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Usage of Gamification and Mobile Application to Reduce Food Loss and Waste: A Case Study of Indonesia

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Abstract

Food loss and waste (FLW) are major global issues, and Indonesia has been identified as the world's second-largest contributor to this problem. Bappenas research indicates that FLW in Indonesia, particularly food waste, is increasing annually, with the household sector being the primary source. In response, we developed a gamification mobile application for FLW, drawing on a case study from Cechetti et al. to encourage households to reduce food waste. We tested the application's acceptance using the modified TAM model and analyzed the data using content analysis. Our findings provide insights into the potential of gamification to address FLW in Indonesia and contribute to environmental sustainability.

Keywords: Food Loss and Waste, Mobile Application, Gamification, TAM, Content Analysis

1. INTRODUCTION

Equivalent to 1.3 billion tons, is wasted annually, making the issue of food loss and waste (FLW) a critical element of the Sustainable Development Goals (SDGs), particularly SDG 12.3. This SDG commits UN members to halve food waste and loss worldwide by 2030 [1, 2]. Research by the Indonesia Ministry of National Development Planning (BAPPENAS) into food loss and waste in the country between 2000 and 2019 shows that Indonesia generates 23-48 million tons of food waste annually, equaling 115-118 kilograms of food waste per capita each year [3, 4]. Furthermore, research by The Economist Intelligence Unit reveals that Indonesia is the world's second-largest FLW contributor, and the country's high FLW levels are not being effectively addressed due to a lack of policy and strategy [3, 4].

Given its negative impact on the environment, economy, food security, and society, the FLW issue is a pressing concern that requires immediate attention. In the past 20 years, the generation of FLW has contributed to an estimated 7.29 percent of Indonesia's average greenhouse gas emissions, which contributes to global warming and climate change [3]. Food waste also leads to the wastage of

valuable resources such as water and energy, resulting in environmental harm such as air and water pollution, erosion, and deforestation [5, 6]. Moreover, FLW has resulted in annual economic losses of IDR 213-551 trillion, equivalent to 4-5 percent of the National GDP. Ironically, despite these losses, Indonesia's level of hunger is the third-highest in the ASEAN region, and the amount of food wasted in the country could feed between 61-125 million people annually [3], [7].

The consumption phase of the food supply chain is the largest source of food waste in Indonesia, according to research [3]. The 2021 Food Waste Index report estimates that Indonesia generates 77 kg of food waste per capita or 20,938,252 tons per year [8]. Consumer habits, such as taking extra portions and lack of awareness regarding the social and environmental impacts of food waste, contribute to this issue. Other factors include excess food inventory, inadequate storage, and misinformation regarding food expiration dates [3], [5]. The Covid-19 pandemic has also led to an increase in household food waste due to a rise in shopping routines through food delivery applications, leading to excessive and unplanned food orders [9].

While there is a lot of literature discussing FLW solutions, most focus on environmental or community-based composting. Informal food-sharing networks have also been gaining attention recently in academia [10]. However, not much literature addresses preventive solutions targeting individual habits directly. Mobile applications, particularly gamification, can support changing and reducing wasteful food habits [5]. However, maintaining user engagement in mobile applications can be challenging in the long term [11]. A study conducted by Soma et al. [12] in Canada found that gamification can help maintain user interaction with applications, leading to a reduction in food waste. Gamification provides involvement, curiosity, and pleasure to increase user motivation and engagement [11].

To address the issue of food waste and support the achievement of SDG 12.3 targets, we developed a gamification-based FLW application on a mobile platform to reduce food waste in households. We followed the case study method of developing and implementing gamification applications by Cechetti et al. [11]. To evaluate the acceptance of the developed application, we used the simplified TAM model from the research of Cechetti et al. [11] and analyzed the data qualitatively using the content analysis method.

2. METHODS

We used the method from the research conducted by Cechetti et al. [11] as a reference for the methodology in system analysis, as well as the design and development of gamification apps. The research conducted by Sari et al. [13] and

Schwaber & Sutherland [14] served as references for implementing Agile Scrum in application development. Meanwhile, Singh & Srivastava's [15] research served as a reference for the qualitative data analysis of the FLW mobile application designed and developed, which is the object of the research's acceptance analysis [15]. Therefore, the research is divided into three studies: survey and analysis of application systems, design and development of the mobile application, and analysis of system acceptance.

