2025 International Conference on Sensors and Related Networks (SENNET) Special Focus on Digital Healthcare | 979-8-3315-9746-7/25/$31.00 ©2025 IEEE | DOI: 10.1109/SENNET64220.2025.11135957

# Design of a New E-Waste Management Platform for Campus Use

Chelli N. Devi
*Kalasalingam Academy of Research and Education*
Krishnankoil, Tamil Nadu
chelli@rocketmail.com

Purnendra Teja Pithani
*Kalasalingam Academy of Research and Education*
Krishnankoil, Tamil Nadu
99220041674@klu.ac.in

T Shiva Prasad
*Kalasalingam Academy of Research and Education*
Krishnankoil, Tamil Nadu
99220041726@klu.ac.in

Mulla Ameer Basha
*Kalasalingam Academy of Research and Education*
Krishnankoil, Tamil Nadu
99220041865@klu.ac.in

T. Gopi
*Kalasalingam Academy of Research and Education*
Krishnankoil, Tamil Nadu
9922005410@klu.ac.in

***Abstract*—The increase of e-waste and its efficient management are pressing problems in recent times, given that people frequently upgrade their electronic devices and discard the old ones. This is more so in colleges and universities with a high student strength and constant disposal of gadgets like smartphones, laptops and iPads. In this work, a dedicated mobile application is developed to facilitate the collection and recycling of e-waste in campus. The app enables users to submit details of old or broken devices; these are collected and taken to certified centers for recycling or refurbishment. The users receive eco-points for every e-waste submitted, which can be used to redeem rewards later. The app was built using Flutter and Firebase, supports all mobile devices and is easy to use. It was tested in real-time in our college campus and found to be highly effective in e-waste management, recycling of old electronics, ensuring sustainability and promoting environmental awareness among the students.**

***Index Terms*— E-waste, sustainability, Flutter, Firebase, recycling, mobile application, waste management, institutional disposal**

## I. Introduction

The widespread use of digital devices in schools and colleges, has made teaching and learning more effective and interesting. But it also comes with the associated problem of increasing electronic waste (e-waste) generation in the form of old phones, laptops, iPads, chargers and batteries [1-2]. This poses a serious environmental concern, if not disposed properly [3-4].

To address this issue, the research work develops a dedicated mobile application for colleges and universities to collect and recycle e-waste. It can be used by the students, staff and faculty members to schedule electronic waste pickup or donate old devices that can be repaired. These devices are checked, repaired (if possible) and sold at low prices back in the campus. The application was created using Flutter and Firebase. It is easy to install and use, secure and shows the nearby service centers. The mobile app was test run in our university campus and received positive feedback. To our knowledge, this is the first-ever application for e-waste management in the college campus.

## II. System Architecture

The mobile application is framed in such a way that it can be altered or updated easily, if a need arises. It also offers a simple user design, safe data storage and an option to request e-waste pickup. The different aspects of its system architecture are elucidated here.

### *A. User interface (UI) module*

The mobile app is developed using Flutter, making it compatible with both Android and iOS operating systems using the same code [5]. It has a minimalist and clean user interface that simplifies the process for users. To report their e-waste, users fill out some general information about the device, upload its photo and report the condition. Depending on the type of user (that is, student or faculty), options will be tailored to suit their needs. The application also has a dashboard (profile page) for the users to view their past submissions, status of waste recycling and eco-points earned for previous submissions.

### *B. Database and backend module*

The app has Google Firebase as its backend, which works in the background to ensure that everything goes on smoothly. It stores various details like user data, device data and service center data using Firestore [6]. Firebase authentication helps track the login and features of the app based on user role (whether student or faculty). Further, photos and documents are stored in Firebase cloud storage. The users can see changes in the app based on real-time updates. Thus, the backend is secure, fast, always online and ideal for use in colleges.

### *C. E-waste submission workflow*

The waste submission workflow and recycling are smooth and easy-to-follow in this app. It offers a one-stop-shop for all kinds of used electronic items and e-waste materials within the campus. In case the discarded product is usable or upcyclable, users can visit the nearest verified service center. This practice reduces e-waste, recycles electronics, minimizes mindless new

purchases and protects the environment in the university premises [7-8].

