ECO NOTES: UX DESIGN OF A VILLAGE WASTE RECORDING APPLICATION WITH REWARD SYSTEM INTEGRATION USING THE USER-CENTERED DESIGN METHOD

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ABSTRACT

Village waste management currently has two main problems: lack of a digitally integrated waste recording system and low community participation in sorting waste due to lack of incentives. This study aims to design a prototype of the ECO Notes application as a village-based waste recording solution, adapting features and interfaces through a User-Centered Design (UCD) approach. Comparison with current methods shows that the Digital Waste Bank focuses more on transaction recording, while the IoT-based Waste Monitoring System, effective for city scale, is less suitable for village limitations. The design methodology includes conducting literature studies and interviews with village officials and local communities to identify functional and non-functional needs, followed by the creation of low-fidelity and high-fidelity prototypes. Evaluation was conducted using a User Experience Questionnaire (UEQ) comprising six rating scales on 12 respondents. The evaluation results showed that the highest scores in the Perspicuity aspect (1.68), indicating ease of understanding of the application, and Novelty (1.25), reflecting the solution's novelty compared to previous methods. Overall, the application received positive responses in all aspects, confirming its advantages in accessibility, sustainability, and community engagement. Thus, ECO Notes is considered worthy for further development and testing on a wider-scale user.

Keywords: *Waste Management, User-Centered Design, Digital Record Keeping, Community Participation, UEQ*

1. INTRODUCTION

Waste management in Indonesia is a complex issue due to its vast territory, high population, and diverse regional characteristics. The National Waste Management Information System (SIPSN) 2023 data shows that the total waste disposal reached 40.2 million tons per year, with 60.44% of this coming from households, such as food scraps, plastic packaging, paper, and other types of domestic waste [1]. This aligns with research indicating that the increase in waste generation is driven by population growth, urbanization, and the suboptimal management system [2].

In rural areas, challenges are even greater due to a shortage of facilities, transportation systems, and waste processing units. Manual or non-existent data recording on waste volume, type, and frequency makes it hard for village officials to compile reports, apply for government assistance, or evaluate environmental programs like waste banks [3]. Low public awareness worsens the situation, with indiscriminate disposal negatively impacting health and the environment [4], [5].

Previous studies have proposed digital solutions like Digital Waste Banks for transaction recording and IoT-based Waste Monitoring Systems effective in city areas. However, these aren't fully suited for villages with limited infrastructure, very limited government incentives, and relying mostly on local community contributions.

This research proposes ECO Notes, a prototype of a village-based waste recording application using User-Centered Design (UCD). This application enables village officials to record daily waste disposal data, classify waste types, and display community contribution statistics visually and in real-time. The novelty of this research lies in the integration of a community contribution-based reward system with intuitive UX design, to increase local community participation and awareness. This research proposes an integrated, sustainable, and village-specific waste recording model, while filling the gap in previous methods that lacks of technology, incentives, and user experience comprehensively.

2. LITERATURE REVIEW.

2.1. Waste Management

Waste management is a series of activities that include reducing, sorting, collecting, transporting, processing and disposing waste in a systematic and sustainable manner [6]. The main objective of waste management is to minimize the environmental and public health impacts, while maximizing recycling and reuse value.

2.2. Digitalization of Waste Management

Digitalization of waste management applies information technology and digital systems to record, report, monitor, and manage waste data in an integrated manner [7]. Digitalization gives more accurate, transparent, and efficient data management compared to manual systems, and enables coordination between managers and the community.

2.3. Incentive and Reward System

Incentive and reward systems reward individuals or groups for their contributions. In waste management, incentives are used to encourage positive behavior, such as sorting and actively participating in waste management programs, thereby increasing motivation and sustaining engagement [8].

2.4. User Centered Design (UCD)

User Centered Design (UCD) is a system design approach that puts users at the center at every stage of development. This approach focuses on user needs, characteristics, and limitations to create user-friendly, effective, and appropriate system [9].

