Ecofy App UX Design using User-Centered Design Approach for Waste Management

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Article Info

Abstract

Indonesia faces a significant waste management challenge, particularly with plastic waste, which poses severe environmental risks and has low recycling rates. This study aims to address these challenges by designing and developing the Ecofy application using the User-Centered Design (UCD) approach. The focus is on creating a solution that not only meets user needs but also effectively facilitates the waste management process, making it more accessible and efficient for the general population. The UCD methodology was employed to ensure that the application's features are intuitive, user-friendly, and tailored to the local waste bank model, which encourages recycling at the community level. The research involved multiple stages, including user needs assessment, iterative design, and usability testing, to refine the application. The findings demonstrate that the Ecofy application significantly enhances the effectiveness of waste management by offering practical tools for users to sort, manage, and recycle waste. Furthermore, the implementation of this application is projected to reduce the burden on Final Processing Sites (TPA), lower environmental pollution, and increase recycling rates, especially for non-biodegradable materials like plastic. The success of Ecofy could serve as a model for other regions facing similar waste management issues, contributing to broader sustainable development goals in Indonesia.

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INTRODUCTION

The waste problem in Indonesia is a serious issue that involves various environmental, health, and social aspects. Every year, Indonesia produces millions of tons of waste, with around 64 million tons recorded in 2020(Gutama & Iresha, 2023). Waste in Indonesia consists of various types, including organic waste, plastic, paper and metal, with plastic waste being of particular concern because it is difficult to decompose and pollutes the environment in the long term (Wibowo et al., 2021). In addition to inorganic waste, organic waste can cause its own problems. Piles of organic waste can form methane gas, while methane gas itself is one of the causes of the formation of greenhouse gases in the atmosphere after carbon dioxide gas (Ro'aini & Azizah, 2024).

Currently, the accumulation of inorganic and organic waste causes many problems for the environment. According to data from the Ministry of Environment and Forestry (KLHK), in 2023, around 65.83% of waste in Indonesia will be disposed of at the final processing site (TPA). Waste management that only relies on TPA has various negative impacts on the environment. One of the main impacts is soil and water pollution due to leachate. Soil and water pollution due to leachate, which is a liquid that forms when rainwater seeps through piles of waste and carries with it various hazardous contaminants, is one of the main impacts of waste management problems (Suleman et al., 2023). Landfills are also a major source of greenhouse gas emissions, especially methane, which contribute significantly to climate change. (Przydatek et al., 2024).

In addition to the huge amount of waste in Indonesia and the environmental impact it produces, the level of waste recycling in Indonesia is still relatively low. Data from the Ministry of Environment and Forestry (KLHK) shows that in 2023, the level of plastic waste recycling in Indonesia will only be around 7% of the total plastic waste produced.

This figure is far below the recycling rates in other countries that are more advanced in waste management. For example, in Europe, the recycling rate of plastic waste can reach more than 30%, with some countries even exceeding 50%. This low recycling rate has a significant impact on the environment. Unmanaged plastic often ends up in landfills or in the natural environment, causing soil and water pollution and contributing to greenhouse gas emissions.

The waste problem in Indonesia, involving large volumes of waste and low recycling rates, demands innovative and sustainable solutions. Waste banks are present as one of the effective solutions to reduce waste generation and increase recycling rates. (Ariefahnoor et al., 2020). A waste bank is a system where people can deposit sorted waste for recycling, and in return, they get economic incentives, such as cash or other forms of exchange value. Waste banks have great potential to reduce the amount of waste that ends up in final processing sites (TPA) (Wahyuni et al., 2022). With the existence of waste banks, people are encouraged to separate organic and inorganic waste from the source. Inorganic waste that still has economic value, such as plastic, paper, and metal, is collected in waste banks to be recycled. This directly reduces the volume of waste that must be managed by landfills and reduces the risk of soil and water pollution caused by leachate. (Ivakdalam & Far, 2022). Waste banks play a vital role in increasing recycling rates in Indonesia. With the existence of waste banks, recyclable materials become more accessible to the recycling industry. This helps increase the supply of recyclable materials needed by the industry, while reducing dependence on new raw materials that are often more environmentally damaging.

