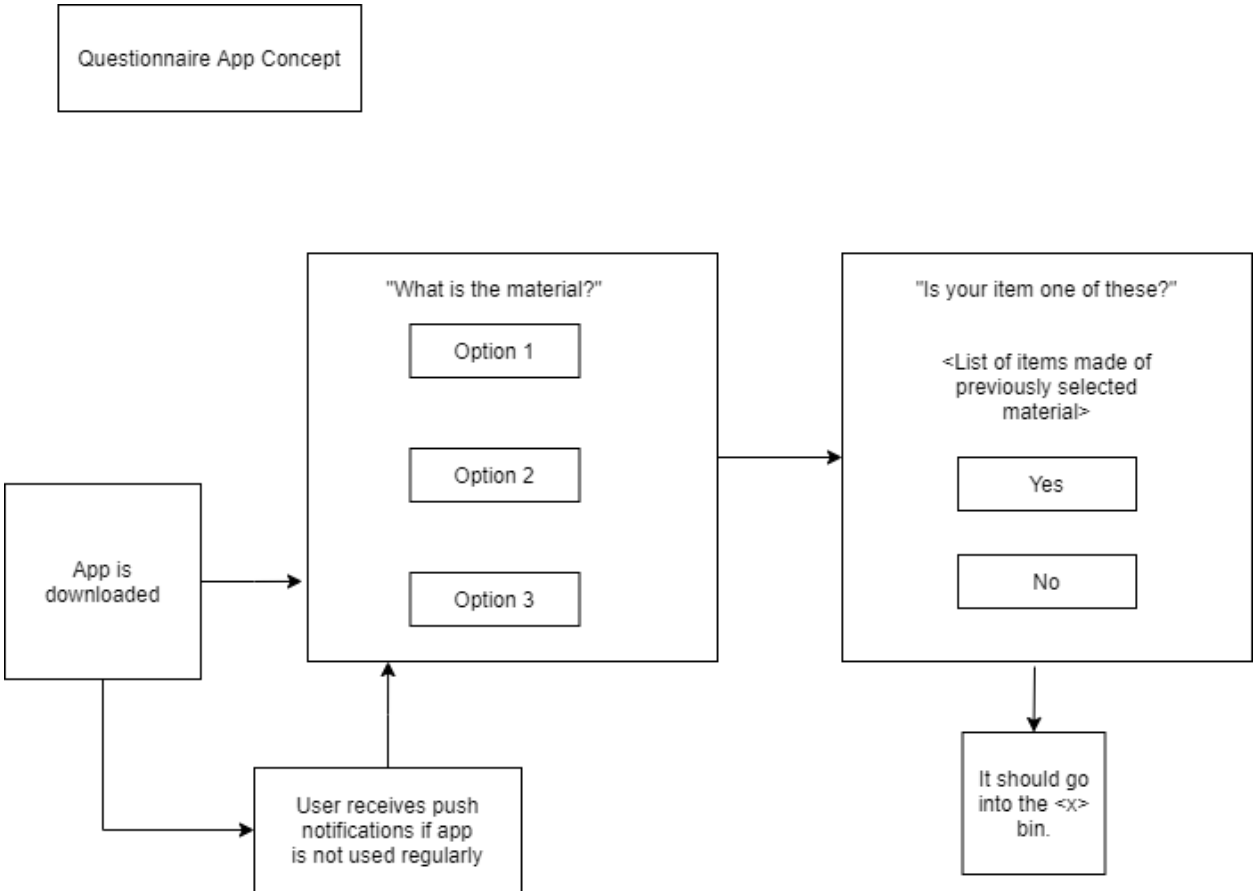
4.2.1 AR Barcode Scanner

This product would function essentially as a barcode scanner. The scanner would use AR technology to determine the material of the scanned object, and the screen on the back would inform the user where said object should go.



