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Title: Designing a Digital solution for improving Electronics waste recycling practices supporting SDGs: ***A Case study using Participatory design principles***

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Abstract

Kathmandu valley, the largest EEE market of Nepal is experiencing emerging challenges with the rise of electronic waste (e-waste). Data from Nepal's department of Environment shows that 18000 metric tons of e-waste were generated inside Kathmandu valley in 2017. While e-waste management is one of the biggest and serious issues, the Nepal government has not given the required priority to tackle the problem. The use of electronics has been growing and will continue to do so as technology advances but the lack of proper guidelines and regulations regarding proper disposal or reuse of electronic waste can cause serious problems by directly affecting human health, the environment and holding back sustainable development. The problem of e-waste has convinced different environmental agencies of various countries to innovate, develop, and adopt environmental solutions and a better strategy for E-waste recycling.

The main objective of this research is to analyse the e-waste recycling scenario in the context of Nepal and to use this data and understanding to design a digital solution as an intervention and instrument for co-constructing sustainability transitions in electronic waste recycling practices. This research conducts an intensive literature review, interviews with different stakeholders, questionnaire with a young user group and a virtual future workshop.

Using the Theory of Planned Behaviours, the researcher observed that although individuals have keen interest in recycling their electronic appliances, they are not being aided towards their recycling habits due to several different factors such as lack of proper facility, insufficient information etc. Although many of the participants in the research have great willingness to recycle, they are not able to do so because of the system where they are not given any educational awareness regarding the different forms of recycling and are not provided with the right means to do so.

The data collected from the various data collection methods had guided the design of the mobile application as a digital solution to improve the current problem in the practices of e-waste recycling.

The concept of the mobile application is based on the 3Rs of the sustainability practices: Recycle, Repair, Reuse. And the main features of the application are based on 5 Information system roles (i) Information element; (ii) Gamification element; (iii) Education Element; (iv) Communication service and (v) Trading platform.

This research starts with an attempt to understand the challenges of both the recycling companies and individuals based in Nepal, and based on the data collected throughout the research, ends with offering a solution in the form of a mobile app for e-waste management.

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Abbreviations

E-waste = Electronic Waste

CEPHED = Center for Public Health and Environmental Development

EEE = Electrical and Electronics Equipment

MTS = million tons (MTs)

TPB = Theory of Planned behaviors

ASA= Activity system analysis

TA= Thematic Analysis

FW= Future worshop

1 Chapter 1: Introduction

Kathmandu, the capital city of Nepal is situated inside Kathmandu valley along with 2 other small cities Bhaktapur and Lalitpur, covering a total area of 570 sq.km. The total population of Kathmandu valley, which is known as the hub of Information Technology in Nepal, is 2.5 million and it covers 9 % of the total population of Nepal. According to a study performed by Center for Public Health and Environmental Development (CEPHED) as mentioned by Pace Nepal (2017), Kathmandu is the largest EEE market of Nepal which is also known as the business center of the

whole country (PACE Nepal Pvt. Ltd., 2017) Residents of Kathmandu valley have easy access to the Internet, which has resulted in a rapid increase in the usage of Electrical and Electronics Equipment (EEE). When these EEE come to the end of their lifespan and are no longer useful to the people, they are discarded as waste – which is known as electronic waste (e-waste). The contamination of such e-waste on the environment can be hazardous. Most of the e-waste consists of a toxic substance such as lead, cadmium, polychlorinated biphenyls, etc. which directly affects the health of a person by damaging the nervous system, affecting the development of the kidney and heart and causing various other diseases such as lung cancer, allergies, skin disease and so on (PACE Nepal Pvt. Ltd., 2017). It also impacts the environment creating water pollution and air pollution, which directly affects the flora and fauna of the area.

The report presented by Nepal's department of Environment shows that 18000 metrics tons of e-waste were generated inside Kathmandu valley in 2017 (Awale, 2018). E-waste management is one of the biggest global problems which is growing rapidly in Nepal too. Globally 53.6 million metric tons of e-waste are generated each year (Forti, Baldé,, Kuehr, & Bel, 2020) out of which only 17.4 % is officially recorded and recycled. It is estimated that 74 million metric ton of e-waste will be generated by 2030. Many nations around the world, such as China, India, USA, and Europe have their national legislation to address the e-waste problem. Though e-waste management is one of the biggest and serious issues, the Nepal government has not given the required priority to solve the problem (PACE Nepal Pvt. Ltd., 2017). The use of electronics will surely grow with the development of technology but the lack of proper guidelines and regulations regarding proper disposal of electronic waste can cause a serious problem by directly affecting human health, the environment and creating challenges for sustainable development. The problem of e-waste has convinced different environmental agencies of many countries to innovate, develop, and adopt environmental solutions and a better strategy for E-waste recycling. In this research, we are going to study the e-waste recycling problem of the residents of Kathmandu which we are

going to assume as Nepal and design a digital solution which will help and encourage them to recycle the e-waste from their household. This will also contribute towards the achievement of several goals of the 2030 Agenda for Sustainable Development Goals (SDGs).

1.1 Research Objective:

- To determine the people's behaviors and willingness to recycle the e-waste.
- To identify the problem in electronics waste recycling practices,
- To identify the sustainability issues with electronics waste and its potential sustainable practices,
- Design a digital solution as an intervention and instrument for co-constructing sustainability transitions in electronic waste recycling.

1.2 Problem Statement (PS) and Research Question (RQ)

PS: How to design a digital solution that improves Electronics waste Recycling Practices in Kathmandu valley?

1. What are the current practices of E-waste recycling in Kathmandu valley?
2. What is the impact of electronic waste on Sustainable Development and which sustainable practices can be helpful to resolve the problem of e-waste?
3. What requirements should be considered in the design of a digital solution that sustainably improves e-waste recycling practice?
4. What principle should be considered in the design of a proposed digital solution to meet the user expectation with interaction model and interface design?

1.3 Research Framework

A conceptual framework shown in Fig. 1 illustrates how a digital platform can be used to facilitate sustainability transitions in recycling practices of electronic waste. This framework is based on the existing research in the fields of sustainability, recycling practices and Green apps

development. This framework is based on the case study of Mobile Apps for Green Food Practices by Lansink, Spaargaren, & Mu (2019). The case study of Green Food Practices presents the dining out practices with the Chinese and Dutch young consumers (Mu, Spaargaren, & Lansink, 2019). Based on this similar concept, our case study focuses on electronics waste recycling practices with Digital Platform.

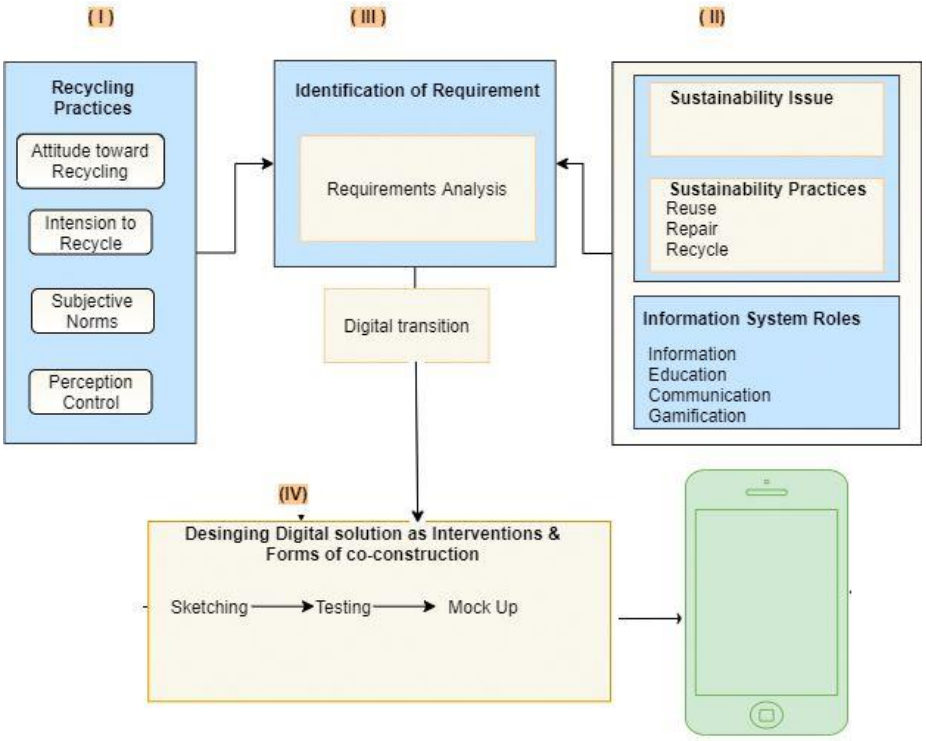


Figure 1 Conceptual framework for designing digital platform based on sustainability E-waste Recycling Practices Source own

The framework consists of the following sections:

I. Identification of problem in electronics waste recycling practices
II. Identification of sustainability issues with electronics waste and its sustainable practices
III. Conceptualizing the design guided by User's innovation and related study.
IV. Designing a digital solution as an intervention & form for co-constructing sustainability transitions in electronic waste recycling.

1.4 Limitation

This research is focused only on e-waste recycling problems faced by residents of Kathmandu valley aged between 20 to 30 as a case study. This research paper does not represent the e-waste recycling problem of the whole Nepal because of the diversity of population and the diversity in the use of technology inside Nepal.

The other limitation of this report is that in Nepal, there is no any department or authority that has recorded or researched the quantity of generated e-waste. So, in the report, the researcher has conducted a questionnaire and has interviewed participants from Kathmandu and has assumed that *mobile phones and the related accessories* are the highest produced e-waste.

The participants involved in research are not a large sample of the entire youth group of Nepal who use these electronic products, and this can affect the reliability of the research. Thus, the entire youth of Nepal producing e-waste cannot be represented with our non-probability sample. Similarly, the age-group of the participants limits the understanding to only a handful of the population that use electronic goods and produce e-waste. The income level and work or school related requirements for use of gadgets also haven't been considered in this research, although these factors highly tend to affect the purchasing and discarding behaviour of the e-goods users. We have also only considered individual level usage of electronic products and there are many organizations that also generate a lot of e-waste.

Another limitation of this paper is the language barrier. This paper is written in English but due to the participants' preferences, the survey and interviews were conducted in Nepali, the official language of Nepal. So, the researcher had to translate the workshop and interviews from Nepali to English. To give a sense and meaning to the Nepali translation, I have translated the

overall idea of conversation rather than making a word-to-word translation because there are several words of phrases that do not have a direct translation in English.

1.5 Project Outline

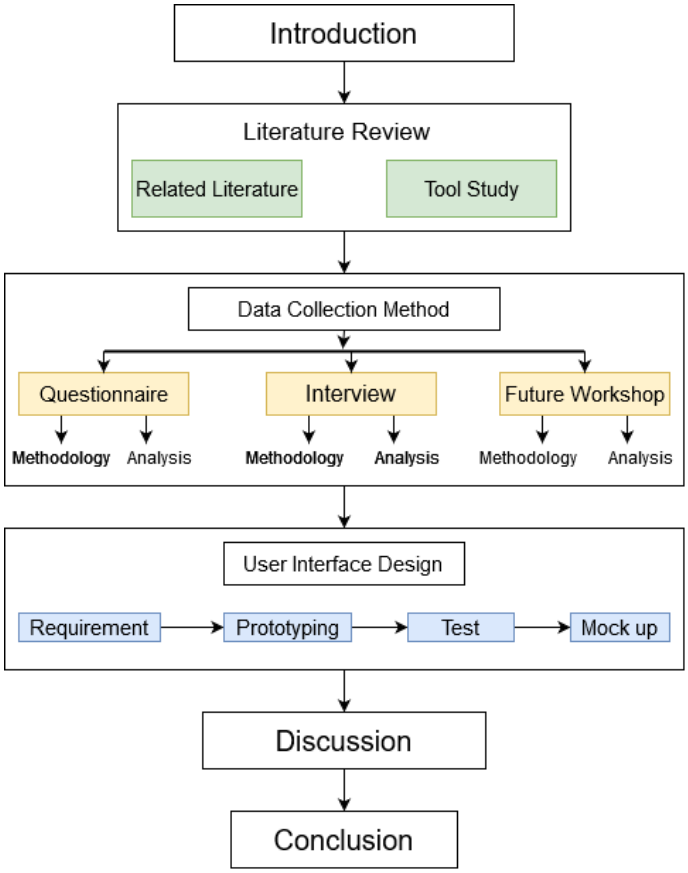


Figure 2 Project Outline; Source own

Chapter Summary

This chapter gives an introduction to the problem statement and justifies that e-waste disposal is one of the emerging problems in Nepal that requires to be tackled with a potential digital approach. Section 1.1 and 1.2 mention the research objectives and research questions.

Section 1.3 describes the conceptual framework of the research and section 1.4 states the limitation of this research.

2 Chapter 2: Literature Review and Tool study

The following chapter presents the literature review. It includes systematic literature search and review of the related literature on a different topic. The following chapter will also discuss related tool study for inspiration for the design process.

- **Literature search**

Literature searches have been conducted on various sources of a database to search the literature for this research. The main sources of the database are Google Scholar, ProQuest, and Ebsco Host. Databases with a broad scope like Academic Search Premier, Jstor and Scopus have also been used. Some of the data is collected from the Aalborg university library (https://www.en.aub.aau.dk/). The full search scheme is located in Appendix 1.

- **Search Structure**

A systematic literature search can guide us closer to the answer to our research question. For this paper, I have used the Building Blocks Strategy, where the required information is placed into a specific block based on a similar term (Schlosser, Wendt, & Bhavnani, 2006). This process starts out with looking for a theme for a search-keyword. The idea for the keywords in the case of this research have been derived from my thesis title and problem statement. Those keywords are searched with a different combination of the search string. “Different combinations in a quick and easy search strategy using Boolean operators: AND, OR and NOT can be used to make the searching process systematic” (Cronin, Ryan, & Coughlam, 2008).

- **Processing the Literature**

The researcher will follow the PQRS-method to make a systematic literature review. “PQRS is a system that facilitates easy identification and retrieval of material, especially when reviewing a large number of publications” (Cronin, Ryan, & Coughlam, 2008, p. 41).It consists of four stages: Preview, Question, Read and Summarize.

2.1 Related Literature

2.1.1 E-waste

The term waste refers to anything that no longer has value to the owner or has reached its end-of-life stage (Porter, 2010). Similarly, electronic waste (e-waste) can be defined as unwanted and old electronic items that are no longer functional and therefore have no value to the owner. Electronics waste is considered as the item generated from electrical and electronic equipment (EEE). Nepal Telecommunication Authority (2017) has defined e-waste as: *”E-waste is a generic term encompassing various forms of electronic and electrical equipment (EEE) which are old, end-of-life electronic appliances and which have ceased to be of any value to their owners”* (Nepal Telecommunications Authority, 2017).

Furthermore, Blade, Forti Gray, Kuehr, & Stegmann (2017) has referred electronic waste to all the electrical and electronic equipment (EEE) that has been discarded by the owner (Baldé, Forti, Gray, Kuehr, & Stegmann, 2017). Global e-waste monitor (2017) has included the definition of e-waste mentioned by Baldé et al. in their report which covers following six categories:

1. Temperature exchange equipment: It includes all types of cooling and freezing items such as refrigerators, freezers, air conditioners, and heat pumps.
2. Screens and monitors: It includes the equipments which have a screen and monitors in it. It includes items such as televisions, monitors, laptops, notebooks, and tablets.

3. Lamps: This category includes lamp items such as: fluorescent lamps, high intensity discharge lamps, and LED lamps.
4. Large equipment: This type of category includes large equipment such as: washing machines, clothes dryers, dishwashing, machines, electric stoves.
5. Small equipment: This includes small equipment such as: vacuum cleaner, toasters, electric kittles, video games and so on.
6. Small IT and telecommunication equipment: It includes items like mobile phone, calculator, computer, printer, etc. (Baldé, Forti, Gray, Kuehr, & Stegmann, 2017)

According to Mario and Casey as mentioned by Hossain, Al-Hamadani, and Rahman (2015) e-waste can be categorized into two types by its physical components i.e. electrical e-waste and electronics e-waste (Hossain, Al-Hamadani, & Rahman, 2015). Electrical e-waste includes refrigerators, washing machines, vacuum cleaners, etc., and electronics e-waste includes televisions, monitors, radios, calculators, etc.

Figure 3: different type of e-waste by Mario and Casey 2008 as mentioned by Hossain et, al. (2015) Source: Mario and Casey 2008; Schwarzer et al. 2005 uploaded by Md Sahadat Hossain (2015)

With the development of modern technology, a large amount of e-waste is generated each year. According to the United States Environmental Protection Agency (USEPA) as mentioned by Hossain, Al-Hamadani, and Rahman (2015) the growth of e-waste has been increased as a proportion of global solid waste generation and currently contain 8 % of the total volume of current municipal solid waste (Hossain, Al-Hamadani, & Rahman, 2015). Likewise, the Basel Action Network (BAN) has estimated that the global e-waste generation has increased from 9.3 million tons (MTs) in 2005 to 50 MTs in 2012 as mentioned by Hossain, Al-Hamadani, and Rahman (2015) in their report (Hossain, Al-Hamadani, & Rahman, 2015). The data shows that e-waste is one of the globally emerging challenges.

2.1.2 E-waste: An Emerging Global Challenge

The consumption of electronic products is increasing rapidly these days. Electronic waste management has become one of the major global issues. It is estimated that 44.7 million metric tons of e-waste was generated in 2016 globally, which is equivalent to almost 4,500 Eiffel towers (Baldé, Forti, Gray, Kuehr, & Stegmann, 2017). Coming to 2019, the e-waste has been increased to 53.6 million metric tons (Forti, Baldé,, Kuehr, & Bel, 2020). Only 17.4% of the e-waste is officially documented as properly collected, whereas 82.6% of the e-waste was not formally collected and managed, which means that an estimated $57 billion worth of gold, silver and other valuable material were dumped or buried rather than being recycled or reused (Forti, Baldé,, Kuehr, & Bel, 2020). The report said Asia generated the highest quantity of e-waste in 2019 at 24.9 million metric ton, whereas America generated 13.1 million metric ton and Europe generated 12 million metric ton of e-waste (Forti, Baldé,, Kuehr, & Bel, 2020). It is estimated that in 2030 the e-waste generated will be more than 74 million metric ton worldwide. The e-waste issue is now seen as a global issue that needs to be addressed for proper management.

Asia has become the main source of world waste generation, Hotta et. al., as cited in (Khatri, 2019) where China is the top e-waste producer generating 10.1 million metric ton of e-waste in 2019 (Forti, Baldé,, Kuehr, & Bel, 2020). It is estimated that China will generate around 27 million ton of e-waste by 2030. China accounted for approximately 70% of the worldwide generated e-waste each year (Zhang, Schnoor, & Zeng, 2012). As China generates a large amount of e-waste each year, its national legislation regulates the collection and treatment of fourteen types of e-waste (Forti, Baldé,, Kuehr, & Bel, 2020). Likewise, Japan generates 2.5 million ton of e-waste each year, which are collected and recycled under the Act on Recycling of Specified Kinds of Home Appliances and the Act on Promotion of Recycling of Small Waste Electrical and Electronic Equipment (Forti, Baldé,, Kuehr, & Bel, 2020). Considering the e-waste problem as a serious global issue, different Asian countries such as: India, China, Japan and South Korea have

amended their law to address the proper management of e-waste. But most of the developing Asian countries like Nepal, Bhutan and Bangladesh still do not have proper e-waste legislation and because of it, e-waste management issue is becoming one of the major issues for such countries.

According to Hossain, Al-Hamadani, & Rahman (2015) some of the developing countries from Asia such as: India, Bangladesh, Pakistan and from Africa such as: Ghana, the Ivory Coast, Nigeria and Liberia have become a destination for dumping the e-waste. According to the UNEP press release report, the US sold 350 million second hand computer units in 2004 and 3 billion units in 2010 to Asia and Africa which resulted in increase in e-waste dumping in Pakistan by 125%, India by 97.3% and Bangladesh by 37% since 1991 (Hossain, Al-Hamadani, & Rahman, 2015). All the dumped e-waste is contaminated with the air, water and soil which directly affect the environment and the health of an individual. E-waste can be hazardous as it is composed of a mixture of different complex materials and components containing more than a thousand different toxic and non-toxic substances (Stefan, Andréa, Gregory, Stéphane, & Pascal, 2005).

Rapid changes in technology is one of the reasons why large amounts of e-waste is generated. According to Hossain, Al-Hamadani, & Rahman (2015), changes in the technology replace the existing model of the electronic product or makes old models useless, less valuable and non-functioning in certain cases, which results in converting such electronic goods as waste (Hossain, Al-Hamadani, & Rahman, 2015). Furthermore, Gurauskienė (2008) has also mentioned that rapid changes in the technology help to generate large volumes of e-waste (Gurauskienė, 2008). According to Zhang, Schnoor, & Zeng (2012) in China, the domestic generation of e-waste is rapidly increasing due to the increasing popularity of modern electronics (Zhang, Schnoor, & Zeng, 2012). So, when the technology gets advanced and changes rapidly the e-waste will increase in the same ratio.

2.1.3 E-Waste management in Nepal

In Nepal, there is no officially established system to separate any kind of waste (Parajuly, Thapa, Cimpan , & Wenzel , 2017). Generally, the government collects waste every 3rd day in a big truck where people mix all kinds of waste. There are no separate containers or special rules regarding the separation of the different kinds of waste. Even if the waste is separated by an individual, then the personnel collecting the waste will eventually mix the waste in the collecting trucks with other waste. There is no proper waste management system in Nepal. Parajuly, Thapa, Cimpan , & Wenzel (2017) in their research has mentioned that landfilling is only the waste management system adopted by the Kathmandu municipalities (Parajuly, Thapa, Cimpan , & Wenzel , 2017). In the future, Nepal may face hard times if the waste cannot be recycled as it is very dangerous to dump waste at landfill sites (Khatri, 2019). Due to lack of infrastructure residents of Kathmandu are bound to mix all kinds of waste. Some of the private companies and NGOs collect the waste in Nepal but they charge a certain amount of agreed fee (Parajuly, Thapa, Cimpan , & Wenzel , 2017). Nepal Telecommunications Authority (2017) mentioned in the report that some of the KABADIS of Nepal buy the e-waste from the customers and resell it to electronic repair shops and only then, the e-waste is being recycled (Nepal Telecommunications Authority, 2017).

Khatri (2019) has mentioned that although the import of electronic products in Nepal is accelerating day by day, the government of Nepal has not given any required priority for the e-waste management system (Khatri, 2019). Chakraborty, Selvaraj, Nakamura, Prithiviraj, Ko, & Loganathan (2016) has stated in the UNEP report in their research that the consumption of electronic goods are increasing rapidly in Nepal but till now, waste characterization studies have not been initiated (Chakraborty, et al., 2016). Every year with the development of advanced technology, the demand of electronics in Nepal is increasing rapidly but due to lack of proper policy and e-waste management system, Nepal may be in danger. Khatri (2019) has said that the

biggest problem regarding the e-waste in Nepal is that there is no specific set of rules regarding the proper e-waste management system (Khatri, 2019). Hence, it can be observed that the government of Nepal has not taken any step in managing the e-waste.

2.1.4 Relation of E-waste problem with Sustainable Development Goals

Figure 4 17 SDGs introduces by UN Conference Source (Baldé, Forti, Gray, Kuehr, & Stegmann, 2017)

As, the demand of 21st century and growing awareness on sustainability in 2012, The Sustainable Development Goals (SDGs) was introduced at the United Nation. This initiation has created a set of universal goals that target to end poverty, save the planet and build a prosperous life for all living beings. The increase in the number of electronic wastes is also one of the biggest challenges to achieving SDGs. Electrical and Electronics appliances (EEA) like smartphone, laptop, television, radio, desktop computer etc. are the variety of EEA that we use in our daily life. There is an increase in the number of consumptions of such EEA due to several factors like growth in the technological sector, people changing habits due to materialistic lifestyle, digital growth in the service sector. All these EEA is made up of different toxic material and hazardous chemical components which has potential adverse impact to any living being and ecosystems. Increasing levels of e-waste and its improper management will directly impact the economy, society and environment (Baldé, Forti, Gray, Kuehr, & Stegmann, 2017) (Baldé, Forti, Gray, Kuehr, &

Stegmann, 2017).. Therefore, it is necessary to address this problem and support SDGs from every individual and organization.

Research study in the topic of e-waste will help generate more data and better understanding of this problem which helps to contribute to the achievement of several SDGs. Practices of proper e-waste recycling will address the SDGs related to protection of environment and health. Business emerged from the concept of e-waste recycling will create an employment opportunity and economic growth. With this research, we expect to address the several targets of SDGs and contribute to the achievement of following goals of the 2030 Agenda for Sustainable Development.

- **Good health and Well-being:**

To ensure the healthy life of a living being is one of the targets of Sustainable Development Goals (SDGs). Currently, the world is facing a problem with sustainable e-waste management. Due to lack of proper e-waste management system several countries of the Africa and Asia are dumping their e-waste on the landfill sites (Baldé, Forti, Gray, Kuehr, & Stegmann, 2017) that directly contaminates the air, soil and water, which affects the health of a living being. Baldé et. al., (2017) mentioned that a proper and sustainable e-waste management system helps to reduce the number of deaths and serious illnesses caused by hazardous chemical contamination (Baldé, Forti, Gray, Kuehr, & Stegmann, 2017). So, the design of a sustainable e-waste management system helps to meet the target of good health and well-being.

- **Clean water and Sanitation**

Another target of the Sustainable Development Goals (SDGs) is to minimize the water pollution and target to achieve universal access to safe and affordable drinking water (Baldé, Forti, Gray, Kuehr, & Stegmann, 2017). Unsustainable dumping of e-waste can affect the water

resource. The mixture of e-waste on water will pollute the water and result in suffering from different kinds of diseases. The sustainable management of e-waste will help in minimizing water pollution.

- **Economic Growth**

SDGs aims to promote the policy that supports productivity activities, creativity, job creation and innovation (Baldé, Forti, Gray, Kuehr, & Stegmann, 2017). Zang, Schnoor & Zeng (2012) mentioned that e-waste contains valuable and reusable materials such as gold, silver, copper and plastics which can be recycled and can be a potential business that helps to upgrade the economy (Zhang, Schnoor, & Zeng, 2012). Report of Pace Nepal (2017) recommends establishing a recycling plant in a developing nation like Nepal which helps to generate the income and job opportunity (PACE Nepal Pvt. Ltd., 2017). Establishing a recycling company will uplift the economy and create the opportunity among the people. China is one of the nations that has given job opportunities to a large number of its population through recycling plants which is one of the major sources of income (Zhang, Schnoor, & Zeng, 2012).

- Life Below Water

Marine pollution is one of the major issues SDGs want to address. Due to increase in technology and commercial use of marine resources different types of marine waste has been increased. The e-waste having plastics, metal, coppers and other elements in it can cause danger to the life below the water. So, recycling such materials can save the life below the water and balance the marine ecosystem.

2.1.5 Sustainability Practices of E-waste

The development of mankind has been directly affecting the environment and ecological system which results in climate change, resource depletion and affects the existence of species.Hardi and Zdan (1997) have mentioned that "*sustainable development commits us to considering the long-term and to recognizing our place within the ecosystem*" (Hardi & Zdan, 1997, s. 9). The development of mankind has been directly affecting the environment and ecological system (OLGAN, GÜLER, & KAHRİMAN-ÖZTÜRK, 2012) which results in climate change, resource depletion and affects the existence of species.Hardi and Zdan (1997) have mentioned that "*sustainable development commits us to considering the long-term and to recognizing our place within the ecosystem*" (Hardi & Zdan, 1997, s. 9). All the produced waste should be managed sustainably. The European parliament and the Council of the Union (2008) has designed a waste management hierarchy which set priorities for the efficient use of resources (THE EUROPEAN PARLIAMENT AND THE COUNCIL OF THE EUROPEAN UNION, 2008). The waste management hierarchy sets a framework to handle waste which encourages the community to avoid and reduce the generation of waste. It also explains about the methods of reuse, recycle, recovery and disposal of waste. The solution for this research question is inspired from the waste management hierarchy, as it explains the main objective is to manage the waste sustainably. This thesis will be focusing on 3 major components i.e. recycle, repair and reuse and the solution will be based on this 3R concept. With the help of this solution, people will be encouraged to recycle, repair and reuse their e-waste.

Figure 5 Concept of 3rs of Sustainability source own

Recycle:

Recycling is one of the sustainable waste disposal techniques. Nindyati (2014) has mentioned recycling as a green behavior (Nindyati, 2014) .Olgan et. al., (2012) mentioned that recycling behavior positively impacts the environment and economic status of people. With the help of our solution users will be able to easily recycle their e-waste and support sustainable development.

Repair:

Repairing the electronics instead of throwing out and buying new products will save the money of the person and reduce e-waste. Our solution will encourage people to repair electronics and give them easy access to their repair shop.

Reuse:

Reusing the product if it can be used will help to reduce the waste. Our solution will encourage people to reuse their old and unused electronics in a new way. For example, it will inform people how they can use their broken and old cable to decorate their room. Our solution motivates people to think how to reuse old products and make alternatives to another one.

2.2 Related Tool Study

In order to understand the general design idea about the application related to a sustainable solution, the researcher had conducted a short study on several applications available on Google PlayStore and Apple App Store. The main goal for this tool study is to get an overview on the main design aspect and features that are used on different applications based on several sustainable solutions for waste management. This would help the researcher to generate the ideas that have already been researched and how we can contribute in this field by improving the platform with better solutions. Similar research has been conducted by Brauer, Ebermann, Hildebrandt, & Remane in their research paper in 2016. Brauer, Ebermann, Hildebrandt, & Remane (2016) hves stated in their research paper that, there was more than 260 application in google play store that were related to the environment (Brauer, HIIdebrandt, Ebermann, & Remane, 2016).Their study shows an overview of a mobile application that aims to encourage environmental sustainability and referred to those apps as ‘green apps’ (Brauer, HIIdebrandt, Ebermann, & Remane, 2016). The same term ‘green apps’ will be used to refer to all the environmental-related applications discovered during this research.

Green apps Searching Process in Play store & App store

To search for the related existing green apps, the researcher conducted a comprehensive search process in Google Play Store & Apple App Store using a different keyword. Brauer et. al,

(2016) had listed a variety of different keywords in their paper used for searching green apps in the play store (Brauer, HIIdebrandt, Ebermann, & Remane, 2016).

Keyword	Occurs
Environmental* sustainability	2117
Sustainable development	508
green* sustainability	162
Sustainable city	74

Table 1 mostly occurrence keyword source (Brauer, HIIdebrandt, Ebermann, & Remane, 2016).

Out of 22 keywords from Brauer et. al, (2016) research, Environmental sustainability has the highest occurrence which can be considered as the important facets to be overlooked (Brauer, HIIdebrandt, Ebermann, & Remane, 2016). Besides that, the researcher selected 3 more other keywords which had terms related to sustainability and green city. These keywords were used to search in Google Play Store and Apple App Store and all the generated results were listed. Keywords suggested by different bloggers to find a list of related apps were also used. Moreover, a pearl growing method was used to search other relevant applications where one app is used to search for other related and appropriate applications (Ramer, 2005).

After the researcher came up with a list of several applications, the apps were classified into different groups. The classification of all those apps were based on the Nickerson et al. (2012) *method for taxonomy development and its application information systems* (Nickerson, Varshney , & Muntermann, 2013). Brauser et al. (2016) (Nickerson, Varshney , & Muntermann, 2013).

Brauser et al. (2016) used this method in their green apps analysis process which had inspired this research to follow the similar classification guidelines on our research (Brauer, HIIdebrandt, Ebermann, & Remane, 2016).

In the first step of the green app's analysis process, the apps were classified based on their domain and goals. For the analysis process, the data from the text description was used in the app store and the developer site on which they have described the main goal and character of the application. Later, a list with the application name, short description, supportive feature on application was created. The final list of applications has been discussed further in Appendix 26 and sorted for further study. All relevant apps were categorized in YES category and irrelevant apps in NO category. To find out which app is more relevant for further study, all the irrelevant apps were filtered out based on following criteria:

1. If the main purpose of the app is not related with Recycling and Sustainability Practices.
2. If there is not enough information about an application in the App store or Developer site.
3. If the application is somehow related with another application which was already reviewed.
4. If the application Interaction model does not look promising to this study.

After this, the relevant apps were sorted, further study was continued with the goals and functionalities of relevant apps. To identify the Information system(IS) role of relevant apps, the roles concept was used from the analysis of green apps by Brauer (Brauer, HIIdebrandt, Ebermann, & Remane, 2016). Brauer mentioned that *Informate* is the most used role with the green apps. The main purpose of this role in the apps is to provide information in the form of, eg., news or tips. Another mostly used role in the green apps is *Transformate* which allows people to switch their routines by offering services or more sustainable products (Brauer, HIIdebrandt, Ebermann, & Remane, 2016). However, there were three more roles: *educate, gamify, and collaborate* that emerged during the analysis of Green apps (Brauer, HIIdebrandt, Ebermann, &

Remane, 2016). Brauer describes *Educate* role with the character that engages users in the learning process using teaching material to educate the user about the environment problem and solution (Brauer, HIIdebrandt, Ebermann, & Remane, 2016) .*Gamify* role consists of the solution that are not typical games but contain a gamification element like ranking , badge, points, rewards etc. (Brauer, HIIdebrandt, Ebermann, & Remane, 2016) Lastly, *Collaborate* role is composed of two elements where the first concern is to collect the data from the user where the user enters the environmental data and upload information while the second element is concerned with the user engagement to share ideas or action with other users via different social media components. Using the concept of these IS roles, we have sorted our relevant apps with their domain function.

2.2.1 Result & Analysis of Tool Study:

The analysis of the green apps for this study shows interesting results that support the research. All the seven relevant applications look promising to this research and help to identify the core function that any green apps should consist of. Here is the list of the relevant apps mentioned with their goals and specialization.

Jump is one of the promising green apps in the app store. This app is designed to encourage people to take positive actions that improve sustainability and well-being. The three main approaches used in this app for user engagement is *Technology, Gamification & Communication.* It has a feature that drives behavioral changes and tracks and measures the impacts of the user. It also provides friendly competition between users and rewards the top performers which motivate the people to take action.