There are solutions that can be used to realize a waste bank, one of which is the development of a waste bank application. In developing the application, several things must be considered, for example, user comfort in running the application. It must be considered whether the design that is designed does not make users feel confused, whether the navigation in the application is clear and contains information that is easy to understand, and whether the features in the application already describe the waste bank model at the location where the waste bank is located. (Sunartama et al., 2023). To realize the design of a waste bank application, an appropriate method is required.

This study (Haidar Luthfi & Arfiani, 2024a; Putra & Ma'sum, 2024) designed two waste management applications using different approaches: User-Centered Design (UCD) for the Sampahocity application and Design Thinking for the waste pick-up application in Indonesia. Both are designed to improve the efficiency and convenience of users in managing waste, with features such as waste categorization, pickup orders, and drop-off to waste banks. The test results show that both applications are user-friendly and receive good ratings, supporting increased public awareness of the importance of effective waste management.

In contrast, this research uses a more comprehensive method by integrating

Hierarchical Task Analysis (HTA) to detail user needs more specifically and emphasizes community-based waste management with features that support environmental sustainability and increase waste recycling. In addition, this journal pays special attention to the waste bank model and features that are in accordance with local needs, while previous journals focused more on the aspects of waste collection and pick-up.

The method that will be used is User Centered Design (UCD) as shown in Figure 1. UCD is a user-centered problem-solving methodology, starting with assessing user needs and finding innovative solution ns to address the issues identified. This approach allows developers to better understand user needs and create more effective solutions. The data collected will be used to identify areas for improvement in the application, such as adding new features, improving usability, and ensuring the application provides benefits to users in managing waste. The data collected will also be used to contribute to sustainable solutions to the waste problem in Indonesia. (Haidar Luthfi & Arfiani, 2024b).

From the previous explanation, it is known that the waste problem in Indonesia is increasingly concerning. The increasing volume of waste and the low level of waste recycling are major challenges. Waste banks are present as an effective solution to reduce waste generation and increase recycling. In realizing the waste bank model, it is necessary to develop an appropriate waste bank application design. This application will be designed with an intuitive design, complete features, and easy to use by various groups of people. By using the User Centered Design (UCD) method, it is hoped that public interest in using waste banks will increase, public participation in waste recycling will increase, the amount of waste disposed of to landfills will decrease, the level of waste recycling in Indonesia will increase, and environmental pollution due to waste will decrease. The development of a waste bank application with a user-friendly design is an important step in overcoming the waste problem in Indonesia and achieving sustainable development goals.

METHODS

A. Planning a Human-Centered Process

At this stage, the UX design process for the Ecofy application begins by identifying user characteristics that match the target needs in waste management. This information is organized in the form of personas and mental models. Personas help understand the user's initial experiences, needs, and problems in waste management, including personal data, problems, needs, and motivations. Mental models are created based on the results of the questionnaire to understand what users know about waste management.
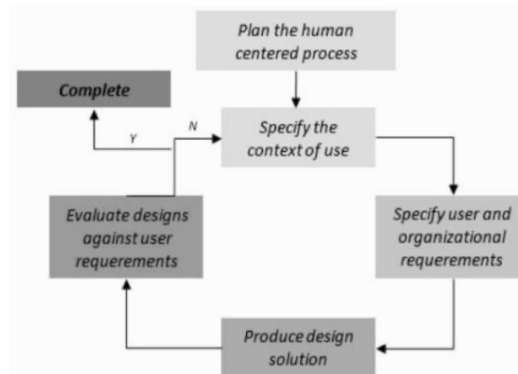

Figure 1. User-Centered Design Stages (Abras et al., 2004)

B. Determining the Context of Use

This step involves determining the context of use of the Ecofy application to understand how users will interact with the application in various situations related to waste management. This helps map the use of the application in the user's daily life.

C. Determining User Requirements

At this stage, user needs for the Ecofy application are identified and described in the form of a Hierarchical Task Analysis (HTA). This task analysis is designed to understand how users' complete tasks related to waste management using the application, so that users can achieve their goals effectively.

D. Defining the Solution

This step involves designing a design solution for the Ecofy application, including creating wireframes, application interfaces, and style guides. Wireframes and style guides are prepared to ensure consistency in the application design. Wireframes provide an overview of the application design structure, while style guides maintain the consistency of components in the application. Furthermore, the application interface is created in the form of a high-fidelity prototype.

