A Food Waste Mobile Gamified Application Design Model using UX Agile Approach in Malaysia

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***Abstract*—Food waste is a significant worldwide issue in landfill management. Due to improper implementation, technology applications related to food waste collection and its management system are still lacking in practice. The available applications have yet to address the issue of food waste management. Constructing an interactive mobile application is necessary for managing food waste collection for the decomposition process using Black Soldier Fly (BSF) treatment. Furthermore, as the mobile application requires participation from various user backgrounds, maintaining user involvement has become a priority. Gamification has emerged as one of the approaches that might favourably affect individual engagement behaviour. A comprehensive game element design is required where it focuses on how gamification can influence user engagement. This study aims to model the food waste gamified mobile application design to benefit Malaysia's decomposition ecosystem. It includes gamification, management features, and data visualization for reporting and will involve users from households, businesses, and the BSF farm. This paper presents the modelling process of a new mobile application design for this concept of study. The UX agile approach was used in gathering and designing the application requirements as it allows for active participation from all stakeholders. The result shows that the experts agree on the application design. This research will indirectly benefit the BSF industry in Malaysia, and it will have a significant impact on gamification, user experience, and food waste management in the direction of a sustainable environment.**

***Keywords*—Avatar; food waste disposal; mobile apps; gamification; data visualization; black soldier fly**

I. Introduction

Information system focuses on providing solutions to business processes for better operation management, information, and supporting the decision-making process. Recent technological advancements have transformed the way business processes are carried out. In this context of the study, the technology transformation includes the business process of collecting food waste from sources (households and businesses) and sending it to farms for treatment using black soldier fly (BSF). This treatment is one of the methods used to keep organic waste out of landfills [1]. With BSF as a treatment agent, food waste disposal is environmentally safe and cost-effective [1 – 2]. It is known that BSF decomposes food waste into animal feed and compost. Thus, the quality of food waste is critical for BSF production. As a result, food waste preparation should adhere to the guidelines provided. Therefore, food waste producers should be cultivated with proper, clean, and safe disposal. It is necessary to simplify the procedure of food waste disposal for them to actively participate in keeping the surrounding environment safe [3]. This procedure could involve everything from waste preparation to waste collection and delivery to the farm for further processing.

As smartphones become more prevalent in daily life, using them to support food waste processes ranging from waste cultivation to collection will allow individuals and society to contribute to environmental sustainability. However, in order to contribute, they must be driven or motivated. Current food waste collection, disposal, and decomposition systems or mobile applications on the market are not related to collection, disposal, or decomposition. They are merely about raising awareness about food waste and recycling [3 – 5]. Although technology intervention in food waste operations may be attracting much attention worldwide, it is unlikely to be internalized for use by other landfills, particularly those commercially produced for the Malaysian market. This paper argues that it is deemed necessary to have an application that can stimulate community involvement and an application that can assist landfills in conducting their business operations, particularly in the case of the Malaysian context of studies. Gamification offers a game-like experience to a serious or monotonous type of work. This experience will make the users interact with the system not because they are forced to but because they want to use it and be a part of a fun and appealing system. As gamification aims to motivate users, its application may benefit food waste management. Furthermore, because the national aspiration is toward digitization, there seems to be a significant effort to improve the organization's information system management in all aspects of the operation.

This paper presents the development and modelling of a smart mobile gamified application for managing local food waste, a case study in the Malaysian context. Using BSF, the technology will support food waste requests and collection business processes for later decomposition arrangements. This technology is made available through mobile apps that include gamification, waste management features, and data visualization for reporting. The application can help to support the government effort to preserve the environment, especially the food waste disposal and ecosystem of BSF. For that purpose, the groundwork of the system application design and development are described, the results from the design usability testing are presented, and this design later be modelled as a guideline for similar system implementation. Given the current literature review, it shows that this research would be a significant digital application if implemented in the context of Malaysia.

The following is how this paper is structured: First, as an introduction to the study, this paper reviews work related to food waste and BSF in Malaysia, food waste technology adaptation, and the use of gamification in the related application. Second, it describes the study's materials and methods. The description includes the development methodology, the mobile application's requirements and design, as well as design validation. The third section contains a discussion of the results of the design usability test. A model for such an application is created as a result of the design activities and is presented in section four. Finally, concluding remarks and recommendations for future work are presented in the final section.

II. Related Work

A. The Model Development Process

Historically, most countries, developed or developing, have relied on landfills as final waste disposal sites [6 – 7]. Today, many developed countries have made other options within the waste hierarchy mandatory to reduce landfilling. Developing countries, particularly impoverished urban areas, rely on unsustainable solid waste management, primarily dumpsites. Over 90% of waste generated in low-income countries is either openly burned or disposed of in landfills [8]. Dumpsites receive all types of waste, including organic waste, and exposure to rainfall causes the production of leachate and methane. It contributes to the problem of climate change. Unknowingly, food waste is one of the wastes that has significantly contributed to the global dumpsite problem.