Second in the list of our green apps is ***Oroeco,*** which is the application that tracks users' climate impact through everything they buy and eat or the energy they use at home. It also provides personalized tips to improve their activity. It consists of the feature that compares,

collaborates and provides a scope of competition with other users in a fun way and allows them to earn points and prizes.

Joule Bug also has mobile gaming, social media and educational features. Besides that, this app enables users to be part of local or national challenges within the platform and see who the greenest user is. Users can themselves create a challenge in the local community and invite nearby users for the challenge. Information about sustainability related news and tips also makes this app one of the best in the list of green apps. This app helps people learn about sustainable practices and become aware of the problems related to improper waste management practices.

Another promising app in our relevant app lists is ***Co-Go***. This app has a location-based service that connects the user with a whole range of businesses that share the sustainable eco value in their business. Before users start using the Co-Go app, they select the preferences that match their interest. Then once the app understands the user values, it will suggest the companies nearby that match their preferences, like restaurants, supermarkets etc. Moreover, this app records all the transactions made by the user through this app and shows them, in expenditure results, the impact that they made to support sustainable business.

Recircle is another application that connects corporations which have similar goals and objectives toward sustainability. The main feature that makes this app different from others is that with just a few clicks, buyers will provide a door-to-door service to pick up the stuff. It also shows a nearby recycling center where people can drop their waste for recycling. This app also records all the recycling activities of the user and rewards the user with points.

ReGain is a donation platform where people can donate their good quality items for resale purposes or donate their unwanted or defective items to reduce landfills. This app features the discount coupon service to the user whenever they donate their unused items. While using

this app, users get access to find the drop-off point nearest to them or request for a pickup. It has a minimalistic design and only focuses on donation of a few specific items.

Go Green Denmark has an application-based solution called "***Go Green Guide''***, which is a common hub for all sustainable consumers and businesses. This app guides users to find businesses in different categories that promote sustainability through their business. It is the bridge connecting the gap between businesses and consumers that supports sustainability. This platform helps to find the business that runs on the sustainable business model and helps people make green choices whenever they shop.

Analyzing the tools to inform design principles

Based on analysis of the seven green apps, one of the common patterns noticed was the use of colour. Most of the apps use green as the primary colour in the app adding the hint of sustainability through colour pattern. (Delong & Goncu-berk, 2012) had mentioned that green colour is commonly used to promote sustainability. However, every app was distinguishable from each other in terms of interface model design. Features like the reward system have been observed in five of the green apps which aim to encourage users to change their behaviors. Besides the reward system, communication or collaboration is a common feature that is implemented to engage users within a community to get inspired from each other with recycling practices. A feature like the educational support from Joule Bug can be useful in our design too, guiding people with knowledge on small do-it-yourself (DIY) projects where people can get different tips and ideas to repurpose their electronics waste. Another promising feature implemented in several green apps is to record the user impact. Collecting user data to analyses user behaviors can help users view their electronics waste recycling activity and the impact they

had made by reducing the landfill with e-waste. The concept of donating and selling from the Regain app is also useful in our design where people can donate or sell their unused electronics item to another user. Another useful feature used in Go Green Guide, ReCircle & Co-Go is the location-based service. This feature in our design will help people to find a nearby recycling or repairing centre.

All of these features have been used as an inspiration for the application design of this research. The study of related applications based on sustainability practices gave insights on the different aspects of the interface and interaction model. However, the solution design as an outcome of this research will target the needs of the local Nepalese community and their preferences. So, further research was continued to understand the core problem in the Kathmandu valley to figure out the community preferences on solutions to tackle the problem of e-waste through a digital platform.

2.3 Theory

In this section, Researchers will present the theories seen in figure 1 and discuss how this has been used in this research. Section 2.3.1 contains the theory of planned behavior that has been used to understand the people's perception about current e-waste practices and willingness to adopt new practices that examine their recycling behavior. Section 2.3.2 will present the activity theory that is used for the analysis and understanding of people interaction through their use of tools and artefacts.

2.3.1 Theory of planned behaviour

Most of us think that people’s behaviours are determined by their attitudes. However, an attitude is not the only factor that determines people’s behaviours. Theory of planned behaviours(TPB) presents more predicting factors that affect the human behaviours. It is used to

examine the behaviours of people by analysing their intentions. There are three main factors; Attitude, Subjective Norm, & Perceived Behavioural Control that determine the intention of people (Azjen & Maddel, 1986). Attitude has a direct effect on the intentions which effect on the behaviours. Subjective Norm, i.e., social pressure and expectations of others have also a direct effect on the intention. However, Perceived Behavioural control which is influenced by external factors like facility or schemes may or may not affect on recycling behaviour.

In this research, Researchers will examine whether or not the people of Kathmandu Valley;

a. Have Positive attitude towards the practices of e-waste recycling.
b. Get influenced by external factors to adopt new behaviors of recycling practices
c. Think that society is expecting them to practice e-waste recycling.

All these factors will help to understand their intention to practice e-waste recycling, adopting the new behaviours.

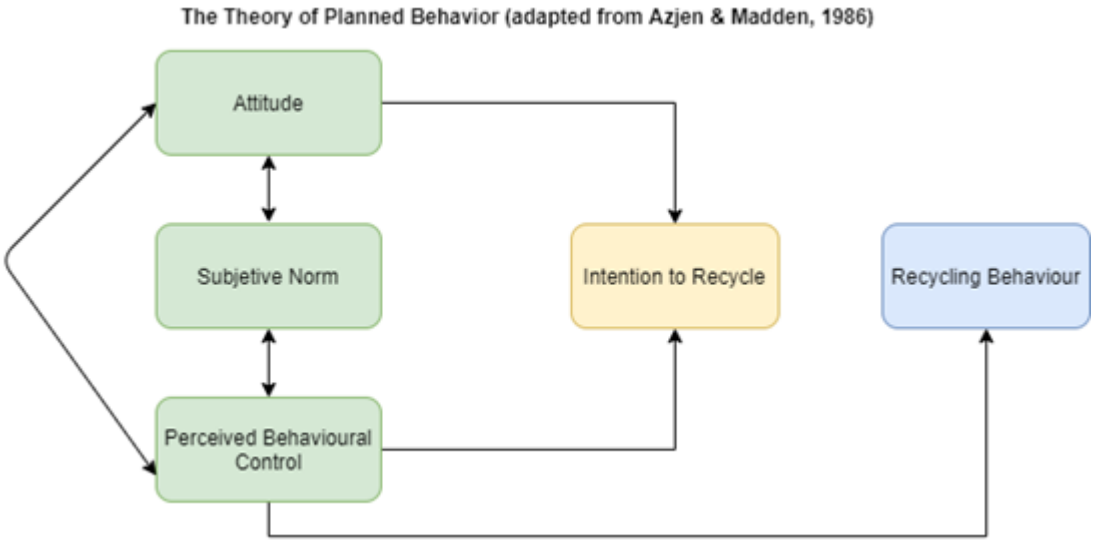


Figure 6: Theory of planned behaviours(adapted from Azjen & Madden, 1986)

The above figure 6 illustrates that the attitudes towards the behaviour and subjective norm are determining factors of the intention to perform a certain action (Strydom, 2018).

"Attitude is a personal factor which refers to a person's evaluation of the behavior. Subjective norm is a social factor which refers to social pressure to comply with a certain behaviour". (Strydom, 2018, p. 3). Social pressure is defined as the perceptions, beliefs, and judgments of other people related to recycling. In the above figure, perceived behavioural control may be the actual behavioural factor because it affects the intention and when the intention is positive, it changes the behaviour.

2.3.2 Activity Theory

"*Activity Theory is a theoretical framework for the analysis and understanding of human interaction through their use of tools and artefacts*" (Hashin & Jones, 2014, p. 1). This theory originated from the socio- cultural tradition in Russian psychology by Aleksei Leontiev (Engestrom, 1996).

In Activity theory, Activity is broken into an analytical unit of subject, object and tool where subject is the participant from which the viewpoints is studied, the object is a proposed problem or activity by subject and the tool is the mediator that helps to transform the object into outcome executing the action (Hassan , 1998; Hashin & Jones, 2014). Later on, Engestrom modified the original theory adding two extra units of analysis: Rule and division of labour. Rules create a set of conditions on how the subject may act while Division of labour creates a distribution of work among the community (Hashin & Jones, 2014).

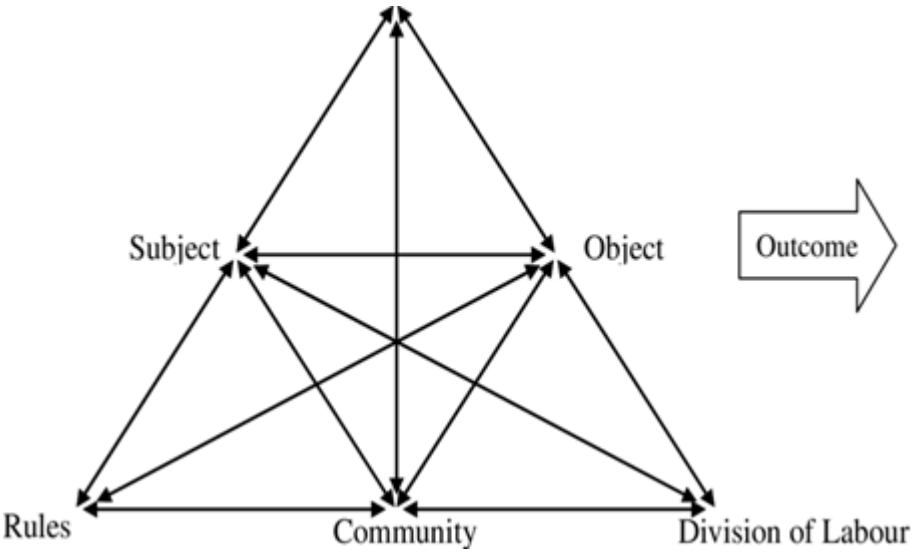


Figure 7 Engestrom Expended Activity Theory Model source Engestrom, 2001

The above figure shows an expanded activity theory model which is based on the concept of Leonetive and Vygotsky´s (1978) theory methods. With the use of this framework, we will perform systematic analysis of qualitative data and understand complex interactions between subjects with two interacting activity systems.

Principle of Activity Theory:

From these principles. we will use the contradiction to identify the tension and conflicts that emerge in our activity system. Engeström proposes four levels of contradictions (Engestrom, 1996)

1. Primary: It occurs within the elements of activity systems (e.g. within the community).

2. Secondary: It arise between the elements of an activity system (e.g. between the community and subject),

3. Tertiary: It arise when activity participants face situations where they have to use an advanced method to achieve an objective (e.g. when they are introduced a new technology),

4. Quaternary: It occurs between the central activity system and outside activity systems.

Chapter Summary

The above chapter gives an overview of a systematic literature search, related literature review, and related tool study. Section 2.1 reviewed the related literature on the e-waste recycling problem and its impact. Similarly, section 2.2 presents the related tool study, and section 2.3 present the theory we are using on our research.

3 Chapter 3 Methodology

Methodology can be defined as a systematic analysis of methods used in a study. It is an overview about the research method, how the research was carried out and how the data was collected. This section shows how this study has been conducted. This paper is based on a mix of qualitative and quantitative research and is abductive in nature. This project follows the user-centered design as a participatory approach involving users throughout the design process. Our design process goes through iterative analysis, design, development, and implementation, based on collaboration among the target user group, the stakeholders and the researcher using contextual design principles and theories.

3.1 Research Philosophy

Ontology is a branch of philosophy that tries to provide ideas of entities in all spheres of being (Barry, 2012, pp. 47-68). This reality can also be something that we are going to prove or our viewpoint towards reality. In our context, social ontology can best describe our philosophy towards the paper which indicates to understand the underlying structures that affect individuals

and groups and how it plays its role in our e-waste idea and their behavior towards it. As humans tend to see things in a different phase in different ways this philosophy helps us get closer towards the truth.

3.2 Research Approach

The research approach defines the way a researcher collects and presents the data. This relates to the reasoning process adopted by the researcher. Mainly, research approaches are categorized into three groups: deductive, inductive, and abductive. According to Thornhill, Lewis, & Saunders (2019), in the inductive approach, a theory is developed from the data. Similarly, in the deductive approach, a conclusion is made based on existing theory, and researchers accept, reject, or revise through data collection (Thornhill, Lewis, & Saunders, 2019). Considering the nature of the research problem, we will use the abductive research approach. In the abductive research approach, researchers can go back and forth between inductive and deductive approaches. Saunders, Lewis, & Thornhill (2019) mentioned that the abductive research approach allows us to generate, define, or modify the existing theory (Thornhill, Lewis, & Saunders, 2019) in her research paper, has mentioned that inductive research strategy is used to answer 'What' questions, while the deductive strategy can be used to answer 'why' questions, whereas the abductive strategy can be used to answer both 'what' and 'why' types of questions (Malhotra).

3.3 Research Strategy

In this research, the problem and solution for current waste recycling practices with the people living in Kathmandu or residing there for over 3 years has been studied. Thus, the case study approach has been adopted. Cresell (2003) has defined a case study as a method by which "researcher explores in depth a program, an event, an activity, a process, or one or more

individuals" (Cresell, 2003). According to Yin (2003), a case study is conducted when the aim of the research is to answer "how" and "why" questions (Yin, 2003). Yin (2003) has categorized case study into three groups: explanatory, descriptive, and exploratory (Yin, 2003) .Descriptive studies collect the information about contexts, events, and the people, which consist of 'who' 'what'' where'' when' or 'how' questions (Thornhill, Lewis, & Saunders, 2019).The aim of a descriptive study is to describe a population, situation, or phenomenon accurately and systematically. Explanatory research is conducted for a problem that is not studied before, which helps to understand the problem better. The aim of explanatory research is to increase a researcher's understanding of a subject. In this research, the researcher uses an exploratory study which is "set to explore any phenomenon in the data which serves as a point of interest to the researcher" (Zainal , 2007, p. 3). This study is conducted for a better understanding of the problem to gather new insights into such topics of interest and answer the "how" and "what" questions (Thornhill, Lewis, & Saunders, 2019). The goal of the exploratory study is to formulate problems more precisely, collecting explanations, excluding unrealistic ideas, and clarifying concepts.

3.4 Research Design

Before starting user research, it is essential to choose research design, which will provide a strong foundation for answering our problem statement. Saffer has mentioned that there are four major approaches to create any successful product i.e. user- centered design (UCD), activity-centered design, systems design and genius design (Saffer, 2010). Activity-centered design focuses on the task and activities that need to be accomplished. Similarly, system design focuses on the components of a system. Genius design focuses on the skills of the designers to make a successful product. Whereas, user-centered design (UCD) focuses on the users' needs and goals (Saffer, 2010). In this project, the researcher is focusing on the problems faced by individuals and companies regarding electronics waste and its recycling in Kathmandu, in order to design a digital

solution for them based on their specific problems and preferences. Thus, user-centered design (UCD) was chosen for the research design.

UCD approach involves users in every stage of the project. Saffer (2010) mentioned that "*Goals are really important in UCD; designers focus on what the user ultimately wants to accomplish. The designer then determines the tasks and means necessary to achieve those goals, but always with the users' needs and preferences in mind"* (Saffer, 2010, p. 110). UCD is a process that centers around the users during the design or development of the product. With the use of UCD, one can reduce errors and improve the productivity of a product (Endsley & Jones, 2011). UCD prioritizes the users' needs and preferences and involves the users on every stage of design which helps to design a user-centered product. UCD processes include user research, prototyping, user testing and iteration which allows to structure and innovate the design (Burleson, Dunks, Wery, & Oppegaard, 2012) .Harris, McCartan, Verheijden, & Lundh (2014) defined UCD as a design process in which the needs, requirement, and capabilities of the end users or their representatives are considered at every stage of the design process (Harris, McCartan, Verheijden, & Lundh, 2014) has used active users' participation on their design where they used following diagram to illustrate the position of active user involvement:

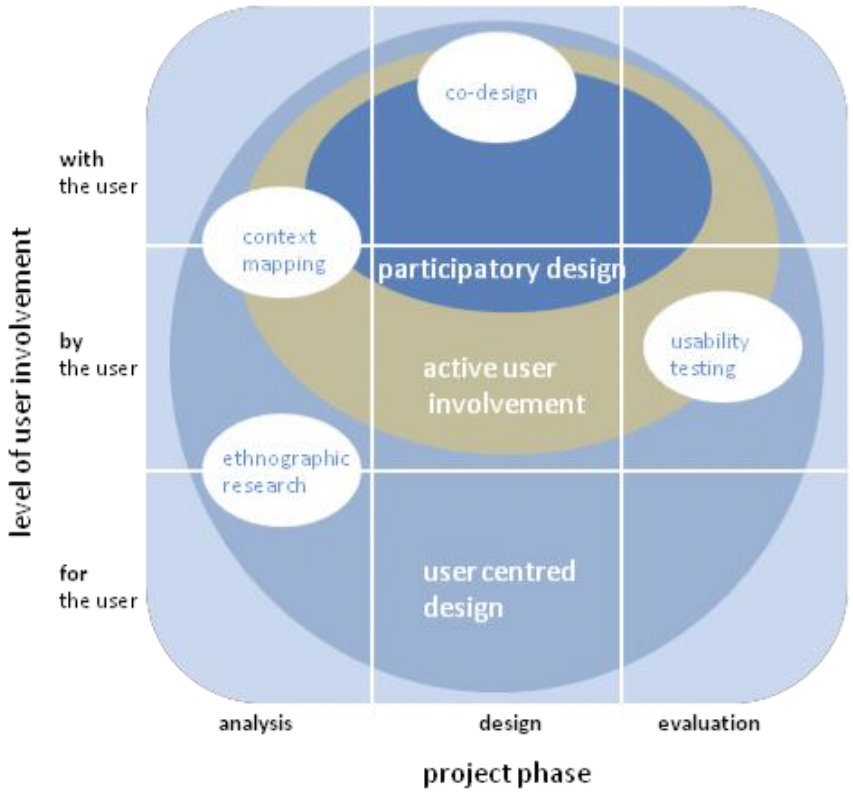


Figure 8 relation between user centred design, participatory design source (Harris, McCartan, Verheijden, & Lundh, 2014)

Harris, McCartan, Verheijden, & Lundh (2014) mentioned that the above two bottom row; active user involvement & user centered design of the diagram represent traditional UCD method in which designer and users have different roles (Harris, McCartan, Verheijden, & Lundh, 2014) . Designers usually generate the solution to users on the basis of explicit knowledge. The knowledge can be generated through interview, survey, observation, usability testing, etc. Such traditional UCD may not address issues like: early validation of user requirement, obtaining a multi-perspective review, Gathering rich user insights (Harris, McCartan, Verheijden, & Lundh, 2014). All the issues can be solved through the top segments of the figure in which participatory design method has been developed.

In participatory design or modern UCD method the designer and users work together to solve the problem. According to Simonsen & Robertson (2013) participatory design can be defined as *"a process of investigating, understanding, reflecting upon, establishing, developing, and supporting mutual learning between multiple participants in collective 'reflection-in-action"* (simonsen & Robertson, 2013, p. 18) Participatory design is a process of bringing all the stakeholders into a design process to understand, meet and sometimes preempt their needs. Simonsen & Robertson (2013) mentioned that on participatory design participants mostly undertake the two principle roles of users and designer where the designers tried to learn the realities of the user's situation while the users attempt to articulate their desired aim and study necessary technological means to obtain them (simonsen & Robertson, 2013)

While reflecting the relation between UCD and PD, Carrol mentioned that user-centered design can be both participatory and non-participatory (Carroll, 1996). In general understanding, participatory design is considered as an approach where the user is directly involved throughout the system development process. This explanation is correct when we look at it in terms of their relationship but does not cover the complete meaning. There are more distinctions between PD and UCD (Carroll, 1996).In the context of model-based engineering approaches to UCD, User involvement is replaced through user description and In the empirical approach to UCD, the user is involved through surveys and tests of random user samples. Both approaches involve the user as record, subject and case both not as a full participant (Carroll, 1996) .However, UCD is participatory when the user is a full participant during the design process and brings their expertise in critical and typical scenario of use and be able to articulate specific design requirements (Carroll, 1996).

To identify the problem and test the solution, the researcher will conduct interviews, and obtain further data through a questionnaire and a future workshop in which there will be

interactions with users and have their involvement throughout our design process. Thus, we consider our UCD approach as a participatory design as shown in figure 8.

To emphasize the practices of participatory design, the researcher used the User Innovation Management (UIM) method approach. According to Kanstrup, UIM is a method used to cooperate with users, creating and managing spaces enabling them to participate and contribute toward innovation in the early stage design process (Kanstrup & Bertelsen, 2011). In the traditional design method, the user is involved at the end of the design process just to test product design. The main problem with the traditional design method is that if a user suggests a new idea, it is expensive to make changes at the end of the design process. A user can be considered as a practice expert and have massive treasure of knowledge about our product because they are the one who live in the practice of the design (Kanstrup & Bertelsen, 2011). Therefore, products should be designed around the value and needs of the user.

UIM Consists of three themes and six steps. All these steps help to make the design process systematic, reflective and participatory.

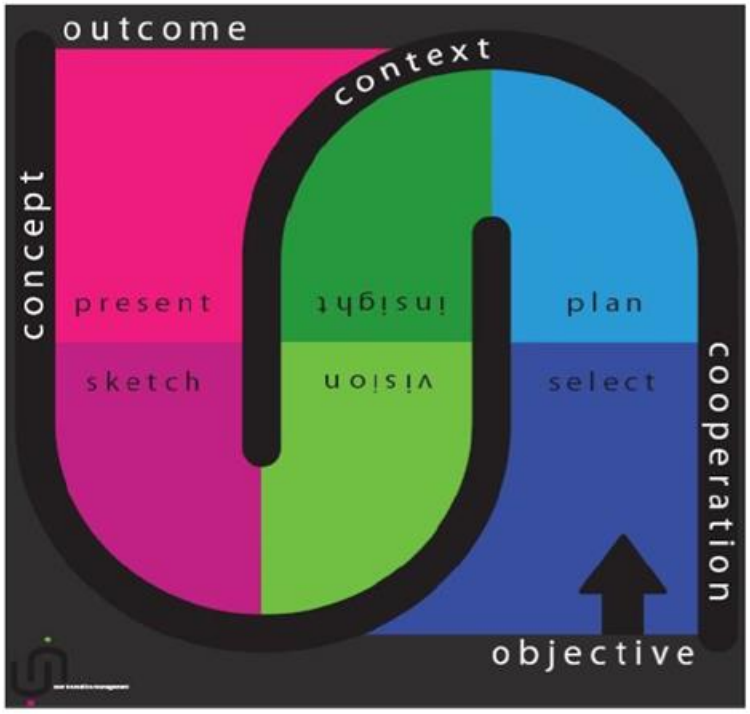


Figure 9 UIM steps for managing user innovation source (Kanstrup & Bertelsen, 2011)

Figure 9 shows the UIM steps and themes for managing the user innovation process. In the first theme *Co-operation*, the researcher selects the users and plans the design process. In the second theme *Context*, the researcher focuses on contextual understanding of the problem and generating visions for possible futures. In the third theme, *Concept* the researcher manifests the design ideas and sketches the prototype of the design. In this research, the UIM method is not adopted as a complete method of design, instead the researcher uses the first two themes Co-operation and Context as a participatory method involving the users throughout the process. But in the third theme Concepts, the researcher designs the prototype with partial participation of users only in a testing phase. Due to Covid-19, the restrictions against group-gatherings posed a challenge to conduct sketch design together with the users. So, the researcher decided to sketch the design without the active participation of the users.

Our project is based on the interaction of users with digital solutions that relate to HCI. HCI is a cross-disciplinary area (e.g., engineering, psychology, ergonomics, design) that deals with the theory, design, implementation, and evaluation of any product or system that humans use and interact with (Kim, 2015).

HCI is one of the important factors while designing products that require user interaction. Although it is important in the field of design, it is difficult to maintain HCI design fulfilling the user needs because any HCI product consists of a multi-objective task which involves the consideration of many things together. Kim (2015) mentioned that the HCI design depends on the types of the users, characteristics of the tasks, capabilities and cost of the devices, lack of objective etc. (Kim, 2015). In the history of HCI design, researchers and developers have worked together to figure out the basic principle of constructive HCI design. These principles are considered as a fundamental solution that is applicable to almost any HCI design. Kim has mentioned these main HCI principles that need to be considered while designing the product that interacts with users.

- Know the User
- Understand the task
- Reduce Memory Load
- Strive for consistency
- Remind users and refresh their memory
- Prevent Errors/Reversal of Action
- Naturalness

3.5 Methodological Choices

In this research, a mix of qualitative and quantitative approach will be used where the work will be divided into two parts. During the first part, the researcher will be using a quantitative approach. Quantitative research is regarded as one of the methods to collect nominal and ordinal data from the close-ended question, measurement from the experiment, etc. (Denscombe, 2010). We will get quantitative data from the questionnaire and usability test. And during the second part, the researcher will be using a qualitative approach. On qualitative data, the data are shown as words and pictures; they are mostly designed to understand the complexity of human behavior, and these are mostly studied by the researcher and other social scientists (Seaman, 1999). We will get qualitative data from the interviews and future workshop. Hence, the researcher will use a mixed method where both qualitative and quantitative data are collected, analyzed, and merged into one or more studies (Palinkas, et al., 2011).

3.6 Data Collection Method

In this research, the researcher will be collecting two forms of data i.e. primary data and secondary data. Here in this section, the researcher explains the two forms of data collection technique.

- **Primary data**

Primary data are the kind of data that are collected for the first time which defines the originality in the research methods (Kothari C. , 2004). According to Hox & Boeije (2005) "*primary data are data that are collected for the specific research problem at hand, using procedures that fit the research problem best*" (Hox & Boeije, 2005). In this research, we will collect primary data in means of questionnaire, interview, future workshop and usability test.

- **Secondary data**

Secondary data are the kind of data which have already been collected by other agencies or personal for their own use (Kothari C. , 2004). Hox & Boeije (2005) mentioned that the secondary data are the "material created by other researchers that is made available for reuse by the general research community" (Hox & Boeije, 2005). During our research, we have used documentary research methods that review, analyses and categorize secondary sources such as private or public written documents (Mogalakwe, 2006). In our research, we will collect secondary data through literature search and related tools and research study.

3.7 Data Analysis

- **Thematic Analysis**

Thematic analysis (TA) is a method to analyze qualitative data which classify and present the theme that relate to the data (Alhojailan, 2012).It is one of the most widely used methods to analyse qualitative data. Braun & Clarke (2006) has mentioned that "Thematic analysis is a method for identifying, analysing, and reporting patterns (themes) within data" (Braun & Clarke, 2006, p. 57). One of the reasons that we decide to use TA is because it is one of the flexible methods and like other methodologies, it is not tied to a epistemological or theoretical perspective (Maguire & Delahunt, 2017).. The goal behind using thematic analysis is to identify themes and use these themes to address the issue (Maguire & Delahunt, 2017)..

During the analysis while coding the data, we proceed to use emergent coding by two coders where we will make the category on the base of the participant's response rather than existing theories. Braun and Clarke (2006) have mentioned that the first stage of coding is to get familiarized with data which means reading the results several times and searching for patterns before coding (Braun & Clarke, 2006) .When we collect the participant's response and go through it all, the initial concepts that seem interesting were noted down by different coders. After we finish noting all the initial concepts, we again go through all the noted concepts and compare the

notes. And we reconcile if any difference shows up. After that, we made a category merging all the similar concepts. The final list of categories is revised by both coders many times. We have used both subjects and themes as a measure of coding to apply the category to participants' responses.

In our analysis, we have used Braun & Clarke (2006) six phase guide framework to conduct thematic analysis (Braun & Clarke, 2006).Following are the six phases to conduct TA as mentioned by Braun & Clarke (2006):

1. **First phase:**

In this phase, we tried to familiarize ourselves with the interview data. For this we have transcribed the recorded interview. As recommended by Braun & Clarke (2006) we listened to the audio recording of the interview, taking notes of the initial idea as we read the transcribed data (Braun & Clarke, 2006).

2. **Second phase:**

In this phase we generate the initial codes. We start this phase with the systematic analysis of the data through coding. Braun & Clarke (2006) have mentioned that codes are the building blocks of analysis where the analysis is a brick-built house with a title roof, themes are the walls and roof and the codes are the individual bricks and tiles (Braun & Clarke, 2006). We code only the relevant and interesting data for our project. In this step we formulate the code from the data.

3. **Third phase**

In this third phase of TA, we collect the codes from the second phase, identify the pattern among them and generate the theme. As Braun & Clarke (2006) has mentioned that there is no fixed rule to generate the theme (Braun & Clarke, 2006), we created a potential theme to represent our code.

4. **Fourth phase**

In this phase, we revise the generated theme and make sure all the code fits in it. If we feel that the code does not fit on a theme or the theme is inappropriate, then we merge it with a more suitable one. The themes that do not have enough information are combined and the themes which have large information are divided.

5. **Fifth phase**

In this phase, we name and define each theme. While naming the theme, we try to keep it descriptive which helps us to understand the data. The purpose of this phase, as Braun & Clarke (2006) mentioned is to '. identify the 'essence' of what each theme is about' (Braun & Clarke, 2006).

6. **Sixth phase**

In this final phase of TA, we generate the report of our analysis. The report is generated comparing the codes and themes. This phase is also known as the writing-up phase. Here we discuss all the data, interesting literature and provide sufficient examples to support the analysis.

3.8 Ethical consideration:

In this research two basic ethical principles from the Belmont Report of 1979 as mentioned by Bordens & Abbott (2011) were taken into consideration (Borden, Abbott, Kenneth, & Bruce, 2011). The two principles include *respect for persons* and *beneficence.*

1. **Respect for persons:**

We informed all the participants about the purpose of the study and their role in the research. We did not force any participants to be part of the research or use deception. Although the information was presented orally participants were also given a written consent form with all the information which they signed before being part of research as recommended by Bryman (2012, p. 140) which can be seen in Appendix 1, 17 & 19.

2**. Beneficence**:

In the consent form, it is mentioned that being part of this research is completely voluntary. Participants will be getting paid or will be rewarded. Participants are free to skip the questions if they do not answer. We have not forced the participants to answer all the questions. Furthermore, participants were open to withdraw the session whenever they wanted. To avoid harm to the participants we assured that the data will not be missed use and the participant's data will be kept private and only be used for thesis paper.

Similarly, as a researcher we both being from Nepal it immensely helps us to know which group of people use the internet, gadgets, and digital platform. Our advantage was we knew from the start that the age group of 19-30 uses the electronic mostly in Nepal. And as we also belong to the same age group we tried to relate with them and make them comfortable and understand the impatience they have as this age group is fast result oriented. Further, we used words like 'electronics good' and hardware while talking with participants as the majority of them understand e-waste as mobiles and laptops so we intentionally used those words to get a more credible answer.

3.9 Trustworthiness of the research

In our research, we have measured the trustworthiness of research as mentioned by Mark Saunders (2012) (Saunder, 2012).

1. **Credibility**

We have worked hard to make our participants understand and give as many authentic answers to our questions as possible, as the credibility depends on the legitimacy of participants giving more credible answers under similar conditions. However, as human nature changes with time, we acknowledge their view may change. This is the reason why we have tried to make our participants as calm and comfortable as possible before the interview. We went for a long informal conversation beefier taking the interview which helps us to get to closer to the truth.

2. **Transferability**

As we have tried to make as concrete and to the point as possible under similar circumstances any other researcher will get similar results so our result can be generalized in a similar age group and background.

3. **Dependability**

"Dependability aims to replace reliability, which requires that when replicating experiments, the same results should be achieved" (Stumpfegger, 2017). Traditionally, the more robust the result inclined towards facts more reliable the data is similarly our research can be duplicated under similar circumstances.

Chapter Summary

In the above chapter, the methodology of the research is detailly explained. In the research, both primary and secondary data are together being used as a data collection method. Similarly, the research type will be abductive research and the research will be based on participatory design. The research is mixed of qualitative and quantitative approaches. Both qualitative and quantitative data will be collected, analyzed, and reviewed in the research.

4 Chapter 4 Questionnaire

In this section, researchers will discuss the methodological considerations of our questionnaire research. A questionnaire is a primary data collection method that contains a series of questions as well as other suggestions to collect respondent information (Muhammad & Kabir, 2016). Muhammad & Kabir (2016) have also mentioned that the questionnaire is

cheaper, does not require much effort as verbal or telephone surveys (Muhammad & Kabir, 2016). Gangrade (1982) has mentioned that questionnaire as “a device for securing answers to questions by using a form which the respondent himself fill in” (Gangrade, 1982).

4.1 Questionnaire Methodology

A questionnaire is a series of open-end and close-end questions that are sent to the respondent to gather information (Muhammad & Kabir, 2016). Bryman (2012) has mentioned that the advantages of the questionnaire are that it is a cheap, quick, and effective way of obtaining data (Bryman, Social research methods, 2012). Muhmmad and Kabir (2016) have stated the data of the questionnaire is fast and easy to analyze because of built-in tools (Muhammad & Kabir, 2016). An alternative of a questionnaire could be survey but it is not suitable for our project. This research has used a sample group from a small group of people and the survey is suitable for a large group of people. In a survey, if questions are confusing it may affect the results. But while conducting our questionnaire Researchers will be physically present with respondents and clear their misunderstanding. While conducting survey Researchers have experienced that people do not show any interest and fill random answers. There is a low rate of people filling the survey but when researchers are physically present while conducting a questionnaire, researchers will get a reliable answer and the return rate is also 100%. Day & Evers (1999) has mentioned that conducting questionnaire will get quality of responses (Day & Evers, 1999). Thus, Researchers chose to conduct a questionnaire instead of a survey.

4.1.1 Development

Gangrade (1982) has mentioned the ingredients for a good questionnaire should be clarity, brevity, unambiguity, reliability, and communicability (Gangrade, 1982). So to ensure our

questionnaire be good and meet all the requirements researchers have followed Gangrade's (1982) guidelines for making a good questionnaire (Gangrade, 1982). On the questionnaire, the language researchers used is simple and easy to understand. To avoid confusion, Researchers made a separate question for different ideas. Researchers met the participant a day before the questionnaire and interacted with them. Researchers did not talk much about the project but to be more friendly and to build up the confidence of participants he told them about his experience studying at Aalborg University. The next day during the questionnaire session, researchers had a good bond with all the participants, they seem confident to ask the questions about the project.