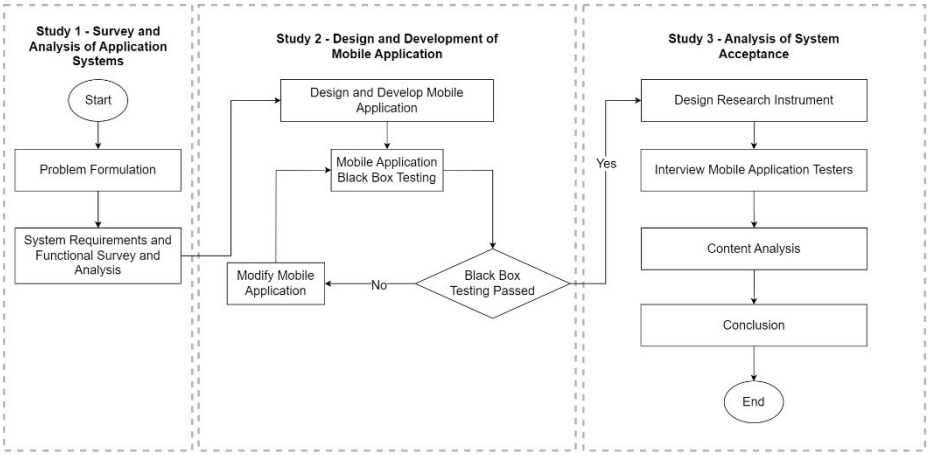


Figure 1. Research Flow

2.1. Survey and Analysis of Application Systems

The survey data were collected using a semi-structured interview with Diyah Maharani, Waste4Change Project Development Executive, who took part in writing the report on Food Loss and Waste in Indonesia published by Bappenas [3]. The interview questions were based on the research by Barone et al. [16], who conducted qualitative interviews to identify the main goals of consumers, as well as their attitudes toward reducing food waste. The results of the interviews helped determine the target users and design Ishikawa and UML diagrams, which include use case diagrams and activity diagrams [11].

Based on the results of the analysis, between food waste and food loss, food waste in Indonesia increases every year, and households are the highest food waste contributors [3]. The level of household food waste is higher due to the large number of households compared to other sectors, and middle-income households produce more food waste [17]. Therefore, the target application users are middle-income households.

> "The middle-income households often eat at home compared to the high economic class. After buying groceries, they will stock up on the refrigerator

and buy more than what is needed" *(Diyah Maharani, Project Development Executive Waste4Change)*.

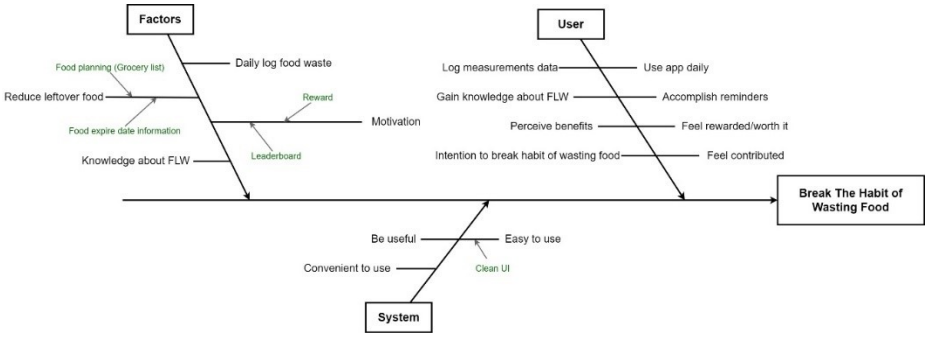


Figure 2. Ishikawa diagram for FLW application system analysis

2.2. Design and Development of Mobile Applications

The next stage is creating an interaction flow to determine 'where' and 'how' the gamification system is implemented. Then investigate and select the elements often in gamification applications. The gamification elements used in the application are points, badges, and leaderboards, which these three elements are the most common elements of gamification [12], [18]. After determining the gamification elements, applications are developed based on the Android operating system with Android Studio tools, Kotlin as the programming language, and Firebase as backend services, also using Agile Scrum as an application development framework. Application testing is carried out in a Black Box test, checking the functionality of the software and ensuring input and output data following the application design [19].

