Development of User Interface Design for Electronic Waste Collection with a Design Thinking Approach

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Abstract

Various advanced technology products that can facilitate human life cause disruption, which has led to an increase in environmental pollution due to the rise in electronic waste. The management process and public knowledge about electronic waste management is still significant issue in electronic waste management. This provider of electronic waste collection facilities and information is needed. One of the existing electronic waste collection facilities is a government website, while application-based waste collection facilities still focus on plastic and other household waste. In addition, there are several complaints in operating the application-based electronic waste collection facility. One of the biggest problems is the interface design of this application, so this study will discuss the interface design of the electronic waste collection application. This study uses a design thinking approach to the solutions to the resulting problems can be oriented to customer needs. By using in-depth interview methods, empathy map tools, personas, kansei engineering, prototype, and several tools in usability testing, researchers will design recommendations that suit the needs of its users.

Keywords

User Interface, Application, E-waste, Design Thinking, Kansei engineering

1. Introduction

Various products of advanced technology that can facilitate human life cause disruption which has led to an increase in environmental pollution (Khan et al. 2012). The increasing use of technology for economic growth is increasing rapidly in developing and poor countries, causing the amount of electronic waste (e-waste) which is globally estimated to have reached 65.4 million tons in 2017 (Yoshida et al. 2015).

There are 3 reasons why e-waste is an environmental issue, namely; (1) rapid growth in the amount of e-waste, globally at 4 percent/year (Ardi & Leisten 2016; Sumasto et al. 2019); (2) the content of hazardous and toxic materials such as heavy metals (lead, cadmium and mercury) in e-waste (Yoshida et al. 2015); (3) the nature of e-waste that has economic value, because it contains materials such as recyclable materials. (Krol et al. 2016). In some countries, e-waste management can be divided into two major groups. In the first group, the informal sector with human labor is still used in the collection of segregated waste to carry out work such as (1) sorting, weighing, and moving materials; (2) Loading and unloading plastic, glass, or metal containers; (3) Identification, transfer, storage and dismantling of e-waste (Popa et al. 2017). The relationship between technology and the environment is very crucial and multidimensional. Interaction between humans and computers or commonly called human-computer interaction (HCI) is a science that discusses communication and interaction between users and systems.. The mobile application is developed for end-users who are intended to use it to dispose of their household electronic waste (e-waste) (kai Kang dean 2019). In the digital era where there are many applications to facilitate the distribution of waste in the form of applications, the UI display of this application is more focused on plastic waste and other household waste but has not

facilitated more in terms of electronic waste collection. One solution devised in these countries is to digitize household waste collection through mobile applications that act as a bridge between households, collectors, and recycling companies (F. Behnamifard1 etc.).

1.1 Objectives

The purpose of this study is to determine the design of a user interface prototype for electronic waste collection according to user needs and to test the usability of the prototype design.

2. Literature Review

One of the impacts of the development of technology and information is the increase in solid waste in the form of electronic goods. Electronic goods that can no longer be used and have expired are known as electronic waste (e-waste) or commonly known as electronic waste (Deubzer 2011). Challenges in electronic waste management include: (1) the diversity of electronic waste in terms of size, weight, function, and material composition; (2) New technologies are constantly emerging; (3) The content of hazardous materials that need to be managed equally; (4) Metal components that have high economic value and; (5) Different groups of electronic waste management (Conti and Orcioni et al. 2019). A user interface (UI) is a device interface or program screen that allows interaction between your device or system. User Experience (UX) is a term that covers various user experiences (emotions, attitudes, behaviors, and others.) throughout the interaction. User Interface according to the Interaction Design Foundation (2018) is the process of creating an interface in computerized software or devices with a focus on appearance or style. Based on the Interaction Design Foundation (2018), User experience (UX) is the process used to design products that provide a meaningful and appropriate experience for the product's users. Design Thinking uses a solution approach that is oriented towards user needs to solve problems. The Design Thinking approach is an approach with a structured process (Schallmo 2018). According to Fontichiaro (2015), Design thinking can be used for product design, work plans, and digital designs such as brochures, applications, and web pages. Based on the Interaction Design Foundation (2018), design thinking consists of 5 phases, namely Empathy, Define, Ideate, Prototype, and Test, which will be most useful when dealing with unclear or unknown problems.