4.1.2 Questionnaire Design

It is very important to choose the right question to get an effective result. If the questions are not made on the right process, then the results researchers get may not be appropriate. So, to make a good and effective questionnaire, researchers have followed the Gangrade (1982) process of construction of the questionnaire. Gangrade (1982) has mentioned the process of construction of the questionnaire can be divided into six steps which are: deciding what information should be sought, deciding what type of questionnaire should be used-structured or unstructured, writing the first draft, re-examining and revising questions, pretesting, and editing the questionnaire and specifying procedures for its use (Gangrade, 1982).

While making questions researchers have included both open-end and close-ended questions. Goodman, Kuniavsky & Moed (2012) has mentioned that closed-ended are quicker to answer and preferable whose result is easier to measure (Goodman, Kuniavsky, & Moed, 2012). To make the answer clear and to the point, researchers have used the open-end question to follow-up close-ended questions. For example, when asked “Have you ever given your e-waste to the recycle company? researchers included open-end questions saying, “*if yes how have you*

contacted?". (Kuniavsky, 2003)has stated that the open-end question should only be included if qualitative answer provides a deep knowledge than a quantitative answer.

Day & Evers (1999) in their research has categorized the low response rate question type or the question in which respondents do not show interest in replying (Day & Evers, 1999).. While designing the questions researchers have considered Day and Ever's (1999) category of questions type which has a low response rate and tried not to include such kinds of questions. When there is open-ended question including a lot of reading participants do not show interest on replying, also low respond question includes the question where the responded has to involve in a lot of writing and the question which are not well-separated visually from other questions (Day & Evers, 1999). As mentioned by Muhammad & Kabir (2016) researchers have not used any emotional or bias word and phrases which may affect our result (Muhammad & Kabir, 2016). To make all the questions clear and avoid confusion researchers have not used double-barrelled questions (Muhammad & Kabir, 2016). The questionnaire consists of 23 questions in which participants must respond and there was one follow-up question on question number 16 which participants will only fill if they had given their e-waste to the recycling company.

To attract the attention of the respondent and gives the sustainable feeling researchers used green colour for all the question and begins with a simple question. DeLong and Goncu-Berk (2012) have mentioned that green colour is used to promote sustainability (Delong & Goncu-berk, 2012) .To understand if the participant is familiar with e-waste at the beginning of the questionnaire, researchers asked simple and clear close-ended questions. Researchers tried to understand the top e-waste produced by everyone on a year and the number of electronics they purchase each year. Researchers have included a series of the question and considering demographic question at the end of the questionnaire as recommended by Muhammad and Kabir (Muhammad & Kabir, 2016). The questionnaire consists of three part: Theory of planned behaviours, Technological behaviours and Demographics Detail.

Part 1	Theory of Planned Behaviours • Attitude • Intention • Perceived Behaviour control • Subjective norm
Part 2	Technological Behaviours
Part 3	Demographics • Age • Gender

Table 2 Three part of Questionnaire source: own

4.1.3 Sampling

Researchers have conducted a questionnaire for the BBA 3rd year student of Babylon National College. There were 20 student respondents, out of which 13 were male and 7 were female. The respondents were age between 20 to 28 years old. Researchers have printed the questions on a paper and decide to give the paper to each respondent.

One day before the questionnaire, researchers spend almost 2 hours with participants. Researchers want to be familiar with all the participants, so researchers not only discussed the project but also share my personal experience studying at Aalborg University. Researchers shared my personal information with participants which researchers believe they had trust in researchers from which they will share their personal experience too while filling the form. After two hours of interaction with the participant, they seem friendly and curious about the project

and happy that they can contribute to the project. Before giving the form to the participant researchers explained the aim of our project in detail and their data will only be used for educational propose. They were also asked that they can raise the question if they have any confusion or can say no to fill the form any time they want.

4.1.4 Questionnaire Pilot test

Researchers conducted a pilot test to reduce the error and ensure all the questions are ready to answer. A pilot test is conducted on the same pattern as a real questionnaire. Based on time taken on pilot test researchers have estimated the time for our questionnaire. As Bryman (2012) has mentioned the pilot test helped us to estimate the time (Bryman, 2012). Researchers conducted the pilot test with 4 students from Babylon National College. While pilot testing, researchers observe the participants and encourage them to ask if they have any confusion. On a pilot test, all the participants seem confident and answered all the questions. So, researchers did not change any question.

4.1.5 Analysis

While analyzing the data researchers have used descriptive statistics. After conducting the questionnaire on a paper, Researchers manually import the data on an excel sheet. Excel is used as a tool to analyze and visualize the data. The analysis can be seen in section 4.2.

In open-end question number two, researchers asked the participants to list top three e-waste they produce each year which is only the open-end question researchers asked. In the analysis researchers extract the answer and decide to conduct thematic analysis as researchers found it is a suitable method to analyse the data. Thematic analysis can be seen in section 4.2.

4.1.6 Validity & Reliability

As researchers have shared our questionnaire to BBA 3rd year students of Babylon National College where there were 20 students, which is not a sample of the entire youth of Nepal using electronics. This can affect the reliability of the questionnaire. Reliability in the questionnaire refers to stability in the measurement. Bryman (2012) has mentioned the result should be the same when using a similar sampling method at a different time (Bryman, Social research methods, 2012). Therefore, researchers cannot generalize the entire youth of Nepal who produces e-waste from our non-probability sample.

Researchers tried to ensure the accuracy of the result. The accuracy of the questionnaire depends on the respondent's desire and ability to respond to the honest and trustful detail. To establish trust and curiosity one day before the questionnaire researchers have visited the respondent and spend almost 2 hours where researchers interact on a different topic. The next day when researchers conduct a questionnaire participant seems friendly and curious to fill a form. As researchers was there during the questionnaire researchers explained all the questions to the participant in a group and asked to ask me if they have any confusion on any questions. To avoid biases all the participants were kept in the same classroom and everyone was allowed to ask the question and fill the form.

4.2 Questionnaire Result & Analysis

In the following section the result and the analysis of questionnaire will be discussed in detail:

- **Demographics:**

From the result of the questionnaire, researchers analyse the 3rd part which collects the demographics detail of respondents. As shown in figure 10, Of the total respondent(n=20), 65% were male and 35% were female. It was expected to see the smaller number of females since the sample group was from the Computer science background and the own experiences of researchers, there were always a few numbers of female students as compared to males. Regarding the age of respondents, As shown in figure 11 all the participants were young between the age group of 20 to 28.

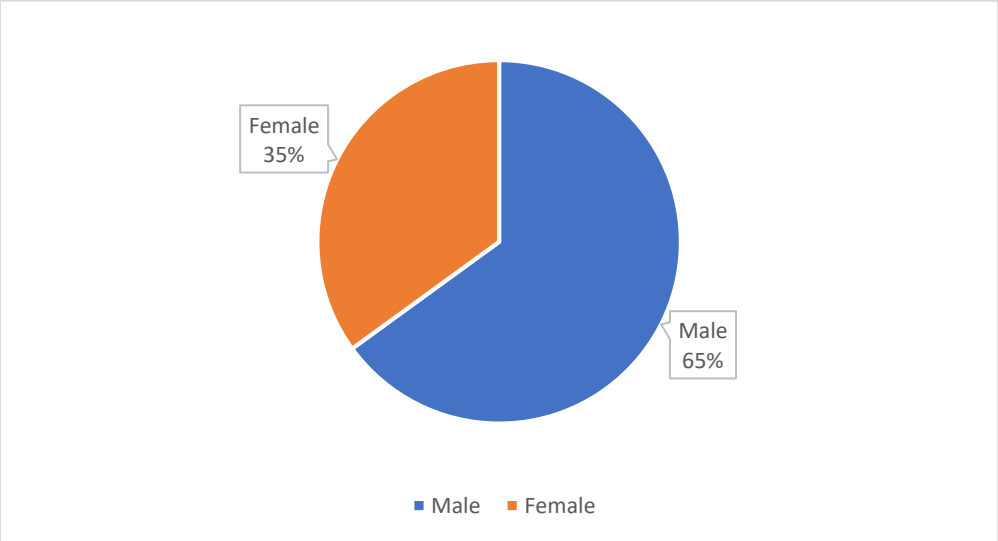
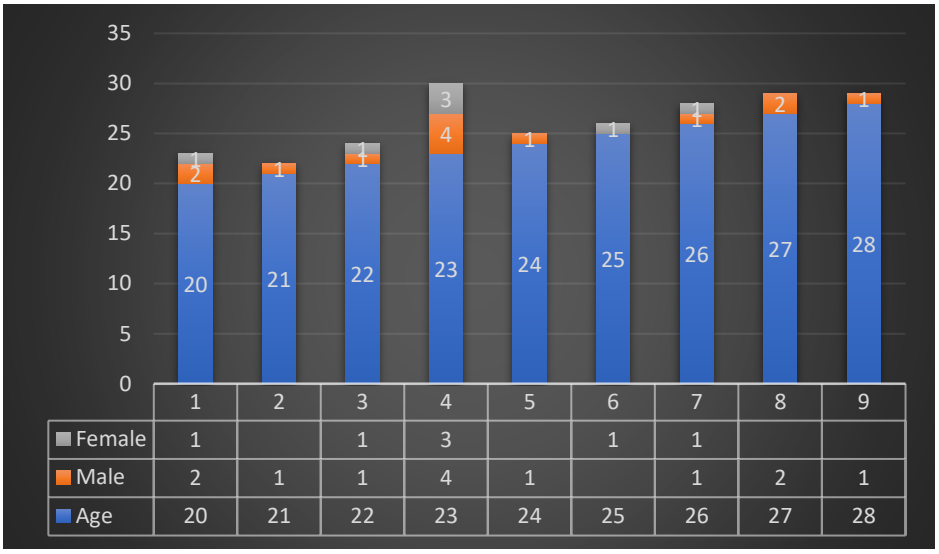


Figure 10 No of Participant in percentage by gender group source own



	1	2	3	4	5	6	7	8	9
Female	1		1	3		1	1		
Male	2	1	1	4	1		1	2	1
Age	20	21	22	23	24	25	26	27	28

Figure 11 No of Participant in percentage by gender and age source own

- **E-waste knowledge**

Out of the 20 participants, all the participants knew what e-waste is. This shows that respondents will not answer the questionnaire without any prior knowledge about e-waste.

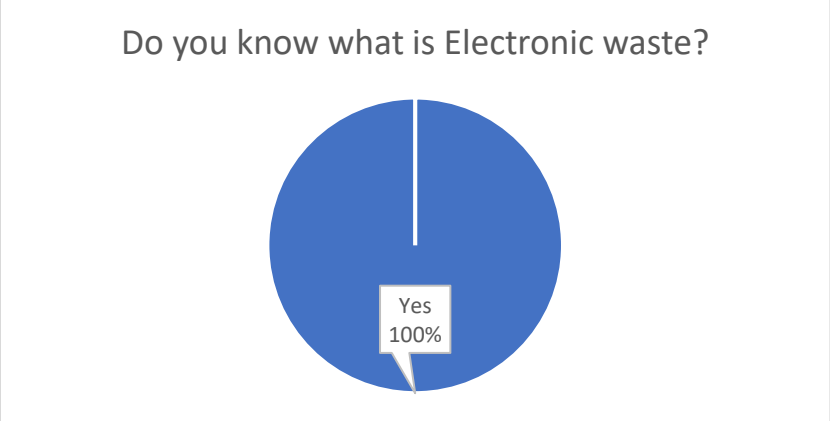


Figure 12 Response of participant about E-waste knowledge souce own

As all the participants know what e-waste is, they know all the electronic waste they produce in their homes and office. Researchers assume they also know the work of an e-waste recycling company. Out of the 20 participants, all the participants knew what e-waste is. This shows that respondents will not answer the questionnaire without any prior knowledge about e-waste.

- **Electronic waste they produce:**

Researchers have asked the participant to fill the top three e-waste they produce each year. 100 % (n = 20) participant has mentioned about the phone and its part. The mobile phone and its accessories are the top produce e-waste among all participants. Mobile and its parts include a mobile phone, phone charge, and earphone. Similarly, 65 % (n = 13) of the participant produce e-waste from the computer and its part. The computer and its parts include a computer, keyboard, mouse and computer cables. Likewise, 60% (n = 12) of the participant generate e-waste from the tablet and its part. Tablet and its part include tablet, iPad and tablet charger. 50 % (n = 10) of the participants mentioned they produce e-waste from tv and video game. E-waste

from TV and videogame includes Tv, Tv cable, Video game, Playstation, Playstation cable. Similarly, 30 % (n = 6) of the participant mentioned bulb and cables are one of the top three produced electronic waste. 25 % (n = 5) of the participant has stated music player is one of the top three e-waste they produce each year. The music player includes mp3, iPod, mp3 charger and music player. Similarly, 25 % (n = 5) of the participant mentioned one of the top three produce e-waste is from the watch. The top three e-waste produced by participants are shown on the following graph:

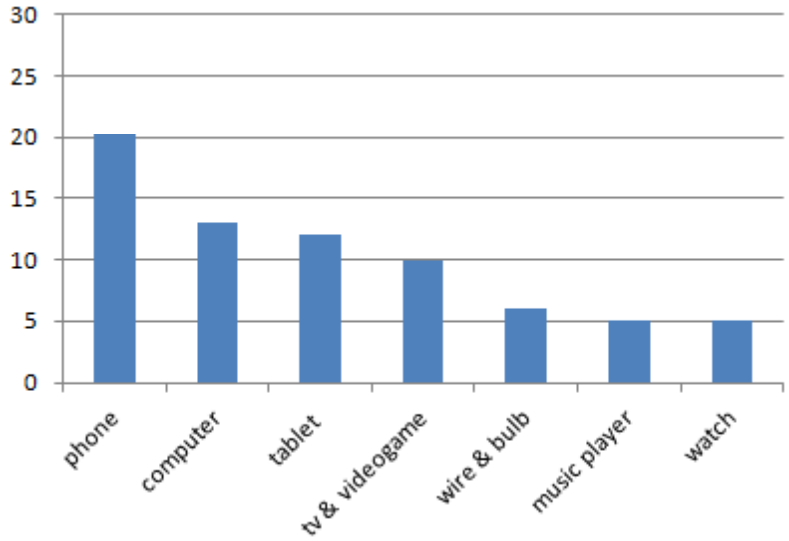


Figure 13 different types generated ewaste mentioned my particpant source own

From the above graph 13, researchers can say one of the top three e-waste produced from most of the participants is from Phone, computer, and tablet. Among 20 participants everyone mentioned the top e-waste they produced each year is from phone and more than 60 % of participants mentioned the phone is the top 2 e-waste they produce each year. From our sample questionnaire, researchers can say most of the participants produce e-waste from the phone, computer, and tablet **which will be considered as focused e-waste** during the application design.

- **E-waste recycling practices**

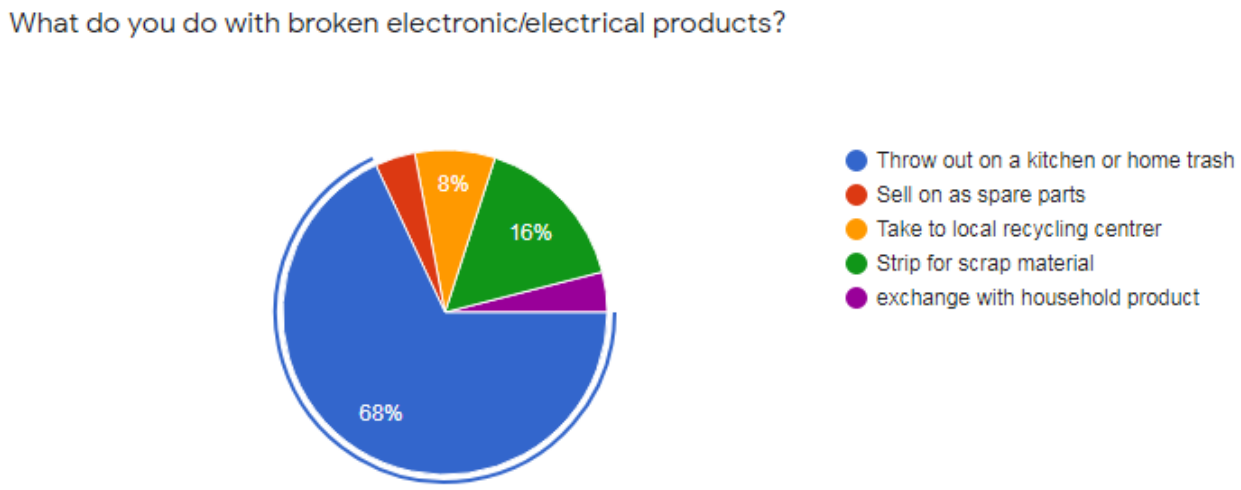


Figure 14 Response of participant on what they do with their ewaste source own

The above chart 14 Shows that most of the participants throw their e-waste together with kitchen or home trash. From the above chart, one of the answers seems very interesting that some of the participant exchange e-waste with household product means there could be a company who takes all the electronic waste and give a household product. Exchanging e-waste with the household product could be their business model which researchers will study in detail when researchers interview the recycling companies.

- **Current recycling practice**

100 % (n = 20) of the participant prefers to give their e-waste to the recycle company but only 20 % (n = 5) of the participant has given their e-waste to recycle company. Rest 80 % (n = 20) of the participant has never given their e-waste to any recycle company. Among 20 % (n = 5) who have given their e-waste to recycle company 12 % (n = 3) of the participant has contacted e-waste company through social media. Similarly, 4 % (n = 1) has dropped their e-waste to the local e-waste company and the remaining 4 % (n = 1) has given the e-waste to the people who come to the participant's home and asked for it to recycle. The chart for it can be shown as below:

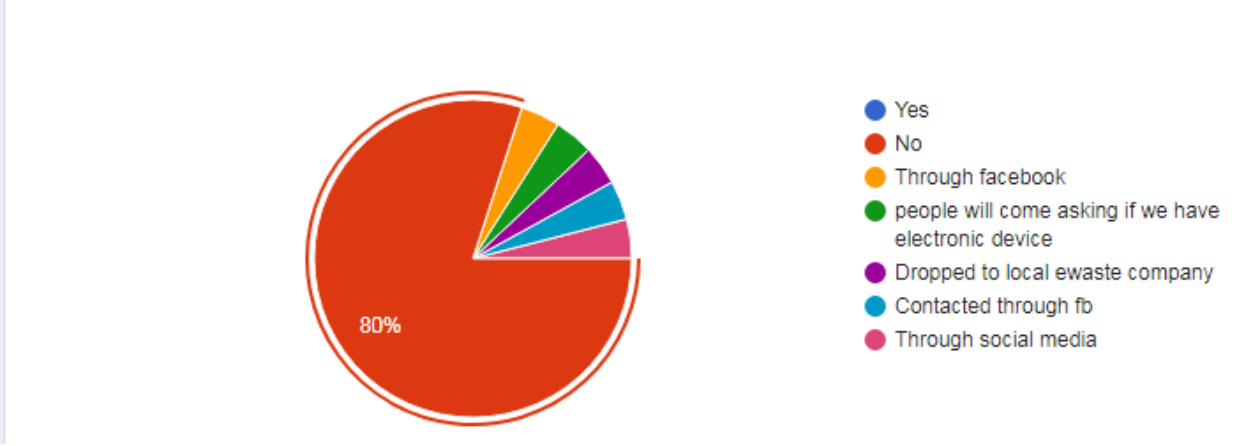


Figure 15 : Response of participant if they have recycled there or not Source own

One of the answers is very interesting that people will visit and ask the e-waste to recycle. When researchers looked at this form individually, researchers found this is the same participant who exchanged e-waste with household product means there should be someone who visits participant home and ask for e-waste and exchange it with the household product. In the interview with the expert, researcher's inquiry about this company or business model who visits participant house and exchange with the household product.

Researchers have asked participants how they want to get rid of e-waste they produce from home and office where 92 % (n = 23) of the participant mentioned they are looking for local pickup. Similarly, 8 % (n = 2) of the participants wants separate e-waste container in local areas. It means most of the people want someone to pick e-waste from their home or office. When researchers design an app, researchers must consider there should be a pickup facility too.

- **Technological Behaviours**

As shown in figure 16 Researchers have asked participants to fill the preferred way to contact e-waste recycling companies in which 70 % (n = 14) of the participant prefer to contact through recycling applications. Similarly, 20 % (n = 4) of the participants prefer to contact through social

media, and the rest 10 % (n = 2) of the participant prefer to contact through a phone call. In the same part of the questionnaire, researchers also asked participants to select the digital platform they prefer to use in the practices of e-waste recycling. Among n=20 participants, 60%(n=12) of them selected mobile application, 25%(n=5) selected web application and 15%(n=3) mentioned other platforms like Facebook, Phone service. The illustration of digital platform selection is shown in figure 17.

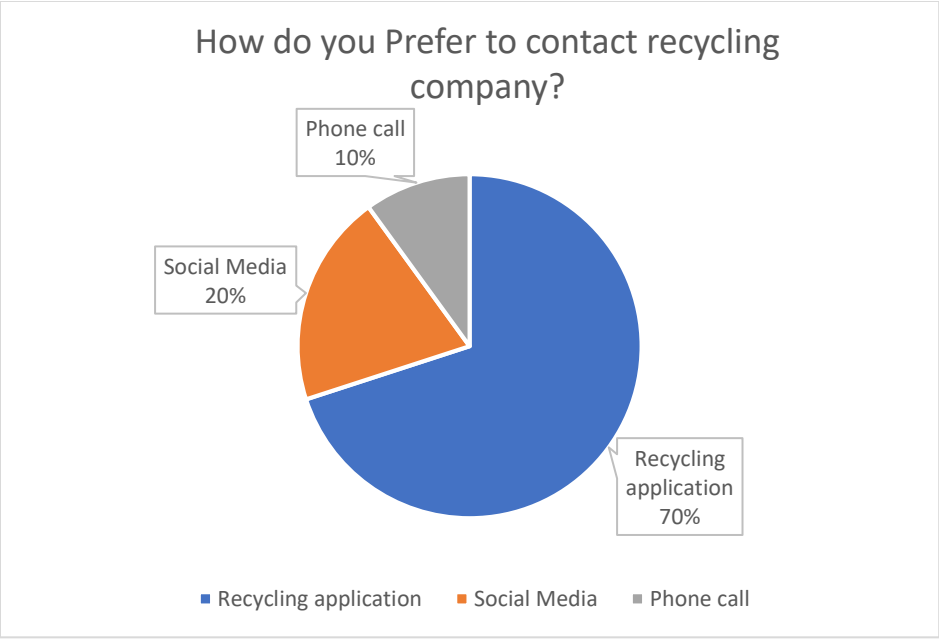


Figure 16 Response of participant how they want to contact recycling company source own

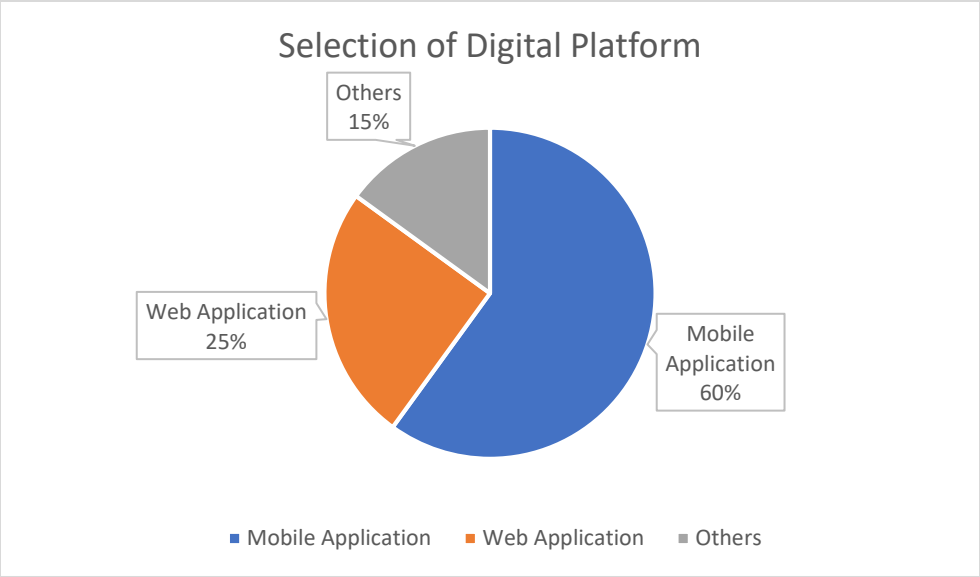


Figure 17 Response of participant selection a digital platform in ewaste recycling practices source own

Analysis of Questionnaire Theory of Planned Behaviors

The analysis of the first part of the questionnaire focused on examining participant perception and willingness in the practices of e-waste recycling using the Theory of planned behaviours.

- **Recycling Behaviors**

The questionnaire of recycling behaviours consists of two components: a "Frequency of Recycling Activity"; a "Taking responsibility to recycle".

Out of the total participant (n=20), 25% of the participant(n=5) reported recycling behaviour. The other 65% participant(n=15) does not agree that they do any e-waste recycling activity in their households. The 25 % of a participant who reported that they recycle e-waste includes very

less recycling activity where only 5%(n=1) said that they often recycle their e-waste with local recycling companies while rest 20%(n=4) said that they don't often recycle their e-waste but they do recycle it with local waste collector person maybe once in a six month. Although there is a small recycling activity happening, 75% of Participants (n=15) reported that they want to take responsibility for recycling their e-waste from households.

The result from this study shows that only a small fraction of people (5%) recycled their e-waste frequently but most of them want to take responsibility to act on recycling. So, it is necessary to improve in the current practices so that more people can act responsibly while recycling e-waste.

- **Intention to Recycle**

The questionnaire of recycling intention consists of three components: "Prefer to separate waste"; "Prefer to recycle waste; "Likelihood to drop recyclable e-waste".

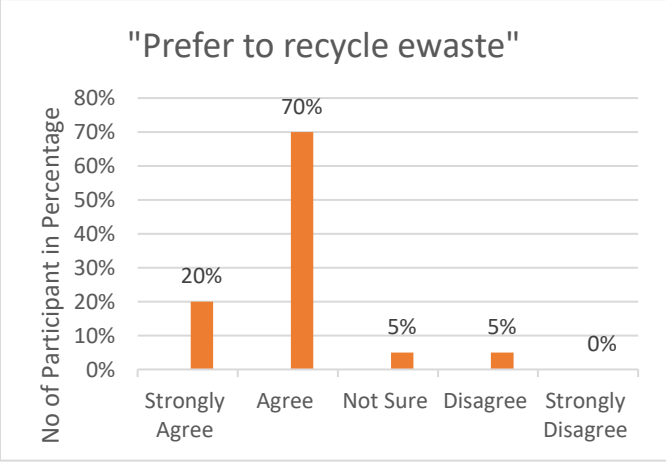


Figure 18 Response of participant if they agree or disagree for preferring to recycle ewaste source own

The above chart diagram illustrates the percentage of people willing to recycle e-waste. According to this figure majority of people are keen to recycle e-waste, where 20% (n=4) are

strongly agreeing to recycle the e-waste and 70% agrees to recycle it. However, 5% (n=1) are still not sure and not willing to recycle e-waste. Therefore, this survey shows that 90% (n=18) of people are positive about recycling their e-waste.

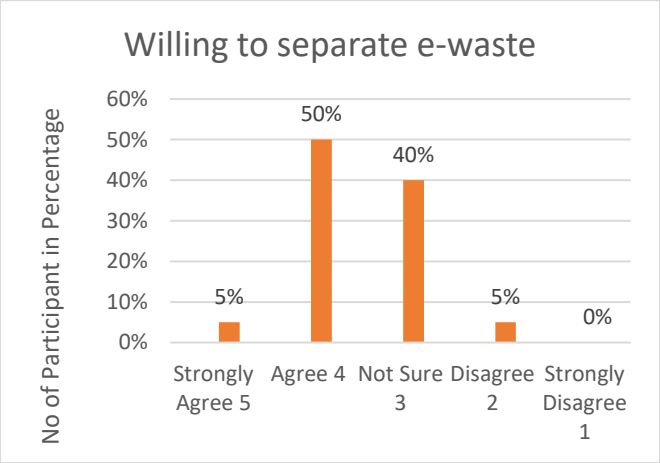


Figure 19 Response of participant if they agree or disagree for preferring to separate ewaste source own

The above chart demonstrates the percentage of participates who are willing to separate e-waste. As per the chart, 55% (n=11) in total agrees and strongly agrees to separate e-waste. In contrast, 5% (n=1) have disagreed to separate e-waste. However, 40% (n=8) are still not sure about separating their e-waste. This results in that majority of respondents have a positive response in separating their e-waste.

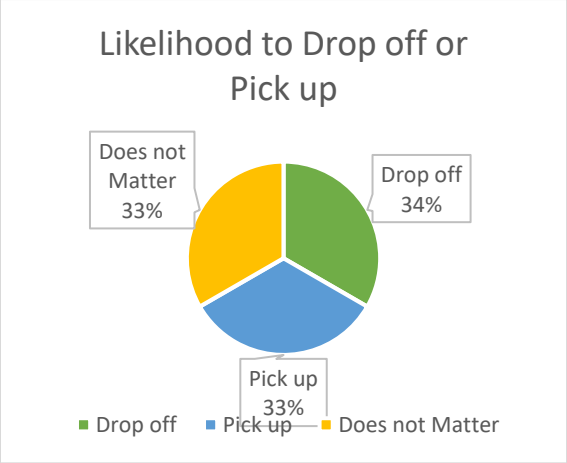


Figure 20 Response of participant if they prefer to drop off e waste themself or wants to pick up service. Source owns

From the above pie-chart, researchers can see that 34% of respondent prefers to recycle their e-waste by dropping off whereas 33% are willing to pick up to recycle the e-waste. However, 33% of the participants said it does not matter whether it is drop off or pick up.

- **Attitude toward Recycling**

The questionnaire of recycling attitude consists of three components which include recycling as: “Good-Bad Practices”, “Useful-Useless practices”, “Easy-Hassle practices”.

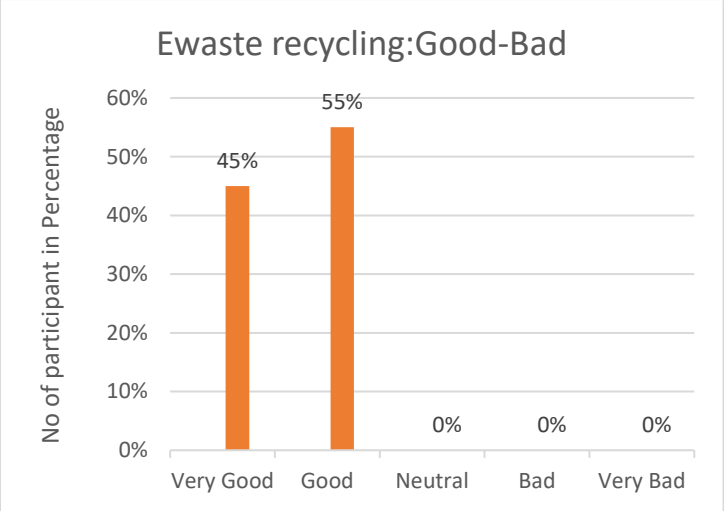


Figure 21 Response of participant what they think recycling as good or bad practices source own

The above chart diagram illustrates the percentage of respondents who think e-waste recycling is good or bad. Here, all the participants think e-waste is a good practice where 45% (n=9) has responded to it as very good practice and 55% (n=11) have responded to it as a good practice. This results that recycling e-waste is fully considered as a good practice that shows the positive attitude of respondents.

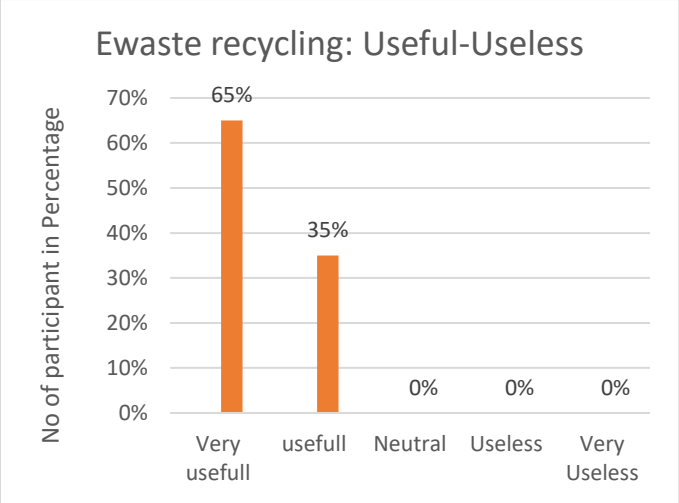


Figure 22 Response of participant what they recycling as useful or useless practices source own

The above chart illustrates the percentage of participates responds towards the usefulness of e-waste recycling. Here, all the participant thinks e-waste is a useful practice where 65% (n=13) of participant responded as very useful practice and 35% (n=7) as useful. None of

them were neutral or found it as a useless practice. Therefore, the positive response result that e-waste recycling is considered as a useful practice.

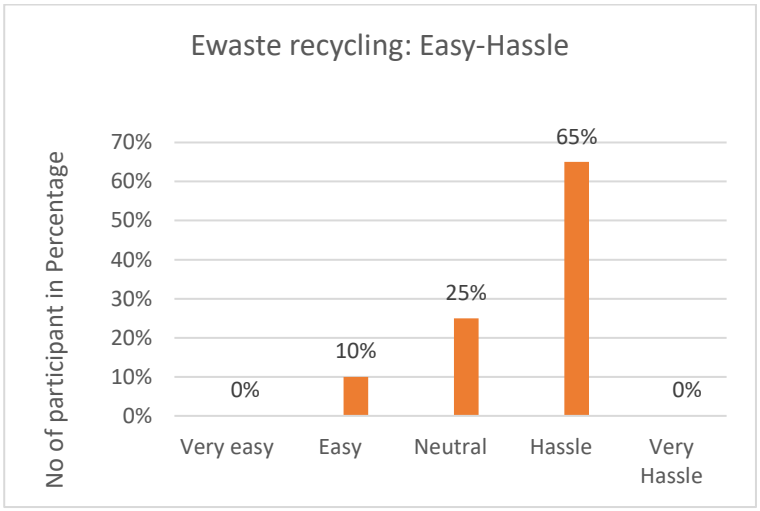


Figure 23 Response of participant what they recycling as Easy or Hassle practices source own

The above diagram is about the attitude of participants towards recycling e-waste as an Easy practice or a Hassle practice. Here the majority of respondents responded it as a Hassle practice which was about 65% (n=13). 25% (n=5) of them were neutral about this practice. Only a few responded e-waste recycling as an Easy practice with 10% (n=2). This shows that most people find it difficult to practice e-waste recycling and give a negative attitude towards it.

