Waste Watch : A Truck Scheduling App For Maloleños

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Abstract

This project was pushed through to engage people towards proper waste collection, through the utilization of mobile devices of the communities residing in the City of Malolos. The study aims to develop and implement a sustainable and efficient waste management collection system by informing the residents of the garbage truck collection schedule available on their mobile devices.

Additionally, it has a platform to receive and review complaints of improper waste management resolved by their respective community officials. The mobile application was developed using the Agile Scrum Development methodology. The study also utilized a mixed approach of both quantitative and qualitative methods, through surveys and interviews. Alongside such, descriptive research methodology was also employed, in assessing the effectiveness and efficiency of the mobile application. The mobile waste management application Waste Watch : A Truck Scheduling App For Maloleños provides a friendly user experience with a minimalistic designed interface. It included a streamlined waste collection scheduling for easy creation, management and viewing of waste collection schedules. The study yielded an overall mean of 4.56, with a descriptive equivalent of "Strongly Agree", indicating high satisfaction levels for both residents and barangay officials. This positive outcome demonstrates the success in attaining the project's objectives and signifies the probability of integrating waste scheduling with the use of on-hand technology.

Keywords:

Garbage Collection. Waste Management, Community, GPS Tracking, and Technology

1. INTRODUCTION

Development and Change, one of the world's constant systems that continue to happen as humanity's life ebbs and flows and time is at a constant pace towards the future. With these developments and changes comes with waste and litter that remains as everything gets replaced and be improved upon. It is not an understatement that people can be far too carefree and careless of where they dispose of their litter. Waste management is one of the actions of environmental management for improving environmental quality so it is best that people are reminded of such liberty to preserve and minimize the destruction of the surroundings [1].

Solid waste management affects everyone; however, those most affected by the negative impacts of poorly managed waste are largely society's most vulnerable-losing their lives and homes from landslides of waste dumps, working in unsafe waste-picking conditions, and suffering profound health repercussions [2]. As it currently stands, heaps of plastic, paper, cans and bottles are scattered everywhere. The negative impact creeps up as the people are not taught properly of the consequences they can inhibit given enough time. Leave these waste piled up overtime without proper management and soon enough they would be at the end of the aforementioned dangers. That is why it is crucial for proper waste management and collection to be enacted and improved upon as soon as possible. Management of waste is a responsibility of every human being living on this earth so no one should be the wiser to disregard a big responsibility that each of us has [3]. Ultimately, citizens fail to recognise their role in waste management and become unwilling to either pay for service delivery or participate in clean-up campaigns [4]. In an effort to raise awareness and keep people in line towards the effort of clean-up, technology is now then utilized to modernize the approach and to make it accessible.

The use of technology in waste management is a growing area of interest, with a focus on smart waste management systems [5]. One such utilization of technology can be found in a similar study conducted in India, where the system would automatically generate an efficient route to the available garbage trucks enabled with smart GPS monitoring system, which in turn would be integrated with an algorithm for maximum collection of waste and fuel efficiency [6]. There has been such a case where fellow researchers created a web-based application

for proper waste management. Waste will be collected from the user's doorstep as per his/her request to avoid bad treatment/disposal of waste. There will be a real time monitoring of the dumper in order to provide accuracy, live status and no malpractices. [7]

With the issues given with the development of technology and the waste it produces, the researchers have used the opportunity to develop a system that will help garbage collection. The system aims to promote proper and sustainable waste management for the residents of Malolos. Additionally, providing a medium for the residents to raise awareness or concerns about the current state of the community's waste management.

1.1 Project Objectives

The main objective of this study is to develop "WasteWatch: A Truck Scheduling App For Maloleños, a mobile application – will help promote the practice of a sustainable waste management of the residents through an efficient and effective mobile application.

Specifically, the succeeding objectives were also taken into consideration: (1) to utilize an organized waste collection schedule using on-hand technology; (2) to promote the use of waste collection scheduling application; (3) to spread digital awareness among residents residing in the City of Malolos; (4) to strengthen community involvement and collaboration by incorporating social features within the application.