3. Methods

The research method used is semi-quantitative**.** The stages carried out in this research are several stages: The first stage is to determine the topic of the problem by conducting a study of several phenomena and problems that arise from several references. The design thinking method approach as a clear guide that can be followed during design development. In the next stage of literacy studies, researchers conducted searches from several journals and previous studies regarding the topics and problems raised in this research**.** The data collection stage in this study uses a design thinking method approach as a method framework. The design thinking method consists of several stages: empathize, define, ideate, prototype, and test. Processing questionnaire data carry out data processing to determine the number of clusters for data collection using the Kansei engineering method. Practitioners use this methodology as a best practice to ensure that designs meet specific standards and are appropriately explored, developed, and tested. The reasons behind choosing this methodology mainly are as follows: some other alternatives, such as Think360 Ux Process Cycle, UIUXTrend UX Process, and Methodologies are not as well documented as Design Thinking, and Design Thinking is an incremental methodology, which is suitable for small startups because it focuses on a high level of communication between teams and a fast iteration and refinement process.

4. Data Collection

This study uses the type of primary data collection. The collection process is carried out by conducting a pilot survey regarding the current situation. The pilot survey used a quantitative questionnaire that was then analyzed as a cluster division. The following process of the cluster will be conducted in-dept-interview, which is qualitative. In this interview process, the researcher asked the respondents how their experience was with understanding e-waste, the obstacles they faced, the difficulties they faced, the unavailability of needs, and other questions aimed at knowing the needs and opinions of users regarding e-waste. Next, the researchers mapped the results of the in-dept-interview to see the constraints or phenomena in each cluster related to electronic waste.

This questionnaire was distributed online via google form with a total of 60 respondents. Some of the questions used in the questionnaire are respondent’s personal data, the understanding about e-waste, the frequency of internet usage and about Difficulties encountered or responses to e-waste collection. The data collection results obtained the distribution of respondents' self data, namely: by age, respondents belonging to generation Y (millennial gene) reached

34% with an age range of 20-40 years. The second distribution is X, with an age range of 41-55 years with a figure of 33%. Then the Z generation, with an age range of 19-25 years, reached 33%. The majority of the respondents are male, 62% and the number of female respondents is 38%. The distribution of respondent's domicile is around Jabodetabek (Jakarta,Bogor, Depok, Tangerang, Bekasi), was from West Jakarta 28%, Central Jakarta reaching 12%, North Jakarta reaching 12%, Tangerang reaching 17%, Bekasi reaching 11%, South Jakarta reaching 5%, East Jakarta reaching 5%, Depok reaching 5 %, and Bogor area 3%. The majority of respondents have jobs as an employee.

The next step of data collection after used questionair was in-dept interview**.** Interviews were conducted on a minimum of 5 respondents for each generation from X, Y, and Z to get usability problems compared to testing a more significant number. The questions in this interview are respondent's demographic self data: name, age, domicile, status, occupation, and gender. In the following interview process, we explore respondents' experiences related to electronic waste.

The next step of data collection is using the Kansei engineering method. This quantitative data collection was carried out through a Kansei questionnaire consisting of several Kansei words. Measurement of quantitative data using a scale of semantic differentials. The process of collecting data by asking respondents to choose Kansei words that match the secondary object of the study using five semantic differential scales. There are fifteen selected Kansei words: informative, comfortable, modern, easy, simple, consistent, structured, neat, funny, creative, unique, clear, and systematic. After collecting data through the Kansei questionnaire, the following process determines the design elements for the design of the new user interface design. The design element category is determined based on references from google design elements. The following is a table of design elements for each variable for each category as a reference for designing the user interface design of the waste collection application. The next step was making prototype from the results of data collection.

5. Results and Discussion

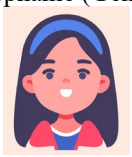
The first phase of this research is to Empathize. In this part, we want to capture the profile of our users. Here we can use a method called persona to represents our market target; persona must be made and defined by conducting a survey and interview in which we can then categorize the result and pattern into multiple personas (Table 1).