E. Evaluation of Requirements

At this stage, usability testing of the Ecofy application is carried out using the System Usability Scale (SUS) method for target users. The purpose of this test is to assess the level of usability of the application in the context of waste management. The test results are analyzed, and if

the results are not satisfactory, iterations are performed to improve the design until the application meets user expectations. If the test results are satisfactory, the process continues to the next stage.

RESULTS AND DISCUSSION
A. Planning Human-Centered Processes

The questionnaire, in the form of a digital survey, was given to two user roles with different personas for each user role. The difference in personas aims to gain insight from several users widely because each persona has a different identity and behavior towards the application to be developed. In this writing, the questionnaire was given by involving 10 respondents consisting of 5 residents, 5 managers/villages, with 14 questions.

Tabel 1. Questionnaire

Number	Question	Answer Options
1	How much waste do you produce at home per day/week/month?	- Less than 1 kg - 1-2 kg - 3-5 kg - More than 5 kg
2	How do you usually dispose of your household waste?	- Thrown into public waste bins - Burned - Composted - Sold to waste collectors - Other methods (mention)
3	Do you have difficulty managing your household waste?	- Never - Rarely - Sometimes - Often - Always
4	What are the main obstacles you face in managing your household waste?	- Inadequate waste disposal sites - Lack of education about waste management - High waste management costs - Lack of time to manage waste - Other obstacles (mention)
5	Do you know about the waste bank program?	- Yes - No
6	If yes, have you ever participated in a waste bank program?	- Yes - No
7	What do you know about the benefits of the waste bank program?	- (Fill in the answer freely)
8	Are you willing to participate in a village waste management program?	- Yes - No
9	If yes, what type of village waste management program are you interested in?	- Scheduled waste collection - Waste sorting at home - Organic waste composting - Waste banks - Other programs (mention)
10	Are you willing to sort your household waste by type?	- Yes - No
11	Are you willing to deposit your organic waste to the village waste bank?	- Yes - No
12	Are you willing to pay a monthly fee for the village waste management program?	- Yes - No
13	How much are you willing to pay per month for the village waste management program?	- (Fill in the answer in the form of rupiah)
14	What are your expectations for the village waste management program?	- (Fill in the answer freely)

Based on the questions in the questionnaire, it can be concluded that residents need waste management for several main reasons:

1. Difficulty in managing their own waste:
   Many residents have difficulty in managing their household waste, either due to limited landfills, lack of education, or other obstacles.
2. Funding needs for organic waste management:
   Villages need funds to run organic waste management programs, such as collecting, processing, and recycling organic waste. A waste bank with a waste management subscription can be a solution to help villages obtain these funds through community participation.
3. Improving the cleanliness and health of the village environment:
   Good waste management can help maintain the cleanliness and health of the village environment.

4. Encouraging community participation and concern:
   Village waste management programs can be a forum for the community to participate and show their concern for the environment.
5. Supporting environmental sustainability:
   Sustainable waste management can help reduce negative impacts on the environment, such as soil, water, and air pollution.

B. Determining the Context of Use
   Based on the results of the research conducted at the "Specify the Context of Use" stage in the Ecofy application research, an in-depth understanding of potential application users was conducted to determine their needs and expectations. This process begins with interviews with individuals who act as primary users in waste management in their environment.

Table 2. User Persona

User Persona		
Demographics	1.	Name: Rini Andriani
	2.	Age: 38 Years
	3.	Gender: Female
	4.	Status: Married
	5.	Occupation: Housewife
Activities	1.	Separating household waste for recycling.
	2.	Collecting organic waste for compost.
	3.	Using an application to order waste collection services.
Expertise	1.	Familiar with using smartphone applications.
	2.	Understanding the basics of waste management.
Motivation and Goals	1.	Keeping the environment clean.
	2.	Reducing household waste.
	3.	Educating children about the importance of recycling.
Problems	1.	Difficulty finding timely waste collection services.
	2.	Lack of information on how to recycle properly.
	3.	Inconvenience in using existing waste management applications.
Needs	1.	Easy-to-use and intuitive application.
	2.	Feature to schedule waste pickup.
	3.	Practical guide on how to separate and recycle waste.

Once the user persona is determined, a mental model design is carried out to understand how users think and interact with the waste management application. This mental model is important to ensure that the application is designed according to the habits and needs of users in their daily lives.

1. Users want an application that provides step-by-step guidance in waste management.
2. Users expect the application to provide notifications for waste collection schedules.
3. Users are more comfortable with a simple interface that immediately shows the main features.