4.2.1 Questionnaire App

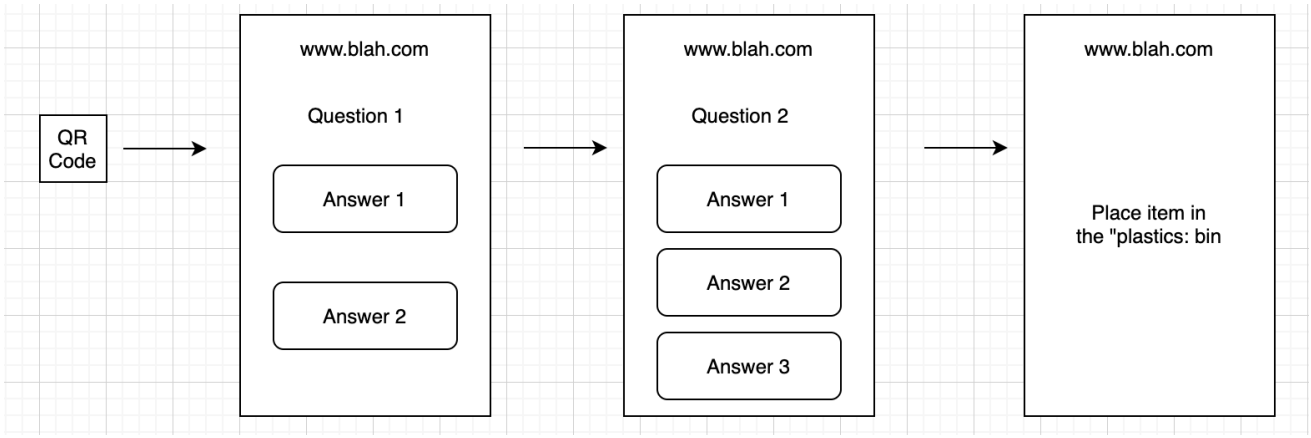
Below is a flow chart of a phone application for recycling. It would function as a questionnaire, that the user would go onto when they are unsure about if something is recyclable, and/or where it should go. There would also be a functionality that alerted the user if they have not used it in a while.



