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Mobile-based Waste Bank Aplication Design: A Case Study of the Anggrek Sectoral Waste Bank

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KEYWORDS
waste; waste bank; prototype; black-box; system usability scale

ABSTRACT
Waste banks are a solution proposed by the government to manage waste collectively and help reduce waste problems. However, over time, several issues have arisen, such as the process of depositing waste by customers who have to bring waste to the waste bank location, manual recording of waste deposit data, and withdrawal of savings balances that still require personal communication with the management. Therefore, an application is needed to address these problems of waste banks. This study aims to design a real-time Android application to overcome these challenges, with a case study on the Anggrek Sectoral Waste Bank in Wiyung District, Surabaya. The development of this application uses the prototype development method. The results show that the application performed successfully in all situations, with a satisfactory level of user satisfaction. This is evidenced by the results of testing using 46 test cases with Black Box Testing and evaluations of 35 respondents using the System Usability Scale questionnaire, which yielded a score of 75. The combination of good functional performance and high satisfaction indicates that this application is ready to be used optimally according to the needs of the waste bank.

Introduction

Waste management is a significant problem faced by the community, both in urban and rural areas, because every individual produces waste. The increase in Indonesia's population of 276 million people in 2023 exacerbates this situation, with the amount of national waste recorded at 13,653,648.03 tons. Every year, it is certain that the volume of waste will always increase along with the increasing pattern of public consumerism (Amaliah, 2020)(S., 2024) (Ediana et al., 2021).

One of the solutions that has been implemented to overcome the waste problem is the existence of a waste bank, which functions as a community-based waste management system with a focus on recycling. The Anggrek Sectoral Waste Bank (BSSA), located in Wiyung District, Surabaya, has been operating since 2015 and aims to invite residents to sort waste that has a selling value. However, many waste banks still face operational

constraints, such as difficulties in recording transactions, managing member data, and monitoring the flow of waste in and out (Susilowati et al., 2023)(Kurniasih et al., 2024).

As technology develops, several studies have shown the benefits of using digital applications to improve data management efficiency. For example, the development of Android-based applications for waste management has proven to be effective in making it easier for customers to make transactions and obtain information in real-time. This solution helps in reducing recording errors and increasing customer involvement in waste bank activities (Yunita et al., 2021).

Although digital application solutions have shown positive results, there are still gaps in terms of system integration and user experience. Some apps do not fully accommodate the specific needs of each waste bank. And also the lack of additional features that can further motivate customers to actively participate. In addition, limited access and digital literacy in some regions are also obstacles to the implementation of this technology evenly.

In this study, the prototype method is used as a software development project management method. This method has the advantage of generating rapid iterations and receiving direct feedback from users, which increases accuracy in meeting user needs.

This research offers the development of an Android application specifically designed for the needs of the Orchid Sectoral Waste Bank. The app will include features such as customer registration, waste deposits, digital balance withdrawals, and real-time monitoring of savings balances. By integrating e-wallet technology, this application is expected to improve waste management efficiency and provide convenience for customers in accessing waste bank services.

The research began with the problem identification stage, where the needs to be overcome through application design at the Orchid Sectoral Waste Bank (BSSA) were identified. The next step is to conduct a literature review to obtain the latest knowledge and information related to the problems that have been identified and to find solutions or approaches that have been implemented by other organizations. After that, an application design analysis is carried out to provide clear guidance in the development process and ensure that the application created has a well-structured architecture. The development of the application is carried out after the completion of the design analysis, and the application is developed according to the design that has been prepared. The final stage is evaluation, where the application that has been built is tested in terms of performance, reliability, security, and usability. The results of this evaluation provide feedback on the effectiveness and success of the application.

Research Methods

In designing this application, the Prototype method is used. This method was chosen based on a literature review which shows that the Prototype method gets optimal results in iterative application development and the implementation of improvements based on direct feedback from users, namely customers and managers from the Sectoral Waste Bank. The use of the Prototype method in app development provides flexibility for rapid iteration based on feedback from users, which is critical to the success of apps that focus on the specific needs of the community. The development process includes several stages. First, the creation of (Amaliah, 2020) a prototype display with the main features of the application. Furthermore, a prototype is directly tested to users from the waste bank application to evaluate the effectiveness and ease of use of the application.