2.5. User Experience (UX)

User Experience (UX) refers to the perceptions and responses that arise from using a system, product, or service. UX encompasses aspects of ease of use, convenience, efficiency, and user satisfaction, which are important indicators in assessing the quality of a digital application [10].

2.6. User Experience Questionnaire (UEQ)

The User Experience Questionnaire (UEQ) is an evaluation instrument to quantitatively measure user experience. The UEQ measures six main dimensions: Attractiveness, Perspicuity, Efficiency, Dependability, Stimulation, and Novelty, thus providing a comprehensive overview of the quality of a user's experience with the system [11].

3. METHODOLOGY

3.1. Research Approach

This study uses a User-Centered Design (UCD) approach that places users at the center of every stage of system design. This approach considers usability goals, user characteristics, task environments, and the workflows involved [12]. UCD was chosen because it is able to produce designs that are inclusive, easy to use, and relevant to the real needs of users, including those with limited technological literacy [13].

UCD has been proven effective in various digital application developments, such as improving the quality of mobile-based product distribution applications by adapting the design to user needs, as well as creating an intuitive beginner-friendly online learning interface [14], [15]. This study applies the UCD approach iteratively through four main stages as shown in Figure 1.

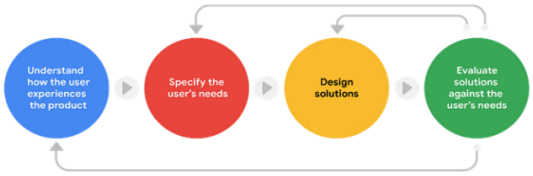


Figure 1. Stages of the User-Centered Design (UCD) Approach

3.2. Heading Understand How the User Experiences the Product

This stage was conducted through literature review and semi-structured interviews to understand the context, obstacles, and needs of village officials and residents. The literature review used keywords: "waste management," "village," "digitalization," "recording," "community participation," and "reward," from indexed journals on the last five years. Interviews were then conducted with village officials and residents. The interviews with village officials explored the recording system, operational obstacles, community participation, and readiness to adopt the technology. On the other hand, resident interviews explored waste sorting habits, motivations, obstacles, and perceptions of incentive-based recording applications.

3.3. Specify the User's Needs

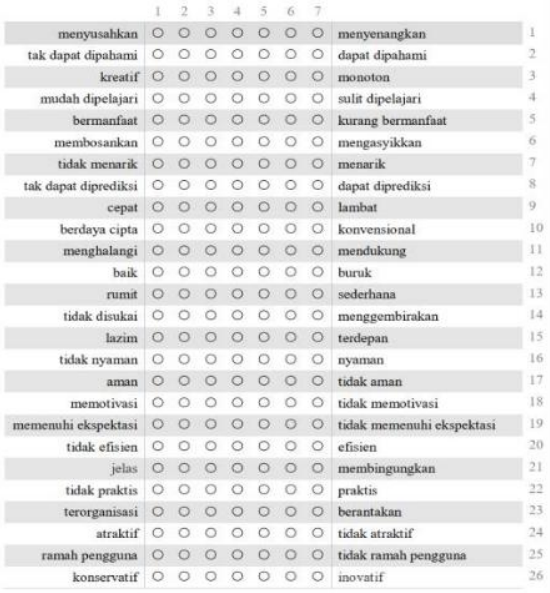
User needs were identified based on interview results and literature reviews, which included functional needs (record keeping, waste classification, data visualization) and non-functional needs (ease of use, security, and system performance).

3.4. Design Solution

The interface design was created in the form of low-fidelity design (wireframe in Miro) and high-fidelity prototype (Figma) following the Material Design guidelines [16].

3.5. Evaluate Solutions Againts the User's Needs

The evaluation was conducted using the UEQ on 12 respondents to evaluate six dimensions: Attractiveness, Perspicuity, Efficiency, Dependability, Stimulation, and Novelty [17], [18], [19]. The UEQ instrument consists of 26 pairs of bipolar statements with a rating scale of 1–7, as shown in Figure 2.