4.4 Michael's Ideas

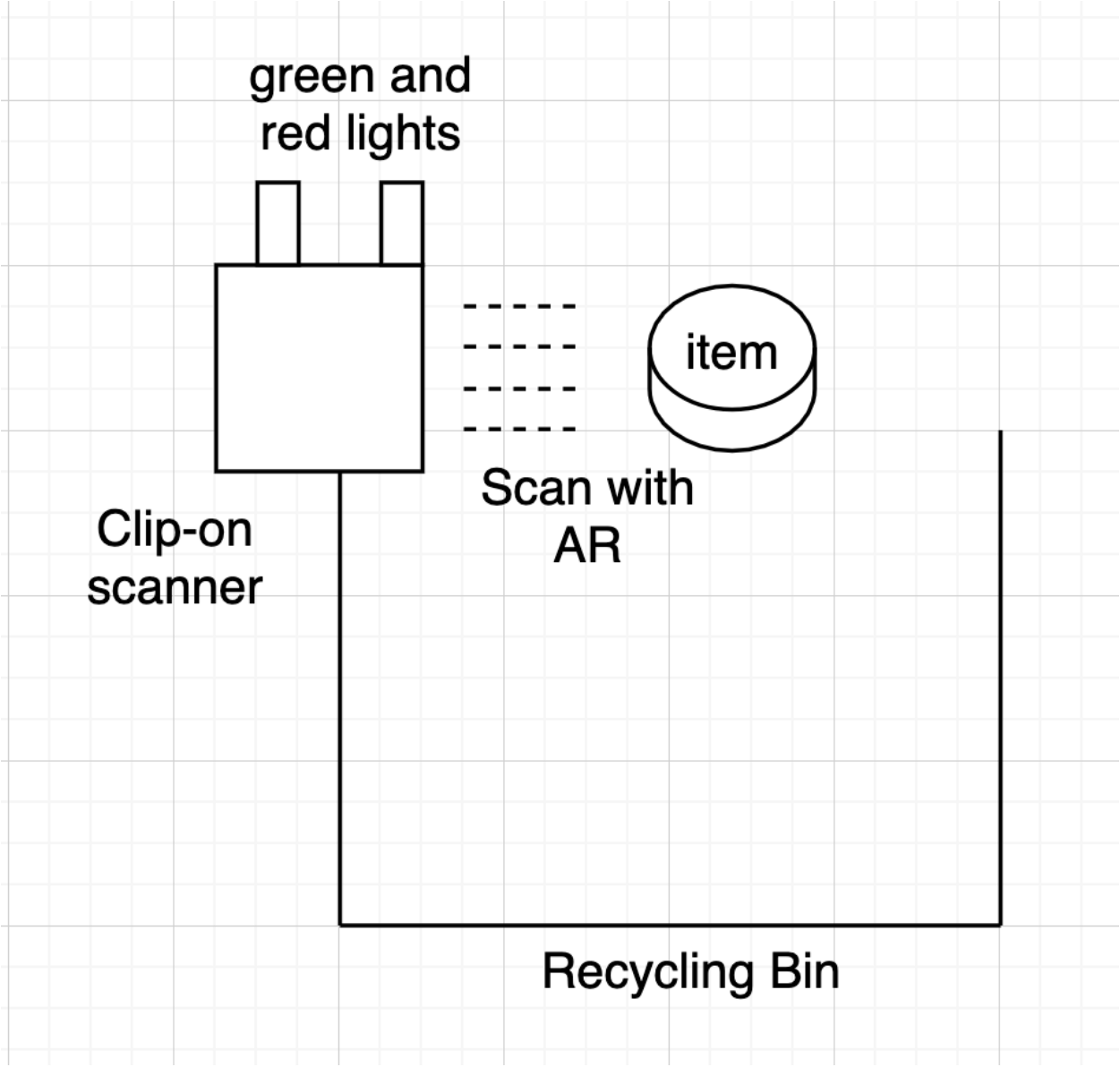
4.2.1 QR Code Questionnaire

A QR code is placed on or near the recycling bin. The user scans the code with the camera app on their phone, which brings them to a website with a questionnaire. After answering a couple questions, the website will tell the user where to place the item.



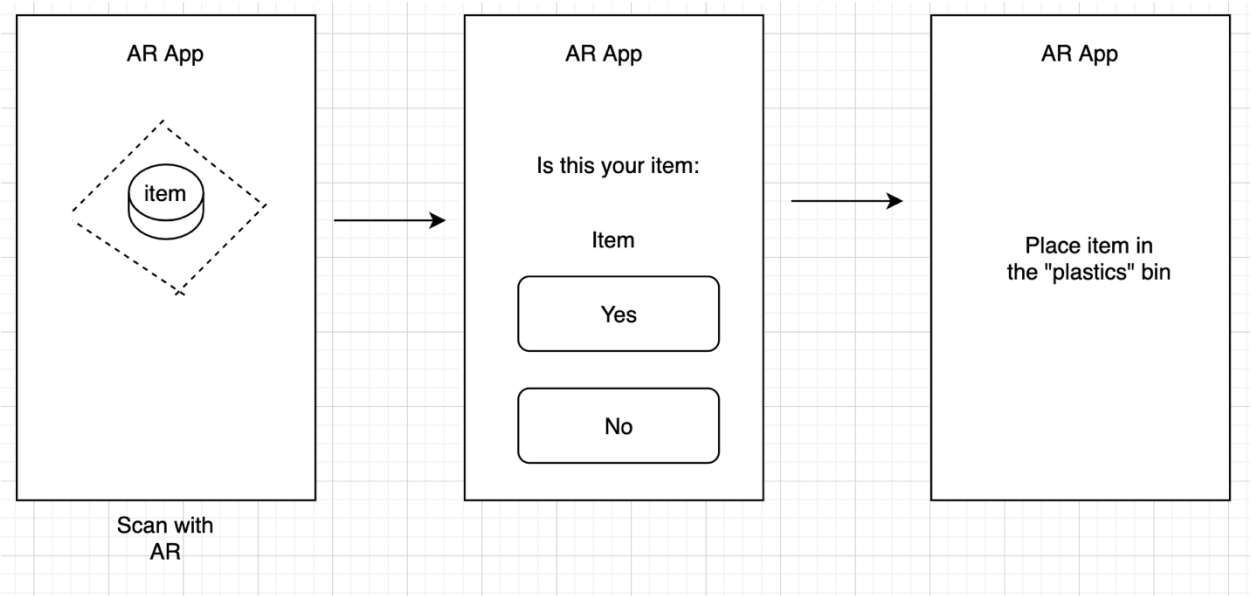
4.2.1 Attachable AR Scanner

A portable scanner is attached on or near the recycling bins. Using AR, the scanner identifies the item and using a green and red light, it will tell the user which bin to place the item in