Critical feedback from users during the test will be used to make changes and adjustments to the features and design of the application according to the preferences of the user.

Use cases describe processes or needs on the user side. Use case diagrams relate to events and events (scenarios) are examples of what happens when a person interacts with a system (Andriyanto & Wansen, 2019; Surorejo & Murtopo, 2023). In application design, you can use *the Unified Modeling Languange* (UML) model to present user needs, one of which is *use cases* (Firmansyah et al., 2019). Usecases work by describing typical interactions between actors and their own systems through a story of how a system is used (Anraeni et al., 2020).

There are two types of users in the system, namely customers and managers. In the use case, the customer is a representation of the interaction between the customer and the system. *This customer use case* diagram has 1 actor who plays a role in this customer *use case*. Starting from logging in to the application to being able to withdraw balances, deposit garbage, check balances, view notifications, view customer personal data profiles, view information on types of waste, pick up garbage and can also view news.

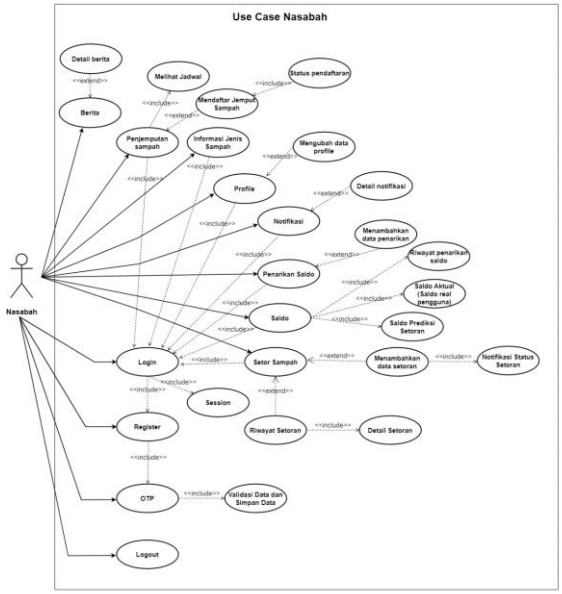

Figure 1. *Use Case* Customer Diagram

The customer use case is a representation of the interaction between the manager or admin and the system. *The use case* diagram of this manager has 1 actor who plays a role in this manager's *use case*, namely the manager of the Orchid Sectoral waste bank. Starting from logging in to the application to being able to deposit customer waste, weighing waste deposits, viewing waste deposit history, viewing balance withdrawal history, managing customer profile data, managing waste types, managing waste selling prices, managing garbage pick-up scheduling, and managing news that will be displayed to customers.

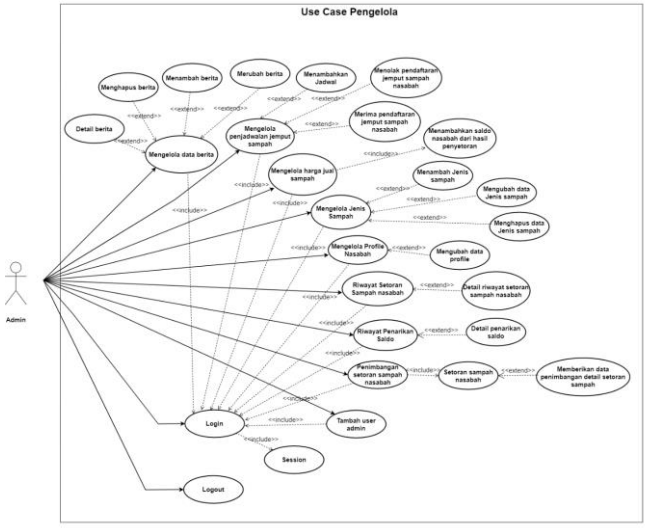

Figure 2. *Use Case* Diagram Manager

Test Scenarios

This study uses two testing methods, namely *Black Box* and *Usability testing*. *Black Box Testing* is a software testing method that focuses on software functionality features without testing the program code. The tester can determine the input conditions and test the program based on its functional specifications. The b*lack box* testing method aims to detect potential errors that may occur when performing data input, which will be reflected through the error display in the software in the event of an error (Fitriana et al., 2022). The use of the method in this study is used to test the functionality and interface appearance of the software. The *black box* which results from this test will be the basis for evaluation, so that if an error display or an unfriendly interface is found and if there is a request from the user. Improvements will be implemented in the next prototype phase (Airudani & Retnowo, 2023). The explanation of the columns in Table 1 is: column number 1 contains related to *the test case* code and test page, column number 2 contains about the case testing to be carried out, then column number 3 contains the expected results from testing, and column number 4 contains the observation results whether it is in accordance with the expected or not.