2.3. Analysis of System Acceptance

This study used the model used in the research by Cechetti et al. [11], which is the TAM (Technology Acceptance Model), with a focus on the independent variables in the form of perceived usefulness (PU) and perceived ease of use (PEOU) and the dependent variable in the form of behavioral intention to use (BI), shown in Figure 3. PU is the degree to which a person feels information technology will help improve his job performance, and PEOU is the degree to which a person thinks information technology provides convenience and does not require much effort. Meanwhile, BI is a person's intention to apply particular information technology [20].

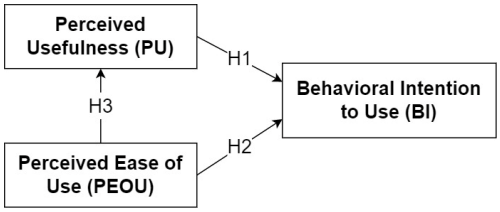


Figure 3. Technology Acceptance Model (TAM)

The following are hypotheses to evaluate the acceptability of the developed FLW application.

Hypothesis 1 (H1) The perceived usefulness (PU) positively influences the behavioral intention to use (BI) the FLW application.
Hypothesis 2 (H2) The perceived ease of use (PEOU) positively influences the behavioral intention to use (BI) the FLW application.
Hypothesis 3 (H3) The perceived ease of use (PEOU) positively influences the perceived usefulness (PU) of the FLW application.

Data were collected using semi-structured interviews with one of the middle-income household members who has an active role in managing food at home. Samples were collected using purposive sampling, in which sample members were selected based on particular criteria, and snowball sampling, in which sample members were selected based on recommendations from other samples [15]. Data were collected until there was saturation in the categories, and the latest data no longer revealed new discoveries [21]. The interview questions were taken from research by Cechetti et al. [11], Jeffrey et al. [22], dan García-Jurado et al [23].

The results of the interviews were analyzed using the qualitative method content analysis. The interview accuracy was checked using the results of the transcript from the interview audio recording. Content analysis extracts meaning from the transcripts then transcripts will be identified, analyzed, coded manually because the number of samples is small. The codes were grouped into categories and re-checked by other research partners to validate the accuracy of the code. Generated codes and categories helped to analyze and interpret research results and define conclusion [15], [24].

Table 1 Acceptance Analysis Interview Guide

Code	Question	Elaboration Question
Variable Perceived Usefulness (PU)		
PU1	Do you think the FLW application is important in managing food waste in your home?	Why is the FLW application (important/not important) in food waste management in your home?
		Which features make you feel the app (important/not important)?