2. LITERATURE REVIEW

A group of researchers came to the conclusion that the process of industrialization and growth of human municipalities goes hand in hand with the production of municipal solid wastes [8]. The components of municipal solid wastes are influenced not only on economic conditions, but also on regional, cultural, and social habits and behavior.

The following proponents concluded that municipal solid wastes must be gathered in an efficient and environmentally sound way. Thus, vehicle routing and scheduling should be given attention as a call of action [9].

A pair of researchers deduced that the waste management chain needs new, innovative, and smart solutions to reduce the amount of waste generated and to improve recycling, making the chain more efficient and significantly more environmentally friendly[10]. A study stated that using an optimal routing for solid waste collection and transport can prove to be essential if sustainability in terms of cost reduction and environmental conservation is a priority in solid waste management[11].

One article concluded that the lack of effective statistical data causes a great difference in the workload of each garbage truck, resulting in an efficient work of waste collection[12]. Using technology to help and supervise the garbage truck drivers on their route. By providing better data using technology, waste collection will become more efficient and effective.

Based on a study, by incorporating a GPS tracking solution into waste management operations, efficiency can be improved, leading to cost savings and increased customer satisfaction. Furthermore, it provides real-time tracking which can assist with the waste management truck's route planning, and offer insights that can reduce operational cost and enhance one's efficiency[13].

Another study identified that GPS tracking for waste management can also be used as time management systems, helping drivers to keep focused and on-task to minimize time, labor, and fuel wastage in the field[14].

Through the initialization of technology towards waste management, a researcher identified that an Android-based waste management application system is designed to cater waste disposal transactions. Thus aiming for an increase in the user's interest and public insight in disposing waste and keeping the community surroundings clean and healthy [15].

A group of researchers stated that online community forums have risen in popularity in the last decade for answering people's queries. Numbers of users and questions erupted thus the integration of quality monitoring is essential for a better user experience[16].

A research study concluded that community participation and perception of waste management activities is important as a decisive first step in waste management activities. Raising public awareness is built on individual awareness and then facilitated by institutions or organizations that will manage it[17].

3. METHODS AND DESIGN
3.1 Research Design

In accomplishing the objectives of the study, Agile Scrum Development methodology and a mixed approach of both quantitative and qualitative methods were used. Agile Scrum Development methodology is a project management system that relies on incremental development. Each iteration consists of two- to four-week sprints, where the goal of each sprint is to build the most important features first and come out with a Potentially Shippable Product[18].

Figure 1
Agile Scrum Development Model
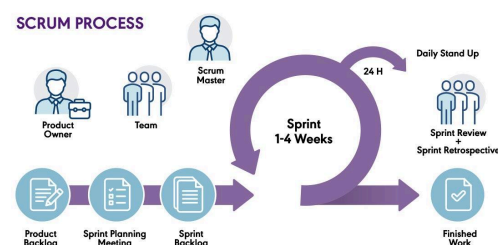
Thus, the project team utilized a week for every sprint that contains backlog items to be accomplished in building the system. The following contents enumerated on the sprint table slowly satisfies the whole functionalities WasteWatch application. Table 1 depicts the list of items in the backlogs assigned for weekly sprinting.

Table 1
Sprint Backlog Summary

Sprint	Task	Backlog Items
1	Resident	Create an account
		Login
		Logout
2	Resident	Simple and user-friendly Dashboard
		Input personal information
		Change password
		Update personal information
		Deactivate account
3	Barangay Official	Update waste collection schedule and provide real-time garbage truck location
		Moderate resident forums
		Change password
4	S-Admin Administrator	Full access to the system
		Access to resident profiles
5	Administrator	Ban and unban residents
		Archive and unarchive residents
6	Resident	View current waste collection schedules
7	Resident	Track garbage truck location
8	Resident	Report waste management / sanitation workers
		Access the resident forums

Furthermore, it is divided into five distinct phases - initiation, planning and estimates, implementation, review and retrospective, and release phase. Number one: Initiation Phase, the initiation phase is one of the most critical steps of the Scrum methodology, as this will set the foundation for the rest of the project. During this phase, outlining a roadmap with the main objectives, goal and deliverables alongside forming the project backlog is conducted. The product backlog is a list that contains features that will be implemented during development, ordered by priority, and follows the format of: As a/the [user role], I want to [product capability] so that [user benefit].