Table 1. *Black Box* Testing *Case Template*

(1)	**Test code**	**Activity**
(2)	Case	
(3)	Result	
(4)	Appropriate or inappropriate	

Another test used in this system is *usability testing*, which is evaluated so that it can be used easily and effectively by users. This *usability testing* uses *the System Usability Scale (SUS*), because in research from (Widayanti & Maknunah, 2021), *the System Usabilty Scale* is the *most popular, reliable and effective usability testing tool and cheap in its application.*

To assess the R score, there are calculation rules that need to be known:

a) For Each question the odd order will be reduced by a value of one.
b) For each question in even order will be subtracted from the value of 5.
c) Add the values of the even-numbered and odd-numbered questions. Then the result of the addition is multiplied by 2.5.

SUS Formula:

$$x = \frac{\sum x}{n}$$

where X is the average score, then for ∑ x is the sum of the SUS scores, and for n is the number of respondents.

Figure 3. Range of SUS Assessment Results Category

Figure 3 shows the categories of SUS assessment results. There are 6 categories, namely very bad, bad, enough, good, good, very good.

Prototype Method

The prototype method is a method used to quickly explore user needs. The main focus of this method is to show the software features to the user through an experimental model, which will be directly evaluated by the user to better understand and find additional needs related to the development of the software (Aji et al., 2023).

Results and Discussions

Application

The implementation stage is a design conversion – a design that has been created using tools and programming languages to produce an application that can be used (Suryadi, 2018). This application is designed for three types of users, namely guests, customers, and managers with different access and features. Each type of user has different access and features according to their needs and roles. The following is a prototype of an application that has been designed based on the design.

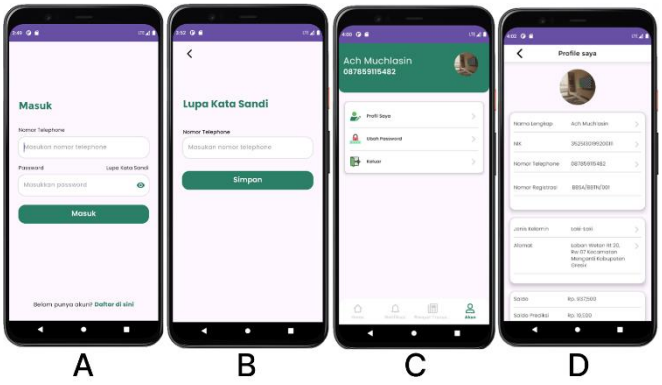

Figure 4. Guest interface display. Login page (A), Forgot password (B), Account (C), Profile (D)

First the Guest view. The login page is the starting point for all users. Here, users must enter their phone number and password for authentication, or press the text "Register here" to head to the account registration page. The forgot password page provides a password replacement mechanism. Users are asked to enter the old password, the new

password, and confirm the new password. After pressing the "Save" button, the system will notify you of the status of the password change.

Account pages allow managers and customers to view profile details, change passwords, and log out of apps. Admins have an additional menu to add new admins, making it easier to manage other users. Finally, the user profile details page allows users to view and change their profile information. For admins, balance, NIK, and registration number are not available. Some profile data can be changed, but the balance and registration number cannot be changed