Malaysia had relatively high percentages of food waste from restaurants and households [3, 9]. According to Abd Ghafar [9], in 2017, restaurants contributed approximately 15,000 tonnes of food waste per day, with households contributing approximately USD 50 per month. In 2021, daily food waste will reach 38,000 tonnes, with household waste increasing by around USD 90 per month [10]. The local authorities are now dealing with a critical situation. One alternative to managing food waste is Black Soldier Fly (BSF). BSF will consume the food waste feed and compost the waste [1 – 2]. It is critical to preserve the ecosystem to create a sustainable environment. As a result, various approaches from various perspectives have been explored to support the effort. One of them is through the innovation of smart technology in assisting the food waste disposal processes for the benefit of BSF.

Food waste disposal management in the literature is centred on food recycling [3 – 4], landfill issues [4], and educational awareness [3, 5]. However, none of this is used commercially in Malaysia. Little is known about information technology that may impact food waste disposal processes and BSF production. High amounts of food waste are required to increase BSF production. Furthermore, the food waste disposal ecosystem should include households, retailers, agricultural industries, the local community, local governments, and the BSF industry. However, due to the limited venue or platform to contribute, communities may find the effort is not encouraged by the local authority or another party. Thus, different individuals' behaviour and perceptions of the importance of beneficial food waste disposal emerge [11]. Besides, the community's awareness of the processes may not be widespread. As a result, there is a lack of involvement and motivation from the communities (restaurant, farm, household) [11 - 12]. In this view, communities may fail to see and realize the urgency to properly dispose of their food waste.

B. Technological Approach to Food Waste Management

Various alternatives should be developed to ensure a smooth domestic food waste disposal process, including food waste readiness, collection, sending to the appropriate farm (validated by local authorities), and verifying food waste disposal compliance. Research by Varhana, Faliasthiunus & Ulfah [13] has recently completed the development of a management system specifically for BSF. They created a traceable waste system that can track, control, and manage waste problems following their authority's policies. They used a waste bank, which served as a waste recipient, distributor, and manager. BSF would be able to generate a high economic value through the waste bank. However, since this application is primarily concerned with the management of BSF production, local communities, businesses, and government involvement may be given less emphasis. Other food waste mobile apps that have been developed are more focused on raising awareness [5], the Zero Food Waste Act [14], and ways to reduce food waste through donation [15]. In Jain et al. [5], gamification is used in a mobile application to encourage students to avoid making messes and wasting food and develop positive behaviour in maintaining a good environment. However, these current inventions do not include management of the food waste disposal process that involves societies for a sustainable environment. Some incentive that encourages them to be a part of the process should be designed and implemented to increase community participation.

Gamification is a practical approach to information management [16]. Gamification is expected to provide a fun and engaging environment for users to complete assigned tasks [16]. Ulla Santti et al. [17] investigated the use of gamification in encouraging users to process and sort their food waste. According to the study's findings, the gamified application can be effectively used to support a change in consumer behaviour, particularly in cultivating food recycling among young adults. Research by Ali & Ahmed [18] created a mobile geo-located system to locate and pattern user-reported food waste disposal. Gamification was used by the application to encourage user engagement with the application. Ali & Ahmed contend that increasing food waste awareness goes beyond food waste reduction. Users must be motivated to participate in the process. All available applications, such as those in [5, 17–18], are concerned with encouraging users to reduce food waste. In this regard, the gamification application differs from the proposed work for this research. However, the use of a motivating element to justify gamification is similar.

The local authority also requires an intelligent system to manage their waste administration better [9, 14]. In this view, a local authority may needs a smart mobile application to cater to food waste movements. The application should involve the local communities, businesses, and BSF farms. An application that allows them to actively monitor the production of BSF livestock from the collection of food waste seems demandable. Such application will indirectly help to improve the production of BSF livestock.

III. Materials and Methods

This section describes the modelling and verification process of developing the proposed mobile application. The description includes the methodology used in the study, the detailed modelling processes involved, and the materials used in the study. The requirement analysis and application design activities in modelling the interactive application for managing household food waste for BSF in Malaysia are presented in detail.

A. Agile UX Methodology

The modelling and verification of the mobile application development follow the agile UX methodology. The methodology was chosen due to the nature of the work that requires active involvement from a system developer, project management, and other system stakeholders. Obtaining collective opinions and approval will be difficult if meetings do not exist or are held infrequently [19]. The study by Akhbar et al. [20] shows that software companies in Malaysia have been opting to adopt an agile approach in their software development projects. This adoption is due to the company's agreement to support the global software development projects, outsourcing the tasks to other offshore companies. The approach seems to have encouraged the collaboration of ideas, staff skills, and company resources between the local and offshore companies. Besides, agile implementation in the context of IS projects in Malaysia was a successful approach in delivering a rapid system implementation [21].