4.2.1 AR App

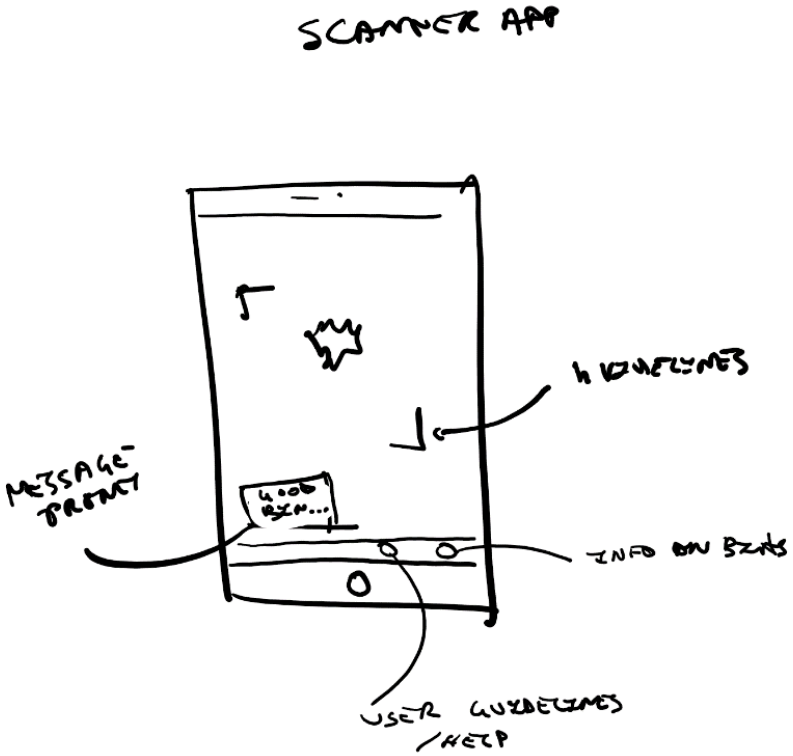
A phone application will scan the item using AR. It will then confirm the item you have with a pop-up and tell you where to place the item.



4.5 Sebastian's Ideas

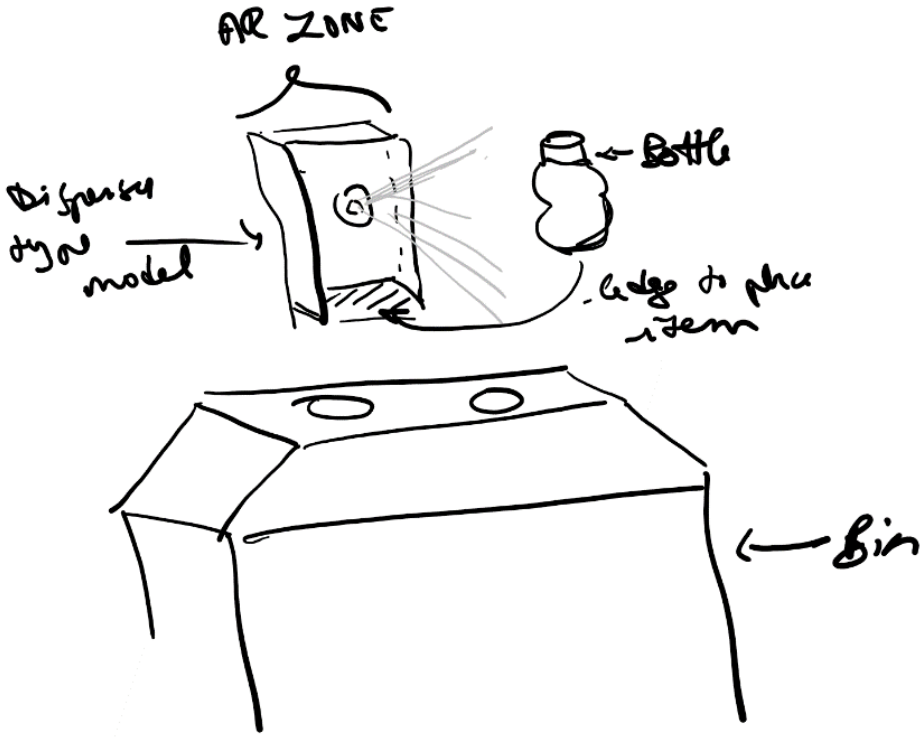
4.2.1 AR App

First idea is to have an app that when presented the image within the guidelines shows whether the item is recyclable through colours associated with an outcome.