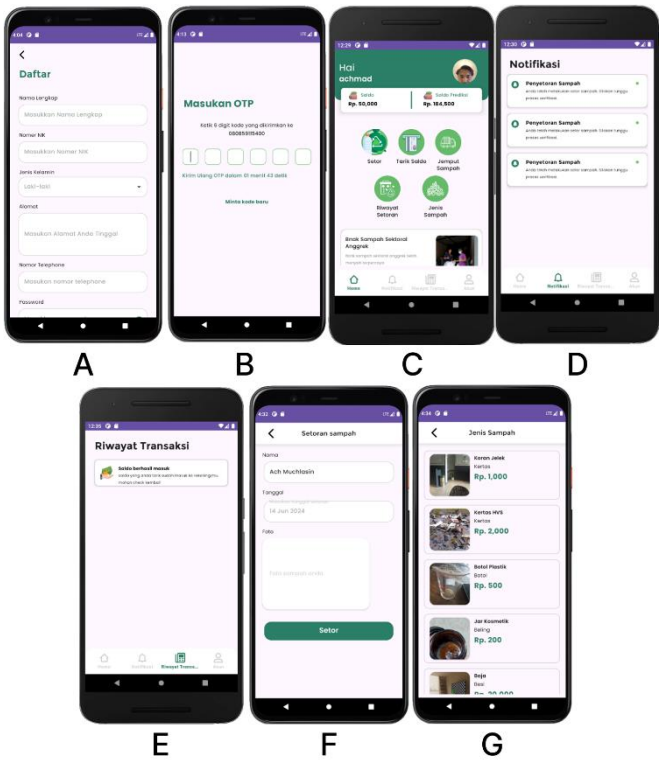

Figure 5. Customer Interface Display. Register page (A), OTP (B), Home (C), Notification (D), Transaction History (E), Waste Deposit (F), Type of Waste (G).

The application interface for customers is designed to meet the needs of users with a variety of specific features. The registration page allows customers to register by filling in personal data such as name, NIK, gender, address, and password, then directed to the OTP Page. On this OTP page, customers enter a code sent via WhatsApp.

The customer's home page provides real balance information, deposit prediction balances, and features such as garbage deposits, balance withdrawals, garbage pickups, deposit history, waste types, warehouse opening schedules, and news lists. The notification page displays notifications from customer activity such as balance withdrawals and trash deposits, with the option to view the details of each notification.

On the Transaction history page, customers can check and verify the status of their transactions, including withdrawal of balances and predicted balances from deposits. The garbage deposit page is designed to support the registration of garbage deposits by uploading photos of garbage for verification and weighing. Finally, the Waste type page allows customers to view data on the type of waste, categories, and prices of waste that can be deposited without being able to make changes.

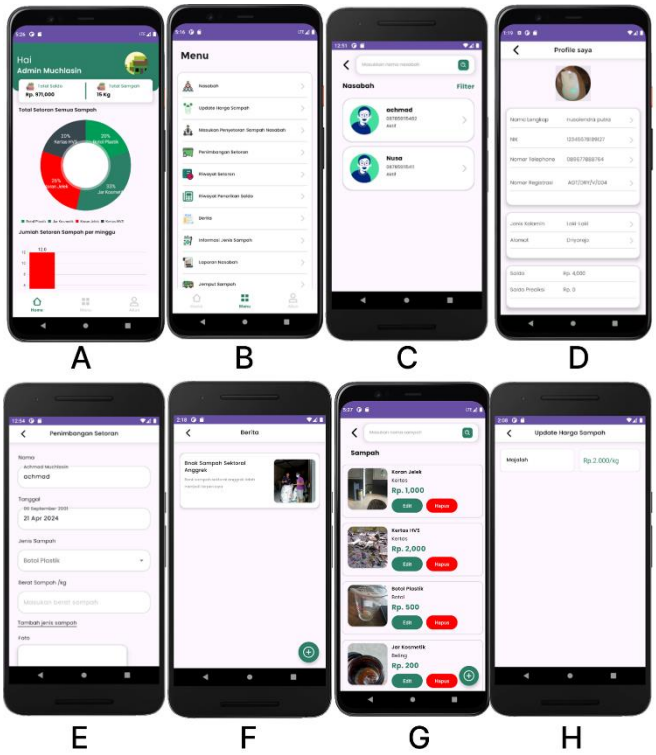

Figure 6. Manager interface display. Home Page (A), Menu (B), Customer Management (C), Customer Details (D), Deposit Weighing (E), News Management (F), Waste Type Information (G), Waste Price Update (H)

The waste bank app manager interface is designed to make operational management easier. The manager's home page displays the total balance of all customers, the total incoming garbage, and a chart of the categories of deposited garbage. The menu page provides access to manage waste weighing, news, customer data, deposits, waste types, waste selling prices, customer reports, and garbage pickup scheduling. The customer management page allows managers to view and manage customer data, including changing data, adding registration numbers, searching, and filtering customer data. The customer details page displays customer details for data review and correction.