The agile UX development lifecycle is a method variation that builds on the Scrum framework [22]. It is organized into two tracks; the agile team and the UX team. The hybrid methodology consists of several phases that are interconnected between the agile team and UX team during the requirements, design, and testing phases. This development lifecycle follows the agile UX framework proposed by Kieffer, A., Ghouti, A., & Macq, B. [19], as illustrated in Fig. 1.

The requirement analysis and designs of the application will be the core and critical elements for this context of the study. Because the process involves the developer, designer, researcher, and potential users (e.g., admin farm, household, restaurant, local authority representation), all stakeholders will validate the requirements, design, and feedback.

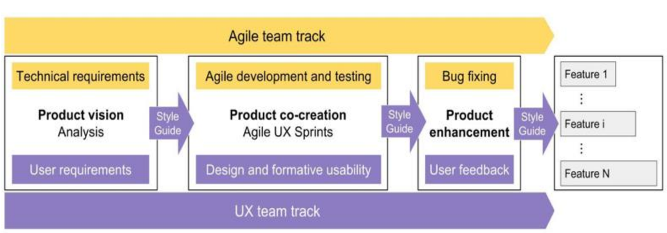


Fig. 1. Agile UX Development Lifecycle. Note. This Model was Adopted from Kieffer et al. [19].

B. Agile UX phases

Based on the methodology in Fig. 1, the application of each phase in this study is described as follows:

1) Product vision: This phase addresses the users and technical requirements. The UX team conducts user requirements, while the agile team obtains technical requirements. The UX team used personas (user stories) and task analysis to analyze the stakeholder's requirements. Meanwhile, technical requirements are gathered based on system development, team, and deployment requirements. The application's specific features are obtained at the end of this phase. Activities for user requirements are explained in the next section, requirement analysis.

2) Product co-creation: The team will design the application user interfaces and create a high-fidelity prototype for each feature during this phase. The designs are the initial features that have been proposed. The team will improve these designs regularly through the sprint activities. This phase also involves two groups, one from the agile team and one from the UX team. The agile team will create a product backlog for each feature and update it as the feature progresses for each sprint.

Meanwhile, the UX team will validate the design by conducting usability testing on each design and prototype. They will then decide what design changes are required in the next sprint. The sprint iterated until each design feature was released. Once released, the high-fidelity prototype will be transferred to development for final product deployment. This phase's research activity is to report on the study's initial design and design verification sections.

3) Product enhancement: The agile team will concentrate on product enhancement, investigate the errors, and correct them as necessary. Meanwhile, the UX team will reanalyze key user feedback and confirm the current designs. In addition, the analysis will feed requirements into other features in an indirect manner.

C. Requirement Analysis

1) Scrum meeting: Two scrum meetings were conducted to determine the system's requirements. The first meeting is for the initial user story and requirement, and the second is to confirm the stories and requirements. The official meeting was conducted online due to the different geo-location and limitations during the pandemic situation. The session involves developers, a system consultant, the system owner, and a system user. Non-official meetings were also held, which were conducted via phone calls and group messages. The consensus of each member on the required features is gathered and synchronized with the user stories. The requirements were later transferred to the initial designs.

2) Personas: A user story is essential for understanding the roles involved in the system application and which features should be designed according to the roles. It aids in clarifying the system's scope and clearly defining users' roles in the system. In this study, the system has three main user stories. The story is as follows.

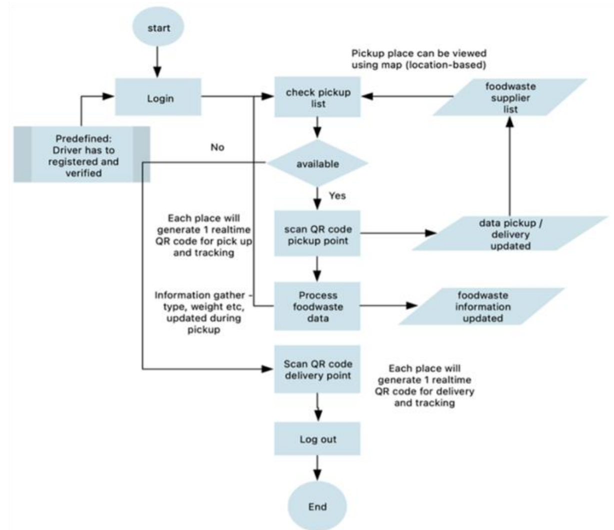
- Collector (rider): A collector is a rider who collects waste from a pickup location and transports it to a designated landfill site. They must apply to be a collector in the application and wait for the admin approval. They will be issued a collector's ID once they have been approved. The application will be using Google Maps to show the location with a tracking destination to assist a rider in picking up the waste. Collectors need to scan a QR code at the pickup and sending locations and confirm the pickup items. Riders must log in to their page to see their dashboard on completed tasks, new collection tasks, uncompleted tasks, history tasks, and revenue collected from the tasks. The rider will be able to update their profile and see their achievements through the gamification elements on their page.