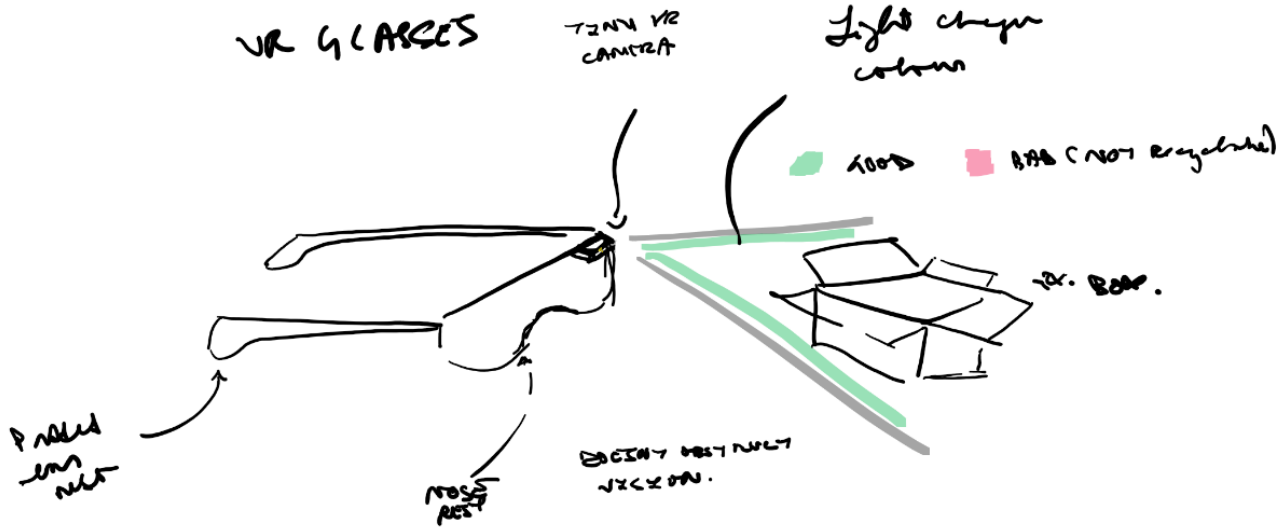
4.2.1 Physical Scanner

Second idea is a physical scanner in a dispenser form that scans the item when placed in the box.



4.2.1 AR Glasses

AR glasses that when put on and the scanner is turned on it will scan so long as it is pointed towards the item and beep based on the outcome.

