

Design of a Mobile-Based Waste Management Application with a Waste Identification Feature as a Public Education Medium

Dandy Cahyo Purnomo¹, Ahmad Hasib Satiri², Eka Aprilia Saputri³, Luluk Khatimah⁴, Hartono⁵

¹Mechatronics Engineering Department, Swiss German University, Jalur Sutera Barat No. 15, Tangerang 15143, Indonesia

²Automation Engineering, Faculty of Technology, University State of Jakarta, Jakarta 13220, Indonesia

³Computerized Accounting, Department of Accounting, Semarang State Polytechnic, Semarang 50275, Indonesia

⁴Directorate of Planning, Information Systems, and Digital Transformation, Padjadjaran University, West Java 45363, Indonesia

⁵Mechatronics Engineering Department, Swiss German University, Jalur Sutera Barat No. 15, Tangerang 15143, Indonesia

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ABSTRACT

The waste problem in Indonesia requires technological solutions to raise public awareness. This study aims to design a mobile-based waste management application as a medium for public hygiene education. Using engineering methods, it has four main features: waste type identification through camera scans, waste disposal management, digital waste management literacy, and a recycled product marketplace. The design stages include system specification analysis, interface design, and functionality testing. System testing results using the System Usability Scale (SUS) method involving 10 respondents showed an average score of 76.7. Based on SUS assessment standards, this score falls into the "Acceptable" category with an Adjective Rating of "Good". This demonstrates that the waste identification feature makes it easier for users to recognize and sort waste independently, and all system functions perform according to design specifications. This application is expected to be an effective digital instrument in increasing environmental awareness and community independence in managing household waste.



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Corresponding Author:

Dandy Cahyo Purnomo

Mechatronics Engineering Department, Swiss German University, Jalur Sutera Barat No. 15, Tangerang 15143, Indonesia

Email: dandy.purnomo@sgu.ac.id

1. INTRODUCTION

The environmental problems faced by almost all countries, including Indonesia, encompass a number of crucial aspects. One pressing issue is ineffective waste management, which can have serious impacts on the environment and sustainability of life. Improperly managed waste can contaminate soil and groundwater, threatening agricultural productivity and ecosystem balance. Furthermore, dumping waste into rivers is a serious problem because it can cause water pollution. Waste that enters rivers not only harms aquatic life but can also cause flooding when river flow is blocked. Furthermore, indiscriminate dumping of waste into rivers can create unpleasant odors that disrupt the comfort of the community and the surrounding environment [1].

Waste management involves not only technical issues and management systems but also community behavior. This means that waste management will not be successful without active community participation, particularly in terms of reuse, reduce, and recycle. One aspect of public behavior is public perception of waste management. This perception significantly influences waste management. If public perception is positive, then community participation or engagement in waste

management will also be positive. Participation from various parties is one of the keys to the success of an activity or program [2].

Waste is a relatively difficult problem to address, especially in large cities. Consequently, waste will become an environmental problem experienced by all countries worldwide if not addressed properly. The majority of Indonesians have low awareness of waste issues. An example of an action that reflects this low public awareness of waste management is littering, which can disrupt comfort. If left unchecked, this problem can lead to new problems such as flooding and other social issues that impact community life [3].

The main objective of this research is to develop an organized waste disposal system to facilitate systematic community waste management. Furthermore, this research also focuses on providing educational media through a camera-based waste identification feature, designed to help the public recognize and sort waste types independently. Through the integration of these two aspects, it is hoped that this application can be an effective instrument in increasing environmental awareness while supporting the creation of a cleaner and more sustainable environment in accordance with global development targets.