   This knowledge is applied in the design of the Ecofy application prototype, ensuring that the designed solution truly meets the needs and preferences of users. The results of this stage are an important basis for further development of the application interface and its main features.

C. Defining User Requirements

In the "Specify User Requirement" stage of Ecofy application research, user needs are identified and described in detail to ensure the application can effectively meet the waste management objectives. This process involves analyzing user tasks through the Hierarchical Task Analysis (HTA) approach, which helps break down large tasks into more specific and structured sub-tasks.

1. Login and Register View
   a. Login:
      1) The user opens the Bank Sampah application.
      2) On the home screen, the user will see the option to Login or Register.
      3) If the user already has an account, they enter their email and password to log in.
      4) If they forget their password, they can click "Forgot Password?" which will direct them to a page to reset their password.
      5) The user enters their email, and the system sends an OTP code for confirmation.
      6) The user enters the OTP code and resets their password.
   b. Register:
      1) If the user does not have an account, they click on "Register Account".
      2) The user fills out the registration form with information such as name, email, and phone number.
      3) After registering, the system sends an OTP code to the email/phone for verification.
      4) The user enters the OTP code, and their account is active.
      5) The user then completes the profile with additional information such as address, trash pickup preferences, etc.

2. Customer Home Menu View
   a. After logging in, users will be directed to the Home page.
   b. On the Home page, there are several main menus: Subscription Registration, Subscription Payment, List of Waste Disposal Sites (TPS), and Customer Notifications.
   c. Users can register for a subscription by selecting the desired package and making payments directly from the application.
   d. Users can see a list of the nearest TPS to dispose of waste.
   e. Notifications update waste collection schedules, promotions, or other important information.

3. Customer Account and Profile Views
   a. Users can access and customize their profiles.
   b. On the profile page, users can change personal information, address, trash pickup preferences, etc.

4. Home View: Coin History, BSCOIN Page, and Leaderboards
   a. On the Home page, users can also view their BSCOIN history (coins earned from certain activities).
   b. The BSCOIN page shows the current coin balance and transactions that have been made.
   c. Leaderboards display user rankings based on the number of coins collected, to encourage healthy competition and active participation.

5. Organic Pickup Feature
   a. Users can order organic waste pick-up services.
   b. In this feature, users select the date and time of pick-up.
   c. The manager will receive the request and pick up the waste according to the specified schedule.

6. Product List View
   a. Users can view various products for sale.
   b. Products can be purchased using BSCOIN or pay on the spot.
   c. Users select the desired product, add it to the shopping cart, and complete the purchase.

7. Home is Deactivated if Residents No Longer Use Subscriptions
   a. If a user's subscription expires or is not renewed, the Home page displays a message that the service is inactive.
   b. The user is given the option to renew the subscription or unsubscribe.

8. Customer Notifications and Subscription Details
   a. Users receive notifications regarding subscription details, including expiration date, payment, and renewal reminders.
   b. Users can review their subscription details and choose to renew or terminate their subscription.

9. Payment Features
   a. There is a special page for subscription payments.
   b. Users can view payment status, available payment methods, and transaction history.

10. Home View If Citizen Unsubscribes
    If the user decides to unsubscribe, the Home page will display information that the service is inactive and provide the option to reactivate the subscription if desired.

11. Admin Page
    a. Admin login and directed to admin dashboard page.
    b. There are options for TPS data collection and new admin data collection.
    c. Admin can add or edit TPS and admin information.

12. Admin Menu View
    a. On the admin dashboard page, there are menus such as Home, sidebar for navigation, admin profile settings, and notification settings.
    b. Admins can customize their profiles and set the notifications they want to receive.

13. Admin Features: Income Details, Waste Recording, Customer Management
    a. Admin can view details of income from subscriptions and other transactions.
    b. The waste recording feature allows admin to record the amount of waste received and processed.
    c. Customer management includes customer details, subscription registration, price settings, adding coins, and subscription time.

14. Admin Features: Store Settings
    a. Admin can add, change, or archive products in the store.
    b. There are features to change product data and view customer purchase details.

15. Admin Features: Customer Details
    a. Admin can view customer details, activate or deactivate customers.
    b. Admin can review customer activity history and customize services as needed.