Number two: Planning and Estimate Phase, during this phase. The Scrum development team does sprint planning, In which the team identifies which they would like to work on during the sprint, called a sprint backlog.

Number three: Implementation Phase, the implementation phase is about the execution of tasks and activities to accomplish product goals and complete project deliverables

Number four: Review and Retrospective Phase, the review and retrospective phase is an essential part of the agile scrum process and should be done after every sprint ends. As it is an opportunity to evaluate what was successful, what needs to be improved and how to move forward by gathering feedback and insights.

Number five: Release Phase, it is the final phase of the Scrum methodology steps and all about preparing the final project deliverable ready[19].

Moreover, Quantitative research was used as it focuses on gathering numerical data and generalizing it across groups of people or to explain a particular phenomenon [20]. Lastly, qualitative research was also used since it involves collecting and analyzing non-numerical data (e.g., text, video, or audio) to understand concepts, opinions, or experiences. It can be used to gather in-depth insights into a problem or generate new ideas for research[21].

3.2 Research Instrument

The proponents of the study formulated questions, which were then utilized in creating a survey questionnaire, printed out and distributed to the target respondents. The constructed questions adhere with the ISO/IEC 25010 quality model, which is a product quality evaluation system determining which quality characteristics must be considered when assessing the properties of a product [22].

3.3 Data Gathering Procedure

The data collection initialized after the proponents had explained and demonstrated the functionality of the mobile application to the respected community officials and residents of the City of Malolos, by administering the survey questionnaire to the respondents.

3.4 Population and Sample

Residents of Malolos, Bulacan and community officials have been selected to participate in this study. A total of 28 Malolos Residents and 2 community officials evaluated the mobile application.

3.5 Statistical Treatment

The study used a five-point Likert-type scale as the method of interpretation for determining the effectiveness of the waste collection scheduling mobile application. Table 1 below shows the range, scale, and descriptive rating.

Table 2
Five-point Likert-type scale

Scale	Range	Descriptive Rating
5	4.50 − 5.00	Strongly Agree
4	3.50 − 4.49	Agree
3	2.50 − 3.49	Moderately Agree
2	1.50 − 2.49	Disagree
1	1.00 − 1.49	Strongly Agree

4. RESULTS AND DISCUSSION
## Development of the Prototypical Program for a Waste Scheduling Application

Diagrams were incorporated to visually represent the internal processes of the system, thereby improving the overall comprehension of its dynamics. These visuals offer a comprehensive overview of information flow and interactions within the system. The context diagram provides a high-level perspective by showcasing major processes, boundaries, and interactions with external entities, as seen in Figure 2.

Figure 2
Context Diagram for Waste Watch
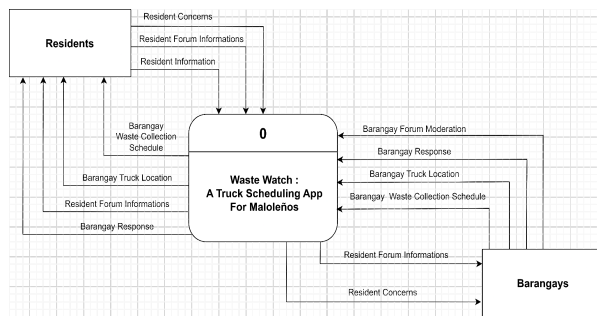
The data flow diagram delves into more detail by breaking down the major processes identified in the context diagram into sub-processes, providing a more granular understanding of the system's functionalities. These entities and data flow processes form a cohesive environment for efficient waste collection scheduling and resident engagement. The devised diagram is displayed in Figure 3