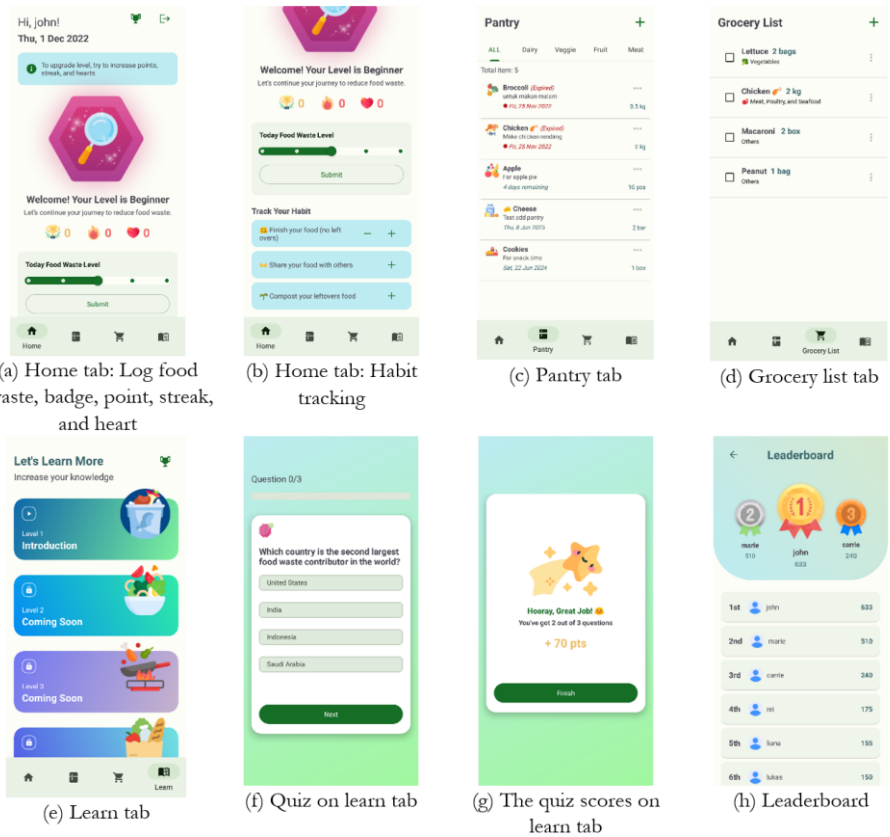
Code	Question	Elaboration Question
PU2	Is the FLW application useful in managing food waste in your home?	Why is the application of FLW (useful/not useful) in managing food waste in your home?
		Which feature did you find the app (useful/not useful)?
PU3	Does the gamification feature of the FLW app make managing food waste a fun task?	Why does the gamification feature of the FLW app make managing food waste such a (fun/not fun) task?
		Which feature did you find the app (fun/not fun)?
PU4	How does the FLW app help you monitor the condition of food waste in your home?	
PU5	How is the intensity of managing food waste in your home after using the FLW app?	
PU6	Does the FLW app motivate you to get involved in managing food waste in your home?	Why does the FLW app (motivate/demotivate) you to get involved in managing food waste in your home?
Source: Cechetti et al. [11]		
PU7	What do you like about this app?	Does this app meet your needs?
		Why does this app (meets/does not meet) your needs?
Source: Jeffrey et al. [22]		
Variable Perceived Ease of Use (PEOU)		
PEOU1	Is your interaction with the FLW app clear and understandable?	What makes the app clear and easy to understand?
PEOU 2	Does your interaction with the FLW app require high mental effort?	What makes FLW applications (much/not much) require mental effort?
Source: Cechetti et al. [11]		
PEOU 3	Is the FLW application easy to use?	How long did it take you to learn how to use the FLW app?
		What causes FLW app (easy/not easy) to use?
Source: Cechetti et al. and Jeffrey et al. [11], [22]		
Variable Behavioral Intention (BI)		
BI1	How do you feel about using the FLW app compared to previous methods of monitoring food waste?	
Source: Cechetti et al. [11]		
BI2	Will you use this application in the future?	Why (will/will not) you use this app?

Code	Question	Elaboration Question
BI3	Will you recommend this app to other people?	Who will you recommend the FLW app to and which features will you recommend?

Source: García-Jurado et al. [23]

3. RESULTS AND DISCUSSION

3.1 The FLW Mobile Application



(a) Home tab: Log food waste, badge, point, streak, and heart
(b) Home tab: Habit tracking
(c) Pantry tab
(d) Grocery list tab
(e) Learn tab
(f) Quiz on learn tab
(g) The quiz scores on learn tab
(h) Leaderboard

Figure 4. Developed FLW Mobile Application

The direct cause of food waste is the behavior of consumers, who are accustomed to taking excess portions and throwing food away. Other behaviors, such as being 'spendthrift' and being tempted by promotions or discounts that cause them to take food or buy groceries beyond capacity and necessity, are due to the 'better than less' perception [3].

> "... From the results of the national FLW study, throwing food away is one of the direct causes of FLW. For some people throwing food away has become a habit. We do tend to take excess portions rather than sufficient portions or less. Those habits have to be fixed henceforth" *(Diyah Maharani, Project Development Executive Waste4Change).*

The home tab (Figure 4a and b) was developed to train the user's habits and be more aware of the level of food waste in the home. In figure 4a, users add their household food waste level every day, from level 1 (none/lowest) to level 5 (highest), the lower the level of food waste, the higher the points obtained. When users make an entry, the points and streaks will increase, also the heart and streaks will increase if users keep making an entry. If users forget to input, the streak will return to zero. The badge and level will change on a certain number of points, there are five main levels: Beginner, Advanced, Competent, Proficient, and Expert. In figure 4b, users can reflect on their daily habits, if they do the good habit, press the plus button and the points will increase, and vice versa.