- **Social Pressure to Recycle (Subjective Norm): (Briefly explain these figure)**

The questionnaire of recycling attitude consists of two components:

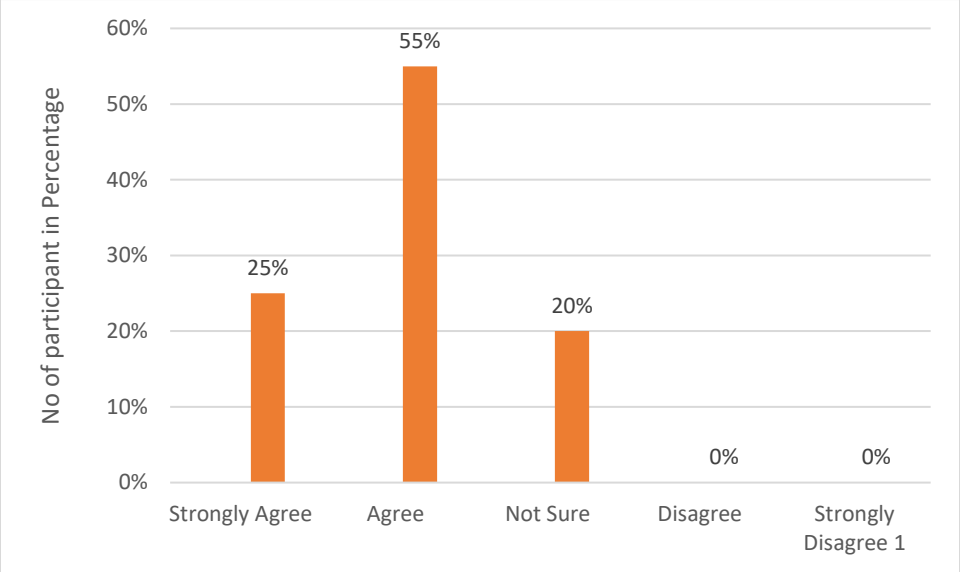


Figure 24 Response of participant if they agree or disagree to practice recycling by seeing other source: own

The above chart illustrates the percentage of people responding towards practicing e-waste recycle if their neighbour or relatives do it. Here, majority of people responded positively where 25% (n=5) were strongly agreeing and 55% (n=11) were just agreeing to practice e-waste recycle if their neighbour or relative do it. None of the participate disagreed about the practices. However, 20%(n=4) of them were not sure about the situation so they neither agreed nor disagreed it. This results positive reaction from social pressure of recycling.

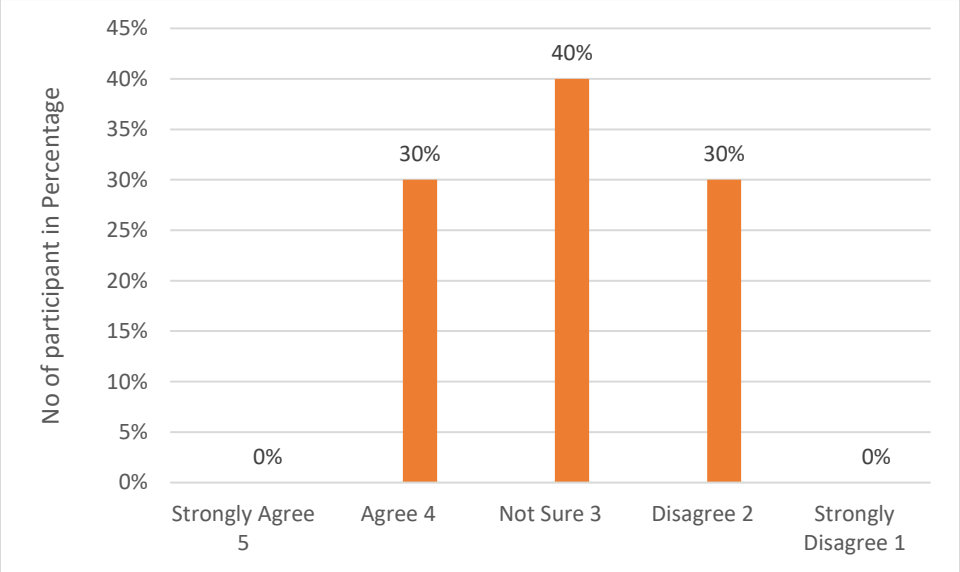


Figure 25 Response of participant either agree or disagree if municipality informed them to recycle ewaste source: own

The above chart diagram demonstrates the responds of the praticipants whether their municipality have informed to recyele e-waste or not. Here only 30% (n=6) of the respondent agreed to do it. Likewise, other 30% (n=6) respondent disagreed to do it. However, with the highest percentage of 40% (n=8) respondents were not sure about the information.

- **Perceived Control**

The questionnaire of recycling attitude consists of 3 components: Facility, to recycle easy-difficult, knowledge about e-waste.

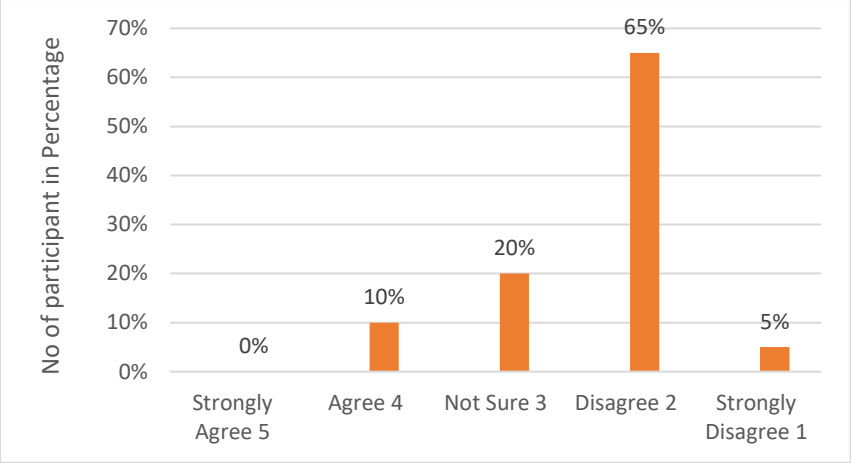


Figure 26 Response of participant if they agree or disagree of having proper facility by municipality source: own

The above diagram illustrates the percentage of participants agreeing or disagreeing that there is a proper facility for waste management by the municipality in their area. Here, most of the participates responded as disagree which was about 65% (n=13). 20% (n=4) of them were unaware of it and only 10% of them agreed about getting the proper facility of waste management.

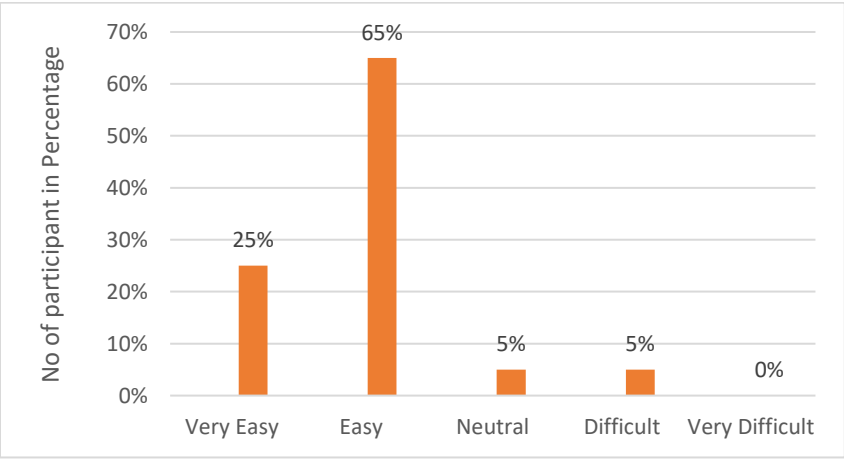


Figure 27 Response of participant what they recycling as easy or difficult practices source own

The above chart illustrates the percentage of participants finding it easy or difficult to practice e-waste recycling with the proper facility. Here, 25% (n=5) of the total participant responded it positively as very easy to practice. Similarly, with the highest percentage of 65% (n=13) responded as easy practice. However, the equal percentage of participant responded it as neutral and difficult with 5% (n=1) in each. This results in that most of the participants find it easy to practice e-waste recycling when there is a proper facility of recycling.

Qualitative Data Analysis

As mentioned on section 4.1.5, researchers did a thematic analysis for question 2 where researchers extracted all the responses of participants. In question number two researchers asked participant the top three e-waste they produce each year where all the participant has answered the top three list of e-waste they produce. Firstly, researchers extract the lists of all participants and go through each list. In the beginning, researchers had three lists from each participant (n = 20). In total, researchers have 60 lists (3 * 20 = 60) from 20 responses. In the second step, researchers categorized all the related list and give it a sub-theme. Researchers both had 8 categories but again when researchers together go through the list and agreed on making 7 categories. After researchers had seven sub-theme researchers again went through all the sub-theme make a theme for each category which can be seen on Appendix 18. From the table the top produces e-waste is from phone, computer, and tablet which we will be focusing on the research. The below figure illustrates the most generated ewaste in Kathmandu valley based on the response our questionnaire.

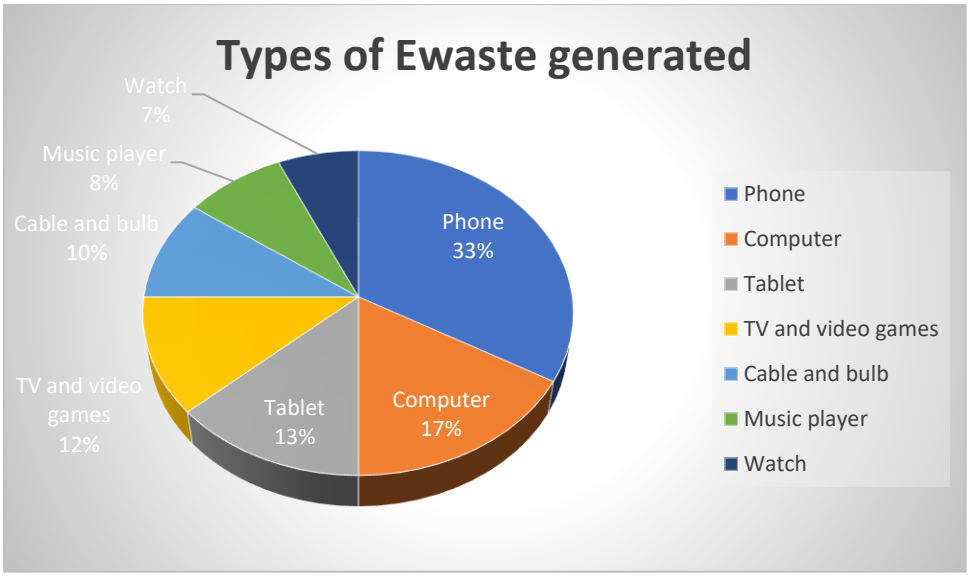


Figure 28 most generated ewaste based on responce of our questionniare source own

4.2.1.1 Chapter Summary

- Researchers found most of the participants produce most of the e-waste from the phone and its accessories.
- Researchers found the majority of the participants throw e-waste together with home trash.
- All of the participants prefer to give e-waste to the recycle company but only 20% (n = 5) of the participant is recycling it.
- Most of the participant would like to contact recycle company through mobile applications.

5 Chapter 5 Interview

An interview is a planned interaction between two people on a selected date and place for a specific purpose. Generally, interviewers ask the question and the interviewee gives answers on a discussed topic. Gill, Stewart, Treasure & Chadwick (2008) have mentioned that interview is the method which can be used to explore the views, experiences, beliefs and motivations of selected participants (Gill, Stewart, Treasure, & Chadwick, 2008). Adhabi & Anozie (2017) have mentioned that “Interviewers are specialized people who act professionally to seek relevant information from subjects to validate their research hypotheses” (Adhabi & Anozie, 2017). Adhabi & Anozie (2017) has mentioned in his journal that Sewell defines interviews in qualitative research as “attempts to understand the world from the subject's point of view, to unfold the meaning of peoples' experiences, to uncover their lived world before scientific explanations” (Adhabi & Anozie, 2017).. Kabir (2016) mentioned that there can be three kinds of interview i.e structured interview, semi-structured and unstructured (Kabir, 2016).

Structured interview

Structured interview is a formal interview where the interviewer asks questions in a standard order on a selected date and time. Bryman (2012) has mentioned that “structured interview, sometimes called a standardized interview, entails the administration of an interview schedule by an interviewer” (Bryman, Social Research Methods, 4th Edition , 2012). Structured interview is similar to a job interview which is fully controlled by the interviewer where the participant is not allowed to discuss another subject matter (Adhabi & Anozie, 2017). In this kind of interview, all the questions are prepared in advance and all the participants receive exactly the same context of question. As all the questions and wordings are pre-decided, there is less interviewer bias which is one of the advantages of structured interview. Because the participant is restricted to answer only the predetermined questions, they cannot discuss or explore other topics, which

is one of the demerits of this type of interview. Structured interviews can be performed when the interviewer has clear understanding on the particular topic and requires a clear topical focus (Kabir, 2016).

Semi-structured interview

Semi-structured interview is an unstructured kind of interview which does not follow any standard method but the interviewer will make a list of guidelines of possible questions (Saunders, Lewis, & Thornhill, 2012). Semi-structured interview is a mix of structured and unstructured interviews in which there will be a predefined initial question, but the participants have the flexibility to pursue a free-flowing format. Adhabi & Anozie (2017) have mentioned that "although there is a set of guiding questions, the response of the subject gives the researcher the flexibility to pose more enhanced questions than the initially drafted ones" (Adhabi & Anozie, 2017) With the semi-structured interview guide, the interviewer gets a proper and clear set of instructions and also can get reliable and comparable qualitative data (Kabir, 2016). One of the advantages of this method is that participants has freedom to express their thought and discuss on the interesting topic. To conduct a semi-structured interview requires skills and it can be time consuming.

Unstructured interview

Unstructured interview is a kind of interview which does not follow any pattern nor has any predefined set of questions. In this kind of interview, there will not be any structured interview guide, but it is a controlled conversation that bends towards the interest of the particular research topic (Adhabi & Anozie, 2017). Kabir (2016) has mentioned that "Unstructured interviewing is recommended when the researcher has developed enough of an understanding of a setting and his/her topic of interest, with a clear agenda for

the discussion with the informant, but still remains open to having his/her understanding of the area of inquiry open to revision by respondents" (Kabir, 2016). Unstructured interviews are usually conducted when the researcher has built enough and clear understanding of the research topic. One of the advantages while conducting an unstructured interview is that it is flexible and easy to conduct which tries to break the communication gap between researcher and participant. This kind of interview can be time consuming and there is a possibility to get diverted from the related topic.

In this project, the researcher decided to use the semi-structured method to interview all the participants. Semi-structured interview is suitable for this research because we will have some follow-up queries for our sample question set (Newcomer, Hatry, & Wholey, 2015). Semi-structured interview is flexible for us to conduct, encouraging two-way communication and helping participants to express their point of views.

5.1 Interview Methodology

According to Kabir (2016), "the semi-structured interview guide provides a clear set of instructions for interviewers and can provide reliable, comparable qualitative data" (Kabir, 2016). Herewith, and to structure our interview and explore the participants' thoughts, we decided to conduct a semi-structured interview.

Kabir (2016) has recommended to proceed with the semi-structured interview in an informal and unstructured way so that relevant and meaningful semi-structured questions on the topic of interest can be developed by the researcher. When we proceed with the interview informally, the participants may not feel stressed and be more comfortable in expressing their views.

By conducting a semi-structured interview, we will try to discuss the reason behind unsatisfactory e-waste recycling practices and the things that can be done to solve the problems.

5.1.1 Development

As Kabir (2016) mentioned, we conduct our semi-structured interview with a paper-based interview guide (Kabir, 2016). We prepared the list of guided questions a few days before the actual interview and informed the interviewee 1 week ago about our project and their role in our project. We have used the same oral presentation to explain all the participants about the project and the purpose of the interview which can be seen in Appendix 3.

To have a proper understanding and a better flow of communication, we decided to use both English and Nepali language for the interview. Before starting the interview, we asked participants to choose a preferred language as a means of communication. In order to structure the interview and maintain the high reliability, we have followed the Whiting interview process (2008) for structuring the semi-structured interview (Whiting, 2008). The interview process starts with the identification of suitable participants. Then the next phase is the interview preparation phase where a checklist is drawn up before the interview that identifies practical preparations and areas to be clarified as recommended by Rose (1994) mentioned by Whiting (2008). Preparation phase also includes choosing a quiet and private room for the interview. Similarly, it explains how to record, transcribe and prioritize ethical issues. Bryman (2012) has recommended to use a quiet and private place as far as possible for an interview (Bryman, Social Research Methods, 4th Edition, 2012). Hence, we booked a private hall located in Pepsicola Kathmandu as our interview venue. We decided to follow the 11 steps for designing and conducting semi-structured interviews (DeJonckheere & Vaughn). While preparing questions, we have considered Kvale's (1996) nine different kinds of question category (Kvale, 1996). Due to restrictions on group meetings because of the pandemic situation, we decided to conduct the interviews in two ways. If possible, by maintaining a distance we will conduct a personal interview; that includes face-to-face conversation (Kothari C. , 2004). I. If we cannot meet the interviewee, then we decide to conduct an internet-mediated interview in which we will have an online conversation (SAUNDERS, LEWIS, & THORNHILL , 2016). As mentioned by Kabir (2016), we decided to record

the interview to transcript it later for the analysis (Kabir, 2016) .To save time, it was decided to only transcribe the interview questions and answers and omit all unnecessary parts of the conversation.

5.1.2 Participant

We had planned to conduct a semi–structured interview with 15 participants but due to the lockdown related to the coronavirus case, we could only interview 6 participants in total. Among the 6 participants, 5 are from Nepal and 1 is from Denmark.

Interviewee	**Job Roles**	**Code**	**Age**	**Gender**	**Location**
Recycling Company from Denmark	Supply chain Manager	C1	38	Male	Denmark
Recycling Company from Nepal	Manager	C2	42	Male	Nepal
NGO	Founder	N1	48	Male	Nepal
Resident of Kathmandu living in Nepal	Student	R1	24	Female	Nepal

Resident of Kathmandu living in Nepal	Student	R2	27	Male	Nepal
Resident of Kathmandu living in Nepal	Student	R3	25	Female	Nepal

Table 3 Demographics detail of interviewer source : own

Participants from Nepal

Among the five participants from Nepal, one of them is a co-founder of an e-waste recycling company known as Eco General and another works as an assistant manager for an NGO called JADEKUBURA.

The main purpose of the NGO is to motivate people to save the environment. The interviewee from the NGO is responsible for planning meetings, contacting students and social workers and informing them for the awareness programmes on e-waste recycling. All of the participants are from Kathmandu.

Participant from Denmark

The researcher also interviewed one of the employees of a recycling company from Denmark, who has been working in an Electronics Refurbishing company called BlueCity since 2014. He works as a Supply chain manager in the company and is responsible for the company's business development in the Nordic countries.

5.2 Interview Result & Analysis

In this section, the interviewed data and results from different stakeholders is discussed. All of the interviews were conducted virtually through Zoom and Messenger. The result from the interviews is analysed using the Thematic Analysis method's five-steps approach. Besides that, the interviewed data is also analysed using the Activity system analysis (ASA). Using the ASA, the researcher discussed the problems of the different stakeholders in the practice of e-waste recycling and identified systematic contradiction and tensions between two activity systems. The following section discusses the resulting data from each stakeholder.

5.2.1 Interview Result of the E-waste Refurbishing Company in Denmark

BlueCity is an e-waste refurbishing company in Denmark dealing with pre-used electronic goods. The company buys and sells used electronics through different channels. They have physical stores as well as online channels for their commercial activities. The company runs the business model on circular economy and sustainability solutions with e-waste. In the interview, the supply chain manager of the company talks about different factors and potential barriers that demotivates people to practice e-waste refurbishing and adopt the new practices of using second-hand electronic devices. The following figure shows the thematic map from the interview with the E-waste Refurbishing Company where the interviewee talks about 5 main themes in the topic of E-waste refurbishing practices for people.

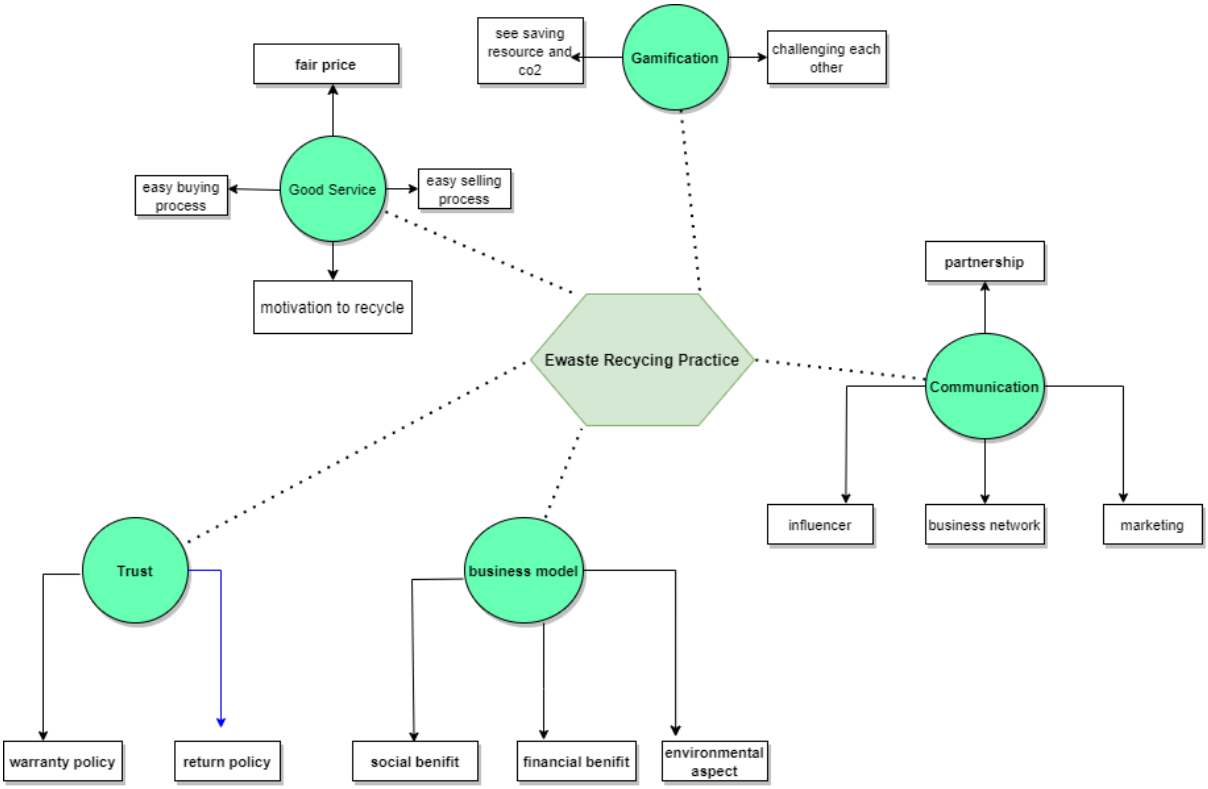


Figure 6: Thematic Map of Interview with C1; Danish Ewaste recycling company

Trust: Convincing people to purchase or sell refurbished electronic products is difficult. Trust can be considered as a main issue to influence a change in people's behavior. It is important for the company to make their customers feel secure when they trade their e-waste. This applies to both cases - whether someone is selling the e-waste where the risk of security comes with customer data or while buying the used product where the quality and life period of the product cannot be measured. Regarding the problem of security, C1 mentioned that there should be a high level of trust between the company and the customer, which can be solved with warranty and return policy.

"Feeling secure is essential as well, since there needs to be a higher level of trust between us and the customer - therefore we have a 2 years warranty and 14 day return right on all products, which goes above what the consumers get when buying new goods."

From answer 4: Appendix 14.

Trust Relate to TPB:

Providing a secure service and privacy to the people can change someone's *attitude toward recycling* when they think of recycling electronics waste through recycling companies.

Communication: Another factor that affects the behaviour to practice e-waste refurbishing is through influencers or network of people which has a high reach of target people. Connecting with the right people and creating a wide range of Networks with like-minded people in the field of sustainability, plays a vital role for the Business marketing and promotion to reach the people. In the current context, social media is the strongest platform for influencing people to become potential customers and there are many influencers with a high number of followers who can directly or indirectly influence the behaviour of these group of people.

"the best way to get in touch with most users in a proper way is through word-of-mouth. We have some influencers who help us with this, but also some non-paid ambassadors who like our concept. These are very valuable, whether it being on a blog, Facebook etc. But currently I think Instagram is the strongest platform for the environmentally aware"

From answer 6: Appendix 14

Communication Relate to TPB:

The element of communication in the design solution can act as a *social pressure* to adopt the recycling practices. When people see others around them practicing e-waste recycling, then it encourages them to change their behaviours as well.

Good service: It is also another factor that helps convince people to change their current practices of recycling. When people deal with the trading of refurbished electronic products, they usually do not want to haggle with potential buyers. If there is a good facility of buying and selling unused or defective electronic products, then, it would encourage more people to adopt the practices of managing their e-waste sustainably.

"For people selling their used electronics, some of the main factors have been an easy process. They will be able to get more if they sold it privately, but that also means haggling with potential buyers, buyers not showing up as agreed etc. In addition, the environmental aspect is becoming more and more important, as long as they also feel they are getting a fair price."

From answer 4 : Appendix 14

Good Service Relate to TPB:

When there is a good facility of recycling e-waste with the easy service of buying and selling without any haggle, this will act as a *Perceived Control* over the mindset influencing people to have a positive attitude towards recycling.

Gamification could be a factor that can motivate people to practice a sustainable living standard where one can challenge others for their sustainable behaviours in daily life. It could have a great impact on the lifestyles of people if they can see how much resources and Co2 they are saving. This could also be a reverse tactic where people can see how they are affecting the environment with every behaviour related to purchase and consumption etc. So, it would be helpful to use gamification in the practices of e-waste recycling.

"In addition, I think many people could be motivated to see how much they are saving in resources and CO2. So also including their personal habits at home - e.g. how they are recycling there."

From answer 8: Appendix 14

"gamification could be a great idea. If you could compete against friends (B2C) and see who most are environmentally friendly with their habits; being the way we eat, the restaurants we visit or whether we buy and sell used electronics. Or B2B - companies challenging each other - this would have a lot of positive CSR effects as well."

From answer 9:Appendix 14

Gamification Relate to TPB:

The element of gamification in the design of the solution can also act as a *social pressure* to adopt recycling practices. When one can see the impact of their recycling behaviours and compete with others in acting sustainably, this can have a positive and direct effect on the *intention to recycle*.

Beside this, the practices of e-waste recycling in a sustainable way could open a possibility for entrepreneurs to start a new **business model** with the concept of circular economy with e-waste recycling. This could help both in the financial sector by generating a lot of job

opportunities in the market and making an impact in the society by saving the environmental problems caused by the hazardous components from e-waste. But C1 suggested in the interview that a Digital solution focusing only on e-waste recycling practices might not be enough traction. The concept of living a sustainable lifestyle with proper recycling practices in a digital platform could be more effective to implement as a real-world solution.

"Not sure, if an app specifically for electronics would have enough traction. A general app of "living sustainable" could be good. Go Green (the business network we are in) have a city guide of living sustainable is pretty good"

From answer 8: Appendix 14

The key points to be considered from this interview in the design of digital solution are as follows:

- Build trust with the customers in terms of data security and privacy.
- Reach the people through influencers or collaborate with like-minded people.
- Provide better service without any haggle during the refurbished goods' buying and selling process.
- Challenging others in the practices of e-waste recycling or checking one's own impact could help motivate people.
- Concept of a "sustainable living" app could be a better option which could cover the practices of recycling all types of waste, not only e-waste.

5.2.2 Interview Result of E-waste Recycling Company in Nepal

In this section, the researcher will analyze and present the result of the interview with the assistant manager of the e-waste recycling company based in Kathmandu.

During the interview with C2, the researcher tried to explore the current e-waste recycling practice, problems, and business model of the recycling company. The following figure shows the thematic map of the C2 interview on which the interview was based:

Limited customers

Inside Kathmandu valley, only a handful of people recycle their e-waste. The offices and organizations are starting to sort and recycle their e-waste but there are a limited number of individuals who are involved in this recycling practice. It is clear from the interview with C2 where he mentions, "Our company is not a large-scale company. We have limited clients. We collect the waste from the Kathmandu valley".

From answer 4: Appendix 10

"We have both kinds of customers. But there are very few individuals who recycle e-waste. We always accept all kinds of customers either they have 50 kg of waste or just 1 phone".

From answer 5: Appendix 10

In both statements, C2 mentioned that the number of clients they have is very limited although they collect the waste from the entire Kathmandu valley. So, it is one of the biggest challenges for the recycling companies in Nepal to reach a large number of people.

Company difficulties

Although Kathmandu is the capital city of Nepal and relatively more developed in terms of education and technology as compared to the rest of Nepal, residents of Kathmandu are not aware of the problem caused by e-waste on the environment and human life. C2 on the interview said:

"One of the biggest challenges we face, not only we but all the recycling companies of Nepal face is to change the mindset of people regarding waste segregation....”

Answer 7: Appendix 10

“...another problem recycling company face a lack of policy that the government does not have any policies, plans, and motivational schemes to inspire both recycling companies and the public. Similarly, we do not have a suitable infrastructure like modern vehicle, separate bins in local area, and tax free on machinery to collect and recycle e-waste."

Answer 7: Appendix 10

C2 stated that the public is not aware of the importance of e-waste recycling and it is very difficult to convince them. It is one of the major responsibilities of the government and recycling companies to inform people about the effect of e-waste on the environment.

C2 mentioned that the government has not made any policy to inspire recycling companies and the public. So, lack of government policy is also one of the obstacles for the effecting running of an e-waste recycling company. It was also found through literature review that the government of Nepal has not prioritized e-waste management and there are no rules to regulate it. Lack of government policy can be one of the reasons for not having a large number of recycling companies and users in Nepal. Likewise, it can also be said that the government of Nepal has not designed any scheme to motivate people to get involved in recycling. C2 stated that they do not get any tax discounts or motivational schemes while buying machinery or running the e-waste recycling business. So, it can be said that the government of the nation is not motivating the e-waste recycling company and the public to involve in the recycling process.

Similarly, another major obstacle that recycling companies in Nepal are facing is the lack of facilities. Inside Kathmandu valley, there are no separate bins to sort different kinds of waste. Due to the lack of enough bins, people cannot store their e-waste for a long time and the company has to pick the e-waste even if the amount of e-waste is small, otherwise it will be mixed

with other waste. Moreover, C2 also mentioned that recycling companies lack modern vehicles for collecting waste. Because the government is not giving tax discounts and a scheme to small recycling companies, they cannot afford the modern vehicles and advanced machinery which affects the performance of the company in a way that they cannot reach a large number of people or provide training to sort and recycle the e-waste and motivate people to recycle the e-waste.

Reasons for not recycling e-waste

During the interview, C2 was asked the reason behind people not recycling e-waste where C2 focused on 3 major reasons: lack of facility, lack of awareness, and lack of communication. C2 said that “There is no doubt that there should be a better facility for the people as compared to what they have at the current context but at the same time people should be self-aware that they also involved in recycling practice and save the environment, as well and we are trying to reach as much as people in the local community to teach them the recycling practices with the limited resources and get connected with the company for any kind of services to recycle their electronic devices. Right now, we have not reached a large number of people. But our plan is to get connected with the people throughout the Kathmandu valley ".

Answer 8: Appendix 10

Through this statement, C2 observes that people are not getting better facilities that can make recycling an easy task for them. From the user's interview analysis also, we found that lack of facility is one of the reasons why people are not recycling their e-waste.

Similarly, the lack of awareness is also another reason why people are not recycling their e-waste. P4 here has argued about self-awareness. People who are aware of e-waste problems are also not recycling their e-waste. The reason could be because of lack of facility but it is also people's

responsibility to help in the recycling process. So, the people who are aware should get involved in the recycling process.

Similarly, C2 has mentioned about the communication between the recycling company and the public. Currently, the recycling company has not reached a large number of people, but their target is to reach throughout the Kathmandu valley. The reason why people are not recycling their e-waste is because of the communication gap between users and recycling companies. It seems it lacks a platform that connects the recycling company with a large number of people. C2 also stated that if the recycling company will reach a large number of people then the company can teach and motivate them to get involved in e-waste recycling with limited resources.

Gamification

Regarding the concept of Gamification, C2 said that it could be a factor that can encourage people to practice e-waste recycling. But he also mentioned that it might not be effective in the context of Nepal. “Gamification is a good solution in general to encourage people for new practices but in the context of Nepal, not everyone is likely to be a part of the game in their social behaviours”. However, while reviewing his statement he also said that there should be the practice of giving a ‘reward’ to the customers who often recycle their e-waste, it makes it clear that the Gamification element could be a feature in our solution. Gamification does not mean a full-fledged game in a mobile application, but it can be also only a small element like a reward or badge system which acknowledges the customer for their good practices of recycling.

"we do provide our customer special service or reward like extra money or some cinema ticket when they often recycle through our company. Sometimes we also make a lucky draw competition through our Facebook page, so that more and more people can connect in our social media and we can reach them to share information and service.

Communication

C2 mentioned that currently, customers can contact the recycling company through email, social media, and telephone calls. The telephone call is a popular medium practiced by both the recycling companies and the public. C2 said that "We have email, social media, and telephone. Customers can use one of any medium to contact us. Among all of it, the telephone call is mostly practiced medium. We also use the telephone to contact our customers." answer 10: Appendix 10

From the above statement, it is clear that the recycling company still practices the traditional way of communication. One of the reasons the company could not reach a large number of people could be because of this communication method.

Recommendations

During the interview, C2 was asked how the recycling practice inside Kathmandu valley can be improved where C2 mentioned 4 major points. First, the government of Nepal should make an e-waste policy and plan to encourage individuals and recycling companies. Second, the public should be made aware about recycling e-waste and its process. Third, there should be an easy communication medium between recycling companies and individuals, and lastly, there should be a gamification element to inspire people to recycle their e-waste. If the mentioned 4 points are implemented, then the recycling practice will get improved said C2.