Figure 3
*Level 1 Data Flow Diagram for Waste Watch*
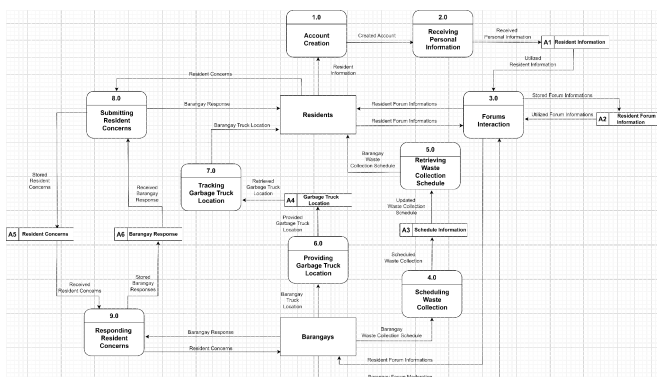
Objective 1. Mobile-accessible waste management app

The development and design of the app has been well adjusted to cater to everyone who has access to their mobile devices. The design that was well crafted for the was made to ensure that the UI integrated within the app is well-adjusted for the eyes for out users with the chosen color palette and fitting in with the theme of the app, as well making each button and functionalities easy to use and understand. Figure 4 illustrates the main menu of the app that is accessed by the general population.

Figure 4
WasteWatch Dashboard on resident's side
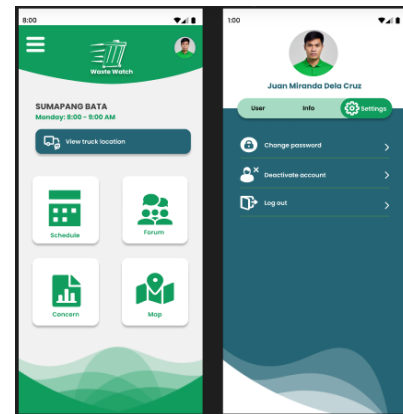
Objective 2. Streamlined waste collection scheduling

The process of community officials creating waste collection schedules and residents viewing said schedules are made simple and user friendly, for the creation process by default displays the current month and allows community officials to select whichever day(s) they want to select in the month, so long as it hasn't passed yet, inputting their preferred time slot and also allowing them to input multiple time slots in the same day. Allowing residents to view all the posted waste collection schedules and all its time slots for the current month. Figure 5 depicts the user interface that can be accessed by the barangay officials.

Figure 5
Waste Collection Scheduler
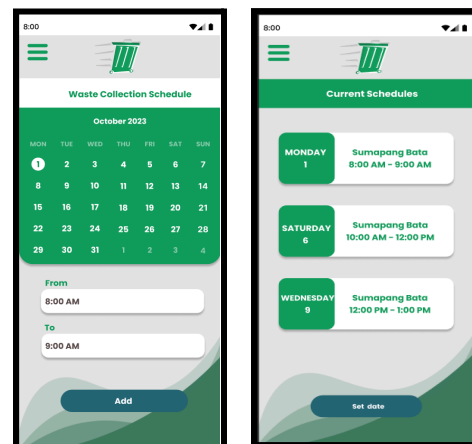
Objective 3. Promoting Digital Literacy and Awareness in the City of Malolos

With the advent of the modern age where tech becomes closer to being a necessity for everyone, the application has been well adapted to be used in various forms of mobile devices and that we encourage each citizen to utilize their devices in making the most of our app. The app also raises awareness of the current situation of waste in each of their respective barangays and to promote cooperation of both barangay and occupants to participate in a cleaner and safer community. Figure 6 shows the map feature that can be accessed inside the application.