### D. Services coordination module

The application also includes a separate option to access service centers within and outside the campus. The certified service centers will test the devices, repair them and update the status in the app. This makes it easy to plan waste pickups and recycling, if the users want to upcycle their old products or earn cash incentives. In future, the university can enable professional upcycling and recycling of used electronics by collaborating with recycle and service centers.

## III. Methodology

The flowchart of the proposed method is presented in Fig. 1. In addition, the various tools and technologies employed, different phases in app development, design of the user interface and varied user roles (such as, student and faculty login) are discussed in this section.

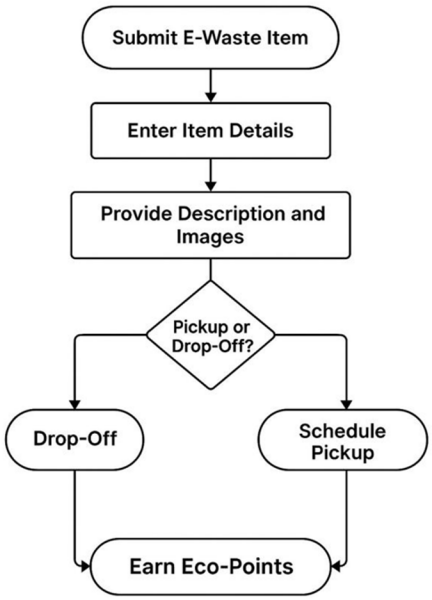


Fig. 1 Flowchart of e-waste management in the proposed application

### A. Tools and technologies used

The frontend of the application is built using Flutter to ensure compatibility with different platforms. Firebase is used for the backend to handle various aspects like login, data storage, image storage and real-time updation. These functionalities make the application easy to build and use on different devices with Android and iOS operating systems [9-10].

### B. App development

The proposed mobile app is built in stages. Initially, the problems in e-waste management faced by the students and faculty members are surveyed. Based on these issues, basic app designs are proposed using Flutter and Firebase. Subsequently, additional features are included for product upload and access to service centers [11]. The developed application is then tested on different machines and users, followed by a pilot test at the university level. The feedback received is used to further improve the mobile app.

### C. UI/UX design

The user interface is developed in an easy-to-use manner, similar to shopping applications. Most of the tasks can be accomplished in 2 to 3 taps. Further, color labels and icons are included for easy access to important features. The instant messages and immediate updates received by the users make the app more reliable and user-friendly [12]. Notably, the app's UI design is inspired from other established frameworks like Google's Material Design and Apple's iOS Human Interface Guidelines (HIG). The salient aspects of the app, namely, its easy usability, intuitive navigation, iconography and color coding, are designed to align with the standards like Material Design and iOS HIG.

### D. User roles

The application provides different roles and levels of access to varied users for efficient e-waste management. For example, students and faculty post their old devices for recycling or sale, and check its status update using the app. Whereas, service and recycling centers repair or recycle the used gadgets and provide updates to the users. On the other hand, admins manage the whole system, assign jobs and check user reports. Thus, the system ensures different roles and access for various users, keeping the process organized and secure.

## IV. Implementation

The core implementation practices followed in creating the proposed mobile app are outlined in this section. It discusses key areas of the app, such as, its functional workflow, backend integration, user role management, access control, geolocation services and submission handling [13]. The style of implementation is modular, scalable and responsive in real-time. This ensures seamless user experience and efficient data handling.

The core of the mobile app is user-initiated operations like electronic waste submission, its status tracking and interaction with service centers. These operations are event-driven and connected to the Firebase backend. A sample pseudocode for product submission is presented here to facilitate easy understanding:

```
validateInputFields();
generateUniqueSubmissionID();
uploadImageIntoFirebaseStorage();
saveItemDetailsIntoFirestore(userId, itemName, itemCategory,
condition, imageUrl, status:"Pending Review", timestamp:
currentDateTime);
showConfirmationToUser();
```

This demonstrates a modular flow of the code, which ensures that all submissions are completed with full metadata, securely stored in the cloud and immediately accessible to both service centers and administrators.