By analyzing these tasks, the Ecofy application is designed to provide ease and convenience for users in managing waste more effectively. Each step in the task analysis ensures that the application meets the needs of users by providing relevant and easily accessible features. This process also helps in identifying areas that require further improvement or adjustment in the application design.

D. Defining the Solution
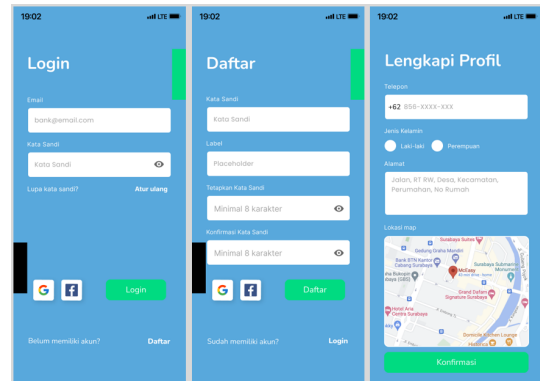1. Login and register to view
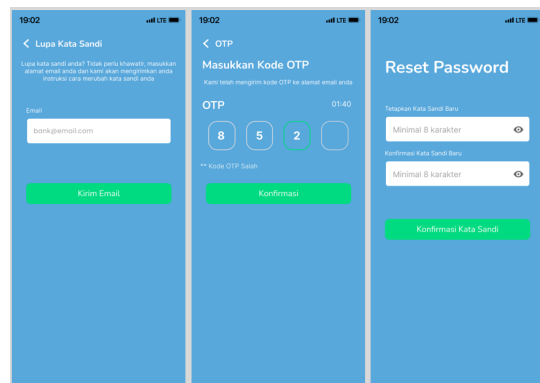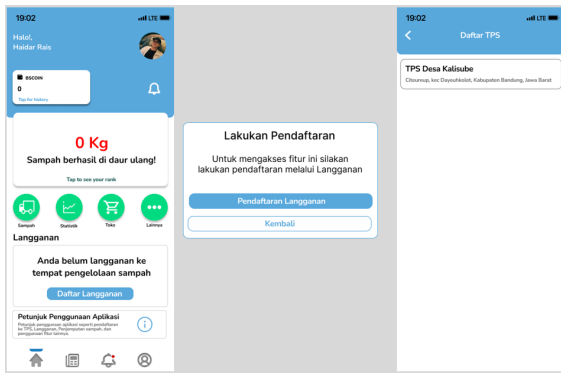

Figure 2. (a) Login View

Figure 2. (b) Register View

Figure 2 (a) and Figure 2 (b) show the view of the pages on the login and register menu. There are login pages, account registration, complete profile, change password, confirm otp code, and reset password.

2. Customer Home Menu Display, Subscription Registration, Subscription Payment, and Customer Notifications

Figure 3. (a) Home Menu

Figure 5. Home, Coins, and Leaderboard

Figure 5 shows the view from the home page. There is a BSCOIN page to store coins and a leaderboards display.
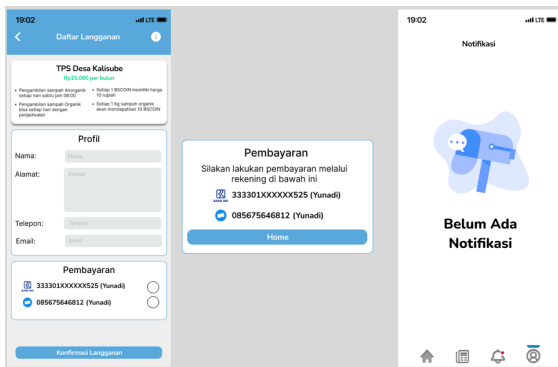
5. Organic Waste Pickup Feature