"From my point of view to improve the recycling practice of Kathmandu valley firstly government should make an e-waste plan and policy. The government should make a rule that people are not allowed to mix their different kinds of waste and should provide a bin where people can throw

sorted waste. Likewise, to encourage the recycling company government should give schemes like tax discounts, and a low-interest loan, etc. Similarly, the public should also be informed about the problem caused by e-waste and the way they solve it. It is our responsibility to aware people and encourage them to recycle e-waste. We are trying our best to reach the larger public. But due to limited tools and manpower, we have not yet reached the whole Kathmandu valley. So, another important thing which can improve recycling practice is that there should be an easy excess between the public and the recycling company. Similarly, there should be a reward system for those who recycle their e-waste". answer 11: Appendix 10

The key points to be considered from this interview in the design of digital solution are as follows:

1. At first, the customers were investigated where it was found there were limited customers inside Kathmandu valley who recycle their e-waste. Another topic that is investigated is the problem that the recycling company is facing where the researcher marked 4 major problems. The first problem is the public is not aware that they need to recycle their e-waste, the government lacks a plan and policy, e-waste recycling companies are not motivated to establish as a business organization, and there is a lack of proper facilities.
2. Similarly, the reason behind people not recycling e-waste was also discussed where the researcher found 3 major reasons. The first reason is that people are not aware of the recycling process, the second reason is they do not have enough facilities to make their recycling process easy and the third reason is the people do not have an easy medium to contact the recycling company.
3. Likewise, the researcher found the recycling company is using the traditional medium to contact its customers because of which it could not reach a large number of people.
4. Discussed a process to improve recycling practice where 4 major topics were observed which are government plan and policy, awareness program, easy communication, and gamification practices.

From the analysis, it can be said that there should be an easy medium that should reach a large number of people and raise awareness to improve the e-waste recycling process and motivate people to recycle e-waste.

5.2.3 Interview Result of the NGO

This section will explain the result of the interview with an NGO from Nepal. During the interview following major topics were discussed, which is shown in the following thematic map:

Digital Platform

The goal of the organization is to motivate students to save the environment by organizing various awareness programs. N1 mentioned that they have not met the target of student involvement. N1 said that

"*Our target was to involve 500 students this year, but we have reached only 350 students*"

Answer 5: Appendix 12

The above statement shows that the involvement of students in the awareness program is very low. N1 was asked the reason behind it where he said

"*We found most of the students do not want to get involved in such kind of program because they have to present physically. We have interacted with students and found that they think it is a waste of time to present physically in an awareness program. Instead, they prefer to be a part of a virtual program. whenever we post a video or organize a virtual program more than 1000 students get connected".*

Answer 6: Appendix 12

Here N1 mentioned the reason students do not want to participate is due to ***lack of digital platforms***. So, to involve students or youth there should be a digital platform. With the use of a digital platform, a larger group audience can be connected. The above statement also cleared that the ***intention*** of the student is to get connected but with a modern platform.

Awareness

The researcher tried to investigate if the students are aware of e-waste and its impact on the environment or not where N1 said

"*All the students are aware of the e-waste issue from school.*"

Answer 9: Appendix 12

Here it is mentioned that the students **are aware** of the impact of e-waste on the environment. He further added

"*Although in the school they learn about such issues and know about it when the time comes to execute in real life, they don't follow it*".

Answer 9: Appendix 12

From this statement, it is clear that the student does ***not have a recycling attitude.*** Even students are aware of the issue they do not work to solve in real life. N1 further explained about the changing attitude of the student where he said

"*When I join this organization none of the students used to separate their waste but now because of our motivation and awareness, they separate the waste on a different container. 54 students in the co-ordination with this organization has placed the big separate container to separate the waste in their street. Gradually the mentality of the student is changing, and they are also motivating others to separate the waste*".

Answer 9: Appendix 12

In this statement, N1 discussed the ***changing attitude*** of the students that can motivate other people to also sort their waste. From the analysis of the above statement, it can be said that the student is ***aware*** of e-waste recycling and its issue and they are ***gradually changing*** their ***attitude*** towards recycling.

Motivation

One of the ways to connect students in the recycling process is by motivating them. N1 mentioned the student will only be involved in the recycling process if they are motivated. He also explained different ways of motivating students such as: rewarding them, making them conference speakers and publishing their name in social media where N1 said

"*The only way to involve students in recycling practice is by motivating them. There can be a different way to motivate students. some get motivated by a reward, some want to get posted on social media and want to be a speaker at a conference. Understanding the desire of the students if they are motivated then for sure a larger number of students will get involved* "

Answer 10: Appendix 12

In this statement, N1 has explained that the behavior of a student in recycling practice can be changed by motivating them.

The key points to be considered from this interview are as follows:

- Students are not interested in physical awareness programs and right now, the digital platforms are not commonly used in this regard.
- All the students are aware of the impact of e-waste on the environment from their school curricula, but they do not have a recycling attitude.
- However, the students' attitude towards recycling practice is changing slowly.
- The way to involve students in recycling practice is by using different motivating ideas.

5.2.4 Interviewed Result of People from Kathmandu

From the interview with the participants from Nepal, researchers tried to understand the people's behavior, intention, and difficulties behind the e-waste recycling practice in Kathmandu valley. During the interview, the various topic was discussed which is shown on following thematic map:

Current recycling Practice

In 2017, 17000 metric tons of e-waste were generated inside Kathmandu valley and the rate is increasing rapidly each year. But the recycling practice of the Kathmandu valley has not been changed yet. People inside Kathmandu valley do not recycle their e-waste which is clarified from the participant's interview. All the 3 participants have mentioned they do not practice e-waste recycling where participants said

R1: *"No, we don't recycle e-waste here in Nepal. I don't think anyone I know recycles their e-waste". From answer 5: Appendix 4*

R2: "*No, I have never recycled the e-waste*". *From answer 4: Appendix 6*

R3: "*No, I did not recycle my e-waste. I have no idea where to contact and how should I start recycling. I even don't know how much they will charge if they take my e-waste. Its free of cost to throw e-waste on local municipality truck together with other waste. I guess I want to know the way and the process before I start recycling*". *From answer 7: Appendix 8*

The above statement from all the participants shows that people of the Kathmandu Valley do not practice e-waste recycling, and it can be said that they do not have recycling *behavior*.

Current e-waste management Practice

The *behavior* of the participants to manage e-waste has been investigated in the interview. Participants were asked the current e-waste management practices of their daily life where all the participants mentioned that they dispose e-waste together with other waste. P3 mentioned that the common waste management practice inside Kathmandu valley is that people store all types of waste together and throw it away after a few days in a municipality truck. Current e-waste management practice inside Kathmandu valley is the reason for the increase in e-waste problems. To solve this problem the current *behavior* of the people must be changed. Only if the people change their behavior and start to separate the waste it will help in the recycling process. So, the big question is how we can change the habits of the people.

Reason for not recycling

People may face several difficulties in recycling the e-waste in developing nations like Nepal where the government has not given priority to e-waste management, similarly, there is no e-waste legislation, and the proper study has not been done to build an effective e-waste

management system. To investigate the difficulties in e-waste recycling all the participants were asked to mention the reason for not recycling their e-waste where participants gave a different reason. The common answer all the participants stated is due to lack of facility, lack of platform and lack of awareness.

- **Lack of facility**

All the participants mentioned that there is no separate bin to store the e-waste. The government or local municipality has not given a separate bin to store different kinds of waste. Similarly, another difficulty is that people have to carry their e-waste if the recycling company is far from home which people may not have time or motivation for. R1 said that

"*I think it is very difficult to practice e-waste recycling in Kathmandu. In Kathmandu, I have not heard about any recycling company and to contact a recycling company is not so easy. It is very difficult to carry waste if the recycling company is far from home. Another problem in Kathmandu is we don't have a separate bin to sort the waste. I would had sorted the waste if there will be a separate bin for separate waste and someone will come to pick the collected waste. And other thing that may affect the I guess people will start to sort the waste if there will be rules by the municipality*". *From answer 10: Appendix 4*

In this statement participants have clearly mentioned that there is no separate bin to sort the e-waste. Similarly, R2 has said

"*No, I do not separate any waste. We have only one container to throw all the waste. So, we don't have any option except mixing everything together*". *From answer 3: Appendix 6*

In this statement R2 have also mentioned that the reason people do not sort the waste is because they have only one bin in their local community. So, it is clear that lack of the facility is one of

the reasons people do not sort their waste. P1 has mentioned that people will start to recycle e-waste once they have a minimum facility such as separate bins. To make a recycling process easy people must get a required facility.

- **Lack of awareness**

Lack of awareness is one of the reasons that people are not recycling their e-waste. From our sample participants' interviews it can be assumed that the majority of the people of the Kathmandu valley do not know the problem caused by e-waste if it is contaminated with water and the environment. The government or local municipalities have the major responsibility to aware people regarding the e-waste problem. But it is seen that the municipality of Kathmandu valley has not informed people regarding the e-waste problem and the procedure to separate the e-waste and recycle it. R1 has said that:

"*No municipality has not informed regarding the separation of waste and people have no idea how to separate it.*" *From answer 10: Appendix 4*

Similarly, participants 2 and 3 have also mentioned that neither municipality nor other organizations have informed about any e-waste recycling process. People are not aware that e-waste can cause serious damage to the environment and it is one of the serious problems of today's modern world.

Similarly, one of the reasons people are not recycling their e-waste is due to lack of awareness. People are not aware about recycling processes that they don't know where and how they should contact the recycling company. R3 has said that:

"*No, I have never recycled my e-waste. I have no idea where to contact and how should I start recycling. I even don't know how much they will charge if they take my e-waste. Its free of cost to throw e-waste on local municipality truck together with other waste but e-waste recycling*

company may charge big amount of money. I guess first I want to know the way and the process before I start recycling". *From answer: Appendix 8*

In this statement, R3 has clearly mentioned that R3 is not aware of the recycling process. R3 thinks recycling companies will charge money instead of taking their e-waste. So, to make people aware and make their recycling process easy is one of the important factors which can improve the recycling practice. R2 has also given similar statement like R3 where R2 said:

"*If the recycling process is easy then I will surely start to recycle. Right Now, I don't know the whole process of recycling and I am not sure where to find recycling company. If my friends or relatives will suggest me from their experience, then I may start to recycle the e-waste*". *From answer 6: Appendix 6*

In the above statement R2 has also mentioned about the e-waste recycling process. From the statement It is clarified that people will start to recycle once they know the complete recycling process. So, the awareness program should be done in a way that it reaches to the large number of people

- **Difficulty in communication**

To have an easy excess with the recycling company is one of the biggest problems the public is facing. Even if people want to recycle e-waste it is very difficult to contact a recycling company. All the participants agreed that to contact a recycling company is not easy.

R1: "*to contact a recycling company is not so easy*" *From answer 12: Appendix 4*

R2:" *I am not sure where to find a recycling company*"

From answer 5: Appendix 6

R3: "*I have no idea where to contact and how should I start recycling*"

From answer 7: Appendix 8

From the participant's statement, it is clear that people are not sure how to contact the recycling company. So, in order to improve the recycling practice, people should have easy access to the e-waste recycling company. The current means of communication should be changed and choose an easy and simple means to communicate.

Willingness to recycle

In the interview, the willingness of the participants has been studied. All the participants are positive in recycling the e-waste. All three of the participants mentioned that they will start the e-waste recycling if they will get the required facility such as: bins to separate the waste and if the company came and picked the e-waste. R2 said that

"*I would surely recycle if such a company would come and pick from me*". *From answer 9: Appendix 6*

Similarly, R3 mentioned that people feel lazy to carry their e-waste to the recycling company if they have to carry it but if the recycling company will come and pick the e-waste then people will start to recycle the e-waste. So, from the interview data it can be concluded that the participants are willing to recycle e-waste, but the government or recycling company should make the recycling process easy.

The key points to be considered from this interview in the design of digital solution are as follows:

- The resident of the Kathmandu valley does not have recycling behavior
- To help in the e-waste recycling process, residents of Kathmandu valley must change their e-waste management habit.

- The three major reasons for people not recycling e-waste were investigated which is lack of awareness, difficulty in communication, and lack of facility.
- If people are given the facility and easy access to the recycling company then they are positive in recycling the e-waste.

From the analysis, it can be said the residents of Kathmandu valley do not have recycling behavior, but they are willing to recycle e-waste. The recycling practice can be improved if the current habit of the people is changed by providing awareness and facilities. And there should also be an easy means of communication that should connect the recycling company and the public.

Activity System Analysis

Our qualitative data is collected from different participants through interview, questionnaires. All that data is analyzed using thematic analysis. With the help of thematic analysis, we have listed the major problems mentioned by people, companies and other stakeholders. All the problems seem important to our research or study but there were few common problems that indicated the viewpoints of different participants towards the common issue. With the help of the activity system, we can see the different objectives of the participant and identify the shared element from the activity system which can be formulated as the main objective between the activity system.

In our research, the Activity system is designed from the viewpoint of 2 different stakeholders. The people and the recycling company.

People: In this Activity system, we have looked at the perspectives of people regarding the e-waste recycling practices. So, the subject for this activity system is the people from Kathmandu city. Our goal on this project is to design an application that solves the problem faced by the subject. So, this prototype of our application is considered as a mediator or tool in this activity system.

All the different problems faced by the people are considered as the object of this activity system.

- Object:

1. Lack of information
2. Lack of motivation
3. Lack of awareness
4. Lack of Facility

Recycling company: In this Activity system, we have looked at the perspective of companies working in the field e-waste recycling. So, the subject for this activity system is the recycling company. Prototype of our application aims to help the company with the problem they had faced fighting against e-waste. So, our prototype is considered as a mediator in this activity system

All the different problems faced by the company are considered as the object of this activity system.

- Object:

1. Motivation: Less motivated people
2. Less environment conscious practices

3. Lack of Facility
4. Ignorance

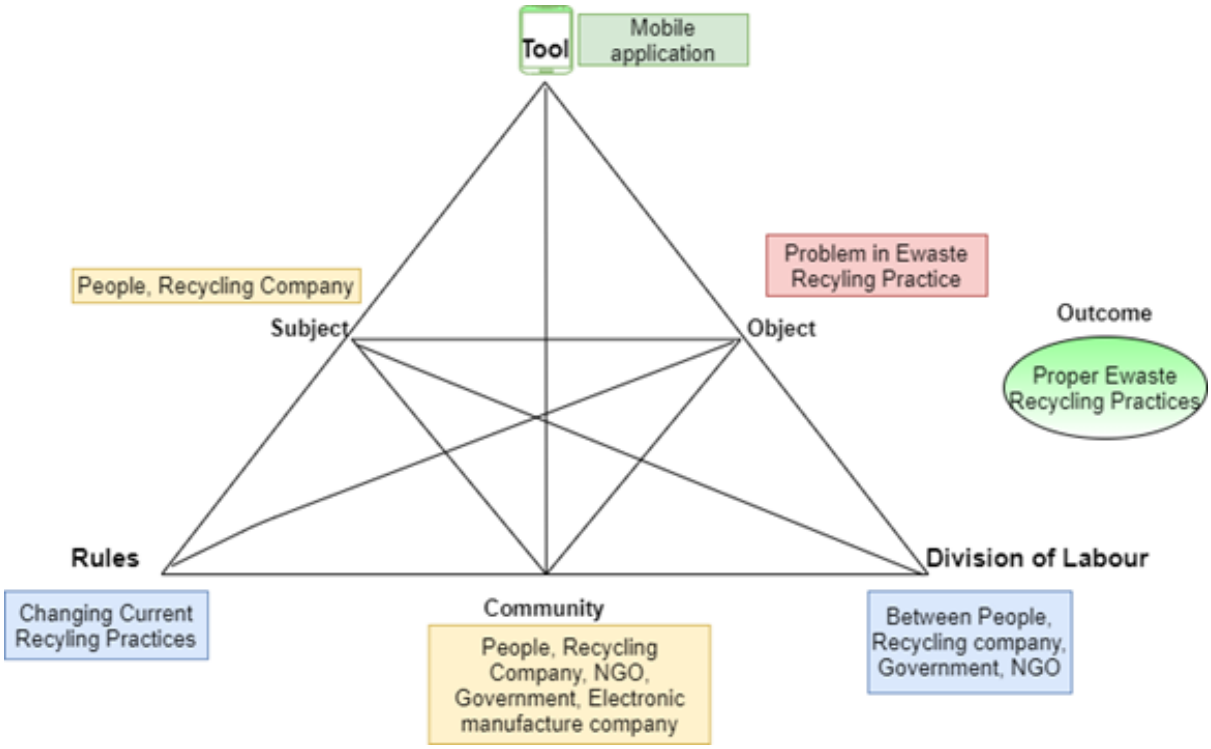


Figure 29 Activity system for ewaste recycling

Finding and Discussion

The findings showed there are several contradictions within and between the elements of activity systems. These contradictions include issues related to improper recycling facilities, lack of information, unawareness about e-waste recycling and lack of connection between people and recycling centers.

1. Facilities:

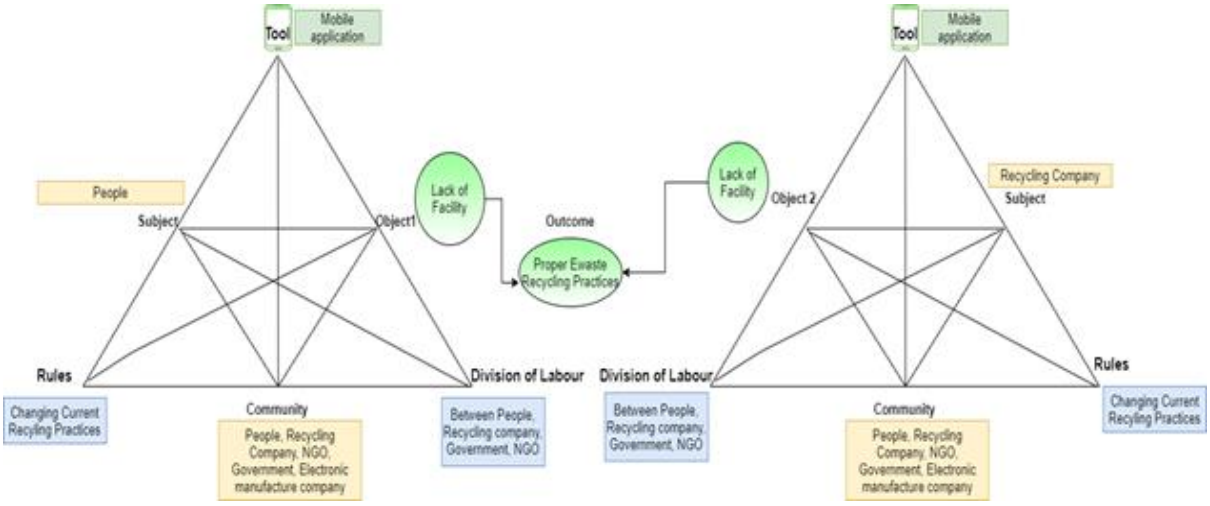


Figure 30 : Activity system of two subject

Due to improper recycling facilities in Kathmandu city, people are facing a lot of problems in several cases. Neither the government is taking this problem as a serious matter nor local community organization works on this issue to facilitate the people with proper management solutions. People and the recycling center both indicated the several problems they faced due to bad management and facility and here we explained the tensions they experienced with their viewpoints.

R1 mentioned that people in Nepal do not know what facilities they should get from the municipality or government for recycling management. They are using the traditional waste management practices where the municipality bus comes every week to collect the household garbage and people just give the box filled with different garbage in the same container. There is no proper management where people are informed to separate the different waste garbage in a separate bin. Some municipalities have informed their local people to separate the trash in different bags but this is not applicable to people unless the Municipality provides them some

proper facilities like trash bin with separate container nearby their house or at least the trash bag in which they can collect the garbage. He explained that:

Our people in Nepal do not really care how the things should work and what should be done to improvise the problem. We are just happy with the things or facilities we have got from the government. This might be because of lack of knowledge. When I was in Nepal, I was not aware about the importance of proper waste management practices. I just do the same practices followed in the local community. Every week the Municipality bus comes to collect the trash from everyone home. We just collect all the trash in the same bag and put it outside the door. But we do separate the recyclable food waste to decompose it and use it to make fertilizer. But the rest of all the wastage like plastics, metal, electronics etc goes in the same trash. I only realized the importance of proper waste management practices once I came to Denmark. Here everything is so managed. All the houses have the proper facility to throw that wastage in the separate bin. This will be a really good practice if the local municipality provides some facility like this to our community. It might not be possible to provide a separate garbage bin in each house but still if they put the big trash bin nearby houses for the local community, people will be more interested to follow that practice. Also, just a simple trash bag distribution in the local communities can be helpful for the people.

This problem was also included by R3. She believes that, our community is missing proper waste management practices. Neither government is taking this issue as a serious matter nor the local municipality. She blamed the local government for their negligence to work on this problem and suggested that “This could be resolved if they upgrade the current practices with better facilities like in Denmark”. *From Appendix 8*

However, when we asked the recycling center about the facilities provided by municipalities, they somehow agreed with the people's statement but also have a different

viewpoint on that. They mentioned that, there have already been a few workshops and campaigns for the people to increase their awareness but it's people who do not show interest. They feel that “People think recycling is a waste of time.”. Some people who are environmentally conscious follow recycling practices from their home. Those people do not look for the facility or depend on the municipality instead they practice recycling from the limited resources they had in their home. But some people always complain about the management and the facility while they don't play their role properly in recycling practices. It’s really hard to change someone's perspective and difficult to encourage them to adopt recycling practices in a sustainable way. C2 suggested that “there should be better facility for the people as compared to what they have at the current context but at the same time people should be self-aware on this matter as well and we are trying to reach as much as people in local community to teach them the recycling practices with the limited resources and get connected with the company for any kind of services to recycle their electronics devices”.

The contradiction that occurs within the community in the form of dissatisfaction & frustration has seemed to demotivate people in practicing recycling in a sustainable way.

2. Motivation:

As mentioned by C2 in his interview, people think recycling practices are a waste of time and they need some kind of motivation to change their habits. In the current context of Nepal, people always look for the easy process and less work. Most of them are still practicing the traditional way of recycling and do not want to step forward changing their habit. In these cases, there should be a new design of practices to encourage people to adopt the better practices and change their recycling habits.

C1, who is the project manager at BlueCity, the company which works with recycling used electronic products mentioned that it would be a good idea to have an app which could motivate

the people to see how much they are saving in resources and CO2 and see how they are saving the environment. He mentioned that:

“Not sure, if an app specifically for electronics would have enough traction. A general app of "living sustainable" could be good. GoGreen (the business network we are in) has a city guide of living sustainable is pretty good. In addition, I think many people could be motivated to see how much they are saving in resources and CO2. So also including their personal habits at home - e.g. how they are recycling there.”

He also suggested that providing information through the application and also encouraging people through gamification could be a great idea to motivate the people to change their habits.

“Information and gamification could be a great idea. If you could compete against friends (B2C) and see who is most environmentally friendly with their habits; being the way we eat, the restaurants we visit or whether we buy and sell used electronics. Or B2B - companies challenging each other - this would have a lot of positive CSR effects as well.”

From Appendix 14

Summary of ASA

The contradictions that occur within and between the elements of activity systems in our research were seen in the forms of difficulties and contradictory opinions. In the current context of recycling practices, People complained about improper management of wastage from the government level and how the lack of proper facilities for the people make the recycling practices difficult in everyone homes. Unawareness in terms of individual responsibility (Division of labour) also creates a confusion for the people where people should have self-knowledge on their responsibility as citizens to follow the recycling practices with the limited resources available to them. As suggested by the Recycling center in Nepal, our focus on the design of the

application should be providing information to the people and making it more accessible for them to find the nearest local recycling center. The opposing views from the recycling company in Denmark indicated the clashes that were in this activity system where the interviewer suggested to focus on the Gamification which was not applicable in the current context. This shows that there should be better planning while designing the prototype of the application. A design based in the Copenhagen context might not be applicable to the people living in Nepal. The results from this study may help to overcome the tension and contradiction while designing the prototype of mobile application.

6 Chapter 6: Future Workshop

In this chapter, researchers present a future workshop, one of the data collection methods using Participatory design approaches. This chapter discusses the potential problem of current e-waste recycling practices and comes up with ideas to solve the current problem.

6.1 Future Workshop Introduction

A future workshop is a small group of discussions that brainstorm the future solution for the current problem. Jungk & Mullert (1987) have stated that the future workshop (FW) is a technique that helps people to design a creative idea for a better society (Jungk & Mullert, 1987). Vidal (2006) has mentioned that FW has been developed by Robert Jungk "wanted to enable and support the development of social fantasy that should lead to conflict resolutions that can be turned against the business-as-usual and the profit-seeking of the establishment" (Vidal , 2006). The purpose of a future workshop is to solve the current problem and develop a creative group solution. In FW, a group of people sit together and discuss a problem and imagine a creative and

innovative solution, by going through four different phases - preparatory phase, critique phase, fantasy phase, and implementation phase society (Jungk & Mullert, 1987). While conducting FW there will be a guiding hand in the form of the group leader who acts as a facilitator. In this workshop both researchers act as a facilitator. The facilitator should be familiar with all the phases and events of FW. Vidal (2006) has mentioned the task of the facilitator is to handle and manage a democratic problem-solving process (Vidal, 2006). While conducting the FW, the facilitator acts as a supervisor whose responsibility is to fix a date, time, and democratically conduct all the phases.

Kanstrup mentioned that facilitator is a reflective practitioner not an expert user. Facilitator main responsibility is to plan and facilitate the workshop, support the user for creation of innovation and transform those ideas into the product design. Similarly, in this research, researcher had act as a facilitator during the whole future workshop and guide the user in different phase and lastly transform participant innovation into design solution.

6.2 Methodology

The future workshop is one of the main Participatory Design methods in this research. This workshop can be considered as the first theme "*Co-operation*" and the second theme "*Context*" of UIM. *Cooperation* focuses on selecting the participant for the FW and making the plan for organizing the workshop while *Context* which focuses on the context of the innovation process for generating insights into the current problem of electronics waste recycling practices and comes up with the vision for a possible solution that helps to reduce the problem of e-waste. The researcher had conducted a workshop as a Participatory Design led by the researcher and then led by the user.

Ferguson & Candy (2014) while conducting a participatory design has mentioned that participatory design can be of two types i.e. traditional participatory design and modified participatory design (FERGUSON & CANDY, 2014). In traditional participatory design, a designer will team up with users from the beginning and do the co-creation. Ferguson & Candy (2014). mentioned that this model is implemented when there is an equal and effective educational system, participants have a common language and cultural understanding of respecting each other and there should be relatively equal power between professional and non-professional (FERGUSON & CANDY, 2014).

And the next method of participatory design is modified participatory design. When the language, class, education level, and cultural norms of the users vary then the users may not be able to express ideas creatively. So, in modified participatory design, in the beginning, the designer leads the co-design process with the aim that the users will lead in a later stage (Ferguson & Candy, 2014).

As shown in Figure 31 we have used the concept of Modified participatory design process where the facilitator will lead in the beginning to make participants comfortable to express their view with other participant who is from different culture, educational background and different region of resident and aim that participants will lead in the next stage.

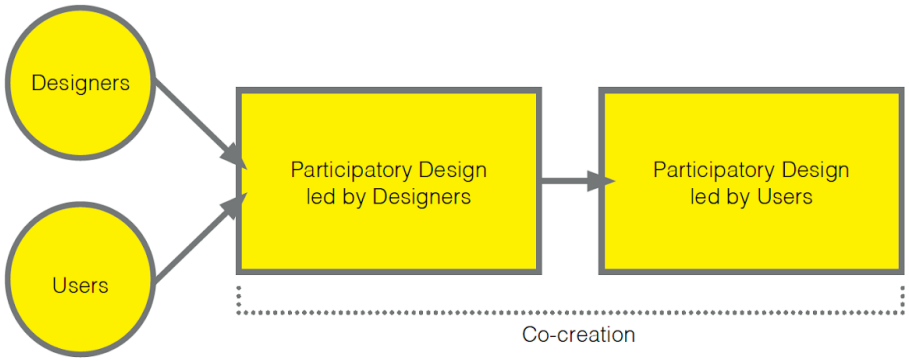


Figure 31 modified participatory design Source: Ferguson & Candy (2014)

However, this makes typical critical thought for researchers to early user participation, *"We need clear direction about our product design before involving users, so we know in which direction we want them to be innovative"* (Kanstrup & Bertelsen, 2011). Kastrup mentioned that when the facilitator points out a direction for the user then it is a critical problem in the user innovation process. User innovation is about participants pointing out the direction for the facilitator, not facilitator pointing out the direction for participants (Kanstrup & Bertelsen, 2011). So, while conducting this workshop, the Facilitator has not acted like a person who shows the direction to the user what they should think of and what they should not. Instead, participants were given an open space in the discussion and innovation phase.

6.3 Setting and Tool

Due to the pandemic situation during our research period, there was difficulty in organizing the workshop. The restrictions against group-gatherings posed a challenge to conducting the workshop in a desired location. Hence, it had to be conducted in a virtual environment through Zoom meetings. All the participants were informed to use a zoom app for the entire workshop. Some of the participants were from an Information Technology background and it was easy for them to adapt to the virtual workshop. However, the other participants, who were not familiar with video conferencing and online collaboration tools, needed to be trained by the facilitator. Different artifacts like mind mapping, card sorting was utilized with the help of an online board called *"miroapp"* and "*Google docs*" for documentation.

While conducting the FW, we followed the four-phase structure mentioned by Jungk & Mullert (1987) which are explained below:

6.4 FW Phase

6.4.1 Preparatory phase

This is the first phase of FW which is about planning, organizing, and managing the workshop. In this phase, all the participants are selected, and the facilitator will explain to them the rules, timetable, the event and purpose of FW. Vidal (2006) has mentioned that it is a crucial phase because all the problems that may arise are usually due to bad planning, poor organization and/or unsuitable physical environment (Vidal , 2006). In this phase, all the participants and facilitators meet in a selected date and place. Vidal (2006) has recommended a cozy and informal room that should have an inspiring atmosphere and there should be materials like paper, pinboards, pencils, tape, 3M Post-It blocks, copy machine, transparencies, lab taps, projectors, toys, etc. Fruits, cakes, soft drinks, tea, and coffee (Vidal , 2006).

6.4.2 Critique phase

This is the second phase of FW. In this stage, the problem is critically discussed in detail. At first, the participants will brainstorm and frame a general and critical question regarding the issue. Thereafter, all the critical views are listed on a paper or on small cards. The main idea behind this stage is to discuss the problem, complain about the negative experiences and cluster them together.

6.4.3 Fantasy phase

In this third phase of FW, participants try to generate creative ideas without any restrictions and boundaries to create a utopian future. Vidal (2006) has mentioned that participants can use brainstorming and “out of the box” thinking technique to generate a creative idea. All the utopian ideas will be written down on a paper and clustered into a group. Different creative games can be played to choose and discuss the most important cluster. The facilitator, in this phase, has an important role in promoting and supporting a fresh approach by allowing all

participants to express their creative thoughts and should be able prevent reactions such as “it is ridiculous” or “it will never work”.

6.4.4 Implementation phase

This is the last stage of FW. In this stage, the participants will choose the most promising and creative cluster from the previous phase and try to adapt the chosen ideas to the real-world issue. The participant will make an action plan and try to implement the selected creative idea. If participants select multiple real-world creative ideas, then the point scoring method can be used.

6.5 Participant

Jungk and Mullert (1987) have mentioned that there should be less than 15 participants in an FW (Jungk & Mullert, 1987). Accordingly, for this research, a total of 8 participants were chosen, out of which 5 participants were based in Nepal and 3 participants, who hail from Nepal, resided in Denmark. One of the participants could only attend the preparatory phase and hence, there were 7 participants during the entire workshop. The researcher reached out to different groups of potential participants and after receiving responses from the interested ones, the sample group of participants were created. All the participants are university students aged between 19 to 30. The purpose of choosing Nepali participants living in Denmark is that Denmark has proper waste management practices, and this allowed for a comparative discussion as the participants from Nepal and Denmark shared their experiences with e-waste recycling. In the initial plan, Researcher wants to enroll 50 % of male participant and 50 % of female participant. So that both gender group can equally contribute to the workshop and present their problem and vision. But while sending the invitation to the sample group, not all the female participant

showed active response on our workshop invitation. So, it was decided to continue with the limit number of participants who were actively interested and response back us to contribute on our project. Among 7 active participant 6 were male and 1 were female. The researcher asked all the participants to choose between Nepali and English language for the workshop and all the participants preferred the Nepali language for communication. So, the FW was conducted in Nepali language and transcribed in English.

Participant Code	*Age*	*Gender*	*Educational Background*	*Location*
P1	*32*	*Male*	*Master's in environmental science*	*Nepal*
P2	*21*	*Male*	*Bachelor's in computer science*	*Nepal*
P3	*24*	*Male*	*Bachelor's in computer science*	*Nepal*
P4	*24*	*Male*	*Bachelor's in computer science*	*Nepal*
P5	*26*	*Male*	*Master's in business administration*	*Denmark*
P6	*25*	*Female*	*Master's in business & Economics*	*Denmark*

P7	*27*	*Male*	*Bachelor's in information Tech*	*Denmark*

Table 4 Participant demographic of Future workshop source: own

6.6 Future Workshop Conducted phase and Analysis

The different phases of FW used in this research, have been explained below:

6.6.1 Preparatory phase

In this stage, all the participants from Nepal and Denmark joined together for the workshop via Zoom. To begin the workshop, the researcher who acted as facilitator for the FW, introduced himself and explained to them about the project and its main purpose of study and the four different phases of the FW. After that, the facilitator asked the participants to introduce themselves and the reason they chose to be part of the FW.

To avoid double talk, the facilitator gave a number to each participant and asked the participant with number 1 to start first, followed by participant number 2,3, and so on. So, each of the participants are hereafter referred to as P1, P2 and so on up to P7. After the introduction, the facilitator explained about the project in detail, highlighting about e-waste and its impact on the environment as well as the tools to be used during the FW. In the future workshop, the participants usually present their viewpoints with the help of sticky notes, which can help them organize the different viewpoints in a systematic way. To tackle this issue in the virtual workshop, the facilitator used an online tool called “Miroapp” for listing the participant viewpoints and also used “Google doc” for documenting the notes from the workshop. Once the facilitator explained

about the tool, the participants were given a set of topics and questions for another session of workshop.