- Household or restaurant: A household/restaurant manager ensures that food waste is ready for collection. They must bag the waste according to the instructions and then be prepared with the description, number of bags, and total weight to be entered into the application. In the application, they can find instructions and information on what is and is not collectable food waste. The household must book the available date and time for collection in the application. Aside from that, they will be able to view the entire collection history and the following scheduled collection. The application also allows for scheduling and cancellation. Households can view their accomplishments and contributions to an eco-friendly environment on their profile page.

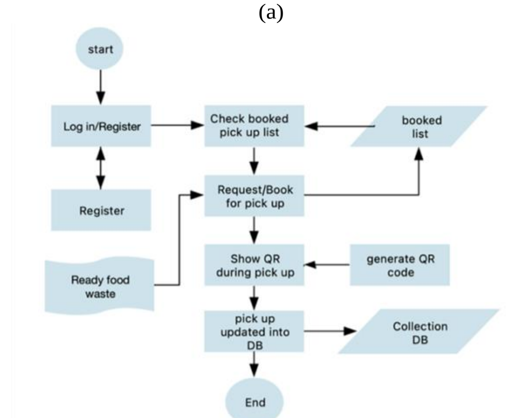
- System Admin: An administrator is a person in charge of the system. The administrator will be able to manage the users. After checking and verifying user profiles, they will manually assign the system's users' roles (collector, household, and restaurant). In addition to auto collection allocation, the admin will be able to assign a collector to collect waste manually. Admin can view and report on all transactions. The admin is also the person in charge of approving waste deliveries and processing payments to the collector.

D. Initial System Design

1) Application function flow: Following the requirement, the user story is used to define the system flow. There are three flows in total: 1) food waste pick up collection flow (Fig. 2a), 2) household/restaurant request for collection (Fig. 2b), and 3) Admin manage the system (Fig. 2c).



(a)



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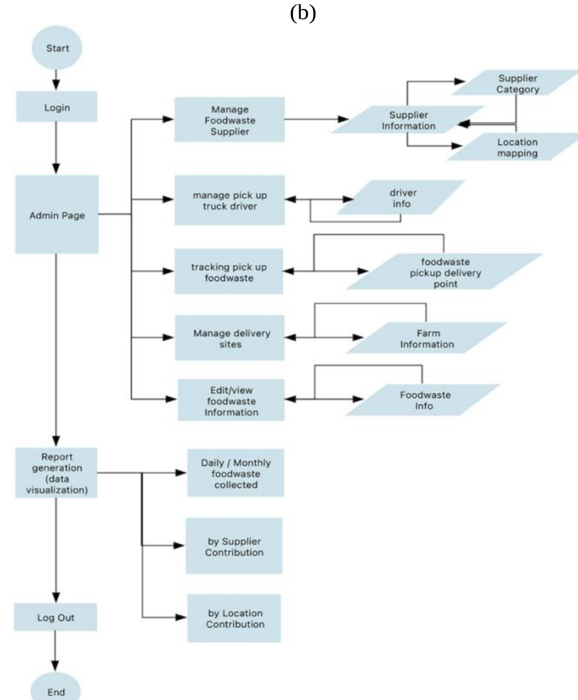


(c)

Fig. 2. (a) Food Waste Collection Flow Chart, (b) Requesting for Collection Flow Chart, (c) Admin Site Flow Chart.

2) Application design: The Figma application was used to create the high-fidelity prototype. Using Figma, it is possible to quickly visualize and present the application to users during the design sprints. The design comprises three main parts in line with the user story. The design includes the screen for signing up and login (see Fig. 3), the main screen for a collector - dashboard of a collection task, transaction history, maps direction for collection, user's profile – with gamification element, and QR code generation (Fig. 4a and 4b). It also includes the main screen for household and restaurant - collector profiles with gamification, transaction history, rewards, and QR code generation (Fig. 5a and 5b).

The gamification (as in Fig. 6a) included points, ranking, level, and rewards. Riders will be awarded points based on the total number of kilometres collected. When they reach specific points, such as 1km to 10,000km, they will advance to the intermediate level, 10,001km–50,000km, and 50,001km and above, they will go to the advanced level. The landfill's administrator can adjust the level. The rank element is determined by the rider's income from the collection. Each rider can convert their points into physical rewards based on the redemption offer made by the participating party.