Table 1. Results Cluster Grouping Based on K-Mean Cluster

VARIABEL	Kluter 1	Kluster 2	Kluster 3
Age	Gen X	Gen Z	Gen Y
Gender	Man	Woman	Woman
Time of using internet	1-3 hour	4-6 hour	4-6 hour
The importance of recycling	Yes	Yes	Yes
Job	Employee	Student	House hold
Domicile	Jakarta Utara	Jakarta Pusat	Tangerang
Marital Status	Married	Single	Married

From the results of the clustering, then each cluster is developed into a persona with more complete details of characteristics and behavior (table 2).

Table 2. Representation of Persona Methods

No.	Persona	Deskripsi
1.	Edy, (Generasi X) 	• Edy is a male generation X with an age range of 41-55 with a job as a private employee. Domiciled in North Jakarta and the process of recycling electronic waste is essential. Types of electronic waste are owned, such as DVDs, children's toys, dispensers, tv, magic jars, cellphones, and lamps. • Internet users 1-3 hours, used for browsing, social media, and watching movies. • Problems faced with e-waste are the long and challenging recycling process, difficulty finding recycling equipment, inflexibility of e-waste distribution transaction times, and sometimes e-waste is given to neighbors to be recycled so that it has no economic value. The large size of the waste takes up storage space. I do not understand the process of e-waste disposal, so throw it away • So from this problem, it is hoped that there would be facilities that help the recycling process in the environment, some facilities make it easier to find electronic waste recycling equipment, there are flexible electronic waste distribution facilities, there is information on electronic waste recycled from the type or size of waste.
2.	Stephanie (Generasi Z) 	• Stephanie is a generation Z woman with an age range of 19 – 25 years with a job as a student. Domiciled in Central Jakarta and the process of recycling electronic waste is essential. Types of electronic waste owned include cellphone waste, fans, chargers, and earphones. • Internet users 4-6 hours and used for browsing, watching movies, social media • The problems faced are not doing recycling because there is much electronic waste that cannot be recycled, the location for the distribution of electronic waste is far away, goods are not easily decomposed, so they are confused about how to dispose of them, afraid that the discarded waste will turn into waste because they do not know information related to electronic waste. • So it is hoped that there will be a recycling facility that provides information related to electronic waste that cannot be recycled with those that can be recycled, the existence of means of distributing electronic waste, and flexible facilities such as the pickup order process.
3.	Debora (Gen Y) Millenials	• Debora is a generation Y woman with an age range of 26 – 40 years with a job as a housewife. Domiciled in Tangerang and the e-waste recycling

		process is essential. Types of electronic waste are owned, such as waste dispensers, magic jars, cellphones, lamps, refrigerators, chargers, roll cables, and other household appliances. ● Internet users 4-6 hours, used for browsing, streaming videos, social media, and watching dramas ● The problems faced are not understanding how to recycle, the time for waste disposal transactions with collectors is not flexible, electronic waste is given to other people to be recycled, large waste sizes take up storage space, do not understand the process of electronic waste disposal, so it is disposed of with household waste on another ladder.

From the results of the information from the three personas, several things need to be improved and developed, namely (Figure 1):
a. E-waste pick-up time is more flexible
b. There are application facilities that make it easier to access garbage pick-up services
c. The process of distributing electronic waste with a pick-up order system makes it easy for users
d. The existence of information services related to electronic waste as education for users so that they are not wrong in choosing electronic waste.
From here, we can then go to the Define phase, in which the point of view of the team must be unified. In the define stage, the researcher uses empathy mapping tools as a visualization that concludes the pain and gain points according to the user. This empathy map combines all pain and gain points to form several aspects that include offensive opinions regarding the recycling process or electronic waste collection.

The pain points from generation X include difficulty accessing electronic waste pick-up facilities and not knowing information about electronic waste. So for the gains points, among others, the time for picking up electronic waste is more flexible. Some applications make it easier for garbage pick-up services and satisfying services. In the Pains Persona 2 points pains from generation Y, there are several things, namely remote electronic waste distribution facilities, minimal information on electronic waste distribution, and unclear electronic waste distribution processes. The gain points include several things, namely the existence of facilities and information regarding the distribution of waste that is easily accessible using an innovative phone application, and the existence of an electronic waste distribution process with a more integrated pick-up order system.