Figure 3. (b) Subscription Registration, and Notifications View

Figure 3 (a) and Figure 3 (b) depict the view of the pages on the home menu. There are subscription registration and notification pages.
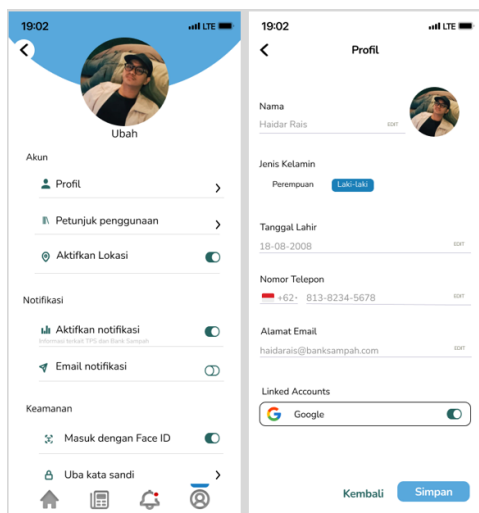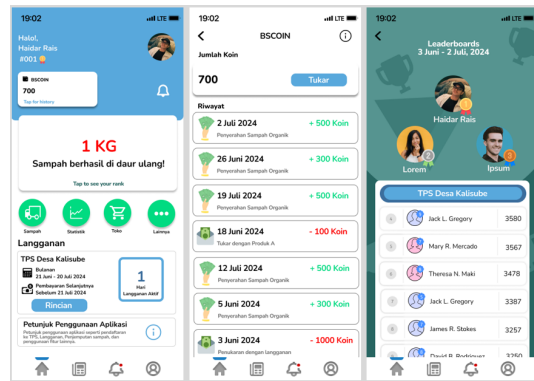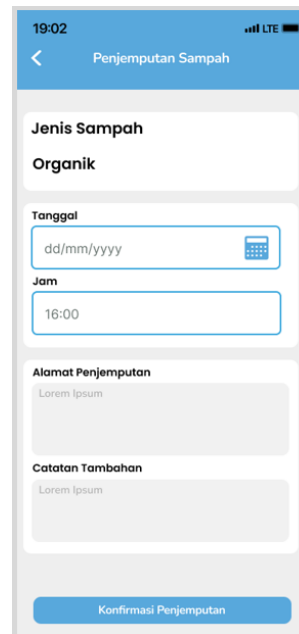
3. Customer Accounts and Profiles

Figure 6. Organic Waste Pickup

Figure 6 shows the feature serves as a liaison between residents and managers. Managers will pick up organic waste directly to residents' homes according to the date and time specified by the user.

6. Product List, Store Items, and Purchase Items

Figure 4. Profile Page

Figure 4 shows the profile page of the application.
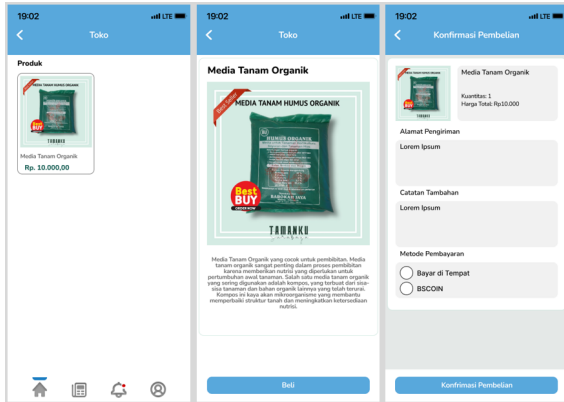
4. Home, Coin History, and Leaderboard

Figure 7. Shop Menu

Figure 7 depict the view from the Store page. There is a Store page that provides products and a display of purchasing goods.
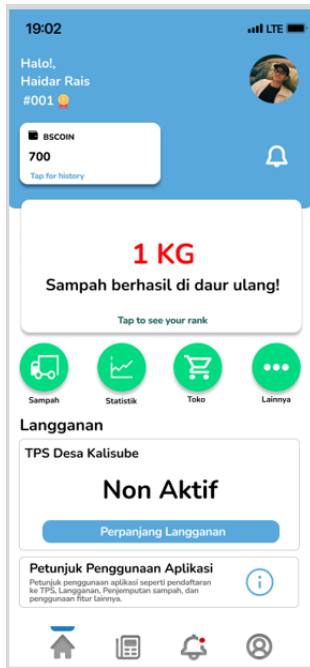
7.   Home Non Active

Figure 8. Home Non Aktif

In Figure 8, if a resident does not renew their subscription, the subscription will automatically be deactivated.