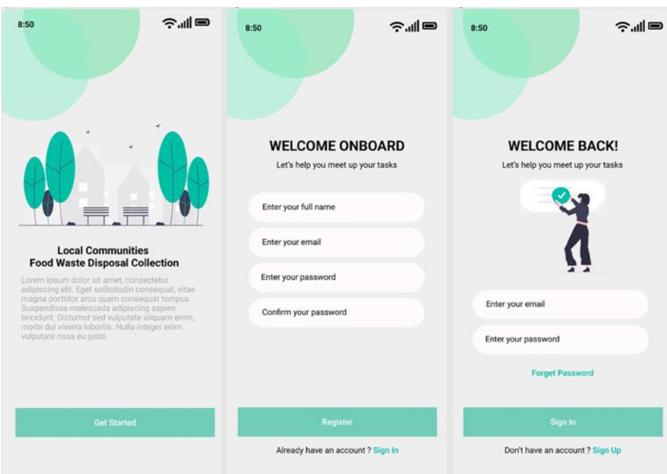
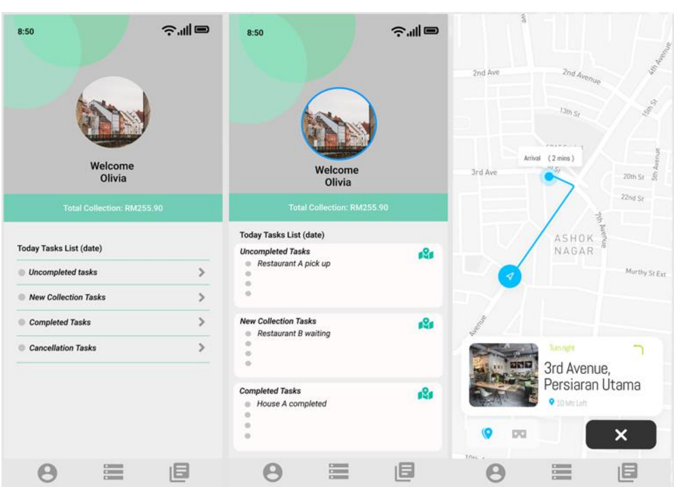
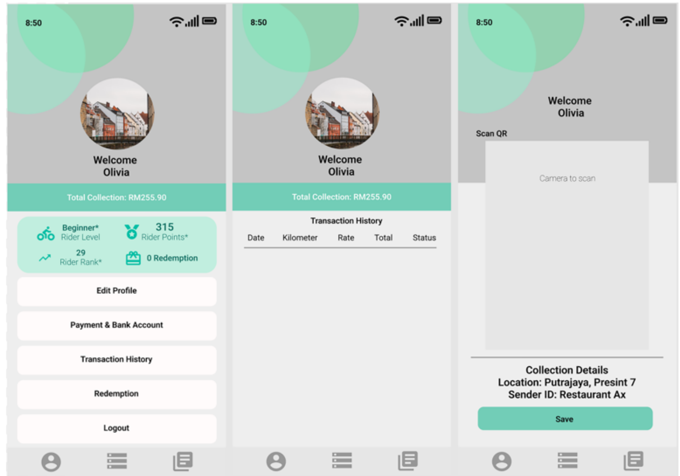


Fig. 3. The Main Screen, Sign Up and Login Screen.

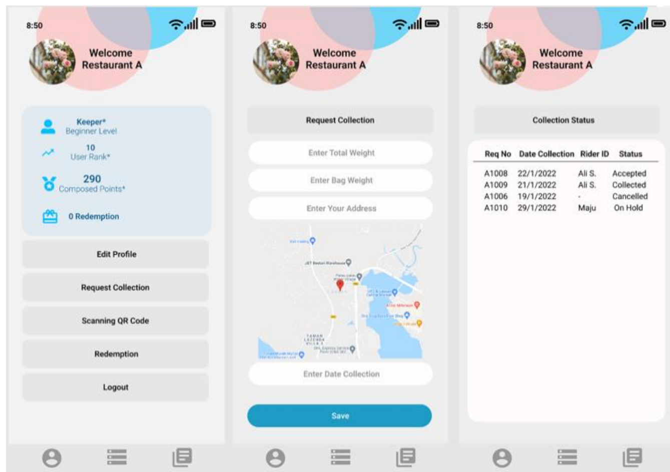


(a)

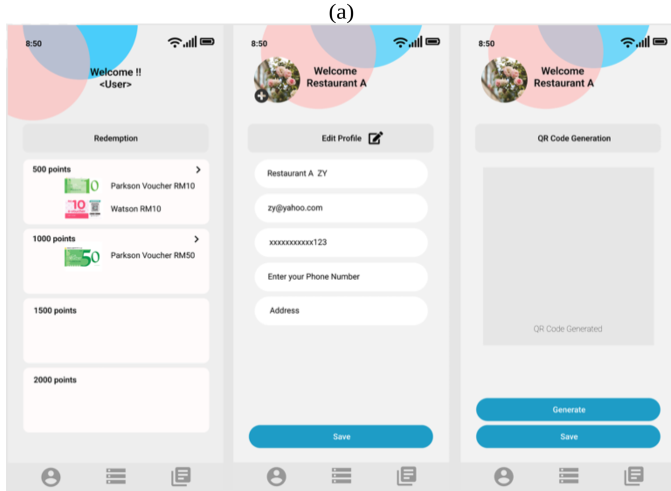


(b)

Fig. 4. (a) Collector's Screen – Dashboard, Task and Direction, (b) Collector's Screen – Profile and Transaction History.