Inefficient food management, e.g., storing food ingredients for too long until it is past their expiration date and spoiled hence being thrown away, is due to no record of the food ingredients list [2]. The pantry and shopping list tabs (Figures 4c and d) were developed so that users can keep track of existing food ingredients and plan before shopping. Making shopping plans is highly recommended for households to prevent excess spending, also by knowing the available food ingredients and how long food can be stored, a household can prevent food from wasting [17], [25]. Moreover, the indirect cause of food waste is the lack of consumer information regarding the FLW issue that influences consumer habits toward food [3]. Therefore, the learn tab (Figure 4e, f, g) is added in a quiz format to broaden user insight about FLW. Every time users make an entry (Figure 4c and d) or play a quiz (Figure 4f), they will get more points. In addition, users can see their ranks and other users' rank in the leaderboard (Figure 4h), so they can compete and boost their motivation.

3.2 Research Participants

The study participants consisted of 23 people from households in the middle economic class. The participants interviewed were household members who have an active role in food management at home. Participants are grouped based on the number of households, age range, gender, workforce status, game players, awareness, and insights about FLW.

Table 2 Summary of Research Participants Characteristics

Participants Characteristic	**N (%)**
A. Number of Household Members	
Keluarga (≥2)	12 (52%)
Individu (<2)	11 (48%)
B. Age (years old)	
20-29	13 (57%)
30-39	3 (13%)
40-49	4 (17%)
>= 50	3 (13%)
C. Gender	
Female	20 (87%)
Male	3 (13%)
D. Working Status	
Working	9 (39%)
Not Working	14 (61%)
E. Game Players	
Yes	13 (57%)
No	10 (43%)
G. Awareness and Knowledge about FLW	
Aware but not knowledgeable about FLW issues	12 (52%)
Aware and understand FLW issues	11 (48%)

3.3 Data Analysis Results and Discussion

The results of the interviews, the positive response to the FLW application (benefits, gamification, and convenience) was 72 percent, while the negative was 10.64 percent. Overall, the results of interviews, the positive response regarding the benefits and gamification of the application have the highest value (57.6%), followed by positive response about the convenience (14.5%) and the decision to use the application (8.1%), a summary chart of information findings interview can be seen in Figure 5 below.

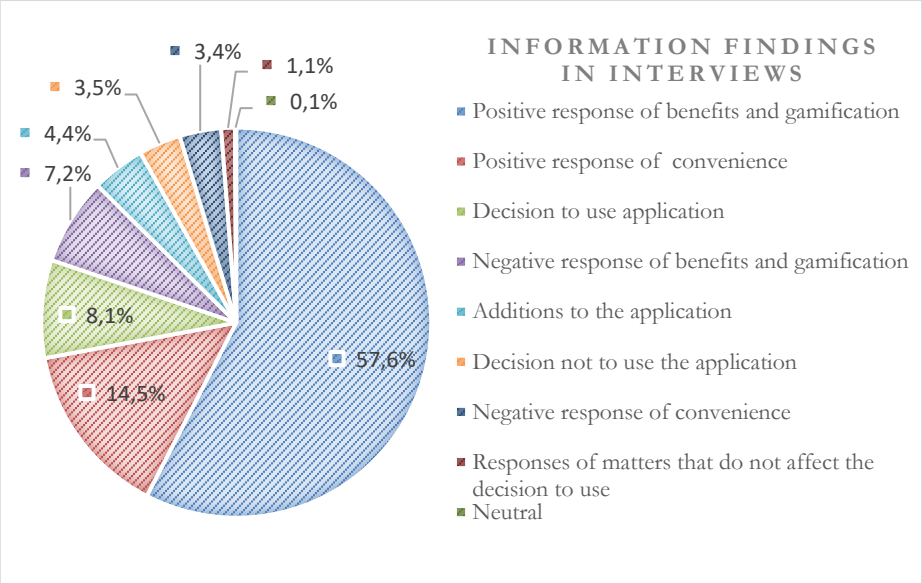


Figure 5. Summary Chart of Information Findings in Interviews

a) Positive Response Perceived Usefulness of the Application

Most participants (n=19) felt that the application was useful and important. They also think the app impacts their daily life positively, and the app's content is very comprehensive. The most preferred features are the pantry and grocery list. The application is beneficial in monitoring food and food waste. Applications are functional in changing habits, recording, and increasing motivation. Applications are also influential in conditions adjustment, managing food and food waste, also increasing knowledge about FLW.