Figure 6
Digital Map with relevant information of each Barangays
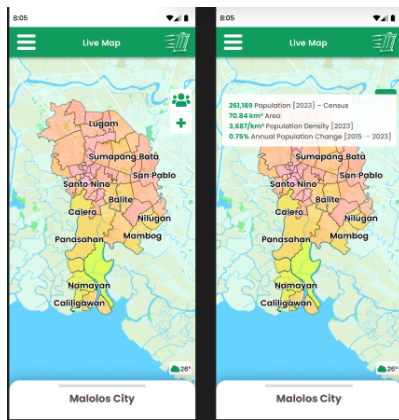
Objective 4. In-app community forum

The in-app forum acts as a dynamic platform for interactive discussions about community waste management. Residents and authorities have the opportunity to openly exchange views, share insights on current challenges, and engage in collaborative discussions to formulate innovative improvement suggestions in this carefully moderated and welcoming environment. The forum's inclusive nature encourages a collaborative effort to improve waste management practices, promote a sense of community responsibility, and strengthen the collaborative spirit among residents and local authorities alike. Figure 7 displays the neatly designed in-app community forum.

Figure 7
WasteWatch Community and forum
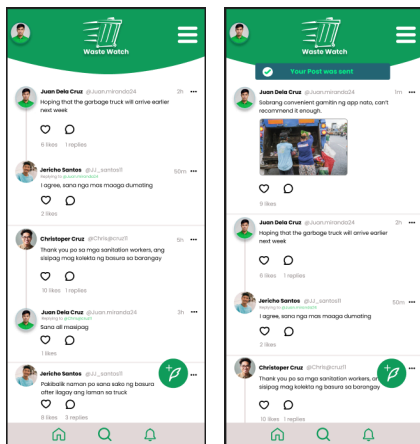
Evaluation of the Developed Prototype Using the ISO/IEC 25010 Standard Model

From the properties rated, Usability received the highest mean of 4.95, which suggests that the WasteWatch application is deemed practical by the respondents. Maintainability ranks second among the highest rating with a value of 4.89, which implies WasteWatch to work efficiently and have a continuity of developments in the future. Altogether, the system received an overall mean of 4.56, corresponding to a descriptive interpretation of "Strongly Agree". This evaluation score signifies the dedication of the project team in providing a premium experience for its user base.

Table 3
Summary Overview of the Respondents' Ratings

Property	Mean	Descriptive Interpretation
Functional Suitability	4.54	Strongly Agree
Performance Efficiency	4.5	Strongly Agree
Compatability	4.47	Agree
Usability	4.95	Strongly Agree
Reliability	4.43	Agree
Security	4.55	Strongly Agree
Maintainability	4.89	Strongly Agree
Portability	4.64	Strongly Agree
Overall Mean	**4.56**	**Strongly Agree**

5. CONCLUSION

This study explored the category of software development in terms of a Municipal Waste Management Application expounding the critical role of organized waste management, particularly on waste collection scheduling. The efficacy of the developed prototype was supported by its evaluation on both the barangays and residents within the City of Malolos, Bulacan. Utilizing the system for complete mobile application development can offer the local barangays within the City of Malolos and their residents to effectively organize waste collection schedules that contributes for an overall better waste management. This app-driven investigation establishes a foundation for similar waste management and scheduling solutions in the setting of mobile application prototype design.

6. RECOMMENDATIONS

In light of the study's findings and conclusions, the following recommendations are offered: (1) enable cross-platform availability to fully synchronize in a web application the features of the system; (2) optimize for multi-platform compatibility, extending from the original Android design to seamlessly support Apple iOS; (3) provide bilingual support to accommodate residents who may prefer using the application in Filipino language; (4) incorporate offline functionality, allowing residents to access basic information and waste collection schedule, for areas with varying network conditions. These logical and comprehensive enhancements will provide a more effective and inclusive waste collection scheduling application for the barangays and residents within the City of Malolos, Bulacan.

7. RESEARCH IMPLICATIONS

Waste Watch: A Truck Scheduling App For Maloleños establishes profound implications for waste management and scheduling strategies. Both government and private sanitation workers can use Waste Watch as an inspiration or reference to effectively organize and manage their waste collection scheduling for their tailored and specific needs on the area they will implement it on. The developed prototype provides a comprehensive concept catering to the ever growing population and changing needs of sanitation workers. In summary, both government and private sanitation workers can enhance their work and allow their target audience to benefit from their modernized approach in waste management and scheduling.

8. ACKNOWLEDGEMENTS

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