To prepare for the critique phase, the facilitator posed a question, based on the problem discussion in Phase 1, to the participants on which they had to give a critical view in the next meeting on a suitable date and time.

6.6.2 Critique phase

This session focused on discussion of the problem and exploring the main cause for it. The facilitator informed that if the participants had any questions or comments, they should raise their hand. Once everyone is clear about the process, the facilitator posted the question for every participant to answer it.

"*What is the main problem faced by the people regarding electronics waste and its recycling in Kathmandu valley?"*

The facilitator explained that the participants would have to discuss the problem without any limitation on thought and gave them 15 minutes to think about the criticism. Furthermore, facilitator explained to present the reason behind the resident of Kathmandu valley not recycling their e-waste. As recommended by Jungk & Mullert (1987), the facilitator asked the participants to keep the answers short and not to explain for more than 30 seconds. The facilitator tried to make sure that all the participants got an equal opportunity to present their points clearly. After which, the participants were given a 45-minutes time slot to present their viewpoint and discuss on the problem.

Participants	**Problem mentioned by participants**

P1	*"Improper management for waste recycling"*
P1	"*People are not well educated about waste recycling*"
P1	*"There is not a good facility for the people"*
P1	*"People are now sure how secure it is to give their e-waste. They feel insecure about data manipulation or misuse from their device"*
P2	*"lack of general awareness"*
P2	*"people don't think e-waste as a problem"*
P2	*"There is no proper recycling policy by the government"*
P2	*"Lack of data in the recycling sector. We could not find enough information about it. So It's really hard for the people to start an initiative to solve these issue"*
P3	*"people are not aware about the e-waste recycling"*
P3	*"people don't know how to recycle their e-waste properly"*
P3	*"There are no practices of waste reparation"*
P3	*"Lack of ecommerce platform for trading. People might be interested to sell it if some one offer them a reasonable price."*
P3	*"lack of skilled manpower to recycle e-waste"*
P4	*"Improper management system"*
P4	*"People don't know much about recycling and they think recycling takes extra time."*
P4	*"People need some motivation to practice recycling, there is nothing facility or services that encourages people to practice recycling properly."*
P4	*"Government is also not taking any good responsibility for its management & policy."*
P5	*"Lack of action by people. People don't act on this problem"*
P5	*"No one is giving pressure on government about it."*

P5	*"People do not know how big an e-waste issue is and its effect on environment."*
P5	*"There is not a proper service from municipality"*
P5	*"People are not sure what can be done with their e waste"*
P6	*"Illiteracy"*
P6	*"people don't want to recycle or sell emotionally attached electronics. For example, a phone from a birthday or 1st computer and eventually a time will come they will throw that away for eg: if they are shifting to a new house"*
P6	*"it is difficult to contact a recycling company. there is not effective and easy platform to contact the recycling company"*
P6	*"Lack of awareness on people"*
P6	*"Weak government policy"*
P6	*"companies are not getting fund for the startup"*
P6	*"Lack of trust and safety about their data."*
P6	*"recycling company are small that they cannot reach throughout the valley"*
P6	*"it is difficult to contact a recycling company. there is not effective and easy platform to contact the recycling company"*

Table 5 List of problem identified in critique phase source: own

During the break, Two Facilitator discussed together on all the viewpoints of participant and sort the similar data under same theme. Both Facilitator merge the viewpoints of participant which looks similar. For e.g., P3 and P5 have mentioned "*lack of awareness*" and P1 mentioned "*people are not aware of e-waste recycling"*. Facilitator had merged it together under one theme as a "*lack of awareness*".

A break after the critique discussion, the facilitator clustered the list of ideas together under the 9 themes and briefly explained to the participants how the list was merged. The

facilitator could have asked participants to categorize and sort the list if the participants were physically together in the workshop. However, in the virtual workshop, two facilitators collaborated in this process to categorize the data. The categorization works of all the data collected in this phase can be seen in Appendix 25.

Lastly, each theme and the list underneath each theme, were briefly recapitulated to ensure that everyone understood what it meant. The full list of recapitulated items is shown following figure:

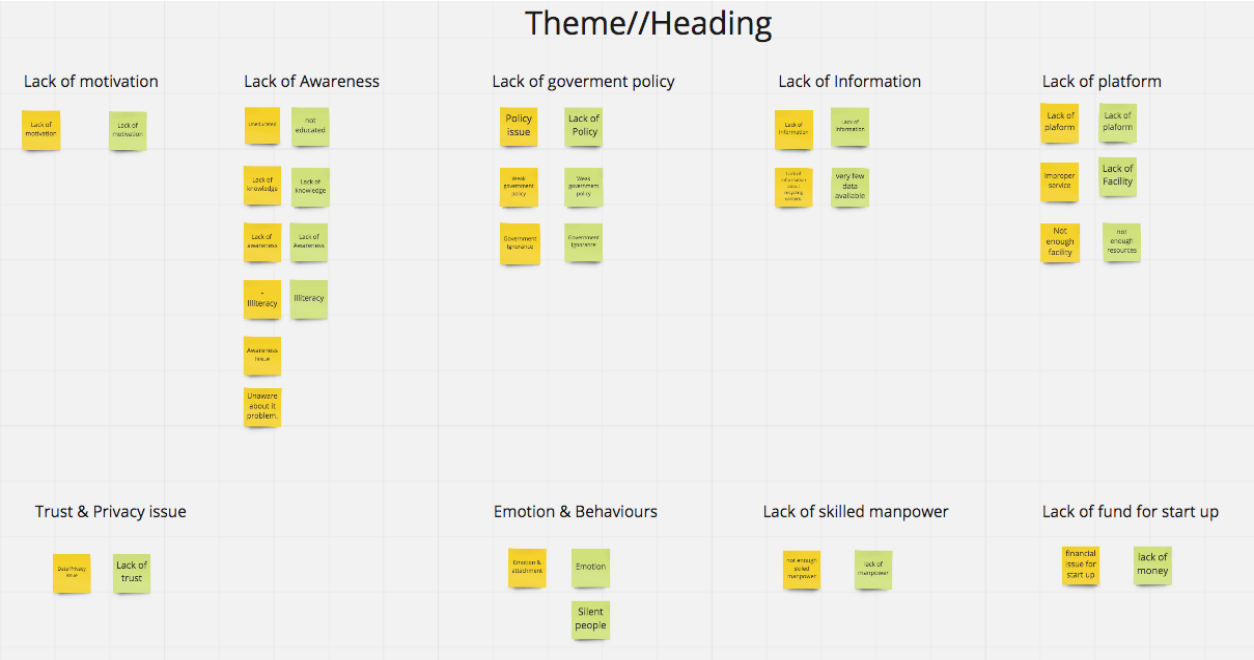


Figure 32 Categorization of all identified problem in miro app source : own link to miro app https://miro.com/app/board/o9J_ktki84c=/

To make the workshop interesting and to figure out the most important problems for further consideration judged by the majority of people, the facilitator arranged a game where each participant gets 5 points which should be allocated for the single theme or multiple theme (Jungk & Mullert, 1987). The highest points went to five headings, which are *lack of awareness,*

lack of government policy, lack of platform, lack of information, lack of motivation, and *trust & privacy issue*.

After that, the facilitator posted the top-scored themes and informed the participants that further discussion on the solution of these problems will focus on the top 5 selected themes. This session lasted for almost 3 hours and therefore, another session was scheduled for the next two phases. The facilitator decided to conduct the fantasy and implementation phases together.

6.6.3 Fantasy phase

The facilitator started the fantasy phase by giving a short overview of the previous phase to move as smoothly as possible into this phase. In this phase, the facilitator tried to disregard all the rules and regulations and encourage the participants to rethink the problems and seek a creative solution. As mentioned by Jungk & Mullert (1987), while conducting this phase, participants should keep in mind the following principles:

- For now, reality does not matter
- Everyone is free to think whatever they like
- There are no limits to the wish, desire and fantasy

As it was a virtual workshop, it was not possible to develop a fantasizing mood with physical warm-up exercises such as playing games or doing yoga. So, the facilitator decides that the interested participants can tell a joke, sing a song or entertain in a light-hearted manner to help each participant relax and come up with possible ideas for the solution. The session was paused

for a 15 minutes break where each participant could give themselves some time to think of a new solution. After the break, the facilitator gradually led the group to the fantasy phase.

First, the facilitator divided the participants into 2 different groups. In group A, there were 2 participants from Nepal and 1 participant from Denmark. In group B, there were 3 participants from Nepal and 1 participant from Denmark. The facilitator asked both the groups to write the negative issues that emerged from the critique phase in a positive form. Group A had to change the following issues into a positive form: lack of awareness, lack of government policy, lack of platform and group B had to change following issues into a positive form: lack of information, lack of motivation, and the trust issue.

For the brainstorming session, the facilitator asked the participants what the solution to the problem could be. The interested participants could raise their hands for the solution, or they could even post in the Facebook group. Everyone had to follow a rule that no one can criticize others' opinions (Jungk & Mullert, 1987). Everyone was free to come out with their inspirations and ideas. Once the participant presented their possible solution, the facilitator noted all statements made by participants and clustered them on miroapp which was shared on the screen with the participants.

Figure 33 Brainstorm solution in miro board Source: own link https://miro.com/app/board/o9J_kthCa7A=/

- **Awareness**:

Awareness is one of the major issues in Nepal in the practice of recycling. People in Nepal do not have proper knowledge about e-waste and its impact on the environment. The education system in Nepal lacks proper practical knowledge on e-waste recycling practices. Every participant accepted this awareness issue. P3 suggested that the practices of waste recycling should start from school-level education. More awareness programmes should be conducted in the practices of e-waste recycling and people should be made aware about the hazardous components in electronics products and how improper disposal of e-waste will have an adverse effect on the environment.

P6 said that there is a lack of skilled manpower in the field of electronics waste recycling. There is no educational platform that generates enough skilled manpower who can work in the

field of e-waste recycling There are not any specific certified education programmes that generate skilled manpower who can repair and refurbish the defective EEE. So, generating more skilled manpower with the educational awareness of e-waste repairing would also create better job opportunities.

- **Information:**

Due to the lack of information, people are not sure where and how they can recycle their e-waste. P1 said that most people in Nepal do not know about the e-waste recycling practices. He suggested that there should be some platform that provides information for the people about what they can do with their unused or defective electronics product. P1 shared his experiences on repairing his defective laptop by watching YouTube tutorials and suggested that providing a repairing guide and recycling tips for people would encourage people to reuse their e-waste. P2 also supported this solution and added that unused electronics products can also be resold to other people.

P5 suggested that It would be better if the electronic manufacturer companies used labelling in their products that indicated whether the particular product can be repaired or not. P5 said *"I really like the concept of bottle recycling in Denmark with the pant system and I think it would be more informative if an electronics product also has this kind of labelling which shows if the product is repairable or not"*. Supporting the idea of p5, P2 also added about the idea of having a label that also indicates what kind of material is used by the manufacturer. For e.g., *"I would be more interested to see if the material used in the product is sustainable friendly or not and this can be implemented with labelling in the product"*.

- **Platform:**

Most of the participants have mentioned that having a proper recycling platform can help solve the recycling problems of Kathmandu valley. One of the major recycling problems in Kathmandu is the lack of enough and separate bins to sort different kinds of waste. P1 has said that *"residents of Kathmandu do not recycle their e-waste because there are no proper and separate waste containers. If there will be separate waste bins in the local community, then people will start segregating their waste which will eventually help in tackling the recycling problem"*. P2 agreed on P1's statement and mentioned *"Having separate bins is a good solution, but it will be more effective if there is a digital bin with an IOT concept which can sort the different types of waste automatically"*.

Similarly, P6 suggested that having a website or a digital solution can also improve the recycling practice. P6 said that *"people are not recycling their e-waste because they don't know where to take and when to take their e-waste. I think recycling practices can be improved if there is a website which suggests the nearest recycling center and is able to schedule a time to recycle"*. P3 agreed with P6 and noted that a proper communication platform between e-waste recyclers can also positively impact the recycling practice. P3 also mentioned that *"if there is a place where all the recyclers exchange their recycling experience or even share the total amount of recycled e-waste, this can motivate other people to recycle"*. Other participants P4 and P5 also agreed with P3.

- **Motivation:**

While analyzing the data, it was found that motivation is also one of the factors that can affect the recycling practice. The effective reward and penalty system can motivate people to improve their recycling practices. P7 mentioned that *"awarding a reward can motivate people to improve their recycling practices"*. If the award is given to an e-waste recycler, it can encourage other

people too to recycle the e-waste and at the same time, people will be motivated to recycle for the next time too. P7 mentioned that the reward can be anything from money to a gift card or their names appearing in a local newspaper from which others can also be motivated. P7 also discussed the penalty system which will probably stop people from carelessly mixing the wastes. Rewards and penalties are important factors which can encourage the whole society and can make a positive impact on people's recycling practices.

Similarly, people will be motivated to recycle their e-waste if they know what has been done with their recycled e-waste or the impact, they made by recycling the e-waste. P5 mentioned that *"People will be motivated and develop better recycling practices if they get feedback regarding their recycled e-waste from recycling companies"*. Rest of the participants also agreed with P5. Getting feedback from a recycle company regarding, say, the number of trees they saved or the amount of water they saved or what has been done with their e-waste will motivate them to develop recycling habits.

- **Government policy and Facility:**

The government has the main role for implementing the solution of recycling practices from root level. Without government involvement, this problem cannot be addressed at a higher level. People in Kathmandu valley lack proper recycling facilities. P7 mentioned that the municipality lacks management for e-waste recycling practices. In the current recycling practices, a municipality truck comes every three days and picks up the waste. People collect their wastage in plastic bags and dispose of their waste in the truck. P7 added that *"Municipality should place a bin in local areas"*. This would encourage people to dispose of their waste on a regular basis and improve their recycling habits. P5 believes that, *"Neither the government nor the municipality is taking this issue as a serious matter"* and suggested

that *"This could be resolved if they upgrade the current practices with better facilities like in Denmark"*.

P1 believes that the problem of e-waste can only be resolved at some level if the government, electronics manufactures, and recycling companies come together for a solution to this problem. As mentioned by P1, *"Government should cooperate with electronics stores and companies to deal with its problem from root level"*. There should be certain rules and regulations for the manufactures while designing the product and the usage of materials in production. P1 also suggested that the government should make policy for companies to produce quality products with reusable and long-lasting materials.

P3 presents an idea that supports the recycling companies. He thinks that if the government supports start-ups or existing recycling companies with funds, extra facilities or reducing the tax on refurbished electronics products, then it could encourage them to run their business and contribute to the society. For e.g., if the tax charge on refurbished products is reduced by the government policy, then the price of refurbished products would be lower and hence, more affordable. E-waste problem is a major problem and the government cannot solve this problem alone. So, the Government should work together with other stakeholders and make an action plan for a circular economy with the concept of electronics waste.

- **Trust & Privacy issue:**

One of the reasons people do not want to recycle their e-waste is because it may contain their personal and social data. Giving such electronics with personal data to a recycling company may be a matter of risk. So, if there is a trustworthy e-waste recycling company, then people could recycle their e-waste even with personal information. P1 has said that *"recycling a broken electronic device full of personal information to an unknown company is risky for me."* P1 hinted

that people don't want their personal data to end up in the wrong hands. Furthermore, P1 said *"I will only recycle my e-waste containing personal information if the recycling company is a government-certified organisation"*. So, the recycling company should also be trust-worthy and authorized. P3 supported P1 and mentioned *"the government should publish the name of a certified e-waste recycling company"*. So, there should be a strong regulation regarding the handling of e-waste data. P7 strongly agreed on the P1 statement and said, *"recycling practices can be positively influenced if the government should guarantee the safety of recycled data".* The trust and privacy issue can be solved if the government will make a regulation regarding the handling and usage of the personal data.

While analyzing all the creative ideas from participants, we have categorized the solution on different topics based on stakeholder roles and responsibility for e-waste solutions.

Electronic Product Manufacturer Company:

- Long-lasting product with zero-waste material.
- The product should be repairable by the consumer.
- They should label the product with the tag indicating which is repairable and which is not.

Policymakers, regulatory bodies and the government of Nepal

- Circular Economy action plan for Nepal
- Policies to regulate qualitative long-lasting electronic products
- Support funds and resources for a recycling organization
- Support the right-to-repair movement.
- Facilitate the local areas with enough resources for waste management

NGO

- Organize e-waste recycling awareness programmes.

- Organize workshops for e-waste recycling practices.
- Collaborate with schools and colleges to educate children and youngsters about recycling practices.

Recycling Company:

- Recycling companies should be trustworthy toward the customer while handling their defective product which might have their confidential data. In the case of customer concern for their data, they should use some tool to generate a report that shows the deletion of data from defective products.
- Customers could be motivated if the company sent an email or notification of the status of the defect e-waste that is being recycled.
- They should have easily accessible customer services so that customers can get as much information whenever they want.

6.6.4 **Implementation**

We began this phase by presenting the result from the fantasy phase. In this phase, all the participants and the facilitators review the solutions in detail and pick the ones most suited to be implemented practically. While reviewing the solution all the participants agreed that the only thing that can be done with government policy issues is to suggest or recommend ideas to an authorized government body. P1 mentioned that "*to make or change government policy is not in our hand, so the only thing we can do is recommend our idea to the government*". P3 expressed a different perspective and said, "i*t is true that we can't change the policy, but we can put pressure on the government to make an effective rule regarding e-waste recycling through public campaigns*". However, it was agreed that taking a government-level action is out of the scope of this research, and we moved on to search for a more suitable solution.

During the discussion, most of the participants argued that a private company can only solve the trust and privacy issue to some extent unless the government is involved in making a strong policy. Here, P7 mentioned that "*people will not trust the private company even if it transparently explains how the e-waste having personal data is handled unless the government certifies it as a trusted company". The* participants also agreed that people will start to trust a recycling company with their e-waste once they see the result of it working with them. To sum up, the participants believed that the trust issue is something related to government policies and transparency of the recycling companies and hence, this solution was dropped out as well.

- **The most promising solution**

It was observed through the FW that the most promising solution would be the one that would tackle the four different issues - awareness, information, platform, and motivation. P1 suggested that a **reward-penalty system** can be very motivational which can be adopted as a solution. The other participants agreed that this can be a promising solution that can be implemented in the real world and it can motivate people to recycle e-waste.

Similarly, getting feedback from a recycling company regarding the recycled e-waste can also be one of the ways to encourage people in recycling e-waste. Supporting this idea, P5 said, "*people will be encouraged to recycle e-waste if they get feedback from a recycling company about the status of their recycled e-waste*". All the participants agreed that getting feedback from the recycling company is very inspirational which will positively impact the recycling behavior of people. So, **feedback about recycled e-waste** is picked as one of the promising solutions.

Likewise, all participants agreed that having recycling and repairing guides through video tutorials can be helpful in reusing old electronics. It can also be easily implemented in real life and can be effective too. P1 mentioned that he has fixed his broken computer by watching YouTube tutorials. Other participants also believe that video tutorials can be an effective method to reduce e-waste. So, **a repair and recycle guide through a video tutorial** can be a promising solution that can help to reuse and reduce people's e-waste.

All the participants believed that having a website and providing information about a recycling company and the recycling process can change the recycling behavior of people. With an up-to-date website containing information of recycling companies, people can connect with such a company and get information about the recycling procedures. P4 mentioned that having a website or an online platform can reach many people, and this can influence the recycling habit of a large group. P5 agreed with P4 and explained that a virtual platform for a recycling company will attract a large number of people in a way similar to how e-commerce websites have attracted customers. P5 mentioned, "*I believe an online recycling website can increase a large number of customers in the same way as an online shopping website has increased its customer*". All the participants agreed that with the use of the recycling website, it will be easy for people to schedule a recycling time or get information related to recycling. P1 said that *"with the use of online websites people can get information to recycle their e-waste and can easily contact recycling companies*". All the participants agreed that **recycling websites** will make it easy for people to recycle their e-waste and decided to choose this as a solution that can be adopted easily in the real world. It was observed that such a digital can also be used to provide **information** to the users about the impact of e-waste on the environment. P1 mentioned that most of the people of Nepal do not recycle their e-waste because they don't know the consequences of e-waste when it contaminates the water and other surroundings.

Now, all the above solutions which were picked as a result of the FW, can be integrated into a unified digital platform that can be implemented to support the Kathmandu valley community to solve the e-waste recycling problem. Through the digital platform, which will be a mobile application, each of the following issues can be address:

- Recycling companies can use this platform to provide feedback to the public about where the recycled materials end up or how such materials would be used further to build new products.
- This platform will include information about the various recycling companies and the users can connect with these companies in order to know more about recycling practices. Transparent and trustworthy information on a unified platform about such companies, their data handling policy, and the working procedure can help address trust issues. The app, in an advanced stage, should be able to verify the recycling companies' data protection policies and ensure the users of a safe method of protecting their data.
- A point-based reward system can be implemented in this platform - which can keep track of a user's recycling habits, rewarding them with points for every e-waste recycled or for every purchase they make from a recycling-refurbishing store. These points can be then used for, say, obtaining discounts or offers from the stores that sell or produce materials using recycled materials.
- This platform can also be used as a medium where expert videos with tutorials can be viewed by the users to learn how to recycle a specific electronics item. A general repair or recycle guide can allow users to know which things can be repaired easily at home and which things need to go into recycling.
- Knowledge about the harmful effects of careless disposal of e-waste can be highlighted through this platform to provide awareness to the public.

To highlight the necessity of the digital platform as a new mobile application specifically meant for e-waste recycling, it is interesting to note the following observations from the study and the FW:

- Most of the participants of the study indicated that a smartphone is the most used digital communication device in the Kathmandu valley. Laptops and computers are used only by a handful of the population. This makes having a recycling app on the phone the most likely solution (as opposed to having a website) that can reach the maximum number of people across the valley.
- While one of the participants in the FW pointed out that a social media platform like Facebook can be a good digital platform for raising awareness or selling used products through marketplace, the other participants argued that a social media platform, with its multiple features and newsfeed, can often be distracting and diverts one's attention from the actual task. This ensured that having a dedicated recycling app would be the most feasible solution.
- Such an app can be used to inform users about the procedures of recycling, include motivational videos and tips to recycle, and can be an easy way to contact recycling companies - all in one - with further possibilities of adding more required features in the future.

From the FW, the possible features that can be implemented through the digital app, were also noted, as follows:

- **Login info and user account** - for individuals and for recycling companies. For individuals, they can view their points, recycling activities - how much e-waste they have recycled and how they have contributed to the environment with this habit. For companies, they can

have their contact details and further information on how they recycle the goods and what comes out of it and this can be viewed by all users of the app.

- **Awareness and motivation section** - to help users be aware of the impacts of recycling and the adversities related to waste disposal, a section dedicated to educating them with interesting facts and general knowledge would be very helpful.
- **Tutorials section** - where they can watch videos or gain step-by-step guidance on how to recycle, what to recycle or how to repair something simple.
- **Reward section** - where users can see the points they have earned for recycling or for shopping a refurbished electronics product from a verified recycling center. This can also include a scoreboard that can inspire people with a sense of encouragement. This scoreboard, say, can list the top three "e-waste recyclers" of the month and how they have impacted the environment.
- **Marketplace** - just for the users, who would like to sell or swap their used electronic goods with other users.
- **Pick-up feature** - a possible feature that can be included in the app is an option for users to have their disposed e-products picked up from their doorstep by the recycling companies.
- **FAQs** - for recycling related questions

Chapter 6 Summary

This chapter had explained how researchers had used future workshops as one of the data collection methods in this research. The discussion during the future workshop had identified the several problems in the current recycling practices of electronic waste where participants had

mentioned the following theme as the main problem: Lack of awareness, Lack of Information, Lack of Government policy, lack of facility, Lack of motivation, Trust & Privacy.

In order to solve the above-mentioned problem, participants proposed a solution of mobile application where users can get the service of repairing defect electronics product, repair and reuse guide through a blog or video tutorial, resell their unused product and contact the recycling companies for pick up or drop up to collection point. During the workshop, participants came up with the concept of gamification inside mobile applications where users can get rewards and also see their recycling activity and check how much impact they have made by their recycling behaviors. These creative ideas will be considered while designing the prototype of the proposed solution.

The following Chapter will present all the requirements collected through several data collection methods and sort them as features and design elements to implement in the actual prototype design.

7 Chapter 7 User Interface Design

In this Chapter, the researcher will present the design of the application.

7.1 Requirement

The term ‘requirements’ refer to all the attributes that any product should have or perform in a way from users’ perspective. User requirement is the main artefact in the initial phase of any product design that should be collected and analyzed before designing the prototype. After collecting all requirements that emerged from the several data collection methods, the researcher sorts them all under the main 5 requirements as shown in figure in 34: Recycle, Repair, See Impact, Ideas, Buy & Sell.

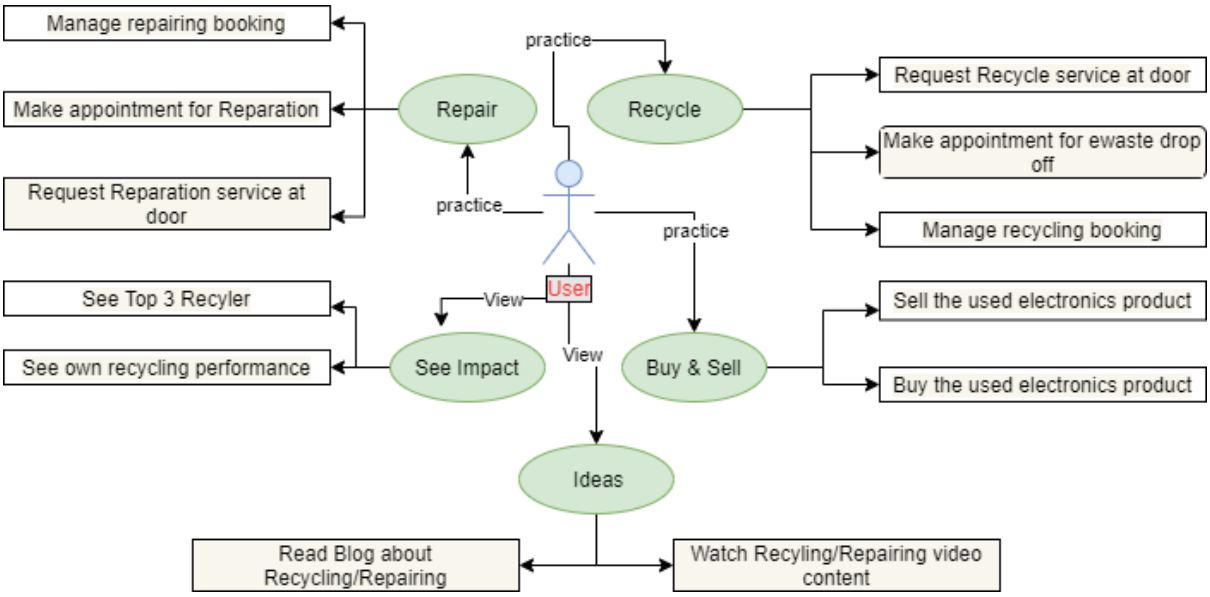


Figure 34 main 5 requirement of the application including sub functional requirement source: own

i. Recycle

With the help of this App, users will be able to recycle their e-waste through three simple steps. They can either drop their e-waste by themselves or can request a nearby recycling company to pick for them. The system will automatically estimate the reward points and money that they will earn from recycling which will give them an idea of the reward they are receiving. Users will also be able to manage their appointment time. For example: if the users wish to change the pick date of their e-waste then they will be able to change the date through the Manage Booking tab.

ii. Repair

A similar concept as above has been applied to this functionality too. Users will be able to repair their electronics in 3 simple steps:

1. Users can request an electronic repairing company to pick their items
2. Or they can simply drop their old electronics in the nearest repair shop.
3. They can also manage the booking time in this case.

iii. Ideas

Another important functionality of the App is to provide video and blog content that provide ideas for repairing and recycling electronics waste. The app users will be able to view as well as create their own video content and blogs with ideas for recycling or repairing the old or broken electronics. The App will suggest a creative idea to turn their e-waste into decorative items.

iv. Buy and Sell

This App will not be just a simple recycling App. With the use of this App, users will be able to buy and sell their old electronics with other users. The users will be able to send messages, bid on the electronics and update the status of their items.

v. Impact

By recycling the e-waste, users will be able to see the impact they made; for example, the amount of water they save by recycling a specific product. While this calculation has to be further researched and would be an estimated general answer for different types of products, the aim of this is to encourage users by showing them their direct environmental or economic impact as an outcome of their recycling. Users will also be able to see the top 3 e-waste recyclers in their area and their recycling impact, which will motivate other users to recycle their e-waste.

When all the requirements were identified, the researcher followed some principle to design the interface of the application. The following section presents the design principle applied in the interface design of application.

7.2 Design Theory (Design Principle):

The Design Principle is a component of a data explication family which includes guidelines, heuristics, rules of thumb and strategic construct to create any product (Fu, Yang, & Wood, 2015). All the products, services, systems or architecture depend on the design principle, both in terms of its foundation or inspiration. Design principle represents the core component of any product, service or system character and associated design process (Fu, Yang, & Wood, 2015). These principles are considered as a fundamental solution that is applicable to almost any HCI design. Kim has briefly mentioned these main HCI principles as listed below.

I. "Know the User": When we are designing the product for the users, we should always understand the perception of the user in the beginning. Kim has used this concept of "know the user" originally from Hansen in 1971 and states that interaction and interface should fulfil the needs of the targeted group of users (Kim, 2015). While determining the target group of users, it is important to collect comprehensive information like age, gender, education level, social status, computing experiences, cultural background. All this information will help us to understand the user preferences, tendencies and different skills and capabilities in both physical and mental level.

II. Understand the task

In HCI design, understanding the user group is not just enough to start the product design. It is relatively important to understand that task as well. In general, the term 'task' refers to the work

that needs to be completed by the user through the use of the interactive system (Kim, 2015) . Kim also mentioned that understanding the task is related to the interaction feature of the product. Interaction model of any system consists of several sequences of subtasks that are required to accomplish the whole task. This sequence of sub-tasks can be different for different types of user although the result is the same. For example, when a user wants to print the paper from a printer, an expert user is provided with the feature of advanced option which is modelled with detailed steps and extra attributes, whereas, for the normal user, the sub-task is modelled with default options that will allow them to complete the task with basic steps. Not all users will have the same level of understanding of the task. Related to this, Kim said that different users' mental models must be reflected in the structure of the interface to simplify implementation for all users (Kim, 2015).

III. Reduce Memory Load

Whenever we open any website or download any application on a mobile phone, a process of learning begins in the brain. Whether we have to search for any specific content or slide the image to view the album, our brain must perform a cognition. When the brain gets loaded with unnecessary content and mental effort is applied then that's called a cognitive load. Designing the interface which requires less memory load as possible is a principle that applies on a theoretical basis. Short-term memory (STM) capacity of humans is about 5-9 chunks of information (Kim, 2015). So, it's necessary to reduce the cognitive load in our design. There are different factors that affect the cognitive load. Jon had mentioned that when there are too many choices with less clarity in the design and require too much thought while interacting with design, the user will have cognitive load (Yablonski, 2016). He also suggested following some principles that help to reduce the cognitive load for the user:

- Avoiding unnecessary elements will help users complete their task without any distraction.

- Leverage common design patterns that will make users familiar with the design and reduce the time of learning.
- Eliminating unnecessary tasks for the user either by offloading a useless task or by setting a default value for an unnecessary field will helps the user to focus on their goal.
- Minimize Choices: When the user has a lot of choices in the design, the mental effort increases. Therefore, we should minimize the choices for the user, through the design of navigation, form and drop-downs.
- Use Iconography with caution: When an icon is used with the wrong meaning or without any value to the design, it creates noises in the design and requires mental processing to infer meaning. Iconography should be combined with text labels to communicate meaning and reduce ambiguity.

V. Strive for consistency

A consistent look of the interface within an application will lessen the burden of the cognitive load. Kim mentioned that consistency should be reflected within the application in both interaction model and interface implementation (Kim, 2015). Tognazzini, Usability Guru at Nielsen Norman Group, states that general looks and feels across the product or design should be maintained in the same pattern that user behaviors can be fully transferable throughout the product (Tognazzini, 2014). Consistency in the interface helps the user develop the usage pattern said Jessie Chen, designer at Zaplabs (Chen, 2016). She suggested that using the same term and established pattern in the design will avoid confusion to the user and shorten their learning curve (Chen, 2016). Consistency in design is an essential principle that we should apply throughout our application content and interaction. It will help our design to improve the user experiences by eliminating unnecessary elements and make sure necessary elements are uniform in a way where all looks and behave in a similar way creating a sense of reliability and familiarity.

VI. Remind users and refresh their memory

Whenever a task involves use of the brain, Cognitive load arises. Continuous load on the brain leads to mental tiredness. Therefore, the design should also have a strategy that gives continuous reminder of valuable information. Kim said that the memory in the human brain dissolves information as soon as the brain starts multitasking (Kim, 2015). He clarifies his point with the example of an online shopping application where the user had to go through the entry of different types of information like buying items, inserting delivery address, bank detail etc. The only ways to maintain the user awareness in this situation is by providing the correct responses, information and continuous feedback. This will not only refresh the user memory but also helps the user to complete the task with better user experience. In our design we should probably consider the strategy of reaffirmation of user action in the app where users should get confirmation or signal after completion of the task. Getting a closure notification of action completion will bring satisfaction to the user's mental picture (Kim, 2015).

VII. Prevent Errors/Reversal of Action

It is common that users make mistakes while interacting with the application. But there should always be a solution where the designer should consider some solution that helps users to commit less error. The interaction and interface of the design should focus on the error free operation (Kim, 2015).. Kim said that all other principles of HCI apply under this principle (Kim, 2015). When we apply the concept of all other HCI principles, it will make our design more interactive with less error occurrence. One of the useful techniques to prevent from error occurrence is by presenting only relevant information or action as required at a given time. For example, when we are using copy-paste action in Microsoft Word, some of the elements get inactive to prevent the user from selecting those elements that might cause problems in user data. But there is always a chance that some user commits the error regardless of better design consideration. So, there should be a feature that allows user to undo the action. This will bring a

user into a comfortable state while interacting with design and increase user satisfaction (Kim, 2015).