> "The apps are quite important because I can plan and record with my phone, so it's more efficient. The apps provide benefits… I can monitor it and know when it expires. If there is no application, I often forget. So that there is no more food waste and food wasted. The most useful feature is the pantry" *(Participant 5, 38 years old, female).*

> "I like the grocery list feature the most because, with a shopping list, we know what we want to buy. The pantry feature is more fun because you can know when it expires… Quizzes are fun too, and good for adding insight. The home feature is fun because I want to know how much food I have left today, whether I am sharing food or not. So, it reminds you that if there is too much leftover food, in the future you have to reduce it… Sometimes because the food is spoiled, you have to throw it away, so you can remember that too… The app is raising awareness…" *(Participant 7, 35 years old, female).*

> "From the food waste management standpoint, it is very important. I can track food ingredients available if diligent. All features are important because they are interrelated. This application is very useful for tracking. It is beneficial so that the food does not go rotten… I can be more aware of only buying what's important… The importance of the apps is clear, we become more aware of the food waste problem… I need it and will use it every day because we can check, monitor, and remind every day not to waste food" *(Participant 14, 21 years old, male).*

The benefits of the application, including gamification, received positive responses from various age groups, 85 percent of the age range of 20-29 years old (n=11), 100 percent of the age range of 30-39 years old (n=3), 75 percent of the age range of 40-49 years old (n =3), 67 percent of the age over 50 years old (n=2). Gamification motivates participants to be involved in reducing the habit of wasting food. These findings align with Soma et al. [12] research, where gamification implementation in reducing household food waste shows positive impacts on behavior and knowledge results. The gamification element brings forth a feeling of appreciation for the efforts. Points, badges, and leaderboards give internal encouragement for development and rewards for continuing to progress [18].

> "Among all the features I prefer the waste log… because it can track and improve habits as well. Points can make me even more enthusiastic… The leaderboard also adds motivation… Encourage me to be more diligent, not to waste food so I can win first place" *(Informant 1, 21 years old, female).*

Some participants (n=2) thought that using the applications and gamification elements can give a sense of appreciation for supporting and contributing to protecting the environment. The participants are already aware of the FLW issue, the gamification elements increase their enthusiasm consequently. This statement was also mentioned by informants in the previous analysis phase. This also may be attributable to the findings of Soma et al. [12] research, where people in Toronto's city have a basic knowledge of food waste, hence they are more probably to intend to use the gamification application. For those who already have awareness about the FLW will be easier for them to take the initiative and be interested in using applications to contribute to reducing food waste.

> "Points, badges, leaderboards give motivation... If I have succeeded, it is a kind of self-reward... It means I have helped the earth to reduce food waste and appreciate the struggle of people who are finding food" *(Participant 3, 21 years old, female).*

> "… Applications can remind us… It can be a kind of self-reflection. If there is an application, at first you are not aware at all, then you become more aware… It is a small form of support for saving the environment too…" *(Participant 12, 21 years old, female).*

Participants (n=19) felt that gamification made using the application more fun and exciting. The addition of gamification also makes the app unique. It fits the definition of gamification that takes fun and interesting elements from games to daily activities [18].

> "Fun application... It is reducing boredom... Giving points, streaks, and hearts are interesting to me... The leaderboard also adds motivation, like 'how come I only rank 4th' means I have to be more diligent not to waste food so I can win first place" (Participant 1, 21 years old, female).

Most participants also found gamification useful (n=17), and some of them thought gamification was important (n=6). The gamification element was also chosen as one of the favorite app features, and they would like to recommend it. Among all the gamification elements, the points and leaderboard elements are the most mentioned elements.

> "In my opinion, the points are just a bonus, a bonus for motivation. More rewarding points than the others because they are in the form of numbers, the more numbers, the more exciting" *(Participant 1, 21 years old, female).*

> "Points are rewarding, reflecting that we are 'the most efficient, the best at managing'. Moreover, seeing the leaderboard is more satisfying, there is pride in itself" *(Participant 2, 43 years old, female).*

b) Negative Response Perceived Usefulness of the Application

Several participants (n=2) thought they did not need an application because the features were unimportant. It was not a daily application that they needed and not the main thing in reducing food waste. Most participants felt that they rarely threw food away and were unaccustomed to keeping records, so the application was unnecessary.