At the point of Pain Persona 3, there are several things: the difficulty of processing electronic waste in the household. The distribution of electronic waste is still carried out independently with an unclear system. As for the gains in Persona 3, namely the existence of applications that facilitate the processing of electronic waste in households, electronic waste is managed professionally with a sound system and has good economic value.

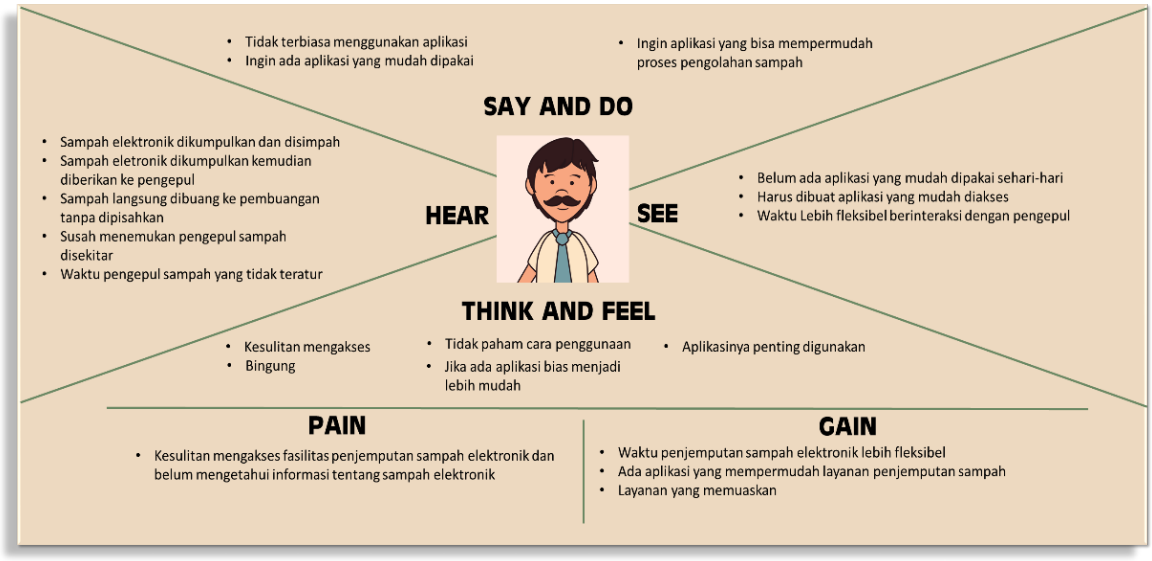


Figure 1. Empathy Mapping Example

Therefore, some of the above personas need collecting or recycling of electronic waste, namely the existence of facilities that are easy to use, flexible, and provide adequate and easy to understand education (Figure 2 and 3).

At the ideate stage, data processing begins by collecting the value of fourteen Kansei words, then reduced using factor analysis so that it is divided into two components, namely component 1 consisting of informative, formal, modern, attractive, consistent, calm, structured, neat, creative, detailed, clear, and systematic and for component 2, namely formal, attractive, cool, neat, funny, and creative. The first component is called the aesthetic concept, and the second component is called the calm concept. After the kansei words are reduced, use the partial least square method to determine the meaning of the design concept into design elements. Fifteen design elements are used in the data processing all selected design elements were obtained from previous research and literature. all design elements used are those that have a range of elements above 0.029. Design elements that have a range of elements below 0.029 will not be used; this happens because the design element does not have a significant influence and can be written NS (not significant) in the table 3.

Table 3. Result Design Element Aesthetic Concept

Kansei Word : Aesthetic Concept		
Range Rata-rata : 0.046		
Category	**Range**	**Konsep Desain**
Header Color	0.041	NS
Header Logo Position	0.039	NS
Title Font	0.034	NS
Header Size	0.040	NS
Footer Size	0.040	NS
Footer Color	0.049	Green
Top Menu	0.021	NS
Body Background Color	0.072	White

Main Body Text Font Color	0.075	Green
Total Pictures	0.008	NS
Small Pictures	0.013	NS
Large Pictures	0.055	2 and more Picture
Medium Pictures	0.047	5 and more
Body Slider	0.088	No
Body Font Type	0.065	Calibri

The average value generated for the Kansei word aesthetic concept is 0.046. This process is carried out to find out the design elements that have a major influence on the respondent's feelings or behavior (table 4).