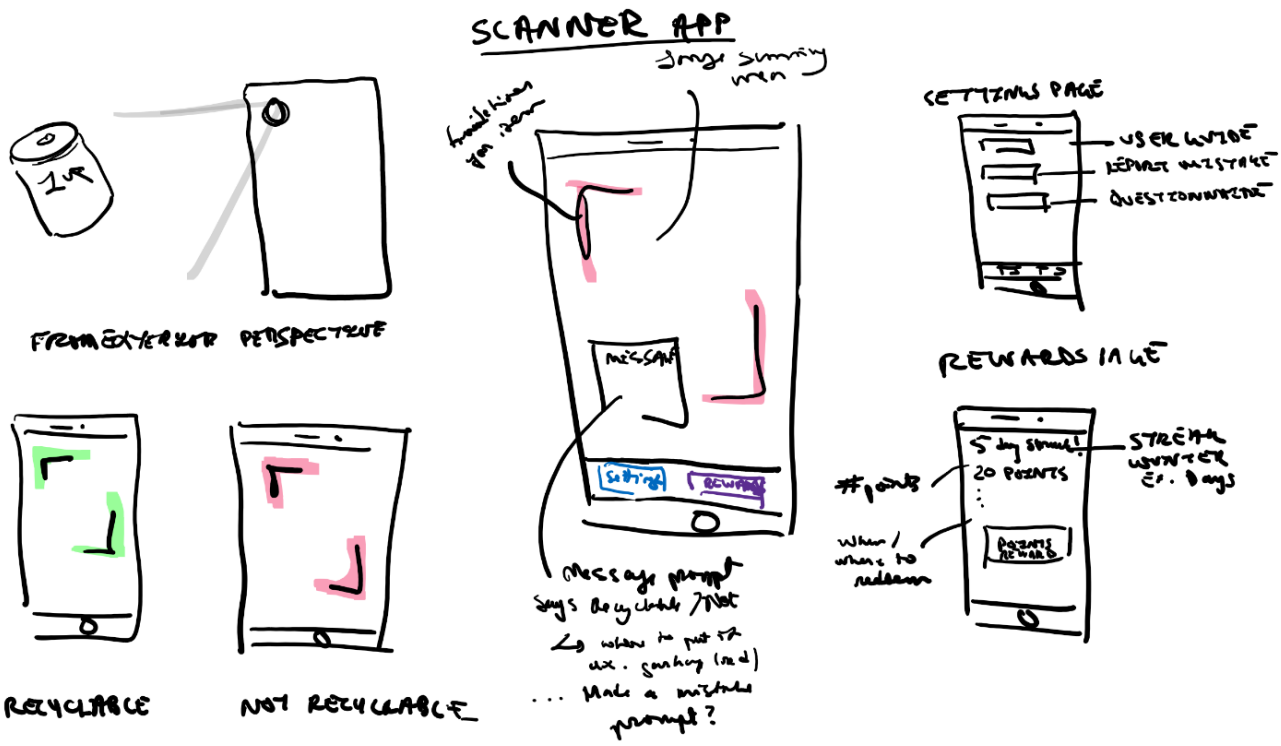


5.0 Selection of Top 3 Ideas

Users require a system that is easy to understand and above all, easy to use. The system needs to be efficient at classifying the desired item and determining its destination. Based on the current system of relying on public knowledge and posters, the **AR app**, **physical scanner** and **QR code with questionnaire** were chosen as the top 3 solutions. The app and physical scanner allow the user to rely on technology to classify the material. These solutions require few steps and are thus great solutions because the user does not need to think. The questionnaire is more complex from a user perspective because the user needs to go through more steps to get to the same destination, however the questionnaire is easier to implement which reaches a larger audience. The end goal is to help as many people recycle as well.

5.1 AR Scanner App

The app would immediately open to the home screen with the camera/scanning tool already open. These would have frame guidelines to help the user position the item in an area that the scanner will pick up, to accelerate the whole process. The app itself would function by scanning the object and creating an image from the object. From there the object would be compared to a database of images and based on the comparison a value would be generated. For example if there were 15 options for how a plastic bottle looks and the item resembles one of the options, a value between 1-15 would be generated. From there based on the range of the value, the app would have conditional statements (in the code) that would lead to the message being prompted and the change in colour. This would tell the user whether or not the item is recyclable and the appropriate bin for the item. Once the decision has been made, the frame guidelines will change colour – red if it is not recyclable and green if it is. A message will also appear, the message will tell the user whether it is recyclable or not, so that no confusion occurs. The message will also prompt the user if they believe the app has made a mistake, in this case the user may be referred to the integrated questionnaire inside the app. There are two other pages, the setting and rewards screen. The settings page will contain a user guide to reduce confusion and provide clarity. There will also be a button where the user can report if a mistake with the system has occurred, the user will enter a message which will then be sent to the team so that the problem can be solved. Lastly, there will be a questionnaire in the case a mistake has occurred, and the user still wishes to determine the fate of the item. On the rewards page, a streak will be shown. The streak will count the number of days the user has opened and used the app to recycle. There will also be a point system that will have a daily maximum and total maximum, the points will be based on the number of items scanned and the streak. The app may partner with local businesses or the local government to provide a reward for the points accumulated. Please see below for a detailed sketch:

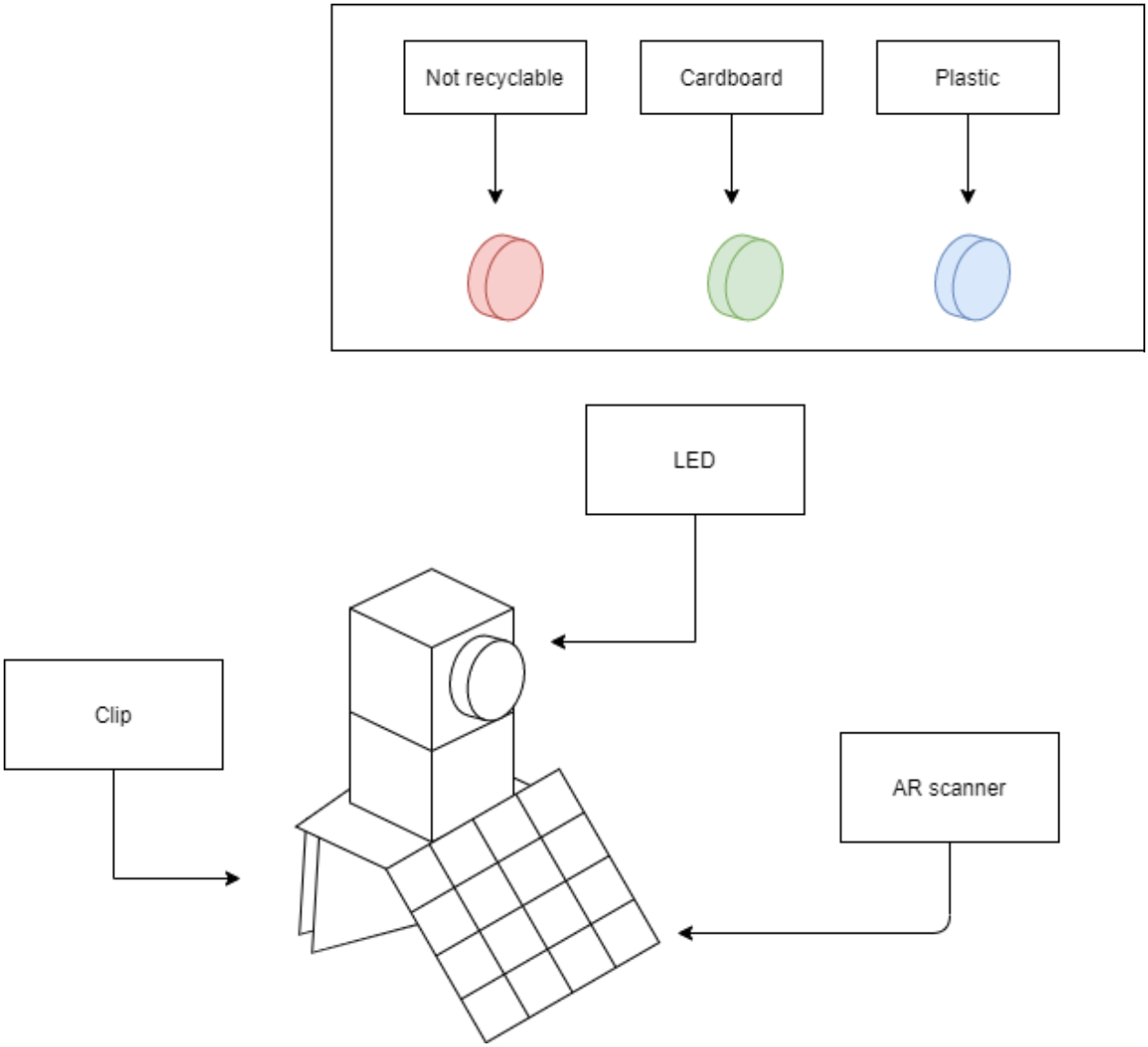


5.2 Physical Scanner

In essence, the concept of a scanner is not dissimilar to the other AR ideas presented. The thing which sets it apart from the others is its relative simplicity with regards to its use. While the argument could be made that a phone application would be more efficient, the physical presence of a scanner in the general vicinity of the recycling bin could serve as a reminder to the user to recycle.

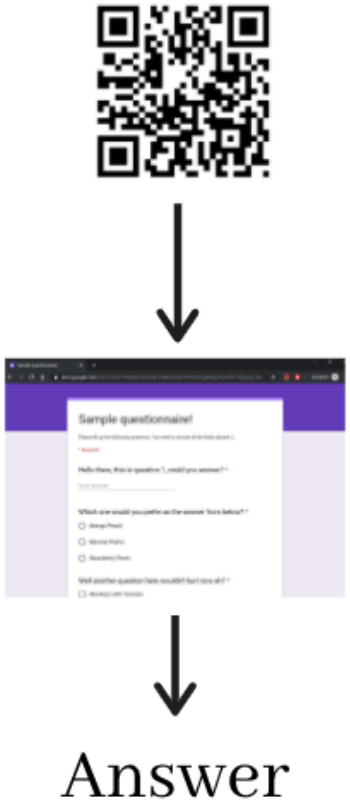
In practice, the scanner would use AR technology to detect the material of whatever object it is presented with, and then inform the user of what to do with it. As an example, if cardboard was placed in front of it, the LED would flash blue, with other colours signifying other materials, and red signifying an object that is not recyclable. The scanner would operate off a database that stores multiple cases of potential recyclable materials for the program to draw upon, to accurately inform the user.

The scanner itself would be lightweight, and easy to affix wherever the user wants to. The reason behind a clipping mechanism of some kind would be to remove effort from the user, and just allow them to place it somewhere and scan as much as they need. Please see below for a detailed sketch:



5.3 QR Code + Questionnaire

The QR Code was one of the ideas considered. The QR code can be printed out and put onto garbage and recycling bins. This way whenever the user struggles to identify which bin their item goes into, the product will always be with them. The QR code can be scanned with any phone, and the questionnaire will open. The questionnaire will ask a series of questions one after the other to the user. Ideally, the questionnaire will provide the user with the correct answer. Please see below for a detailed sketch:



6.0 Analysis & Evaluation

To determine the best of the three main ideas, the different ideas were compared. The comparison was based on the user metrics of performance time, dimension/size, complexity, adaptability, effectiveness, and implementation cost. Each metric was given a weight between 1 and 5 depending on how important they are in contrast to the client needs and requirements. Each idea was then subsequently given a score between 1 and 5 for each criterion. Each score was multiplied with the weight of the criterion and then were added up to form a total, the highest score being the best idea to fulfil the client's needs.