> "Because every time I go shopping, I never take notes. Every time I go to the market to buy goods, I come home and think about what to cook. The point is, what you need, buy it right away... Shopping here is easy... there is a lot of access... I think the features of the application are not important because I never record them, and the food at home usually is eaten. I rarely waste food too..." *(Participant 8, 53 years old, woman).*

Some participants (n=3) felt that the application was not useful. They thought the application did not effect on changing habits and understanding food waste. Correspondingly there was no difference between using and not using the application, meaning the intent of the application is abstruse. Therefore, the application is deemed unhelpful and does not meet needs.

> "This application is not a kind of reminder or something that makes us aware that food waste is like this and that" (Participant 4, 21 years old, male).

> "There is no difference between using an application even more complicated with an application. I cook according to what I want to eat today, I do not cook much at once. I often check food at home, so we do not need an application" *(Participant 6, 46 years old, female).*

There were participants (n = 2) who also chose other alternatives for managing food at home, such as similar note applications and manual recording methods, so they gave negative responses regarding the benefits of the application.

> "The pantry and grocery features can be used in other applications. I also have my notes. Sometimes some people are more comfortable using handwriting or using other apps… For tracking, I have my journal, so this app is not the main way to change habits" *(Participant 11, 21 years old, female).*

A participant (n = 1) thought gamification could not motivate them to be involved in reducing FLW. The gamification feature is not useful because it does not give a sense of appreciation for the effort. Furthermore, the obtained gamification elements are intangible and do not provide direct benefits for everyday life. Some participants also suggested adding rewards such as shopping vouchers or spreading gamification elements on social media that could add social value. Participants who often play games are more critical of the gamification elements thus they think the gamification feature is still not interesting and exciting, which is the application weakness that needs to be improved and further developed.

> "I don't feel triggered. With that point what can I get... It is better to add additional features related to social... It can trigger someone to show to their social media and society so that people are also affected... This feature does not make me chase it until I have no food waste" *(Participant 4, 21 years old, male).*

> "Personally, I do not play games, so points are useless. I would rather have shopping voucher rewards" *(Participant 11, 21 years old, female).*

> "Points are unnecessary and useless because they are intangible" *(Participant 6, 46 years old, female)*.

c) Positive Response Perceived Ease of Use

Most participants (n=19) felt that the application was easy to understand because the flow and steps were simple and familiar. Almost all participants said it didn't take long to understand how the application works. The gamification features do not make it difficult to understand how the app works for non-gamers.

Most of the participants (n=19) also felt that the application was easy to use because it did not require a lot of mental effort when using it. The application is also not complicated and complicated because you only need to press, fill in and enter data. Participants felt that the application was comfortable to use and not burdensome because it was easy to fill out and did not require many steps. Some participants stated that the application gave a relaxed impression, so it was easy to use.

Some participants (n=15) also felt that the contents and intent of the application were clear. When trying the application, they did not feel confused and dizzy because the application was informative, and the steps and application functions were clear, easy to see, and straightforward. The neat and pleasing appearance of the application also made participants feel the application is comprehensible. However, when they saw the home feature for the first time, almost all participants felt a bit confused at first because this feature had never been seen before, so it looked complicated and needed exploration.

> "It is not difficult, there are no complicated features. It did not take long, I immediately understood how the application works… The home feature is a bit confusing because this is the most unique from the application, it is very rare for people to know something like this exists." *(Participant 3, 21 years old, female)*.

Some participants (n=9) also felt that using the application was more efficient and effective because it was enough to check the device and not have to check directly. The app can be opened and viewed at any time, making it easier to organize and check groceries at home while on the move. Participants also felt that manual methods, such as taking notes on paper, were more complicated and easily lost.

d) Negative Response Perceived Ease of Use

Some participants felt that the application was not easy to use (n=4) and troublesome (n=6). Applications are a hassle because they must press and fill out, so using applications is like adding new activities for them, whereas it is easier and

faster to check in person. To open the application requires mental effort because previously not used to taking notes, so it was hard to start something new. Being busy also adds to the reason the application was inconvenient, so they thought it is suitable for people who have more free time. In terms of application flexibility and usability, it is still lacking compared to other note-taking applications, which is also a deficiency in the application that needs to be fixed. The application is not easy to use because there is a lack of information and instructions for use.