Table 4. Result Design Element Calm Concept

Kansei Word : Calm Mode		
Range Rata-rata : 0.083		
Category	**Range**	**Konsep Desain**
Header Color	0.091	Green
Header Logo Position	0.017	NS
Title Font	0.044	NS
Header Size	0.155	Big
Footer Size	0.059	NS
Footer Color	0.255	Green
Top Menu	0.004	NS
Body Background Color	0.085	White
Main Body Text Font Color	0.021	NS
Total Pictures	0.036	NS
Small Pictures	0.023	NS
Large Pictures	0.066	NS
Medium Pictures	0.041	NS
Body Slider	0.334	No
Body Font Type	0.011	NS

For kansei word calm mode of 0.083. Then after all the design concepts have been determined from each kansei word and design elements that are used as a reference, then the next step is making a prototype. The work process flow of this application is a visualization of the results of data processing that has been carried out. The application work process flow is as follows:

User direct delivery to TPS

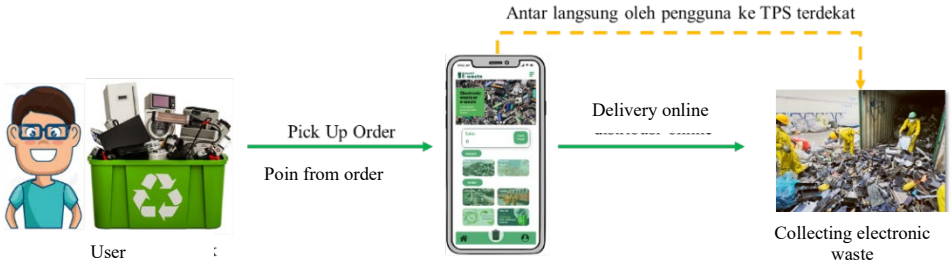


Figure 2. Task Flow application

The work process design for this electronic waste collection application is that the owner of electronic waste can pick up orders from the user's location. Then the pickup order will be processed by the application with two features, namely by online distribution, gojek, grab, or using the second feature, namely the independent feature, which is directly delivered to the nearest location according to the information from the application.

The prototype stage of design thinking is the stage of visualizing the data collection results using the Kansei engineering method as a reference in designing new design concepts. The wireframe design concept for the aesthetic concept theme is as follows in figure 3:

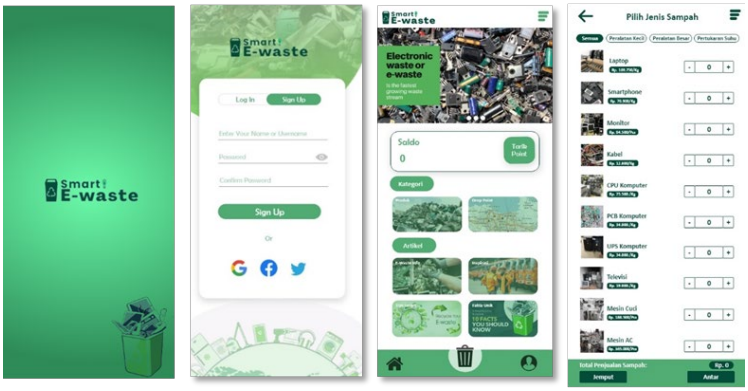


Figure 3. The wireframe design concept for the aesthetic concept

The next concept design is shown in Figure 5 with the theme of calm concept. The design is made based on the reference design elements that have been determined using the Kansei engineering method. The wireframe design for the Calm concept theme is as follows in figure 4:

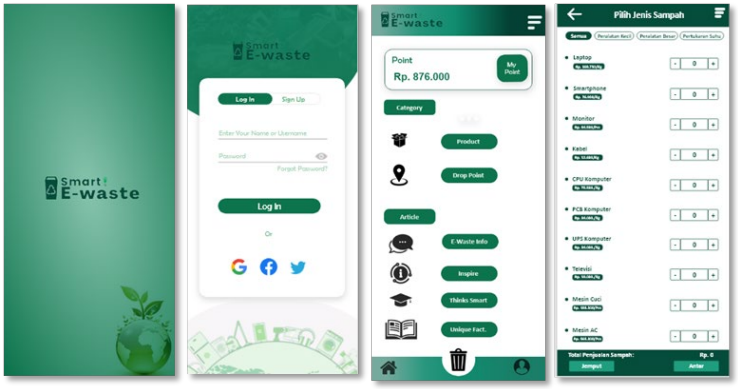


Figure 4. The Wireframe Design Concept for the Calm Concept

The next stage is the testing process using performance metrics to a total of 18 respondents, 6 from the first personas, 6 respondents from the second personas and 6 respondents from the third personas. This test uses 5 task scenarios given to respondents to collect performance metric data on the design concept that has been made, namely (figure 5)

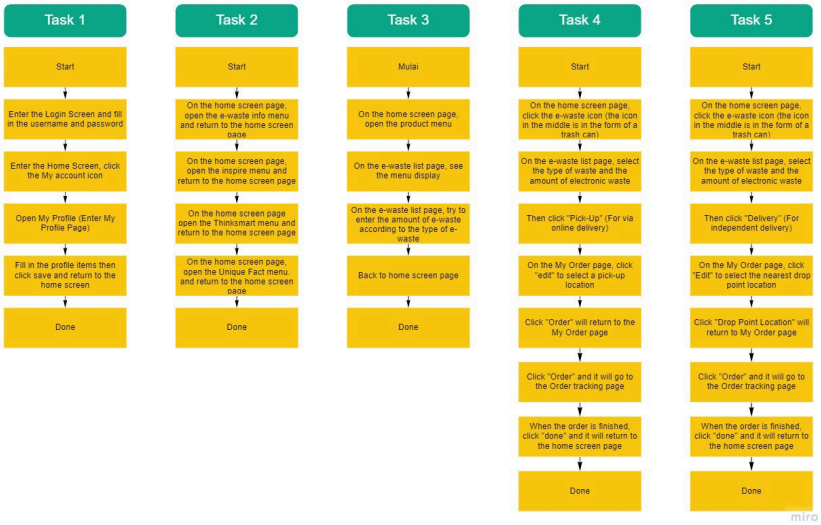


Figure 5. Performance metric task scenario

This test is carried out to find calculations from three aspects of the level of efficiency and effectiveness of the application, namely: The first component completion rate is carried out for data collection in the form of percentage data that shows how accurately the respondent can complete the task. The results of usability testing show that all personas complete their tasks to the end, 100% (Figure 6)

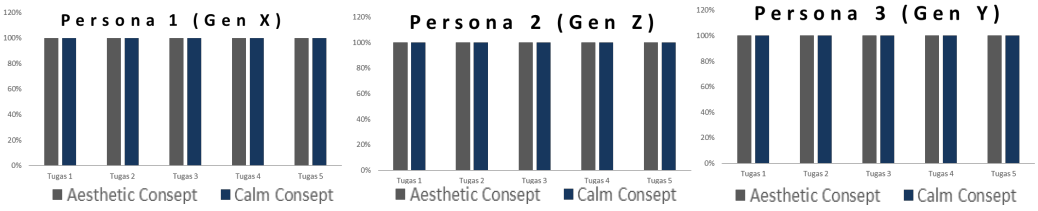


Figure 6. Completion Rate Graph Personas 1-3

The second component is time on task to measure the time it takes the respondent to complete the task scenario that has been done. Retrieval of time data on task items in the form of time data in seconds. Tasks 1-5 calm concepts require relatively longer processing time than aesthetic concepts in the three personas (Figure 7).