2. RESEARCH METHOD

The research method used is an engineering method focused on software development using the System Development Life Cycle model with a Waterfall approach. This method aims to transform waste management system requirements into a structured mobile application design. The overall workflow of this research, from initial problem identification to system testing, is illustrated in the research flowchart in Figure 1 below:

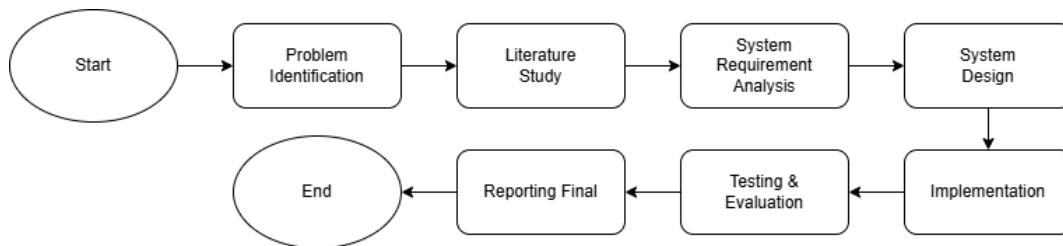


Figure 1. Research flowchart

In this project, we have used the Waterfall model because this model allows analysts to draw and design systems beyond traditional technological boundaries. We have followed a generic Waterfall model where all steps are iterative. shows the iterative feedback approach used to design our system[14].

The flowchart illustrates the research stages using the Waterfall model. The process begins The ease of use of the TPA Mobile application prototype was evaluated using the System Usability Scale (SUS) method. The SUS is a widely recognized tool for assessing the usability of a system, providing a quantitative measure based on user feedback. The evaluation process involves a questionnaire with 10 questions, where respondents rate their agreement on a scale from one to five, with one meaning “strongly disagree” and five meaning “strongly agree”[15].

2.1. Problem Identification Analysis

1. Difficulties in Managing Waste Independently

One common weakness in waste bank management is a lack of understanding of basic statistics, such as calculating waste generation trends, proportions of waste types, average weights, and customer contribution patterns. These analytical skills are essential to support program planning, activity evaluation, internal policy formulation, and the preparation of accountability reports to stakeholders [4].

2. Lack of Waste Disposal Management

Waste management, which still relies on landfills, requires the participation of the entire community. The public needs to be educated on how to manage waste effectively [13] The lack of an organized system to provide information on waste management, collection schedules, and

payment methods makes the waste management process inefficient. Furthermore, the lack of public awareness about the importance of separating organic and inorganic waste before disposal also exacerbates this problem [5].

2.2. System Requirements Analysis

System analysis and design is a step-by-step process for building or developing a quality information system [10]. At this stage, researchers systematically identify and analyze overall development needs, and formulate detailed functional and non-functional specifications that must be met. The analysis is conducted by examining problems related to household waste in the surrounding environment [6].

1. Functionality Requirements

Functional requirements are statements of the system services that must be provided, how the system reacts to certain inputs and how the system behaves in certain situations. In a simpler sense, functional requirements are requirements that contain what processes/services the system must provide, including how the system must react to certain inputs and how the system behaves in certain situations [6].

Table 1. Functional requirements

Functionality Requirements	Function Description
User Authentication	The system must provide sign-up and login features to manage user identities and store user activity data.
Waste Identification	The system must be able to access the device's camera to capture images of waste objects and automatically provide waste classification information.
Waste Disposal Management	The system must provide reporting or scheduling features for waste disposal to make the disposal process more structured and documented.

2. Non-Functional Requirements

Non-functional requirements are limitations on services or functions offered by the system, such as time constraints, process development constraints, standardization, etc. In other words, non-functional requirements are requirements that emphasize the behavioral properties possessed by the system [6].

Table 2. Non-functional requirements

Non Functionality Requirements	Function Description
Operating System	The application is designed to run on Android-based devices.
Security	User passwords in the authentication feature must be protected to ensure account privacy.
Interface Design	The interface uses a simple and intuitive user-centered design concept for ease of use by novice users.

2.3. UI/UX Design

A User Interface (UI) is an element designed to interact through a display screen on a device being used. Creating an effective UI involves creating wireframes, mockups, and prototypes. User Experience (UX) is an individual's perception and response to the product, system, or service they are using [7].

2.4. Usability Testing

The most important Usability characteristics to pay attention to are design and interface. Designing the interface is the main concern to produce a design and interface to meet user needs in accessing the application [12]. The System Usability Scale (SUS) is a usability testing tool developed by Brooke in 1986. The SUS consists of ten questions with a five-choice scale, from strongly disagree to strongly agree, with a rating scale from 0 to 10 [7].