	1	2	3	4	5	6	7		
menyusahkan	○	○	○	○	○	○	○	menyenangkan	1
tak dapat dipahami	○	○	○	○	○	○	○	dapat dipahami	2
kreatif	○	○	○	○	○	○	○	monoton	3
mudah dipelajari	○	○	○	○	○	○	○	sulit dipelajari	4
bermanfaat	○	○	○	○	○	○	○	kurang bermanfaat	5
membosankan	○	○	○	○	○	○	○	mengasyikkan	6
tidak menarik	○	○	○	○	○	○	○	menarik	7
tak dapat diprediksi	○	○	○	○	○	○	○	dapat diprediksi	8
cepat	○	○	○	○	○	○	○	lambat	9
berdaya cipta	○	○	○	○	○	○	○	konvensional	10
menghalangi	○	○	○	○	○	○	○	mendukung	11
baik	○	○	○	○	○	○	○	buruk	12
rumit	○	○	○	○	○	○	○	sederhana	13
tidak disukai	○	○	○	○	○	○	○	menggembirakan	14
lazim	○	○	○	○	○	○	○	terdepan	15
tidak nyaman	○	○	○	○	○	○	○	nyaman	16
aman	○	○	○	○	○	○	○	tidak aman	17
memotivasi	○	○	○	○	○	○	○	tidak memotivasi	18
memenuhi ekspektasi	○	○	○	○	○	○	○	tidak memenuhi ekspektasi	19
tidak efisien	○	○	○	○	○	○	○	efisien	20
jelas	○	○	○	○	○	○	○	membingungkan	21
tidak praktis	○	○	○	○	○	○	○	praktis	22
terorganisasi	○	○	○	○	○	○	○	berantakan	23
atraktif	○	○	○	○	○	○	○	tidak atraktif	24
ramah pengguna	○	○	○	○	○	○	○	tidak ramah pengguna	25
konservatif	○	○	○	○	○	○	○	inovatif	26

Figure 2. Instrument UEQ

3.6. Research Approach Comparison with Current Methods (State-Of-The-Art Methods)

Two previous studies served as comparisons for this research. The first relevant study developed a digital waste bank and focused on recording waste bank transactions, without integrating incentives based on citizen contributions [20]. The second relevant study developed an IoT-based urban waste monitoring system [21]. This study was only effective at the city, but it was not suited to the village with limited infrastructure.

Based on these two previous studies, this study is to design a prototype of ECO Notes that integrates digital record-keeping with a citizen contribution-based reward system and a user-friendly user interface (UX) design tailored to rural communities, making it more contextual and sustainable.

3.7. Place and Time of Research

The research was conducted in Penarukan Village, Kepanjen, Malang Indonesia in June–August 2025. This village was chosen because it did not yet have an integrated waste recording system, but it had active participation from village officials and residents.

3.8. Devices, Tools, and Infrastructure

This study used laptops for interface design and data processing, and smartphones for end-user application simulations. Tools used included Figma for UI design and high-fidelity prototyping, Miro for low-fidelity design, Google Forms for interview data collection, and the UEQ Online Tool for UX evaluation analysis. Supporting tools included an internet connection for collaboration and access to cloud-based apps, and the Penarukan Village Hall as the trial location.

4. RESULTS AND DISCUSSION

4.1. Understand How the User Experiences the Product

The initial stage of the User-Centered Design (UCD) approach aims to understand the actual conditions, obstacles, and user needs in village waste management. Data was obtained through literature studies and some interviews.

4.2. Literature Study Result

A literature study was conducted to map the problems and potential solutions related to waste recording in villages. The analysis showed that the majority of villages in Indonesia do not yet have a digital waste recording system. The process of recording the volume, type, and frequency of waste disposal is generally manual or not done at all, hindering the preparation of environmental reports. Low community participation in waste sorting is also due to a lack of incentives and outreach. These findings formed the basis for developing interview instruments and strengthened the framework of the problems to be addressed through the ECO Notes application.

4.3. Result of Interviews with Village Officials and Residents

Semi-structured interviews were conducted with 12 respondents, including village officials and residents. The results indicated that waste data recording was not yet systematic, village officials experienced difficulties in compiling reports, and community participation was low. However, most residents owned smartphones and were willing to participate if there were some incentives and the convenience of digital recording.