The next aspect is the integration of the frontend with Firebase backend. This facilitates safe user login, manages user identification and provides differential access to the users based on their role. The Firestore database stores all user data, details of e-waste submission, service center profiles, transaction history and recycled products information. Further, the Firebase cloud storage retains the user-submitted images for each electronic item through its storage handling capability. These images are linked to records

so that service centers can assess the physical state of items when required. In addition, the system's backend functionality can be quantitatively assessed using performance metrics like API response time, database query speed, throughput, CPU and memory usage, scalability and system uptime.

Another important aspect to be considered is role management and access control for different users. This means that the login access and permissions given to a student or faculty member are entirely different from those of an admin or service center. The app has a robust system that allows restricted access and permissions to different users. For instance, students and faculty members have access only to product submission, status tracking and profile management. On the other hand, service centers can review product queues, status information, repair information and upload details of the refurbished products. In contrast, the administrator has complete access to all submissions, activity logs, user management tools and analytics dashboard. This role enforcement is achieved by conditional UI rendering and Firestore security rules. These rules achieve data isolation and defense from malicious access to sensitive institutional information or user inputs. The degree of access control conforms to privacy demands and maintains the operational integrity of the system.

## V. Results and Discussion

The proposed mobile application was evaluated for its real time usability and role in e-waste management through functional testing and a pilot study at the university level. The results obtained are elucidated here.

The major aspect of the app is e-waste product submission (illustrated in Fig. 2). The students, staff members and faculty are encouraged to submit their broken or old electronic devices for recycling. A form is filled by the submitter with details like the type of device, its brand, condition and degree of repair. There is an option to include the product image and choose whether it is reusable. Soon after submission, the product is assigned a unique tracking ID and users can monitor its status on their dashboard.

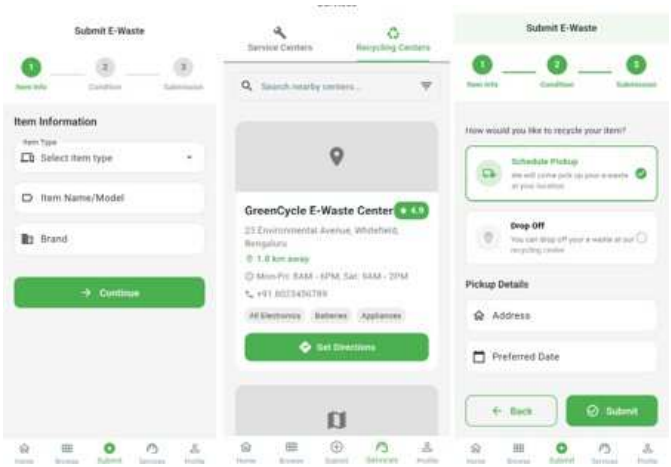


Fig. 2 E-waste submission page in the mobile application

The next phase involves tracking the repair and recycling status of the submitted product. This monitoring is enabled in the user's dashboard. The submitter views 3 status updates, namely: "Pending", "Under Review" and "Recycled". The system also notifies the users as the product proceeds from one stage to the next. The dashboard provides a complete record of all previous submissions and keeps the users engaged in the process.

Furthermore, the app provides varying levels of access to service agencies and admins. The registered recycling and service centers (as seen in Fig. 3) can view the submitted products and their details, update the status of a recycled item and mark the repaired items as reusable [14-17]. On the contrary, admins can track submissions, assign service centers, view reports, manage/ partners and user accounts. The system ensures an overall organized flow and keeps the stakeholders informed at each stage.

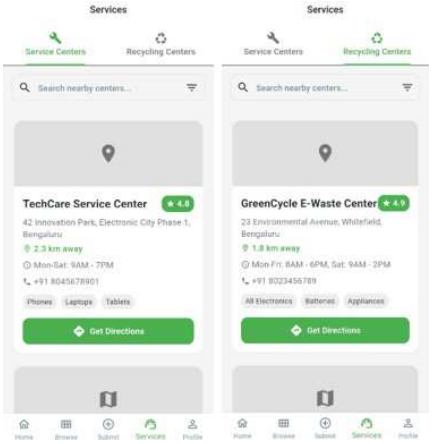


Fig. 3 Service centers and recycling centers displayed in the app

The mobile application works satisfactorily in both Android and iOS environments. It was pilot tested on 50 users comprising of students, faculty members, system administrators and service center personnel. The results reveal that the application loads in an average of 2 seconds and completes image submission within 5 seconds with a success rate of 92%. The system offers real time status feedback in less than 2 seconds.