Table 3. Usability testing questions

Num	Questions
1	I think I will use this app frequently.
2	I feel the app is too complicated, though it could be simplified.
3	I feel the features in the app are well integrated.
4	I feel others will quickly understand how to use the app.
5	I feel there are no obstacles to using the app.
6	I find the app easy to use.
7	I think I will need technical assistance to use the app.
8	I feel there are many inconsistencies in the app.
9	I find the app very confusing to use.
10	I need to get used to it before I become proficient.

3. RESULTS AND DISCUSSION

The results presented represent a solution to the identified problems of limited understanding of waste statistics and the lack of an organized waste management system. Using a Systems Development Life Cycle (SDLC) approach, the research output is a prototype application, which is then tested for effectiveness to ensure all user needs are met.

3.1. System Design Results

The previously identified functional and non-functional requirements were transformed into a systematic technical architecture model and visual design. These design results served as the primary blueprint for developing the application prototype, ensuring that each system component aligned with the solution to the waste management problem.

1. Logical Architecture

Logical architecture provides a visualization of the workflow and interactions between actors and all functionality within the application. This design combines two main models: interaction modeling through Use Case Diagrams and procedural modeling through System Flowcharts.

2. Use Case Diagram

A use case diagram is a type of diagram used in software development methods to illustrate scenarios or activities that a system can perform. In the use case diagram of the system being created, there is one actor, namely the user. The following is an image of a use case diagram [8].

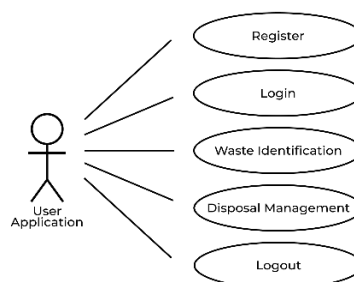


Figure 2. Use case diagram

Illustrates the interaction between user actors and the application's core functionalities to map the boundaries of the developed system. This diagram shows essential services such as user authentication, waste identification features, and waste disposal management integrated into a single platform.

3. Flowchart

A flowchart is a symbolic representation of an algorithm or procedure for solving a problem. Using a flowchart makes it easier for the project team to check for missed points in the problem analysis. Furthermore, flowcharts are also useful as a communication tool between programmers working on a project team. Flowcharts help understand complex and lengthy logical sequences. They help communicate the program's flow to others [9].

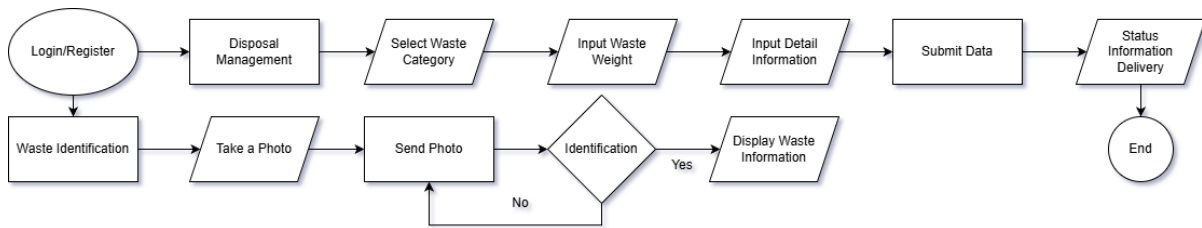


Figure 3. Application flowchart

Presents the system's procedural workflow, explaining the logical steps when users interact with the application. This flowchart visualizes how the system processes data from the initial input stage to generating documented waste classification information and disposal schedules.

3.2. User Interface Design Results

This stage produces a visual design (High-Fidelity Design) for the application using Figma software. The interface design is based on User-Centered Design principles, emphasizing layout simplicity to ensure the application's functionality is quickly understood by novice users.

1. Account Registration and Login Interface

The account registration and login interface is the first step for users to create a personal profile so that identified junk data can be permanently stored. This page is minimalistic in design, with a simple form to expedite the authentication process without confusing new users.