Criterion	Weight	AR App	Physical Scanner	QR Code + Questionnaire
Performance Time	**4**	4	5	2
Dimension & Size	**1**	4	2	5
Complexity	**5**	3	5	1
Adaptability	**4**	4	2	4
Effectiveness	**5**	4	2	2
Implementation Cost	**2**	5	1	4
Total	**-**	**81**	**67**	**52**

6.1 Performance Time

This criterion is of high importance as it was rated a 4 out 5. After evaluating the three solutions, it was determined that the physical AR scanner would be the fastest solution to reach a result. The AR app was a close second as it required one more step than the physical scanner because the user must use a phone app to then access the scanner. Finally, the questionnaire scored much lower as it requires more steps thus more time to provide a result.

6.2 Dimension & Size

This criterion is of little to no importance as it was rated a 2 out 5. After evaluating the three solutions, it was determined that the questionnaire would have the most optimal size as it requires little no memory on a device. Compared to the AR app which scored a little lower due to the fact that it requires an image data bank which requires more memory on a device. Finally, the AR scanner scored the lowest as it is a physical scanner and not a digital app. Therefore, it takes significantly more space than the other two options.

6.3 Complexity

This criterion is of high importance as it was rated a 5 out 5. The evaluation was based on the number of steps it required for the user to achieve a result. The Physical scanner simply requires one step (scan the item). Whereas the AR App requires the user to take out their device, open the application and then scan the item. Finally, the questionnaire has the same steps as the AR app however instead of scanning an item, the user would answer a few questions to get to a result. Therefore, based on the steps taken to achieve a result, the Physical scanner, AR app and Questionnaire scored, five, three and one out of five, respectively.

6.4 Adaptability

This criterion evaluates the ability to make changes on an app to adapt to a new environment or to solve a new problem. This aspect is of high importance as it was rated a 4 out 5. After evaluating the three solutions it was determined that both applications are equally more adaptable than the physical scanner. The reason for this decision is simply because the apps operate off a code. The physical scanner would need new designs and much more testing and spending to make even the slightest adjustments. Whereas apps can simply be modified by altering their code.

6.5 Effectiveness

This evaluates how accurate the solution is, which is why is it rated as highly important rated 5 out 5. After evaluating the three solutions it was determined that the AR app is the most accurate as it does not rely on human opinion like the questionnaire. The Physical scanner should theoretically produce the same results as the AR app. However, with the AR app the user can

confirm with the app if the scanned item is in fact the correct one. Therefore, making the AR app the most accurate option.

6.6 Implementation Cost

This criterion evaluates the cost to implement the tool. The AR app scored the highest as there are many platforms to build an application for free. The AR scanner scored poorly as when it is compared to the apps, its cost is significantly higher. An app can be created once, and an initial cost is paid. However, the physical scanner would need to be built and paid for anytime extra units are required. Making it very difficult to reach larger scales.

6.7 Selection Design Solution

Based on the evaluation using the criteria matrix, it is clear that the best option is the AR app. Though it requires a few more steps compared to the physical scanner, it is much cheaper to implement, easier to adapt to new environments and much easier to scale the project from household tool to commercial use. Compared to the questionnaire, they are both similar when it comes to the platform they use. However, the questionnaire takes more steps to reach a result. Also, the questionnaire relies on human opinion. Therefore, it is prone to more mistakes. Hence, when the AR application is compared to its counterparts, it is the best tool to cater to the client's needs.

7.0 Conclusion

In conclusion, the AR application is the strongest option to satisfy the client's needs. It is in line with the ways of life as everyone always has their smart phones at their disposal. It is easily scalable, as it will have little to no cost to make it available to everyone. Using our criteria matrix, the final evaluation scores for the options are: 81 points for the AR application, 67 points for the physical scanner and 52 points for the questionnaire. Thus, it is clear that the AR application is the best solution to fulfill the client's need of facilitating the recycling process in each individuals households.

Appendix A – Updated Project Plan