(a)



(b)

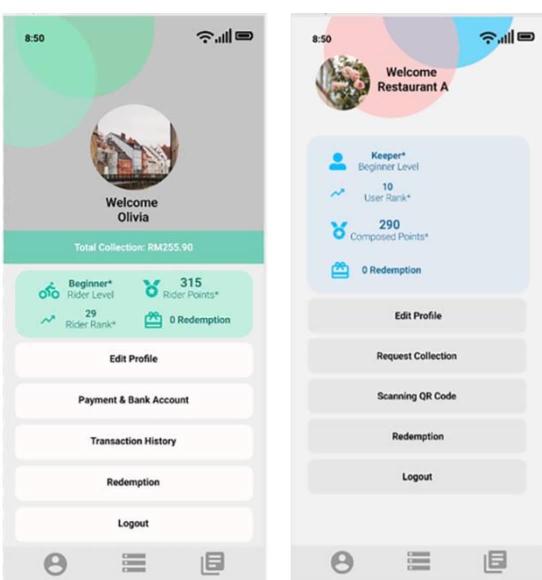
Fig. 5. (a) Household/Restaurant Screen – Dashboard and Request, (b) Household/Restaurant Screen – Rewards and Profile.

Gamification elements in the restaurant or household function include points, ranking, level, and rewards (Fig. 6b). Like the rider, restaurants/households will be rewarded with points based on the amount of waste they send to landfills. When they reach a certain kilogram weight, for example, between 1kg and 1,000kg, their level is changed to the keeper. If the total weight is between 1,001kg and 5,000kg, their level changes to a saviour, and if the total weighs more than 5,001kg, their level changes to a knight. The rank is determined by the total number of kg contributed. The points accumulated can be redeemed based on the redemption offer.

E. *Design Validation*

The designs were validated in the second phase of the Agile UX method. The validation was carried out to ensure that the design applications complied with the requirements and specifications of the users. Six participants were recruited for this purpose to provide feedback on the application's flow and their designs. The process was repeated several times until the final design was reached. The study was carried out via an online sprint meeting. Participants were asked to review the design, flow, and expected applicability when thoroughly applied.

1) Participant and research design: The selection of participants is based on their roles in the system and their responsibility in the system development. Generally, the roles involve collector, food waste supplier – households/restaurants, system owner, system developer, designer, and system consultant. These participants were also the key users of the system. In this manner, they were involved from the requirement phase to the design phase. They are also classified as someone being technologically savvy, as their daily activities involve the use of online systems and applications. The same participants were involved in assessing the proposed systems model design against design specification and system usability – ease of use in completing a specified task, consistency and standard design, and its practicality in implementation. The demographic of the participants is summarised in Table I.



(a) (b)

Fig. 6. (a) Rider's Gamification.(b) Household/Restaurant Gamification.

TABLE I. PARTICIPANT'S DEMOGRAPHIC

Demographic	**No**
Gender	
Female	4
Male	2
Age	
25 - 29	1
30 - 34	0
35 - 39	1
40 - 44	4
Type of Users	
Key users (Non-system developers)	4
Non-key users (System developers)	2
Field of Expertise	
Key User	2
UX/UI researcher and developer	2
Landfill and dumpsites	2

2) Application verification: Before the study began, the researcher formally emailed each sprint meeting's invitation to the participants. The email was sent to obtain their consent and provide detailed information about the study. Following their consent, the online meeting details were emailed to them for confirmation. The meeting begins with a presentation of the system (status and features), usability testing, and a comments and discussion session. The session will typically last 30-45 minutes.

A list of tasks based on the system flow and design is provided for usability testing. The tasks are listed in the following Table II. For this testing, two materials were used – 1) the list of tasks to obtain usability problems raised during each sprint session, and 2) the types of user error measurement usability metric adopted from Kieffer et al. [19] (as shown in Table III) to indicate any usability problem found during the test.

TABLE II. LIST OF TASKS FOR USABILITY TESTING

Sprint (S)	**Tasks**	
Sprint 0:	T1	Sign up, log in, forget password
	T2	View all collection tasks
	T3	Select new task collection and view map for direction
	T4	Request collection (Restaurant)
Sprint 1:	T5	Edit profile, change a picture, edit payment bank info (both collectors and restaurant)
	T6	View transaction history and collection status (both collectors and restaurant)
	T7	Redemption function (both collectors and restaurant)
Sprint 2:	T8	QR code generation and scanning (both collectors and restaurants)
	T9	Review gamification elements (both collectors and restaurants)
	T10	Main menu review (both collectors and restaurant)

TABLE III. TYPE OF USER ERROR

Code	**Type of Error**
UE1	Behaviours that prevent task completion
UE2	Mistaken believes that a task is completed when it is not (or vice versa)
UE3	Misinterpretation of the content
UE4	Oversight of something that should be noticed
UE5	Expression of frustration by the participant
UE6	Participants remark about the possibility of improvement

During the online sprint meeting, participants will personally conduct the test of the design prototype according to the given tasks. Then, participants will note the types of errors they discovered for each system design prototype. For each error discovered, the severity of the error (low, medium, high) will be noted to determine what actions should be taken. Once finished, they will send back the error list to the researcher.