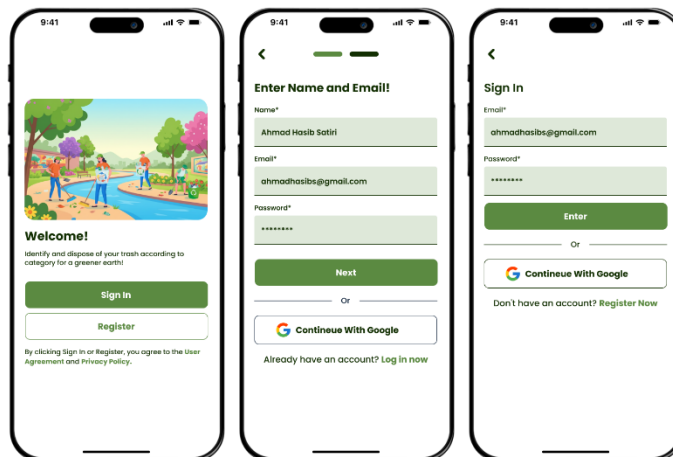


Figure 4. Login and Registration Application

Displays the interface design for registration and account login features, which function to manage user identities and activity data security. This design applies User-Centered Design principles with a simple layout so that application functionality can be immediately understood by novice users.

2. Waste Identification Interface

The waste identification interface is designed to make it easier for users to classify waste types through a live camera scan feature. This page provides clear visual cues to help users capture images correctly, enabling the system to provide accurate identification results.

Shows the primary camera, based waste identification feature that allows the system to perform automatic classification through object scanning. This interface is designed as a digital educational medium to increase community independence in recognizing and sorting waste types independently.

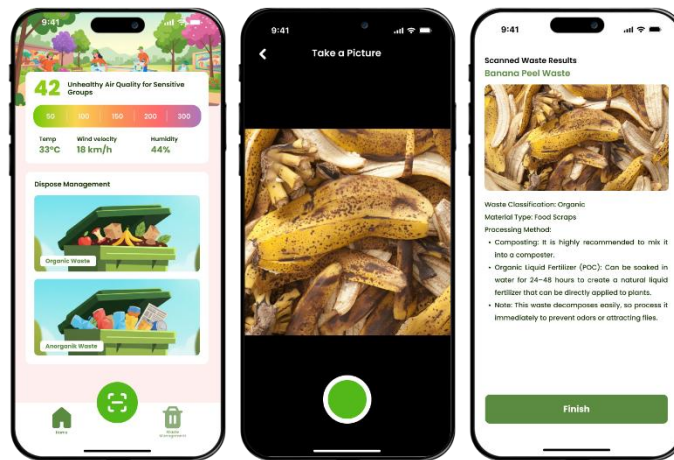


Figure 5. Identification waste application

3. Waste Management Interface

The waste management interface is designed to simplify the process of disposing of previously identified waste. Through this page, users can select a disposal method, specify a pickup location, or locate the nearest drop-off point so that waste can be properly distributed immediately.

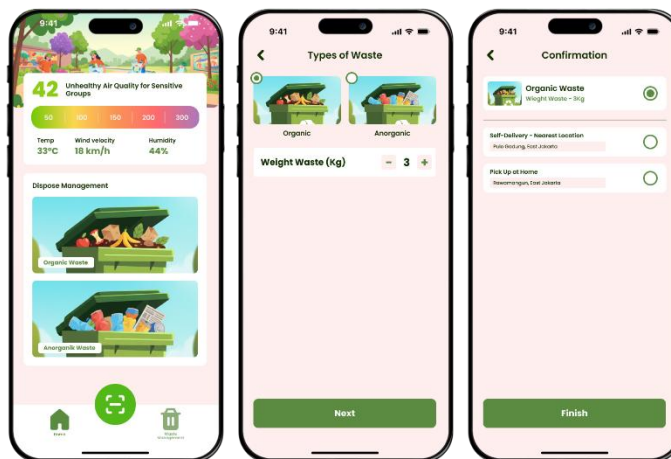


Figure 6. Disgase Management Application

Depicts the waste management interface, which provides structured waste disposal reporting and scheduling features. Through this display, the waste management process becomes more documented and efficient, supporting the goal of creating a cleaner and more sustainable environment.

3.3. User Interface Evaluation

Once the user interface design phase is complete, the next step is to conduct an evaluation to measure the extent to which the design meets user needs and provides usability. This evaluation aims to validate the effectiveness of the application's workflow and ensure that the implemented visual elements align with the principles of a good user experience.