4.4. Category-wise Insight

Based on the interview results, a number of insights were obtained which were grouped into four main categories, namely problems, needs, habits, and obstacles, as shown in Table I. This grouping was used as a basis for formulating user needs at the Specify the User's Needs stage.

Table 1. Summary of Category-wise Insight

Category	Insight
Problems	Waste recording is not done routinely or does not occur at all, making it difficult to prepare environmental reports.
Needs	An easily accessible digital system capable of recording daily data and visualizing community contributions.
Habits	Residents are not accustomed to sorting waste and village officials only record it when necessary.
Barriers	Lack of education, very limited internet access, and the absence of rewards or appreciation for citizens who actively contribute

4.5. Understand How the User Experiences the Product

This stage aims to identify user needs based on the results of literature studies and interviews. Requirements are divided into two main categories: functional and non-functional requirements. Functional requirements encompass core application features that support waste recording and management, as shown in Table 2. Meanwhile, non-functional requirements encompass system quality aspects that support the user experience, which are summarized in Table 3.

Table 2. Functional Requirements

No	Functional Requirements	Description
1	Waste Recording Form	Village officials can record the volume and type of waste per household daily
2	Waste Classification	Village officials can record the volume and type of waste per household daily.
3	Data Visualization	Graphics of residents' contributions and total village waste generation per week/month.
4	Reward System	A scoring system to incentivize residents based on their contributions
5	Transaction History	Residents and village officials can view previous contribution data.
6	Notifications & Reminders	Daily/periodic reminders for waste recording.
7	Multi-Role Users	There are two main roles: village officials and residents, with customized feature access.

Table 3. Non-Functional Requirements

No	Non-Functional Requirements	Description
1	Ease of Use (Usability)	The application should be easy to understand for users with limited technological backgrounds.
2	Responsive and Lightweight	The application can be accessed smoothly on mid-range smartphone devices.
3	Local Language	Available in Indonesian, with a choice of local words familiar to village residents.
4	Data Security	Resident records and data are protected from unauthorized access.
5	Limited Offline Access	Some basic functions can still be used when the internet connection is unstable.

The results of this identification are in line with the approach [22], which emphasizes the importance of systematically collecting requirements based on user roles.

4.6. Understand How the User Experiences the Product

Based on the results of the needs identification, the ECO Notes application prototype was designed in two stages, namely low-fidelity and high-fidelity.

4.7. Low-Fidelity Prototype

An initial low-fidelity design was created using Miro to map out the page structure and basic navigation flow. This prototype included key features such as daily data input, waste type classification, citizen contribution statistics, and a reward system. An example of the initial design can be seen in Figure 3.

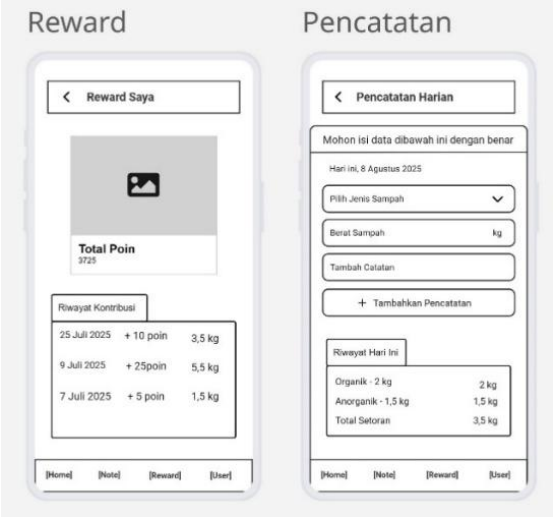
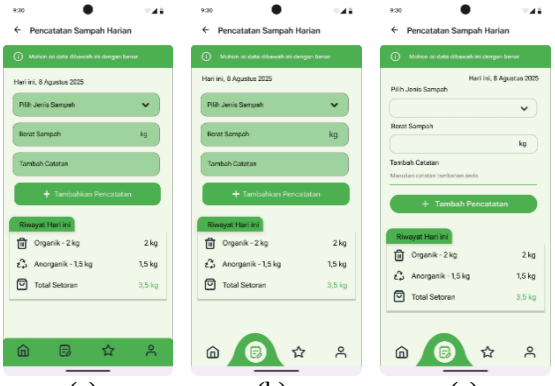