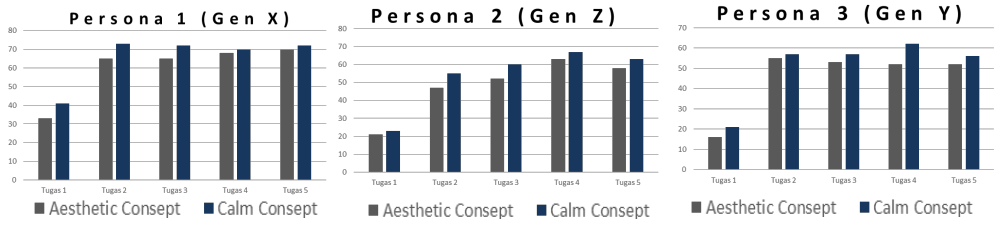


Figure 7. Time on Task Graph Personas 1-3

The third component is an error with data collection carried out from the number of errors made by the respondent when given a task that must be completed. This error is meant in the form of activities outside the scenario provisions to complete a predetermined task. From the three personas, the aesthetic concept tends to have fewer errors than the Calm Concept (Figure 8).

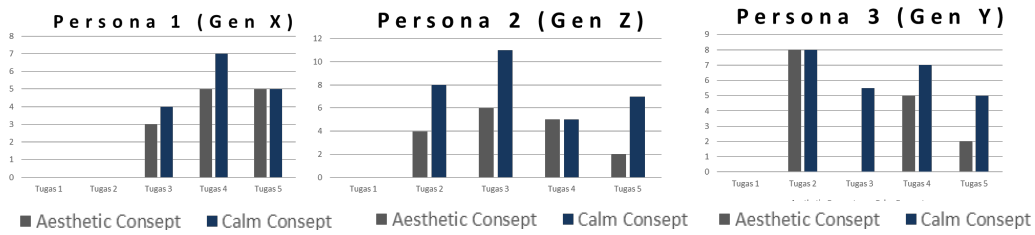


Figure 8. Error Graph Personas 1-3

Taking the PSSUQ survey through a questionnaire on personas 1, personas 2, and personas 3. This data processing uses the average value of overall satisfaction and the three subscales for each persona. Then the PSSUQ survey analysis will explain the results of usability testing to see the satisfaction of each persona. The results of the PSSUQ survey consist of 16 questions with a 7-point Likert scale with the following range 1-7 with 1 category very agree and 7 disagree. Based on the PSSUQ survey, it can be seen that the average value of system use, information quality, interface quality, and overall satisfaction is lower than the PSSUQ Norms value so the respondent's satisfaction score is in the satisfactory category. Of the two concepts, the value of system use, information quality, interface quality, and overall satisfaction tends to be a better aesthetic concept than the calm concept (Figure 9).

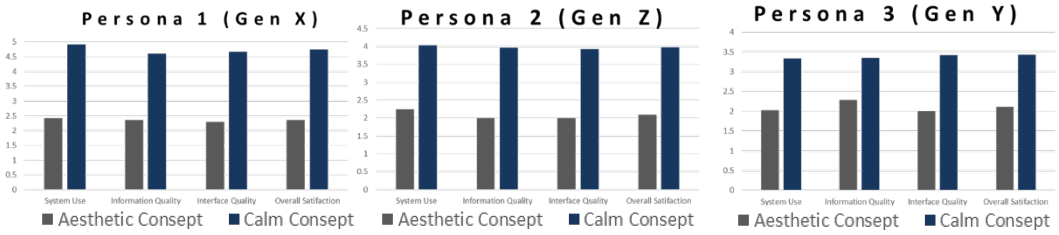


Figure 9. PSSUQ Graph Personas 1-3

6. Conclusion

The Design Thinking method is used to place the user as an objective respondent for the development of a user interface design for a waste collection application that meets user needs. Based on these results, the following conclusions can be drawn:

a. The Design Thinking methodology allows us to develop user interface prototypes for e-waste collection applications. User interface prototype design for electronic waste collection there are 2 concept designs according to data analysis from respondents.
b. The results of the testing process for both designs used performance metrics and the PSSUQ survey to measure the effectiveness and satisfaction of the designs that had been made. Based on the results of the performance metrics test on the aesthetic concept design and the calm concept of the three personas, it can be seen that the aesthetic concept design is more appropriate than the calm concept seen from the time on task and error values and the PSSUQ survey. Therefore, it can be concluded that the right design for the three personas is the aesthetic concept design.

The limitation of the research that is the focus of this research is to develop a prototype interface design for electronic waste collection applications so that for further research it is necessary to carry out further research related to analysis related to usability tests from the prototype design concept of electronic waste collection.

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