1. System Usability Scale Score Analysis

Questionnaires are a well-known usability measurement and evaluation method among developers and researchers. Questionnaires are a type of form designed to obtain information and respondents [11]. The evaluation stage is carried out to measure the level of usability of the application interface design that has been created. This test involved 10 respondents by providing 10 standard SUS statement items covering aspects of ease, consistency, and system efficiency. Each respondent provided an assessment on a scale ranging from 1 Strongly Disagree to 5 Strongly

Agree, with the calculation $(Q1-1) + (5-Q2) + (Q3-1) + (Q4-1) + (Q5-1) + (Q6-1) + (5-Q7) + (5-Q8) + (5-Q9) + (5-Q10)$.

Table 4. System Usability Scale Score Analysis

Respondents	Question Value	Total Value	Average Value
1	$(5-1) + (5-2) + (5-1) + (5-1) + (5-1) + (5-1) + (5-2) + (5-1) + (5-1) + (5-1)$	38	95
2	$(5-1) + (5-2) + (4-1) + (4-1) + (5-1) + (5-1) + (5-1) + (5-1) + (5-2) + (5-3)$	34	85
3	$(4-1) + (5-2) + (3-1) + (3-1) + (3-1) + (3-1) + (5-3) + (5-3) + (5-3) + (5-3)$	22	55
4	$(4-1) + (5-4) + (4-1) + (5-1) + (5-1) + (5-1) + (5-2) + (5-1) + (5-2) + (5-2)$	32	80
5	$(4-1) + (5-3) + (4-1) + (5-1) + (3-1) + (5-1) + (5-4) + (5-2) + (5-2) + (5-3)$	27	67.5
6	$(4-1) + (5-1) + (3-1) + (5-1) + (4-1) + (5-1) + (5-1) + (5-2) + (5-1) + (5-3)$	33	82.5
7	$(4-1) + (5-1) + (4-1) + (4-1) + (4-1) + (5-1) + (5-2) + (5-1) + (5-1) + (5-2)$	37	92.5
8	$(4-1) + (5-2) + (5-1) + (5-1) + (3-1) + (5-1) + (5-5) + (5-3) + (5-3) + (5-5)$	24	60
9	$(4-1) + (5-3) + (4-1) + (4-1) + (4-1) + (4-1) + (5-2) + (5-3) + (5-2) + (5-3)$	27	67.5
10	$(4-1) + (5-2) + (4-1) + (5-1) + (5-1) + (4-1) + (5-2) + (5-2) + (5-2) + (5-1)$	33	82.5
Overall Value		307	76,7

2. Discussion of Results and Feedback

After obtaining quantitative data through calculating System Usability Scale scores, the next step is to analyze the qualitative feedback provided by respondents. This section aims to align the numerical results with actual user experiences when interacting directly with the application interface, identifying which areas are optimal and which still need improvement.

Table 5. Respondent Feedback

Category	Respondent Feedback
Feature Development	Respondents expected additional fundamental features like "Forgot Password" and "Edit Profile" for account security and completeness.
Interaction & Visuals	Users suggested the use of more engaging animations and more efficient transitions to create a more modern user experience.
Technical Aspects	There was a need for advanced technical features like Focus Mode, app speed optimization, Dark Mode, and accessibility features for users with special needs.
User Satisfaction	Most respondents felt the current app was already very good and easy to understand, so drastic changes to its core functionality were not necessary.

4. CONCLUSION

Based on the design and evaluation results, it can be concluded that this research has successfully developed a mobile-based waste management application. Through its key features of camera-based waste identification and waste management, this application can serve as a digital educational tool that facilitates the community in identifying and sorting waste independently.

Testing results using the System Usability Scale method on 10 respondents showed an average score of 76,7. Based on the SUS assessment standards, this score falls into the Acceptable category with an Adjective Rating of Good. This demonstrates that the application interface meets the ease-of-use criteria and is well-received by potential users. However, qualitative feedback indicates the need for further development of authentication features such as forgot password, visual enhancements through animation, and technical optimizations such as dark mode support and accessibility.

This research is expected to be the first step in utilizing artificial intelligence technology for environmental management in the community. Recommendations for further study include fully functional implementation of the software and integration of a database system to support more organized and efficient waste management.

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