8.   Customer Notifications, Subscription Details, Subscription Renewal Confirmation, and Subscription Termination Confirmation
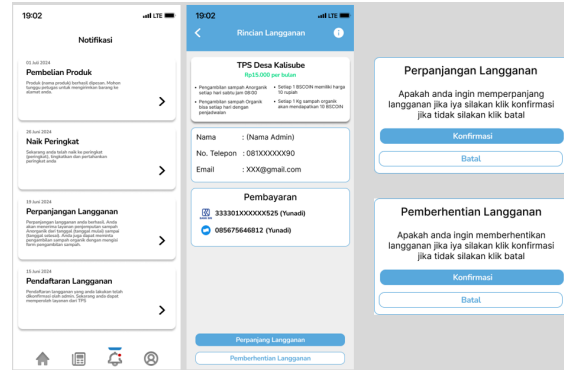

Figure 9. Notifications and Subscriptions

In Figure 9 there is a Notification and Subscription Details page so that residents can check the details, there is also a feature to extend the subscription or cancel the subscription.
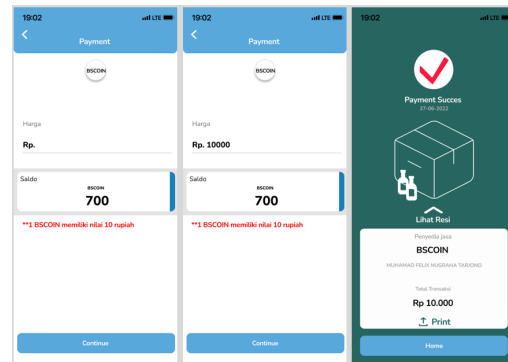
9.   Payment

Figure 10. Product Payment

Figure 10 shows the view of the payment. There is a payment page and payment status.

E.   Evaluation of Requirements

Testing is done with 10 users working on steps to solve a case. The success result is determined by the user having completed the steps from start to finish. The value of the test is determined by whether or not the user experiences obstacles, and the processing time. If in a step the user can pass it without obstacles, then the value of the step is worth the green symbol. If in a step the user needs a specified time to pass it, then the value will be symbolized in yellow. Then if the user cannot pass it in a step and the user asks the technician, then the value of the step will be symbolized in red.

1.   Case 1
    a.   Access the home menu before subscribing.
    b.   Access the subscription menu by pressing the Register Subscription button

to enter the 3rd image, return to the home menu then enter the TPS Register menu by pressing the green icon to enter the 2nd image, press the Subscription Registration button to enter the 3rd image.
c. Select TPS and enter the fourth image.
d. Fill in the customer profile, then select the subscription payment method, and enter the fifth image by pressing the Confirm Subscription button.
e. Return to the Home menu by pressing the Home button and entering the sixth image.

Table 3. Case 1 Test Results

	Step 1	Step 2	Step 3	Step 4	Step 5
User 1					
User 2		RED			
User 3				YELLOW	
User 4					
User 5		YELLOW			
User 6		YELLOW			
User 7					
User 8					
User 9					
User 10					

The results of Case Test 1, as shown in Table 3, prove that almost all users can use this application, but there is one user who failed in Step 2 because he did not understand the instructions given.

2. Case 2
   a. From the Home menu, go to the waste recording menu, select a customer, fill in the waste column with grams, click Save, then return to the Home menu.
   b. Click the Customer Management icon, select a customer, click the Add Coin button, fill in the Add Coin column with a number, then click Save.
   c. Still in the Customer Details menu, click the Add Subscription Time button, fill in the Add Duration column with the number of days, then click Save.
   d. Return to the Home menu, click the Price Recording icon, fill in the Price 1 Coin, Description, and Coin Price Settings columns, then click Save.
   e. Return to the Home menu, click the Shop icon, click the New Product button, fill in the Product Name, Description, and Product Price columns, then click Save and return to the Home menu.

Table 4. Case 2 Test Results

	Step 1	Step 2	Step 3	Step 4	Step 5
User 1					
User 2		YELLOW		YELLOW	
User 3					
User 4			RED		
User 5			YELLOW		
User 6			YELLOW	YELLOW	
User 7					
User 8					
User 9					
User 10					

The results of Case Test 2 as shown in Table 4 prove that in general the payment feature runs quite well, but there are some users who are still confused at stages two to four.

CONCLUSION

Based on the research conducted, the Ecofy application was successfully developed with a User-Centered Design approach to meet the needs of waste management in Indonesia. This application provides intuitive and easy-to-use features, which can increase user involvement in recycling and waste management activities. With this application, it is expected to reduce the burden on landfills and increase recycling rates, especially for plastic waste that is difficult to decompose. Further development and widespread implementation of this application can significantly contribute to overcoming waste problems in Indonesia and supporting sustainable waste management programs.

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