VII. Naturalness

The last major HCI Principle in the design of interaction is “Naturalness”. Kim refers to Naturalness as a quality that is reflected in our daily life in various operations (Kim, 2015).. In HCI, “Naturalness facilitates both user motivation and creativity when interacting with software” (Williams, Noyes, & Groen, 2008). Uses of standard pattern and common element that match with the real-world activity won’t require the user to learn or remember new concepts. Instead, users can easily get familiar with the concept based on their real-world experiences. According Norman mentioned that Affordance is a relationship between characteristics of user interface object and interaction design feature (Norman, 2013). For example, the design of the chair affords that it meant to be sat on, the design of the scissors afford how the fingers should be inserted to holes to cut things. Affordances helps users to map the possibilities of what the object does within the application, based on its conceptual model and supports naturalness in the design by enabling users to adopt their natural behaviors while using the application.

○

HCI for our solution

In our design process, we have followed the HCI design principle mentioned by Kim (2015). In order to understand the user, their problems and behavior we have conducted interviews, a future workshop (FW) and a questionnaire. By doing a detailed research of users, we have generated the requirement on which our design will be focused on. Kim (2015) has mentioned the consistency of the interface, which we have followed. Our App will have the same design

pattern on all the pages. In our design, we made sure that all the pages of the app will have the same color, design and layout which will make it easier to use the app.

Kim (2015) mentioned that users can make mistakes while interacting with the app but it's the designer's duty to design the app in such a way that the error should not affect the users experience. While designing the app, it was made sure to minimize all possible errors. For example, when users are inside Recycle page and start to enter the details about recycling, then all the other buttons should be inactive (unclickable), so that they do not have to repeat the whole process of entering their recycling details all over again, in case they accidently clicked on another button. It is important to take care of this little detail, as there can be a chance of data loss, Similarly, to make sure that the user doesn't have to remember different steps in different pages of the app, we made the design consistent throughout all pages. For example, the repair page and the recycle page have the same three steps, which can be seen in Appendix. The functionality of the page and the design is further explained in detail in mockup section.

The upcoming chapter will present the process of interface design. At first the design starts with prototyping, its testing, redesigning and a mockup design.

7.3 Prototyping

Design prototyping is the first stage of application development. Prototyping is a working model that is built to design, develop, built, and test the designed idea (Walker, Takayama, & Landay, 2002). Buchenau & Suri (2000) have mentioned that prototyping is a representation of the final design that is created to inform the design process and design decision (Buchenau & Suri, 2000). Prototyping is a draft version of a final product which allows one to investigate and refine the designed idea at the early stage of product development. Walker, Takayama, & Landay

(2002) have argued that prototyping can be of two types i.e. high-fidelity prototypes and low fidelity prototypes (Walker, Takayama, & Landay, 2002). The prototypes which look more similar to the final product are high fidelity prototypes and the prototypes that look less similar are low fidelity prototypes. High fidelity prototypes are usually made similar to the final design with the same interaction technique and appearance which can be more expensive and time-consuming (Walker, Takayama, & Landay, 2002). These kinds of prototypes are computer-based and usually allow the user to interact with the interface. Whereas, low fidelity prototypes are usually a first draft of the final product which are mostly designed on paper and are less expensive and easy to make (Walker, Takayama, & Landay, 2002) . These kinds of prototypes are quick to design and fast to change as per users' feedback. According to Newman & Landay as mentioned by Walker, Takayama, & Landay (2002) clients may judge low fidelity prototypes as be unprofessional design (Walker, Takayama, & Landay, 2002) so it is important to explain to the client about the nature of the kinds of prototypes. In the first draft of the design, the researcher decided to use a paper prototype or a low fidelity prototype.

7.3.1 Paper prototyping

Paper prototyping is a method of designing a user interface on a paper with the purpose of testing and refining the interface. Miao, Köhlmann, Schiewe, & Weber (2009) have mentioned that paper prototyping is an early stage of product development which not only helps to understand the concept and identify the weakness of the product but also provide an opportunity to suggest an improvement (Miao, Köhlmann, Schiewe, & Weber, 2009).A paper prototype is one of the usability testing methods which helps identify the issue of an application and discover the missing functionality (Snyder, 2003). Snyder (2003) has defined paper prototyping as:

"Paper prototyping is a variation of usability testing where representative users perform realistic tasks by interacting with a paper version of the interface that is manipulated by a person "playing computer", who does not explain how the interface is intended to work" (Snyder, 2003, p. 4).

Synder (2003) has mentioned several benefits of using a paper prototype. Paper prototyping is cheap to conduct, in terms of time and resources. Conducting a paper prototype does not require any programming or technical expertise. Another advantage of a paper prototype is it provides users feedback early in the development process. So, the content and functionality can be changed according to the user's feedback. A paper prototype promotes rapid iterative development in which developers can experiment with many ideas. According to Synder's (2003) recommendation and guidance to test our design with the user before coding, we decided to conduct paper prototyping (Snyder, 2003). Conducting paper prototyping can be an extra step for an application design or can take an extra time but it will impact the quality of the design. While making the paper prototype we have followed Synder's (2003) guidance where we did not put image or icon, color and the typed text (Snyder, 2003) . In this app, there are types of users i.e. e-waste producers or the normal users, the e-waste recycling companies, and the administrator of the application whose task is to ensure that the app is running smoothly and fix the technical problems when they arise. In this project, we have focused on designing the users' or e-waste producers' interfaces. So, during the prototyping and usability testing, the researcher will be focusing only on normal users or e-waste producers' interface.

Sorting Requirements

Before designing a paper prototype, we first gathered all the functionalities and content that users wish to have on the app through the Future Workshop (FW), interviews and tool study as shown in table 6.

The list of all the features collected from Interview, FW and related tool study is shown below:

Requirement of Application	**Idea collected from:**
Buy & Sell (Marketplace)	FW
Repair Service	FW
DIY Ideas	FW
See you recycling activity	FW, Interview
Top Contributor	Tool study, FW
My booking	FW, Tool study
Contact Us	FW, Tool study, Interview
Login	FW, Tool study, Interview
Log out	FW, Tool study, Interview
Sign up with email	FW, Tool study

Sign up with Social media	FW, Tool study
My Profile	FW, Tool study
About Us	Tool study
Terms & Condition	FW, Tool study, Interview
FAQ	FW, Tool study
Notification button	FW, Tool study
Video about app	FW
Step by Step guideline	FW,
Challenges your friend	Tool study
News feed	Tool study
Show nearby recycling center	FW
Show nearby reparation center	FW
Information about SDG	Tool study

Table 6 List of all the requirements collected from several data collection method source: own

Based on all the ideas generated from several data collection methods, the researcher has created a list of cards as a feature that needs to be implemented in the application. All of those cards need to be sorted and should be placed on a different page. To sort the card and place the content on a different page, the researcher had decided to involve users.

In our application, the researcher decided to make two kinds of Menu Bar - primary menu and secondary menu. In the primary menu, all the important and primary functions of the application were included. In the secondary menu, all the secondary functionalities or least used functions of the app were added. Users were allowed to choose what they wanted on the primary menu and on the secondary menu. A list of content was also created from which the users can choose which item should go into which page. For this purpose, it was decided to use a card sorting method. This method will help us uncover how user knowledge is structured and create an information architecture that matches users' expectations.

Nielsen groups explained the variation in card sorting method in two types, open and closed card sorting. In open card sorting, each participant is given a stack of cards either in a paper card or in a digital platform and then asked to group those cards however they want. Then they have to make labels for the groups they have sorted. But in closed card sorting, the researchers create the labels for the group, and participants are asked to put each card into a group in a way that makes sense from their perspective.

Card sorting Methodology

For the Card Sorting process, the researcher conducted a test on a digital platform called usabilitest.com. There we included the description of the test and sorting process that users must follow to sort the card under the different category which can be seen as below:

Figure 35 Screenshot of card sorting platform source: own

There are seven categories in which users have to sort the card which can be seen on the following figure:

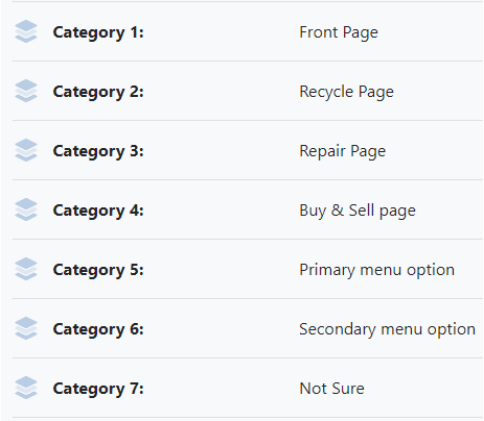


Figure 36 Seven cateogory of heading under which all requirement need to be sorted source: own

The list of cards that need to be sorted are as below:

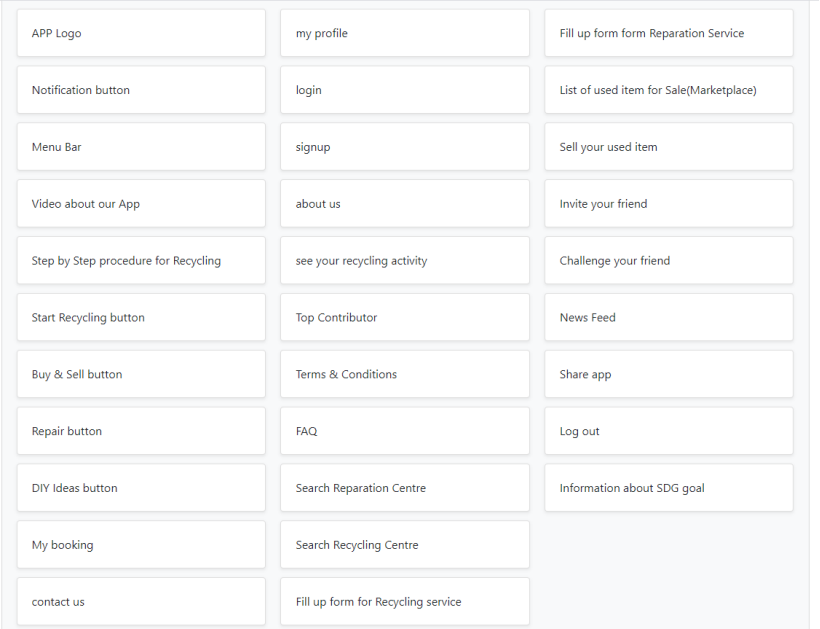


Figure 37 List of all requirement that need to be placed under seven heading source: own

After we had created the card and category, we sent the link of the application to our sample group of participants. We selected the same sample group of users from our future workshop. Figure 38 shows the card sorting application interface and how the card should be dragged into different categories.

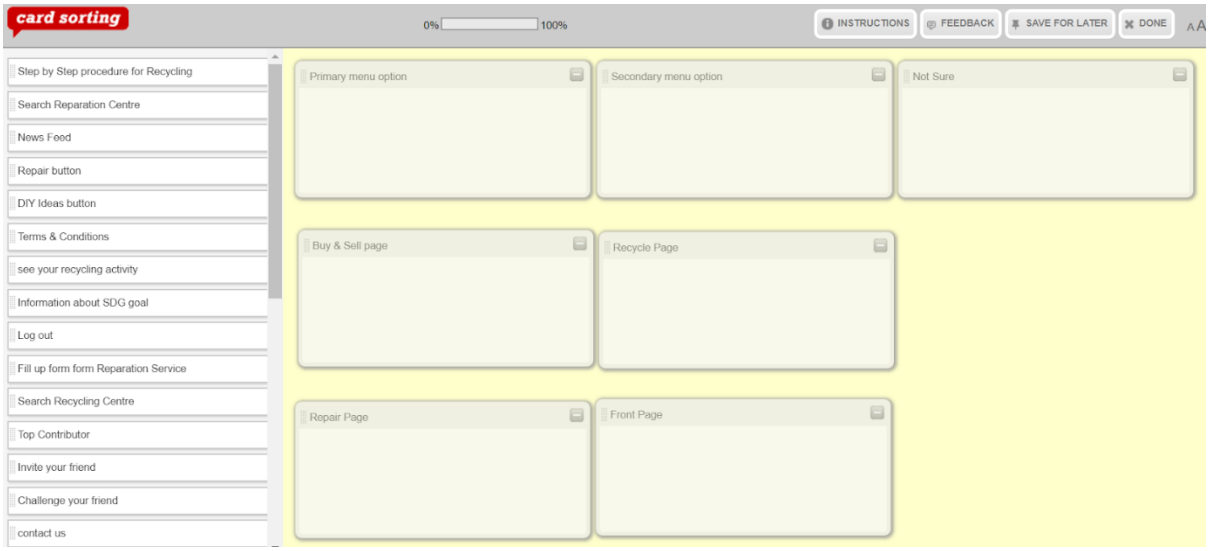


Figure 38 Main Interface of Card sorting platform source: own

When all the participants completed the test, the application itself generated the result in different data formats. We have exported the final data in the form of a percentage. Results from the application can be seen figure 39.

	Front Page	Recycle Page	Repair Page	Buy & Sell page	Primary menu	Secondary menu o	Not Sure
APP Logo	100%						
Notification button	100%						
Menu Bar	86%		14%				
Video about our App	100%						
Step by Step procedure for Recycling	86%	14%					
Start Recycling button	14%				86%		
Buy & Sell button				14%	86%		
Repair button			14%		86%		
DIY Ideas button					100%		
My booking	14%				86%		
contact us						100%	
my profile						100%	
login	14%					86%	
signup						100%	
about us						100%	
see your recycling activity		14%				86%	
Top Contributor						100%	
Terms & Conditions						29%	71%
FAQ						43%	57%
Search Reparation Centre			100%				
Search Recycling Centre		100%					
Fill up form for Recycling service		100%					
Fill up form form Reparation Service			100%				
List of used item for Sale(Marketplace)				100%			
Sell your used item				100%			
Invite your friend						86%	14%
Challenge your friend						100%	
News Feed	43%					43%	14%
Share app						43%	57%
Log out						100%	
Information about SDG goal						43%	57%

Figure 39 Result extracted from the card sorting method source: own

Result of card sorting:

The results from the card sorting test show that all of the users had a common perspective regarding the content for the Recycle page, repair page, and Buy & Sell page. So, we will use the same content on those pages. However, some of the users placed 6 features under the category “Not sure” which seems they were confused with it. But the rest of the participants placed it under the category “secondary menu”. So, we decided to place these inside our secondary menu. More than 85% of the user has placed the same content under the Primary menu bar. There was a contradiction regarding the Newsfeed feature where 43% wished to have it on the front page while another 43% wanted it in the secondary menu and the rest 14% were not sure where to put it. While analyzing the overall content for the front page more than 85% of users had already

selected a 5 list of content which looked more relevant to the front page. Our goal was to provide all the relevant and most used features on the primary menu and less relevant features or less used features under the secondary menu. So, we decided to use the News feature inside the secondary menu. All the sorted cards based on their category are shown in figure XX

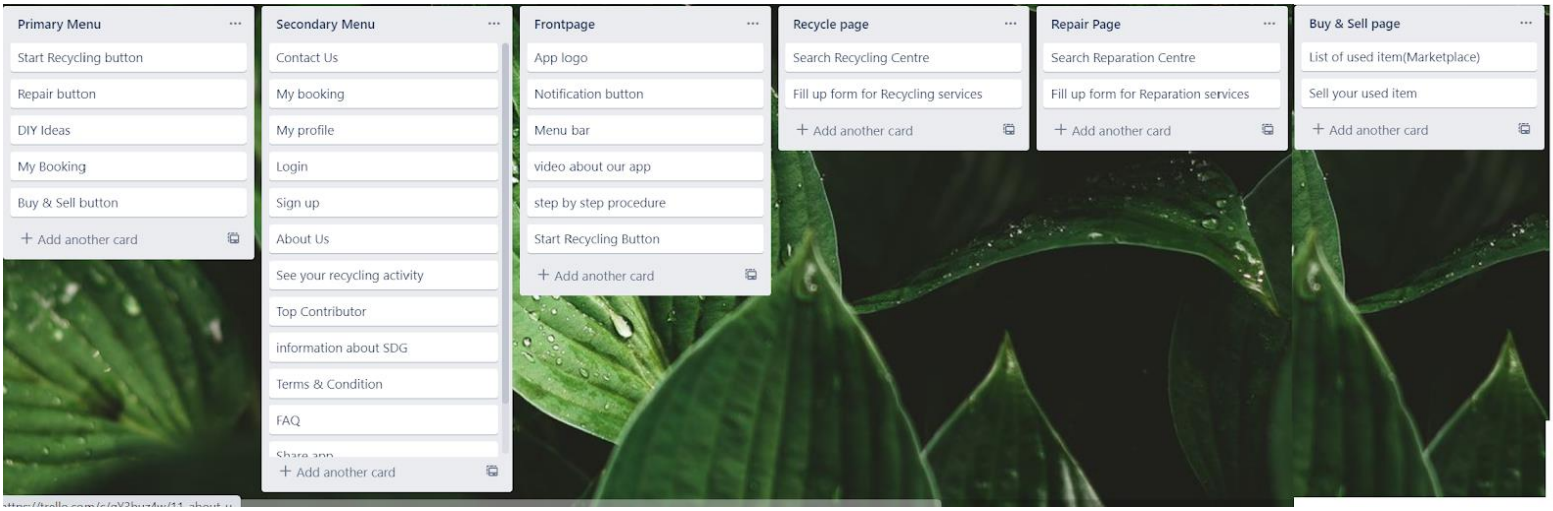


Figure 40 Sorting all the requirement under seven heading based on user preference source: own

7.3.2 Starting Paper Prototyping:

After the researcher selected the content through the card sorting method, the design of the application was sketched on paper. While sketching the paper prototype, the content of the application was arranged by taking the participants' responses into consideration. The first version home page of the application is shown as below:

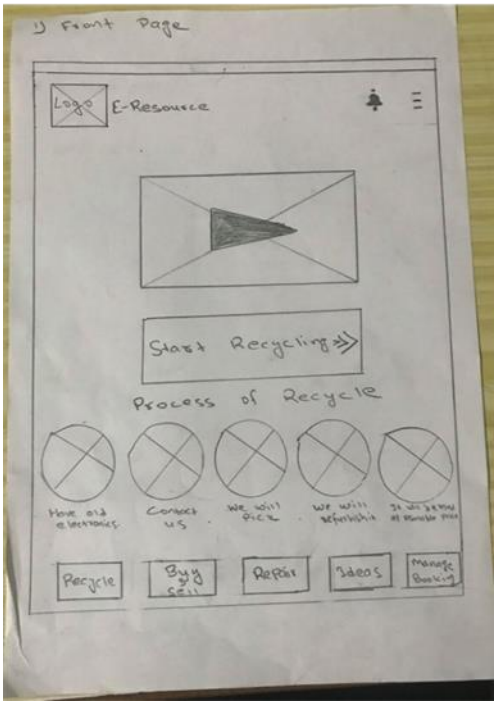


Figure 41 paper sketching of front page of application source: own

On the primary menu, Researchers include all the important and primary functionality of the application. On the secondary menu, Researchers include all the secondary functionality or least used functionality of the app. All the requirements as primary and secondary were categorized by user during card sorting method. Besides including all the main requirement in the Prototype, the design of the application also reflect on the concept of 3R which were discussed in the literature study. The first version of the paper prototype can be seen in Appendix 32

7.3.3 Testing the Paper Prototyping

Before we begin the next step or design the mockup of the app, we decide to conduct a usability test of our paper prototyping. Usability test allows researchers to understand whether their

audience can use their design or not and can give immediate feedback. According to Rubin, as mentioned by Lewis (2006), “The overall goal of usability testing is to identify and rectify usability deficiencies existing in computer-based and electronic equipment and their accompanying support materials before release” (Lewis, 2006, p. 1271).There are several benefits of conducting usability test at the early stage of prototyping. Synder (2003) has mentioned that conducting usability test helps to identify the issue of the application (Snyder, 2003) which is easy and fast to change on paper design. So, we decided to conduct a quick and dirty usability test on paper prototype.

Development

While developing the test we decided to structure it into five parts. We begin the test with a short introduction and conduct a quick preliminary interview in which we try to obtain information about the participant’s backgrounds. The participants are then given 6 tasks and in the next step they are asked to fill in a post-test questionnaire. We conduct a short post-test interview session, in which representative participants perform the given representative task. (Lazar, Feng, & Hochheiser, 2017) . The structure and timeline of the process can be seen as below:

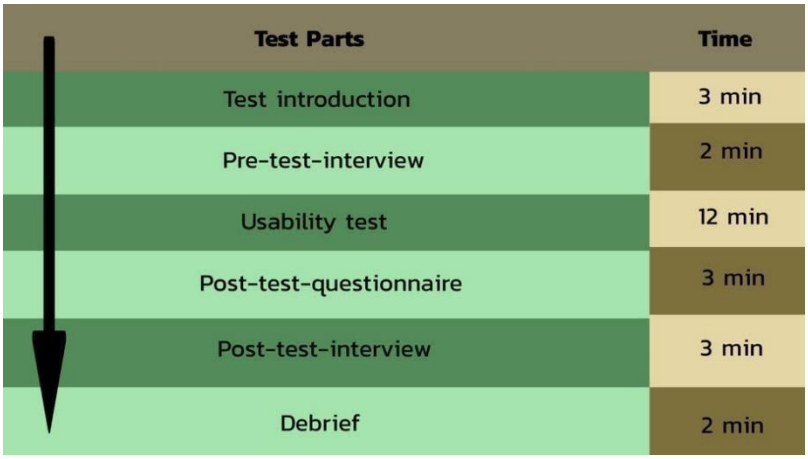


Figure 42 Methodology of sketch testing process source: own

Procedure

We start the test by giving a short introduction about the test procedure and about our research. As Goodman et al. (2012) recommends maintaining consistency, we made a script with the set of instructions for the interviewer. Goodman et al. (2012) have mentioned that researchers can increase consistency by asking the same identical question in a fixed order and by giving the same task to everyone (Goodman, Kuniavsky, & Moed, 2012). Moreover, we made a checklist to ensure every step is followed in the same order to everyone. The researcher played the role of both facilitator and observer during the test. As a facilitator, the researcher helped participants by explaining the task and as an observer, the facilitator noted the interesting information of the participants' responses and recorded whether participants successfully completed the task or not.

Task

To make the tasks as natural as possible and to reduce further clarification, we designed tasks as life-like scenarios. While designing the take we made sure that the difficulty level increased when the test proceeded, such that task 1 was designed to be completed easily as compared to the last task which is task 6.

Tasks:

1. You have 3 old broken phones which do not work properly. You want to get rid of this old phone. So, one of your friends suggests giving it to the recycling company through this app. Can you request a recycling company to pick your phone through this app?
2. The recycling company did not approve your request for pickup. Can you please change the next date for pickup?
3. You have an iPhone X which you are using but, on a lottery, you got iPhone 11 plus. You don't want to keep both the phones so one of your friends suggests selling your iPhone X through this app. Can you please put up your iPhone X for sale through this app?
4. You have dropped your phone while playing a game. Your screen is completely broken. You don't have time to go to the store to fix it. Can you request the repair company to pick your phone and fix the problem through this app?
5. You have recycled the electronics with the help of this app several times. Can you find the total reward point you got while recycling the e-waste?
6. Can you find the top e-waste recycler of this app?

7.3.4 Test result and analysis

In this section, we present the test result and the analysis including the task completion outcomes and the analysis of the post-test questionnaire. To start, we present the details of our participants for the test. Then we present the test result and the analysis of the post-test questionnaire.

Participants

As Nielsen, Lewis, & Turner (2006) have mentioned that 80 % of the usability problem is discovered after testing 5 participants. (Nielsen, Lewis, & Turner, 2006) . Hence, the researcher decided to recruit five participants from Kathmandu city. Among these five participants, three of whom are male and two are female. All of the participants were aged between 25 to 30. Out of the five participants three of them currently reside in Nepal and two of them reside in Denmark. For the better flow of communication, we have used the Nepali language as a means of communication.

Result & Analysis

Task completion

When analyzing the data at first, we have a close overview of all the noted data from the test. Among 5 participants, 4 participants completed all the given 6 tasks. Participant 2 completed all the tasks except for task 5 and task 6 which can be seen on the following table:

Task completion codes:

0: success

1: no success

participant	task1	task2	task3	task4	task5	task6
1	0	0	0	0	0	0

2	0	0	0	0	1	1
3	0	0	0	0	0	0
4	0	0	0	0	0	0
5	0	0	0	0	0	0

Table 7 Analysis of task completion source: own

Reward points were placed on the secondary menu inside the impact page. Participant 2 went through the primary menu and could not figure out where the rewards points could be. Participant 2 also mentioned rewards point on the post-test questionnaire *"…rewards point is a matter of interest for me. I am very much interested to know how much reward point I get while recycling the e-waste and what is the difference between the top recycler and me. It is a matter of pride for me if I became the top e-waste recycler. So, I want it somewhere where I don't have to struggle to find it. It could be on one of the front buttons…."*.

Participant 2 seems to be satisfied with the gamification feature but had difficulty in finding where we placed it. So, he recommends placing it in the primary menu.

Comparing good and bad descriptions

In our post-test questionnaire, we have asked participants to answer whether they liked our app or not. If they liked the app, which features did they like and if they did not like something, which feature did they not like.

All 6 participants said that they liked the app which can be seen in the following table:

Liked the app?

Yes:0

No:1

Participant	Response
1	0
2	0
3	0
4	0
5	0

Table 8 List of liked and unliked where yes= 0 and No= 1 source : own

While analyzing the reason that the participants liked the app at first, we highlighted the keywords that each participant has mentioned in there. And then we extracted the keyword that can be categorized under the topic 'good descriptions'. The list can be seen below:

Good description:

- Useful features in one single app
- Combination of all the features
- Opportunity to get rid of old electronics and earn for this
- E-waste problem will be solved
- Pick-up functionality

Participants think that this app is more than an ordinary recycling app. Buy and sell, repair, and ideas are functionalities that differentiate this app from another recycling app.

In our post-test interview, we have asked participants what features they would like to be added or changed in the app. The transcript of the post-test interview .While analyzing the data we have highlighted and extracted the keywords that can be categorized under the topic 'bad descriptions'. The list can be seen below:

Bad description:

- Confused about going back to the front page
- Struggle to find reward
- Could not see earned amount
- An online chat feature is missing

Participant 4 think all the features of the app are perfect and want to keep as it is however participant 1 could not find a way to navigate back to the home page from another subpage. This is one of the issues which we found while analyzing the data. In our prototype, there was no way to go back to the homepage which we think is one of the serious issues we have to change on the next sketch. Participant 2 argued that top e-waste recyclers can be motivational to others so this feature should be on the primary menu. Similarly, participant 3 also found one issue with the app that there was no section where users can view how much money or reward points they will get by recycling their product. Likewise, participant 5 mentioned the need for an online chat system with a recycling company for immediate support in answering queries related to e-waste recycling.

7.3.5 Second Version of Sketching after test

While analyzing the data of our usability test, we found some of the serious issues through the participants' feedback for the design and hence, we decided to improve and produce a second version of paper prototyping. In our second paper prototyping, we decided to add a way to go back to the homepage from each subpage. Similarly, we added a section where people can see the estimated money and reward points they can earn. We also added an impact page on the primary menu as earned reward points can be a matter of interest and top recyclers could be motivation for people to recycle the e-waste. The second version of the home page can be seen below:

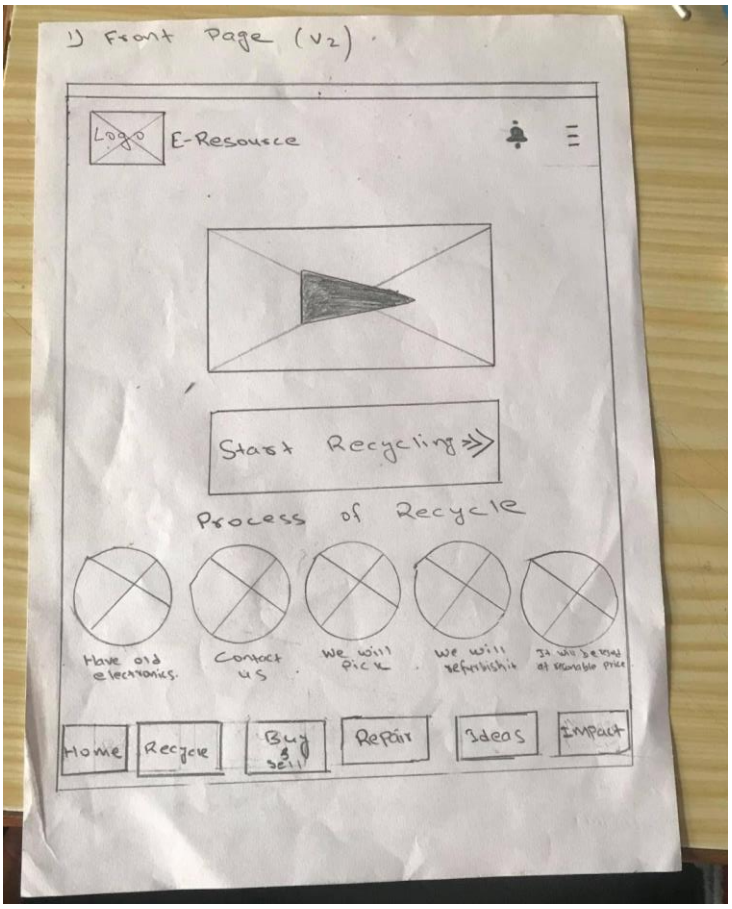


Figure 43 Redesing sketch of front page after testing source: own

In the above prototype, we have added the home button on the primary menu. In the previous prototype version 1, there was not a way to come back to the homepage from the subpage. Adding a home button on the primary menu lets users come back to the home page. Similarly, we decided to add an impact page on a primary menu and placed a booking page on the secondary menu because people will only use the booking page when they get notification about the booking. Because the booking page is not used often, we decided to place it on the secondary menu. Similarly, we have added a place on a recycle page where users can see the estimated reward point and estimated money they can get by recycling their e-waste. It can be seen as below:

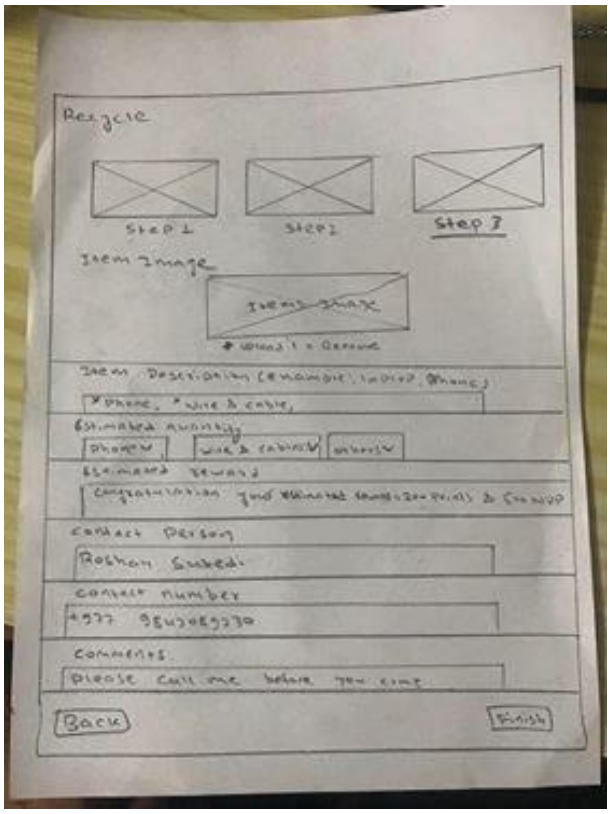


Figure 44 Redesigning element of Recycle page after testing source: own

The rest of the version 2 prototype, updated according to the user's feedback, is presented in Appendix 22.

7.4 Mock-up

After finalizing the prototype, the next step is to give a visual design to an application for which we will design a mockup. A mockup is a visual representation of a final product which includes color schemes, visual style and typography. Mockup can be defined as "*a sketch of a possible user interface(UI) of the application that helps to agree on broad aspects of the UI and can be easily created by any stakeholder*" (Rivero, et al., 2010). Mockup is also known as the final draft of a final product. Mockup can be of two types, which are high-fidelity mockup and low-fidelity mockup. High-fidelity mockup is interactive, clickable and acts like a product. These kinds of mockups have reactive interfaces. Users can use it like a final product. Whereas low fidelity mockup looks like a real product, but the interface is not interactive. Users will not have clickable buttons or a reactive page. We decided to design a high-fidelity interactive mockup.

While designing a mockup we have followed the Gestalt principle of design. Wong (2010) has mentioned that the Gestalt principle is a proposed theory which explains how people organize visual information (Wang , 2010). Graham (2008) has mentioned that designers use the Gestalt principle to improve the visual communication, composition and to organize the information (Graham, 2008). To organize the content of the App and the interface, the researcher has used different Gestalt principles of design such as principle of continuity, principle of proximity, principle of closure and principle of similarity.