IV. RESULT AND DISCUSSION

1) Usability testing: Table IV summarizes the indications of usability errors. The authors discovered that participants misinterpreted the content of a few tasks: task 3, task 8, and task 9. One task (task 5) was mistakenly thought to be completed, while another task (tasks 5&9) was suggested for improvement. Overall, the errors were rated as having a low risk of seriousness. The low risk indicates that the issues raised are not likely to cause task failure, but they may have a minor impact on system efficiency or user satisfaction. Thus, feedback from participants was gathered through comments and discussion sessions for detailed explanation and to work out the proposed solution.

TABLE IV. SYSTEM DESIGN USABILITY ERRORS

Sprints	**Sp0**				**Sp1**			**Sp2**		
Tasks/ Errors	T1	T2	T3	T4	T5	T6	T7	T8	T9	T10
UE1										
UE2					✓ P3/ P4/ P5					
UE3			✓ P1					✓ P2	✓ P1	
UE4										
UE5										
UE6					✓ P4/ P5/ P6				✓ P1/ P6	
Severity					Low			Low	Low	

*P – Participant Code, T – Task Code, UE – Usability Error Code, Sp – Sprint code

2) Design feedback: Table V summarises the experts' feedback based on the remarks and discussion session at the sprints meeting session. The summary is divided into four sections: challenges, improvements, questions to consider, and interesting implemented features. The main areas that need more attention, according to the feedback, are the collection operation, the payment process for collectors, and features for providing feedback on waste quality. As a result, the following actions were put in place.

- Collection operation: using a dynamic QR code, food waste collection at pickups and sending locations could be improved. A dynamic QR code will change over time, making it easier to capture time accurately. As a result, the payment process can be calculated based on the recorded time.
- Payment procedure: the discussion in this section resulted in a manual operation for paying the collectors' commission on waste delivery. The delivery fee will be calculated based on the delivery rate per kilometre and the weight of the waste. The landfill will make weekly payments to collectors. All payment transactions will be recorded; only payment transfers will occur outside the system.
- Providing feedback: it is crucial to rate the collected waste as the land site needs to produce a high quality of decomposed for BSF. Preparation of food waste has to follow the given guideline to avoid receiving food waste that does not meet the standard, and landfills must rate the waste. Any non-compliance should result in negative feedback, and the household or restaurant will be barred from sending waste for an extended period.

The collectors and household/restaurant modules were prioritized following the sprint design meeting. The justification for this was that the functionalities were directly related to the collections processes, which are the application's key features for the key users. After considering all the feedback from the sessions, a series of design concepts were created later to demonstrate the workflow development process.

3) Implementation of agile UX approach: Sprint activities are remarkably beneficial in improving the system's designs and functionality when using an Agile UX approach. On the other hand, the concepts can be easily moulded because they are all aimed at the same goal. During the sprints, participants with varying expertise and skill sets contributed a wide variety of ideas and criticism. Nonetheless, at the end of each sprint session, all participants reached an agreement.

TABLE V. FEEDBACK COLLECTED FROM SPRINT ACTIVITIES

Challenges	Viewpoints and Improvements
- Getting households to use the apps, generate the QR code, and use the code every time collectors collect waste may be difficult for some users who experience difficulties with mobile technology. - How can landfills managers ensure that households and restaurants provide high-quality Waste for BSF and improved decomposition? - Paying collectors via the system immediately after completing a delivery is more efficient than a manual payment. However, it may be difficult for the landfill manager to control the quality of the waste while also managing a fair collection assignment for all collectors. - Gamification in a mobile application required some time to see the effect on collector motivation and behaviour.	- Reminders and notifications should be used when collectors reach their destination (pick up and send locations). - Payment workflows should be improved. - Gamification features should be explained in detail once all data has been integrated. - Data visualization on the collector's dashboard could assist them in effectively synchronizing their work. - Could external devices such as scanners be incorporated in determining the waste quality? - The app's purpose is to make waste collection and distribution easier. It has made a gig platform job opportunity available to local communities. - A reward is an interesting method to appreciate user involvement - Sprint activities gradually demonstrate the system from concept idea to design step-by-step.
Questions to Ponder	**Interesting Features**
- Local community involvement in catchment teaches good waste management ethics and environmental care surroundings. How do you ensure the information provided and feedback to them is actionable? - Is it possible to shorten the work and process of decomposition by using mobile apps?	- Gamification elements are used to encourage users to participate in collecting and delivering food waste. - The designs are acceptable, and the concepts are considered to make sense as they adequately address the requirements. - Feedback and ratings would be relatively beneficial in nurturing households and restaurants in providing quality food waste.