Figure 3. Low-Fidelity Prototype View

4.8. High-Fidelity Prototype

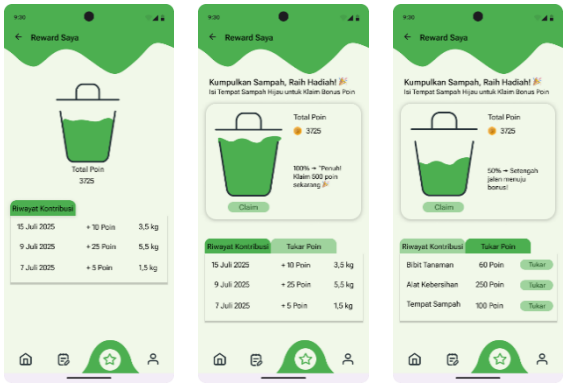


(a) (b) (c)

Figure 4 Garbage Logging Feature View: (a) initial design, (b) first iteration, (c) second iteration

The next stage was the creation of a high-fidelity prototype using Figma, equipped with visual elements according to the environmentally friendly moodboard and following the Material Design guidelines [10]. Iterations were carried out on the Daily Waste Recording (Figure 4) and

Reward (Figure 5) features to improve navigation, readability, and add a point exchange function.



(a) (b) (c)

Figure 5 Reward Feature View: (a) initial design, (b) first iteration, (c) second iteration

4.9. Evaluate Solutions Against the User's Needs

The prototype evaluation was conducted using the User Experience Questionnaire (UEQ) with six assessment dimensions, as shown in Table 4. This instrument was distributed to 12 respondents who were previously involved in the design process.

Table 4. UEQ Calculation Score

UEQ Scale	Number of Items
Attractiveness	6
Perspicuity	4
Efficiency	4
Dependability	4
Stimulation	4
Novelty	4

Table 5. UEQ Evaluation Results

UEQ Scale	Average Score	Interpretation
Attractiveness	1.45	Users are satisfied overall
Perspicuity	1.68	The application is easy to understand and to learn
Efficiency	1.33	Supports user task efficiency
Dependability	1.10	The system is quite reliable and controllable
Stimulation	1.38	Provides a fun and engaging experience
Novelty	1.25	The application is considered quite creative and innovative

The average score results of each dimension are shown in Table 5. Perspicuity has the highest score (1.68), indicating that the application is easy to understand. Attractiveness (1.45) and Stimulation (1.38) indicate that the appearance and user experience of the application are considered positive. Novelty (1.25) indicates a newness compared to the manual recording used previously.

4.10. Comparison with Current Methods

A comparison was made with two digital approaches to waste management, namely the Digital Waste Bank Application [14] and the IoT Waste Monitoring System [15]. The analysis results show that the previous approach focuses on internal recording or city-scale monitoring, while ECO Notes integrates daily recording, a citizen-contribution-based reward system, and data visualization in one application specifically designed for the village context. The UCD-based approach makes the application features suitable to non-technical users, thus having the potential for widespread adoption in rural areas.

5. CONCLUSIONS AND RECOMMENDATIONS

This study concludes that the application of the User-Centered Design (UCD) approach in the development of the ECO Notes application is able to address the problem of the absence of an integrated waste recording system and little participation of village communities in sorting waste. The evaluation results using the User Experience Questionnaire (UEQ) showed a positive response on all scales, especially in the Perspicuity and Novelty aspects, which indicates that the application is easy to understand and has an element of novelty compared to previous methods.

For further research, it is recommended to test on a wider village scale, develop educational features for waste sorting, integrate with local government systems, and improve technical aspects such as offline access, data security, and device compatibility to support sustainability and consistent community participation.

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