Principle of continuity

Principle of continuity states that the elements that are lined or arranged on the same line are considered to be related. In the App, the researcher has used the Principle of continuity to design the steps of recycling and repair. To repair or recycle any product, the app requires 3 steps which and the researcher has aligned these 3 steps on a line to inform users that only 3 steps are required, as shown in the following figure 45

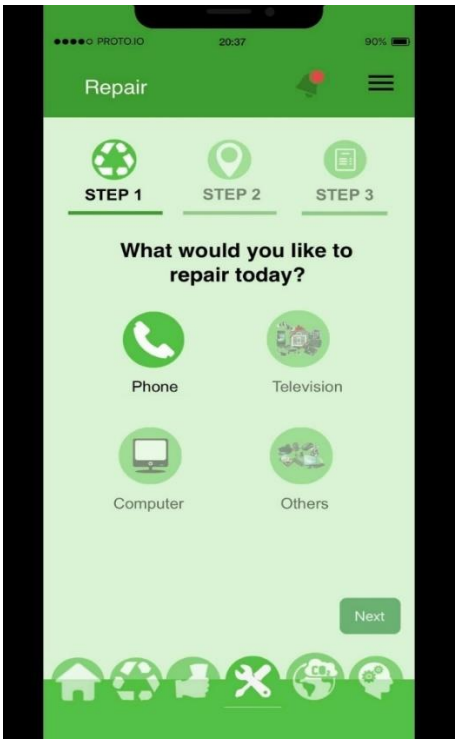


Figure 45 High fidelity mock-up of repair page showing the principle of continuity source: own

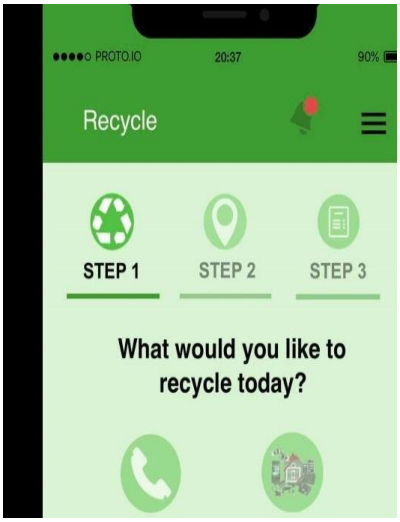
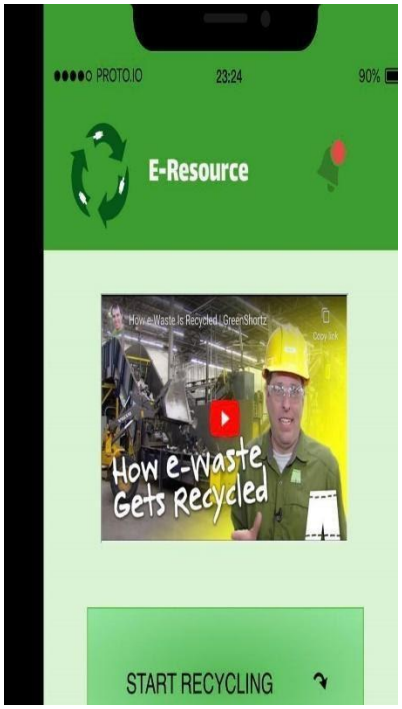


Figure 46 High fidelity of Recycle page showing the principle of continuity

Principle of similarity

Principle of similarity states that elements sharing similar characteristics should be grouped together because the human eye tends to think they are related or have similar functionalities. In the App, the researcher has used this principle, by which the App is divided into 3 major sections i.e. the header, main content and navigation menu. The navigation of the App is leveled down. Similarly, the header is leveled on the top of the page and the main content in the middle which can be seen in following Homepage image.



Principle of closure

The researcher has used the principle of closure while designing the logo and the icon of the App. This principle states that if any visual element misses its part the human eye will fill in the missing information and complete the shape.

Principle of proximity

Principle of proximity states that elements that are close to each other are assumed to be related than the elements which are apart. This principle is used while designing different pages of the App. In the following image, the closeness of each icon and corresponding text suggest that they are related to one another.

7.5 Reflection on main Feature of the application based on Information system roles

The designed application is based on (i)Information element; (ii)Gamification element; (iii) Education Element; (iv) Education Tool; (v) Communication service and (vi) Trading platform.

i. Information:

The application has been designed as an informative platform providing the information about recycling and repairing service. As our result shows that perceived control can sometimes be a useful factor to change the behaviours of users and for that it is necessary to facilitate people with more information about recycling waste practices. As shown **in fig 47**

Figure 47 front page of high fidelity mockup which shows the video introduction about recycling practices source: own

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Figure 48 front page of high fidelity mockup which shows the video introduction about recycling process source: own

Application has a step by step guide video on the Home page which will guide them on the recycling process through the application.

Moreover, Application is based on data driven design which collects the data of user activity whenever they recycle or repair their electronic waste. The stored activity of user recycling behaviours can be seen in the impact feature which informs the user how much impact they have made through their recycling activity through the app (Requirement 1, 2 & 3).

ii. Gamification:

The application has a design element of gamification which encourages users to recycle more through the app. Application itself does not perform as a full-fledged game, but consists of a game element like reward system, tracking of user recycling behaviours, motivating users to act more by displaying top 3 recyclers. The concept of reward systems is not fully studied in this research. So, In the current design, users can only see their points and impact they made by sustainable recycling practices. in the future study on research , it is necessary to build a solution on top of this system which should evaluate the performance of individual users and reward them

with some sort of badge or discount coupon once they have earned a certain number of points with their sustainable performance (Requirement 3).

iii. Education:

People mentioned that there are many online platforms which provide video tutorials and information on various topics. Similarly, it was an interesting idea to provide a video tutorial or step by step guide through a blog about recycling practices which would also help in the coming future to reduce e-waste. This is one of the main attractions of our solution which we have considered to implement as a "Ideas" in our primary menu. This could also help to raise the awareness about the recycling practices.

The result from our questionnaire and the suggestion of people from FW already suggested that Raising awareness can be helpful to influence recycling behavior of people (Requirement 4).

iv. Communication:

The application also acts as a communicating platform which connects user to user and user to recycling companies. This was also a major issue discussed during the workshop where participants mentioned that they are not sure how to contact the recycling companies or where to find them. It is clear that, People lack information on how to approach recycling companies or concerned people from the government. So, to solve this problem, the application acts as a mediator who connects the user with the recycling companies through the app and gives them full access to communicate with them either by requesting for recycling service or asking for any general queries regarding recycling issues.

Recycling company from Denmark also mentioned in his interview that networking between the company through the sustainable business hub platform “Go green Danmark” helps them to connect and communicate with other businesses who work with similar goals to contribute toward the SDGs. Networking with like minded sustainable business model companies will probably help every company to gain people's attention who have a sustainable lifestyle or have a preference to adopt sustainable living practices. So, In the future study of this research, it is necessary to implement a system where all the companies can also use this platform as a networking hub in the field of sustainable recycling of e waste.

Moreover, the Communication element in the app is not only limited for recycling or repairing services but also provides a full accessibility to the user to text with any other user while buying or selling the product. Communication plays a vital role in the field of trading and with help of texting elements in the design of application, it helps users actively engage with the platform and gets connected with other users to text with each other.

There were few more elements of communication that emerged during the FW. Participants were interested to share their performance earned in the app with others through several social media platforms. The act of social pressure in recycling practices makes a positive impact on other recycling behaviours. So, the element like social exposure should be definitely considered as a future implementation where users can share their recycling points and tell others how they are making a positive impact on society with their recycling behaviours. If an application can encourage people to publicise their earned point and their recycling activity (e.g., the frequency they recycle), then others will be motivated by seeing their closed one practicing recycling behaviours (Requirement 1 & 2).

v. Trading:

The concept of buying and selling used or defective electronics waste is the inspiration from a recycling company in Denmark. The company buys the e waste from individuals or companies then refurbishes the defect product and again makes the product reusable before selling to the people. This concept had already worked well in Denmark and the company already made a huge turnover in their revenue in the last 3 year. Similar, Concept was identified in the related tool study app where the app called *reGain* helps people to donate or sell their used item through the mobile app. This kind of application will encourage people to take sustainable action with their unused product and control them before throwing it hazard or mixing e waste with other solid waste. This was also a solution emerged during our FW where many participants agreed people in Kathmandu valley will be more interested to sell their unused or defective e waste and the needy one will definitely buy it if the price is cheap and affordable compared to new one.

This has encouraged us to design the concept of trading platform as a main requirement. But this concept is not new in Kathmandu valley and has already been practiced through platforms like Facebook marketplace and local website hamrobazar. The main drawback in the existing platform is that Facebook marketplace is not fully supported in the region of Kathmandu valley and hamrobazar is just a web platform where sellers post their selling item as an advertisement and buyers contact them and offer a price. Beside the complaint of interactive design of application by FW participant, they also claim the privacy issue with the site like hamrobazar is not trustable and there is a high chance of misusing the person information since the only way to contact on that platform is by publishing seller contact information as a public post. This issue has helped to bring the solution in our application where sellers can post the selling item and buyers can offer a price within the application without knowing seller email and phone number. Moreover, participants also suggest an idea of a bidding system when the seller is not sure for what price the item should be sold for. Giving more possibilities on trading

platforms will make it more user friendly and interactive, filling the needs of larger user groups (Requirement 5).

Chapter Summary

This chapter explains the actual design of application and presents the proposed designed product. Researcher have used the concept of recycle, repair and reuse in the design of the application. Researcher have gone through several iteration phase where in the first phase, he sketches the first draft of prototype then conduct a usability test. Then in the second phase, another updated prototype version was sketched while was turn into the high-fidelity mock-up in the third phase. The overall design of application can be summarized based on following five main element of information system roles (i)Information element; (ii)Gamification element; (iii) Education Element; (iv) Education Tool; (v) Communication service and (vi) Trading platform.

8 Chapter 8: Discussion and Reflection

In this chapter, Researchers have discussed theoretical and methodological reflections and main findings based on the case study of this research. The following chapter reflect on the Design phase, Objective of each phase, Method and finding.

8.1 Structure of Research

Design Phase	**Objective**	**Method**	**Findings related to the Nepalese context**
-Case Study -TPB Model	- To identify the people's behaviors and willingness to recycle the e-waste. - To identify the problem in electronics waste recycling practices.	-Conduct **Questionnaire** with 20 participants -Organize **future workshop** with 7 participants -2 Recycling companies **interviewed** -1 NGO **interviewed**	-Participant claim that they lack enough resources and proper waste management facilities. -There is not enough information in the practices of e waste recycling- -There is not any motivation for people to practice proper waste recycling. - There is no reward or penalty system to maintain recycling practices. - people have a positive attitude to practices e waste recycling but lack knowledge on how and what can be done. - There is a lack of skilled manpower in the field of e waste recycling. -there is lack of government policy to support the recycling practice

		-3 people **interviewed**	
Requirements	- To tie the application design to the Case Study findings	-5 user requirements	**-Recycling Service:** **-Repairing Service:** **-See Impact:** **-Recycling ideas:** **-Buy & Sell Platform:**
Design of the application	To design a mobile application capable of making the users reframe their e waste recycling practices	5 main features	**-Information**: The application provides information about recycling and repairing service. Users can also see the impact result of their recycling behaviors. **-Gamification**: the application rewards users for their sustainable recycling practices. **-Education:** The application provides educational content through video and blog about e waste repairing and recycling. **-Communication: Users** can interact with other users while trading and contact recycling companies for recycling or repairing services. **-Buy & Sell:** User can list and sell their unused electronics or buy the listed product.

Table 9 Structure of Research source: own

8.2 Reflection on Theory and Method

For this research, we are studying the recycling behaviors of a certain aged group of people residing in Kathmandu. Our research is to learn not only their habits of recycling the electronics devices but also to learn their willingness to recycle and figuring out the problems within their recycling practices. Hence, we are adapting the case study approach. This approach aids us for the deeper study and analysis of the recycling behavior of e-waste of youth residing in Kathmandu (Merriam, 2009).

As Yin says a case study approach is helpful on finding not only 'how' and 'why' questions but it

also helps when we have very less control over the circumstances (Yin, 1994). This approach helps us in acknowledging 'how' do Nepalese youth residing in Kathmandu view on the recycling of their used electronic devices and 'why' do they do so (Yin, 1994). In the process of understanding their recycling behaviors of e-waste, we tend to interrogate and analyses their recycling practices of e-waste keeping the youth group as the focus point (Merriam, 2009).

We process our obtained data and retrieved our conclusion using TPB model. With the help of TPB, we understand the behavioral patterns of individuals towards recycling e-waste. Through the course of our research, we realize that people are much involved in the process of finding **solutions** if they feel they are part of it. Acknowledging this behavior, we use gamification, the app which encourages users and lead them closer towards the recycling habit. In TPB gamification is viewed to engage the users in the practices of recycling behaviors, however, we also have to admit, that only few of the participants were asking for these gamification elements. But, as human beings, we know that human behavior cannot be completely controlled or predicted. People tend to change their behavior respective to the contemporary time and

circumstances present. Hence, we as researchers being aware of this, have added education in our digital solutions along with gamification.

The TPB model as explained by Azjen & Madden (1986) advises that individuals are engaged much into recycling when they are affirmative towards the recycling concept. However, we learn through our research that this may not be the case always. As the theory is based on the behavior of individuals of the first world country, this does not hold true in the case of the behavior of individuals of the third world country, Nepal where our research is based. We observed through our research that although individuals have keen interest in recycling their electronic appliances, they are not being aided towards their recycling habits due to several different factors. This finding of ours is in line with Wilma F. Strydom's (2008) findings, who argues South Africans lack sufficient knowledge, positive attitudes, social pressure, and perceived control that would encourage recycling behaviour. Although many of our participants in the research have great willingness to recycle, they are not able to do so because of the system where they are not given any education and awareness regarding the different forms of recycling and are not provided with the right means to do so. Strydom has found that especially South Africa's city dwellers are willing to recycling. These findings are also supporting our findings with the focus on Nepalese, urban young people living in either Kathmandu or Copenhagen. What we can see is, that the young Nepalese living in Copenhagen are more used for recycling, however the Nepalese living in Kathmandu is very eager to develop a practice of redesign.

Through our research, we are delighted to find all our participants have a positive attitude towards the concept of proper e-waste recycling practices. However, a significant number of participants from Nepal indicate that there is lack of proper knowledge and facilities of recycling. We can see a huge gap between the need of people in the practices of recycling and the facilities made available for it by the Government. Our participants provide us with an overview of how the Government sector is not acting responsibly on this issue. The Government has not been

doing anything to implement the recycling practices in the city. Although our research is not focused on understanding the perspective of the Governmental sector on the recycling practices, we cannot still ignore the fact that the Government plays a vital role in the recycling practices of the city and in our case, because of the weak participation of the Government in this issue, the problem in the implementation of the e-waste recycling in Kathmandu persists.

On the other hand, we find Recycling companies believe that blaming the Government for everything is an easier way out in a developing country but the people themselves are hugely responsible for their e-waste. Having said that, they also bring the Government's disregard on the issue to the light. Due to the lack of awareness in the people about the e-waste recycling practices, the companies claim that they have very small numbers of customers. They put forth their problems of communicating with their potential customers as there is no reliable medium in the present. There is no digital medium through which they can reach their potential customers. They strongly focus on the proper recycling service from the government along with enough information and guidance to the people on e-waste recycling should be there in order to resolve the problem.

Through our research, we also find contradictions between the activity systems in the forms of contradictory opinions. We figure out the design concept based on a developed country's context may not be applicable to that of a developing one. We came to realize it through the conflicting opinions between the two recycling companies, one based in Denmark and another based in Nepal. Although we could not do our research in depth based on the activity systems, we realise that further analysis could have been done based on it.

8.3 Reflection on Data Collection Method

Interview

We have conducted semi structured interviews with all the participants from the different roles of interest in this research. Since we had used the semi structured interview format, it was interesting to see how people were more open to express themselves.

If we had used structured or unstructured interviews, our result might have been little different. In the case of unstructured interviews, the interviews might have gone out of track or the relevant answer might not be retrieved if we as interviewers failed to set structured questions in the case of structured interview. After all both, the interviewers and the interviewee were not the experts in this field.

We had conducted all of our interviews online, so there were some instances where it was a little difficult in understanding each other. This was due to the several elements. One of the reasons was technical issues. The internet connectivity in Nepal was very bad and in addition to that, there were electricity cut-off issues.

Since our interviews were virtual, participants were a little uncomfortable and were also getting distracted frequently. Some of the participants were not expressive enough. They would only give a short answer which limited the possibility to understand their perspectives. This could have been easier if only we could have taken the interview physically and not virtually. We could have understood better the perspectives of the participants if we had taken physical interviews. So, in order to compensate that and to help them express themselves more, we followed their answer and repeated the answers again to them so as to insure, that is what they intended to

say. This, in a way, encouraged them to speak and express themselves more in the following questions in the interview.

We did not get a chance to interview 3 of the experts in this field which we had planned to do for. We contacted them but we could not be able to schedule our meetings. If only we had a chance to interview them, our research might have resulted in more valuable findings and solutions along with the specific feature consideration in the design. In addition to that, with the help of their expertise, we would be able to focus on the right problem and its solution.

During the interviews with an e-waste recycling company in Nepal and a e-waste recycling company in Denmark, we found few contradictions between their thoughts regarding the concept of gamification in mobile apps. The Recycling company from Denmark suggested that providing the information through the application and encouraging people through gamification could be a great idea to motivate the people to change their recycling habits. Below is the statement from the recycling company from Denmark.

However, when we asked the similar question if gamification in the app could encourage people to recycle their electronics waste, to the recycling company in Nepal, they had a totally different viewpoint on it. They were focusing on providing the basic digital platform for people. Below is the statement from the recycling company from Nepal.

Through these interviews in two recycling companies in two different countries, we came to understand the actual need and focus on the real problem rather than contemplating some unnecessary ideas which can only be applicable for the developed countries like Denmark and are not at all applicable for the developing countries like Nepal. Hence, we have collected our data in Kathmandu, Nepal and have acted upon the suggestions and solutions based on the perception of the local residents and local recycling companies in Kathmandu, Nepal.

From the interviews, we discovered an interesting fact that people are not aware of the problems caused by e-waste. This has opened a new challenge to understand the real situation

with a bigger sample group. We need to find the answer if this is because of the lack of government's presence in taking responsibilities in providing enough information to the people about the e-waste and its problems or because the people themselves are not willing to take any responsibilities in dealing with e-waste in a proper way.

Questionnaire

The sample group of our research was a group of students studying bachelor's in business study (BBS) in 3rd year. We used a questionnaire method to collect data. We went to the college a day before where we explained about our research to the participants in detail. We pointed out the importance of participants' contribution in the research. This helped them to get much interested in the research. We then answered all their queries and they seemed to understand them all.

Our research sample group was a small group with the same education background studying in the same college. This limited our result as it could have come out different if we had a larger group with different educational backgrounds as our sample group. Since our sample group is very small and belonged to just one college in the Kathmandu Valley, our result does not exactly serve as a representation of a whole Kathmandu Valley.

On question number 6 of our Questionnaire, we asked our participants if they receive any facilities or resources to recycle their e-waste in their local areas. With their yes or no answer, we could have a follow up question where we could ask about the facilities that they are getting currently in their local areas. This would have given us insight into the current facilities and resources that the residents of Kathmandu Valley are receiving.

Similarly, on question number 7 of our Questionnaire, we asked our participants if the municipalities inform them to sort out the different kinds of wastes or not. Here, after their answer, we could have a follow up question where we could ask how the municipalities inform them about it. This would have let us know about the current ways of municipalities providing awareness to people about sorting out the wastes.

We feel our question number 11 in the Questionnaire could be better. Instead of asking them about if they would sell their e-waste, we could have asked them what they would expect in return to their e-waste. They could have chosen their options themselves for eg. money, giftcard or just want to get rid of e-waste etc. This could have given us a clearer view on what actually the participants are looking for in return to recycling their e-waste.

In the same way, on question number 16 and 18 simultaneously, we asked our participants about what they do most of the time in their phones and their computers. We asked them to tick on more than one answer if necessary but did not give them a limit on maximum ticks. As a result of this, we could not get the approximation of the data as the participants tick on every option.

The format of our questionnaire focuses only on the recycling behaviour of our participants. We feel it would have been better if we had included the questions related to the repair behaviour of the participants. We could then learn about if they even try to repair or not their electronic devices before throwing them as wastes. This would have given us insights on the current reparation practices of the participants and the problems regarding them.

Overall, our data collection through Questionnaire method went well but there were places where it could be much better.

Future Workshop

The reflection of future workshop is divided in following two parts:

I. Reflection on Future Workshop Methodology

Future workshop (FW) is traditional a physical workshop tradition (Jungk & Mullert, 1987)

but due to the Covid-19, the workshops were organized as virtual FW.

The virtual FW was a new practice, where the researcher gained new experience and some interesting findings. Some of the problems faced during the virtual FW were as follows:

- **Technical issues**, such as poor network connections and electrical outages, which caused some lags or delays in the discussion.
- It was also a challenge to schedule a suitable time for the meetings due to the **time difference** as some of the participants were based in Nepal and some in Denmark.
- Some of the participants faced **difficulty in expressing** themselves openly as they were not used to online modes of discussion. The researcher had to create an atmosphere to engage them through informal games and activities. The brainstorming and discussion could possibly have been better through a physical FW.

Nevertheless, the virtual workshop turned out to be very helpful in supporting the research. Some of the important points from the FW methodology can be reflected on as follows:

- While the topic of discussion was guiding the session towards the required knowledge-gathering, the participants were not forced into a standardized format and thus, they were able to provide their opinions and arguments as suited to their ideas and understanding throughout the different phases of the workshop. This provided a richer discourse for subsequent analysis.
- Giving each participant a participant number was a great idea to help avoid double talk and confusion as to who should speak.

- The workshop was recorded with the permission of all the participants and this helped in generating notes and facilitating the summarizing of the topic discussions.

Reflection on the finding of FW

The result from the future workshop was interesting and valuable for this research. There were discussions on the problem of e-waste disposal and multiple possible solutions were discussed and debated upon in the workshop. The researcher has categorized these findings into the following topics, which are further divided in sub-topics. Theoretical inspiration for these categorization of this finding is line with the (Brauer, HIIdebrandt, Ebermann, & Remane, 2016) finding on existing roles from Information system which include Information, Education, Gamification and Collaboration. Based on these inspirations, Researcher present the relevant finding under three main topics: Digitalization, Information & Education.

Digitalization

- *Data Security and Privacy*: The participants believe that the recycling companies should be able to brand themselves as trustworthy. This trust can be gained as they handle their customers' defective products which might have confidential data. They should be able to generate a report that shows the deletion of data from the defective products. As there is a high risk of data-misuse while handling some defect e-waste such as phones and laptops, having a procedure to ensure the trust of the customers will help recycling companies to grow and gain more customers in the long run.

- *Smart Technologies for Recycling Bin*: One of the participants suggested a solution of a Smart Bin in a city area that can scan all the waste and separate it based on its material. At some point, people can perhaps also scan their ID through an app that recognizes which user is recycling what. This smart bin technology can then be used to reveal the most environment-friendly user and reward them points and offers as motivation. People

might be interested to see these kinds of innovations and be more engaged in recycling practices. This solution is out of the scope for this research study, but this can be a topic to research as future work in this field.

- *Building a connection between recycling companies and people*: A digital platform like a web or mobile application that acts as a bridge between a company and people might help to solve most of the issues pointed out in this workshop. for example, a trading platform for selling e-waste, providing information and a repair guide for e-waste, showing nearby recycling services, connecting like-minded people, and companies interested in the circular economy for electronics waste.

Information

- *Lack of information* on recycling e-waste stands in the way of motivating the people of Kathmandu valley to practice e-waste recycling. A majority of this population have access to smartphones and the internet. Hence, a mobile application could be a good solution where people can easily access information about all recycling-related questions. The same application can also help people find where and how they can recycle their e-waste.
- One of the participants made an interesting suggestion that there should be *repairability labeling* on electronic goods, so that people can know what can be fixed and what cannot. This will help people be informed about what kind of material is being used in the production and whether the used material is environmentally friendly or not. This strategy has already been implemented by processed-food companies and this helps consumers in understanding the ingredients used in the product and when the product will expire. This eventually helps people with certain food allergies and preferences to make the right choice. So, this similar concept can also be used to inform consumers while buying any electronics device. The concept of repairability labeling is the responsibility of

both the manufacturing company and the government. So this research has not focused on this subject matter but considers it as a future work on top of this research.

- Tracking the user habit of recycling: Gamification is a one of the main elements suggested in other data collection methods as well. It would be a great encouragement for the people to see how much e-waste they have recycled in a year and what impact they have made in the society with good practices of recycling. but when the application can track the user data, there is a risk of data security and mis handling. So, while implementing the feature like tracking user habit, it is important to consider the privacy issue to make sure that data from application will not be mis handled.

Education

- The participants also suggested that there should be an educational institution programmed with e-products repairing courses so that we can generate more skilled manpower in the recycling business. It has been observed that there aren't any such study programmes in Kathmandu valley.
- While there are several online platforms which provide video tutorials and information on various topics, it was agreed upon in the FW that it will be an efficient step to include tutorials specifically dedicated to e-waste recycling and repairs that can help to reduce e-waste incoming future. This is one of the main attractions of our solution which we have considered to implement as a "*Ideas*" in our primary menu.

8.4 Reflection on design of the Application:

We have designed the App considering the user's requirements collected from FW, interview, and questionnaire where FW has been the main method that concludes the digital

solution as a mobile App. So, most of the important features and requirements have been collected from FW. Furthermore, while deciding the features of the App, we have also analyzed the related tool study. Considering all the features that have been collected from the FW and tool study, we have designed the prototype of the app without the physical participation of the users. In the context of Nepal, to arrange the content conducting a virtual workshop or a virtual card sorting is a new technique. So the participants seemed confused while arranging the content virtually. Participants could be more comfortable and be able to generate new and creative ideas if the prototype was designed together with the users physically. With the help of a quick and dirty test, we are able to refine our idea. But we could not test the mockup due to the lack of time and corona lockdown in Nepal.

While designing the content of the app, we have used a different design principle considering the result from user's card sorting for arranging the content. We have implemented the user's preferred feature applying a different design principle. For example, users placed a list of the nearby repair centers and the form needs to be filled while repairing under the repair page. In the design, we have placed the exact mentioned element but using the principle of continuity.

While designing the app, we have tried to keep it as simple as possible, considering the educational background of the users. We were not able to test the mockup or the real final design of the app because of the lack of time. Further, we can test the final design of the app and can obtain the user's feedback. Similarly, we have used the green color to give a sustainable feeling where DeLong and Goncu-Berk (2012) have mentioned that green color is used to promote sustainability (Delong & Goncu-berk, 2012). Although we have used a green color to represent sustainability and made the app as simple as possible, we have not involved youth while designing visual elements. In future testing a final mock-up with youth can be done and their interests towards the app can be examined.

9 Chapter Conclusion

In the following chapter, we summarize our findings by answering our research questions and thus, our problem statement: How can a digital solution improve electronics waste recycling practices in Kathmandu Valley?

1. What are the current practices of E-waste recycling in Kathmandu valley?

The initial survey of the participants of the research indicated that although people, in general, show a positive attitude towards recycling, 65% of the respondents admitted to not practicing e-waste recycling regarding it as a hassle to separate the waste due to a lack of information and proper available facilities for waste management. There is no guidance from the municipality on the separation of e-waste and people end up dumping their e-waste together with other solid waste. This ends up in the landfill with other non-biodegradable waste.

From the interviews with the recycling company and NGO in Nepal, it was noted that there are very few recycling companies from the private sector who try to push towards e-waste recycling but there isn't enough support from governmental sectors providing facilities or resources to those private companies.

The overall result shows that there is a high requirement for the government to come up with a strategic plan working together with private recycling companies and electronics manufacturer companies and communities in order to build a sustainable solution which will improve the current practices of e-waste recycling.

2. **What is the impact of electronics waste on sustainable development and which sustainable practices can be helpful to resolve the problem of ewaste?**

The literature study for this research helped in answering the second research question. Lack of a proper e-waste disposal system ends up compromising the quality of the environment, which ultimately harms human health. Hazardous chemical contamination, as a result of improper e-waste disposal, can cause a variety of diseases, some of which can be fatal. This negatively impacts one of the targets of the UN's Sustainable Development Goals of “Good Health and Well-Being”.

“Clean water and sanitation” and “Life below water” are two of the other SDGs, which are directly negatively impacted by the disposal of e-waste, as the unsustainable dumping of e-waste can affect water resources and the marine ecosystem. The e-waste having plastics, metal, coppers and particles can endanger the life below the water.

The sustainable management of e-waste will help in minimizing water pollution and help preserve the marine ecosystem as well as help in preventing air-borne or water-borne diseases, while promoting better living standards.

One Sustainable Development Goal is to promote economic growth by supporting productivity activities, creativity, job creation and innovation. Establishing an e-waste recycling plant can help in generating new income and job opportunities for people of a community. E-waste also contains valuable and reusable materials such as gold, silver, copper and plastics which can be recycled and can be a potential business to help upgrade the economy.

The 3R concept of Recycle-Repair-Reuse can help resolve the e-waste problem. The outcome of this research is the digital one-stop platform which has been developed to support these 3 sustainable practices. It will connect consumers with recycling organisations, while at the same time offer tutorials for easy repair-at-home solutions and inform and motivate people on alternative solutions on what they can do to reuse their old products instead of discarding them.

3. **What requirements should be considered in the design of a digital solution that improves e-waste recycling practice in a sustainable way?**

The qualitative analysis of all the data collected from FW, interview, questionnaire guided us to find the main user requirement in the design of mobile application. The participant from the FW discussed several problems in the current practices of e-waste recycling. Due to the lack of basic facilities like waste separation containers, lack of proper information about recycling practices and awareness issues, people are not being able to practise e-waste recycling. With all these existing problems, researchers identified the need of **Recycling service** which can provide e-waste pick up and drop off services through the application and can provide the necessary information about the recycling practices.

Besides recycling the e-waste, people also discussed the possibility of the reparation of defect electronic products and the existing problem in the field of reparation services currently.

There are many repair shops currently inside the Kathmandu valley, however there is not enough information about their services in any digital platform. Some of the repair shops have their own Facebook pages through which they provide their service information to their customers. Nonetheless customers have to wait 3-4 days to receive a reply for any basic information as the

shops do not update their information regularly and moreover are not at all active in their Facebook pages. The problem of insufficient information on the repair services of the defect electronic products convinces people to throw their defect products. Thus, providing enough information about Reparation Service through the platform is considered as a second main requirement in the design of the application.

Another potential barrier in the practice of repairing electronic devices is that products like mobile phones and computers contain valuable data which can be misused or leaked during the reparation. Hence, it is important to create a trust-worthy platform which can make sure that the customers' data is secured and handled responsibly during the reparation.

Recycling and Repairing the electronic devices already create a possibility to reduce the quantity of e-waste but there is one more requirement of **Trading platform** for used electronic products from tool study and future workshops. The concept of buying and selling electronic devices already exists in other digital platforms like Facebook marketplace and many other e-commerce shops like 'hamrobazaar.com' in Kathmandu Valley. Nevertheless, the existing platform of Facebook marketplace is not always functional in the region of Kathmandu Valley and the platforms like hamrobazar do not provide a secure data privacy policy. In order to solve these existing problems, trading platforms for used electronics is considered as another requirement in the design of our digital solution.

Another useful requirement identified from related tool study and FW is about finding the creative solutions to the problem. Such as providing creative **Ideas** to redesign the defect electronic products into decorative items or some useful objects in the household. This could help to reuse most of the defective products that can neither be repaired nor be sold.

Lastly, the most preferred requirement which can help to motivate the people for practicing e-waste recycling is seeing their own **Impact** by tracking all the recycling activity of the individual users. The concept of gamification in the practice of e-waste recycling, plays a vital role

to change the recycling behaviors of people and this can be possible by implementing the gamification element like reward or badge where the top recycle can get renowned in the application and all users can see their own impact of recycling e-waste.

4**. What principle should be considered in the design of a proposed digital solution to meet the user expectation with interaction model and interface design?**

An effective design of mobile application should consist of intended features that can engage the user from the interaction design fulfilling the user requirements. The design principle of our application focuses on both interaction model and interface design. The application is based on the concept of the 3R (Recycle, Repair and Reuse) which contains several design elements in each feature. While designing the interaction model of each feature, the idea of 3 rule steps is considered in the design which makes sure that the user can complete the recycling or repairing process within 3 interfaces which simplifies the application usability. Besides the simplicity of the design, other several heuristics are considered in the design of application. Usability Heuristics for User Interface Design of application is based on the HCI principle which says that understanding the users and their needs is the main artefact that needs to be considered in the initial phase of the design process. In line with this principle, this research has collected most of all the requirements from the user innovation method using the participatory method. This has helped us to identify all the main requirements of the user and understand the task. While designing the application, researchers have made sure that design elements on all the pages are consistent. The colour 'green' represents sustainability and it has also been used by most of the sustainability apps from tool study as their main theme colour of the application. So, the interface of this application also contains the colour 'green' as its theme colour code. Another HCI Principle, reducing the memory load and preventing the user making error has also been considered in the design where the design element in repair and recycle pages makes sure that while performing a certain task, all the unnecessary elements will be unclickable to prevent the

user from getting errors. Following up this principle, it is also important to show the status of task completion which makes good affordance in the design. In line with this rule, in our design solution whenever a user completes a certain task, system responses back to the user with the success or failure message on the screen. The other factor that has also contributed in the design of the application is Gestalt law, such as principle of continuity, principle of proximity, principle of closure and principle of similarity, which has helped to design the several elements of the application. Thus all these several factors such as Simplicity, consistency, colors, functionality, proximity, closure, similarity etc. have contributed to design the user friendly mobile application.

10 Chapter Recommendation & Future Work

In this Chapter, Researchers present their recommendations to the different stakeholders who plays vital role in the practice of e-waste recycling. In addition to recommendation, researchers also present specific areas that need to be further studied followed to these research paper.

Recommendation:

1. Government of Nepal should make a strong rules and regulations in the practices of waste management with reward system for proper waste recycling practices and penalty system for not following the rules.
2. The current situation of e-waste management in Kathmandu valley is in worse condition. Therefore, it is necessary to establish department from governmental bodies who will regulate the work to manage the e-waste.
3. Government of Nepal and NGO should create an awareness programme in the practices of e-waste recycling.
4. Electronic manufactory companies should use sustainable recyclable material while manufacturing the product.

5. Government of Nepal, recycling companies and electronics manufacturers should work together and come up with strategic plan to reduce the ewaste and establish a proper ewaste management system.

Future Work

I. This research has not studied on the perception of government regarding the management of e-waste. So, it is also necessary to understand what the Government of Nepal is doing, their strategic plans and policies, to eradicate or manage the e-waste.

II. The sole purpose of this research is to design the e-waste solutions for the requirement of public however, it is also necessary to continue the work to design solutions that can help the recycling companies to connect with the e-waste provider (public).

III. During this research, the basic concept of gamification is implemented with the feature of tracking user's recycling activity and shows the impact. It is necessary to further research on how the data of recycling activity should be analyze and how can it be calculated to anaylse the performance of individual user.

IV. One of the element like social exposure must be considered as a future implementation as it helps the user to share their recycling points and show others how their recycling behavior has made a positive impact on society.

V. The current design only shows the points and impact made by the users while practicing the e-waste recycling. Therefore, in the future study, it is necessary to build a system that evaluates the performance of the users and reward them with some sorts of badge or discount coupon based on their points or performance.

VI. Hence, the future study should be focused on the implementation of a system that allows the companies to use this platform as a networking hub where the company and user can meet and manage the sustainable recycle of e-waste.

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Appendix

Note: The appendix file is attached separately. The below table of content shows the structure of appendix.

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