Moreover, feedback on app performance and utility was collected from the stakeholders. The users found the app easy to use, fast and helpful in handling e-waste in the campus. Particularly, 94% of the users responded that the app was "easy to use" or "very easy to use". Further, 90% of the users were able to make a submission independently, while an 86% opined that the included map feature was helpful in locating the service centers. More than 80% of the participants enjoyed the recycling option as a genuine effort at sustainability. This feedback supports the perceived recyclability and sustainability performance of the app. Nevertheless, an in-depth technical verification of sustainability can be embedded in the system's design by tagging the product type, its material composition and mapping it against the recyclability classification provided by the Central Pollution Control Board (CPCB). Besides, some participants also suggested introducing features like product tagging via QR codes [18] and pick-up drive notifications for easy handling [19]. The overall feedback was highly positive and the users were satisfied with the designed mobile application.

In addition, usability metrics of the app are obtained. The app's usability is tested against documented software usability heuristics for three basic domains, namely, effectiveness, efficiency and satisfaction. It received a metric score of 4.5 for form clarity (submission process), 4.6 for system feedback and responsiveness, 4.4 for visual design appeal and 4.6 for total user satisfaction; the scores are out of 5. The high scores reflect a positive user experience with the app.

The developed institutional e-waste management application is essential to manage the growing increase and proper disposal of electronic wastes in the university. The app offers four main functions, that is, streamlined product submission management, integrated customer service, real-time tracking capabilities and recycling benefits [20-23]. The integration of a tracking feature alleviates institutional waste management problems by reducing improper waste disposal, enhancing documentation and encouraging more users to recycle their used products through registered service centers. Besides, the modular design of the app makes it simple to upgrade and expand to large institutions. The application serves more than a mere waste management app, as it educates the users on sustainability and creates a circular economy with digital responsibility as its foundation [24-25]. The proposed mobile app has functional similarities with other public e-waste management platforms designed by the New Delhi Municipal Council (NDMC), Ahmedabad Municipal Corporation (AMC) and Hyderabad Civic Initiatives. It also aligns well with the salient features provided by privately developed applications like Recykal, Attero, Recyclify, USH India and Indicool.

## VI. Conclusion

The work involves the creation and deployment of a dedicated mobile application for the emerging problem of e-waste management in colleges and universities. The app, designed using Flutter and Firebase, creates a straightforward system for monitoring and managing electronic waste. This involves role-based dashboards, easy product submission, options to recycle old products and convenient access to service centers. Thus, the proposed application enables sustainable waste management by minimizing improper disposal, promoting green practices, educating the consumers and enabling waste tracking to help institutions achieve their environmental goals.

The scope for future work includes leveraging AI-based image recognition algorithms for automatic segregation of submitted waste products based on their present condition and degree of repair required. This reduces human involvement, ensures shorter testing times and promotes scalability for wider application in companies, government institutions and non-governmental organizations. Furthermore, proper implementation of data management and access controls allow a single instance of the system to be used by multiple institutions, possibly at different geographic locations. This can lead to smart national and international e-waste management portals in future.

## References


[1] J. Yla-Mella, E. Pongracz and R. Keiski, "Recovery of WEEE in Finland", *Proceedings of the Waste Minimization and Resources Use Optimization Conference*, Oulu, pp. 83-92, 2004.

[2] R. Wawrzonek, "The prognosis of waste electrical and electronic equipment (WEEE) in Poland", *Proceedings of the Scientist Conference: Young scientist towards modern technology*, Warsaw, pp. 61-68, 2006.

[3] Directive 2002/96/EC, *European Parliament and Council on Waste Electrical and Electronic Equipment (WEEE)*, 27 January 2003.

[4] Directive 2002/95/EC, *European Parliament and Council on Restriction of the Use of Certain Hazardous Substances in Electrical and Electronic Equipment (RoHS)*, 27 January 2003.