Generally, communication and collaboration are the main challenges a company faces in Malaysia when using a UX approach [21, 23]. The programmers faced various challenges regarding the technical aspects, particularly those concerning application design and development. The challenges elicited when connecting the system's requirements and designs between the end-users, the software developers, and the software vendor. The developers and user experience practitioners can become frustrated, particularly when openness to sharing the system problems and solutions is limited to the knowledge or skills of developers and practitioners [24]. In such cases, it would expose their inability to solve problems during the development process. Developers might also experience high pressure in providing seamless progress [21]. However, this situation could be because of several independent factors implemented in various ways. For example, a collaboration between developers of different level of skills level to complete a successful system, input from ethnic diversity provides a different insight into the system implementation, and different levels of technology-savvy among users help to train users to be more competent. Project progress sharing will make the project more visible and transparent. We argue that this variety should provide the team with more valuable input to the projects, mainly in the case of the Malaysian context. These situations have encouraged collaboration, allowing further exploration of the team's creativity. Looking on the positive side, the team could alleviate the challenges with careful team design and well-planned work.

As UX and agile approaches are heavily involved with users in every phase of system development thus, regardless of individual limitations, cooperation from each member is imperative towards achieving the project's aim. The authors anticipated that using an agile UX approach would produce a great system preferred by the users.

V. SYSTEM DESIGN MODEL

The system requirements and designs are reviewed before encapsulating them in a design model specifically for developing such applications for managing local food waste. The model consists of the required components to improve BSF decomposition in the Malaysian context. This model should be used as a guideline when creating similar applications or applying the development approach to software applications.

The model was created to reflect the application's features, purposes, the environment in which it will be used, and its requirements. The applications' core ideas were extracted and summarized from requirements activities to designs and testing into a model. As a result, the model comprises five distinct components, as illustrated in Fig. 7. For each of the components in the model:

- Motivation: As the goal of the apps was to have an interactive application that can support food waste management processes and get local communities involved, motivation elements and a rewards system should be used to connect all the components in the model.
- Stakeholder: The involvement of stakeholders is critical because they must understand their responsibilities and act accordingly.
- Systematic and user friendly: A standard system application should be designed with a user-friendly feature, and the system should be implemented systematically across all aspects of the application. This includes a map showing the collection route and a map that can track collector movement, data visualization to show the waste collection activities and disposal, the payment process, and the rewards system.
- Job opportunity: From the application development process, the application should be able to provide users with job opportunities or, at the very least, a side income opportunity. Collectors are also known as riders, and providing a gig job has become a popular trend in the global economy.

- Eco-friendly approach: The applications should promote an environmentally sustainable attitude by raising awareness of safe and proper food waste disposal practices. This strategy will both educate and develop communities indirectly.

The project management team can better plan for system design and development with this model. The proposed system design concept was generally well welcomed. The participants expressed their excitement to see the result of food waste collection operations after the system was fully implemented.

Fig. 7. The Mobile Apps Model for Food Waste.

VI. Conclusion

Proper food waste disposal utilizing BSF is one way to support the goal of having and keeping a clean and safe environment. The usage of an assistive tool, such as a gamified mobile application for food waste management, is thought to be necessary to ease the disposal processes. This method would require the involvement of the surrounding communities in order for everyone to contribute to a safe environment. Also, by providing this type of application, communities will be able to learn and adapt to proper and safe food waste disposal in their regular lifestyle. However, waste preparation must meet the stated criteria to maintain decomposition quality. It will also assist local governments in monitoring food waste compliance using the application.

This study describes the process of developing a mobile-based application for managing food waste, focusing on the preparation and collection processes. This study's work was based on the Agile UX methodology, particularly its adoption in the Malaysian context of information system development. In the entire process, two teams are involved: agile and UX. The developed design was subjected to usability testing to ensure that the design and requirements were in sync. Feedback on the process flow and its designs aided in achieving the system's goal. The system model was developed as a guideline when developing a similar application resulting from the design process. Overall, the application designs and features were agreed upon for implementation.

Of course, this study has several limitations. One of them was locating and assigning a time for a sprint meeting to all participants. However, an online meeting appears to be more convenient for all parties due to the pandemic. It seems to be more effective in moving from one sprint to another. Then, because working from home has become the new norm, various distractions to complete the work sometimes require time extension, dragging the project timeline. However, the authors believe this is a low-risk situation that can be managed until the project is completed. In future work, the researcher will conduct acceptance testing and assess the effectiveness of the application in the actual environment with the actual users. A study on how the application could affect the BSF industry in a bigger picture, i.e., production and business, should also be conducted. At present, the study's findings indicate that the proposed system design and model are feasible and would contribute positively to food waste and the BSF ecosystem.

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