The deposit weighing page is used to enter the results of weighing customer waste according to its type, which is then calculated at a price. The predicted balance is given temporarily until the price of waste is determined when selling to collectors. The news management page allows managers to add, edit, and delete stories, as well as change news details. The waste type information page manages the data of the type of waste that can be exchanged in the waste bank with the features of adding, editing, and deleting data. Finally, the garbage price update page is used to input the selling price of waste according to the price when selling to collectors. It converts the customer's predicted balance based on the latest price.

Payment Gateway Implementation

To use Xendit's payment gateway feature, users must register to access test mode and live mode accounts. Test mode accounts are used during app development, while live mode is used after the app has been released and used by users. After registration, users can retrieve API keys from Settings to tokenize in each API send or receive. These API keys must be kept confidential and created using the user's account password. Furthermore, users can make a balance withdrawal API request by filling in data such as external_id, account name, account number, amount, bank code, and description. Finally,

users need to register an API callback to receive information about the status of the transaction, which can only be accessed by Xendit.3.3 Test Results

Black Box Test Results

The waste bank application test is carried out with the aim of recognizing potential shortcomings before the widespread use of the system. The results of the test with 46 test cases show that the entire series of tests applied is in accordance with the anticipated, as exemplified by the test cases "TC-001" and "TC-002" in Table 2. From the blackbox testing conducted with 46 test cases, all showed corresponding results, indicating that the system was functioning correctly and meeting the requirements that had been set without any errors or bugs.

Table 2. Test Case 1 and 2 Test Results of 46 Test Cases

(1)	**TC-001**	**Register**
(2)	Register with a telephone number or NIK that has been used	
(3)	The user failed to register and received an error message that the data was already in use	
(4)	Appropriate	

(1)	**TC-002**	**Register**
(2)	Register with the population identification number that has been used	
(3)	The user failed to register and received an error message that the data was already in use	
(4)	Appropriate	

SUS Test Results

For the evaluation of the performance results of the System Usability Scale (SUS), the score generated from the questionnaire provides concise information about the extent of the ease of use of the system.

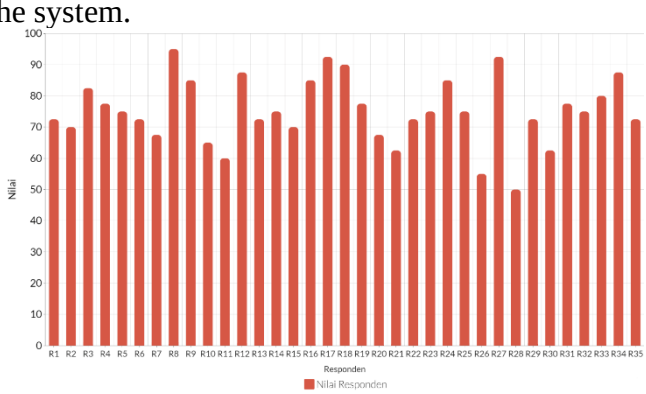

Figure 6. Respondent Value Graph

Based on Figure 6, the average result of 35 respondents who have filled out the questionnaire is above 60. The calculation of the total score results in a final score of 75. If referring to the SUS Score range scale as exemplified in Figure 3, the score obtained from the waste bank application is included in the "*Good*" category and in the "Acceptable" area. This provides a conclusion that the waste bank application that has been designed can qualify as an application that has good usability, can be accepted by users, and provides a positive experience to users.

Conclusion

By applying the Prototype method, the waste bank application at the Surabaya Anggrek Sectoral Waste Bank (BSSA) has succeeded in achieving positive results and high scores in the testing of application performance and usability. This application makes it easy for customers to get information such as balance data, waste deposit results, and withdraw balances without the need to come directly to the waste bank. After undergoing 46 test cases, the application was proven to meet all functional requirements with the expected results. Evaluation with the System Usability Scale (SUS) showed that users gave an excellent rating, with an average score of 75 out of 35 respondents and received the title of "acceptable". The app can run on the Android platform with API 26 (Oreo) specification. The success in the black box trial and SUS evaluation confirms the readiness of the application for use in the Orchid Sectoral Waste Bank (BSSA). With good results in terms of functionality and high user satisfaction, this application is ready to operate as needed in the waste bank.

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