[5] Anazia et al., "Web-based platform for waste management using object-oriented methodology," *Waste Management and Recycling Journal*, vol. 10, no. 2, pp. 98-110, 2024.

[6] V. Ramanujam and D. Napoleon, "Developing an Android app to improve e-waste management: A case study," *Journal of Environmental Technology and Management*, vol. 15, no. 1, pp. 112-125, 2020.

[7] H. Antrekowitsch, M. Potesser, W. Spruzina and F. Prior, "Metallurgical recycling of electronic scrap", Proceedings of EPD Congress, pp. 899-908, 2006.

[8] J. Cui and E. Forssberg, "Mechanical recycling of WEEE", *Journal of Hazardous Materials*, B99, pp. 243-263, 2003.

[9] E. Azheganova and A. Nedashkovskiy, "The impact of digitalization on waste management systems: A literature review and case studies," *Journal of Environmental Management*, vol. 25, no. 2, pp. 234-248, 2020.

[10] K.V. Epifancev and S.A. Solovev, "ECO-365: A JavaScript-based waste management platform for enhanced data handling and automation," *Waste Technology Review*, vol. 18, no. 3, pp. 150-162, 2019.

[11] Y. Lei, W. Lei, W. Ziang and G. Yaxin, "A waste recycling platform based on B/S architecture and genetic algorithms for route optimization," *Journal of Sustainable Waste Management*, vol. 22, no. 5, pp. 234-245, 2023.

[12] M.S. Sodhi and B. Reimer, "Models for recycling electronics end-of-life products", *Spektrum*, 23, pp. 97-115, 2001.

[13] A. Mukherjee and D. Das, "A mobile app prototype for enhancing e-waste management through geolocation, education and incentives," *Journal of E-Waste Management*, vol. 12, no. 3, pp. 45-59, 2019.

[14] E.Y.L. Sum, "The recovery of metals from electronic scrap", *Journal of Metallurgy*, 43, pp. 53-61, 1991.

[15] J.A.S. Williams, "A review of electronics demanufacturing processes", *Resources, Conservation and Recycling*, 47, pp. 195-208, 2006.

[16] M. Buggy and L. Farragher, "Recycling of composite materials", *Journal of Materials Processing Technology*, 55, pp. 448-456, 1995.

[17] M. Samuel, "A new technique for recycling Aluminium scrap", *Journal of Materials Processing Technology*, 135, pp. 117-124, 2003.

[18] S. Artang, A. Ghasemian and I.A. Hameed, "A digital platform for enhancing e-waste transparency and traceability through QR technology," *Journal of Waste Management In novation*, vol. 15, no. 4, pp. 123-135, 2023.

[19] Z.F. Liu, X.P. Liu, S.W. Wang and G.F. Liu, "Recycling strategy and a recyclability assessment model based on an artificial neural network", *Journal of Materials Processing Technology*, 129, pp. 500-506, 2002.

[20] T. Spengler, M. Ploog and M. Schroter, "Integrated planning of acquisition, disassembly and bulk recycling: A case study on electronic scrap recovery", *Spektrum*, 25, pp. 413-442, 2003.

[21] R. Balart, L. Sanchez, J. Lopez and A. Jimenez, "Kinetic analysis of thermal degradation of recycled Polycarbonate/ Acrylonitrile-Butadiene-Styrene mixtures from WEEE", *Polymer Degradation and Stability*, 91, pp. 527-534, 2006.

[22] A.M. Chaaban, "Hazardous waste source reduction in materials and processing technologies", *Journal of Materials Processing Technology*, 119, pp. 336-343, 2001.

[23] J.A. Stuart and Q. Lu, " A model for discrete processing decisions for bulk recycling of electronic equipment", *IEEE Transactions of Electronics Packaging and Manufacturing*, 23, pp. 200-314, 2000.

[24] R. Hischier, P. Wager and J. Gauglhofer, "The environmental impacts of the Swiss take-back and recycling systems for waste electrical and electronic equipment", *Environmental Impact Assessment Review*, 25, pp. 525-539, 2005.

[25] I. Ochiai, "Environmental protection in the electronic and electrical industries", *Journal of Materials Processing Technology*, 59, pp. 233-238, 1996