> "… It is a hassle because it must be filled. I am busy, so I do not have time to fill it out… I think stay-at-home spouses rarely use the app. It is a hassle to use an application to check stock… it is faster to check in person" *(Participant 6, 46 years old, female).*

e) Effect of Perceived Ease of Use on Perceived Usefulness

Perceived ease of use (PEOU) indirectly causes the application to feel useful. This is consistent with findings from Tony et al. [20], in their gamified application adoption study, in which perceived ease of use (PEOU) significantly affects perceived usefulness (PU) [20] hence Hypothesis 3 in this research is supported.

> "The most preferred pantry and grocery features. Its function is more feasible and easier to implement. It makes shopping easier. When going to the mall or the market, I just need to fill in this. When it is done, I just need to check the list" *(Participant 1, 21 years old, female).*

> "After using the application, I can immediately see from my phone, 'what ingredient is about to run out' or 'what ingredient is about to expire', no need to check the fridge again. It is faster to use a smartphone… from the app, we can control shopping too, so we do not buy too much" *(Participant 9, 35 years old, female).*

In comparison, the effect of perceived ease of use on perceived usefulness was clearly seen in participants who did not want to use the application, where they felt the application was not easy to use, so it was not useful.

> "The application is not that important. It is a hassle because it must be filled in... The contents of the stock of the ingredients are not important, because you already know and you just only need to check the refrigerator... Taking note is a bit less useful because it is a hassle" *(Participant 6, 46 years old, female).*

f) Behavioral Intention to Use the Application

Eighty-three percent (83%) (n=19) of participants intend to use the application, and 17 percent (n=4) do not intend to use the application. All participants who

intend to use the application also want to recommend the application to the people closest to them. The features they want to recommend are the pantry and grocery features, which in the previous explanation, these two features were the most preferred in the application.

On the one hand, participants did not want to use the application (n = 4) because they felt it was useless and not easy to use. There are differences in perspective between participants who live alone and live with other people. For participants who live alone (n=2) do not feel the application is easy and useful because the content of the application is assessed as lacking, whereas participants who live with other people (n=2) feel the application is not easy and useful due to environmental conditions at home and busy.

Based on the results, the developed FLW mobile gamification is accepted positively. Both PU and PEOU influence their intention to use the application hence Hypotheses 1 and 2 are supported. This is consistent with findings from Tony et al., in which users tend to choose to adopt applications with gamification more because it gives them benefits in their tasks and is convenient to use [20]. From the results, it is evident that PU has the most influence on the behavioral intention to use the application whereas PEOU significantly affects the behavioral intention to use the application (BI). Therefore, PU gives more leverage to use the application than PEOU, consistent with the findings of Tony et al [20]. It is shown that as many as 11 percent of participants (n=2) who wanted to use the application felt that it was a hassle and added new activities but still wanted to use it because it benefits them.

> "Input is necessary. Even though it is a hassle to input, it is really functional, so I am willing to input" *(Participant 1, 21 years old, female)*.

> "It is quite complicated, but it does not feel too heavy... Even though it is complicated, I still want to use it... The feature is still useful, so I am still willing to use it even though I have to press a lot" *(Participant 22, 47 years old, female)*.

The gamification inside of the FLW mobile application also gets positive responses and complements both the mobile application's usefulness and ease of use, which also affects users' intention to use. The gamification creates fun environments while using the mobile application, which leads to users' enjoyment and curiosity with the mobile application, additionally impacts users' behavioral intentions, and also enhances the impact of users' motivation, consistent with the findings of Treiblmaier & Putz [26]. Therefore, adding gamification elements to the applications can induce higher user engagement and participation rather than the applications without gamification. This may be attributable to the findings of

Soma et al. [12], where the intervention of gamification in reducing food waste helps to generate less food waste and increase food waste awareness more, also the participations are higher than the community workshop intervention [12]. In research about gamification implementation in a mHealth applications by Cechetti et al. [11], gamification is the factor for mobile applications acceptance and motivation, also the application without gamification is less adequate to motivate users in habit changing.

This FLW mobile application is more accepted by younger adults (20-39), especially 30-39 years old. Based on Guner and Acarturk's [27] research, younger adults and elderly confirmed TAM in a similar way. However, for elderly, need more assistance and guidance in using technology. There are no significant acceptance differences between users who live alone and live with family, between working and non-working users, also between game players and non-game players. However, this may be due to the uneven number of participants in each characteristic.

g) Other findings

In the responses related to behavioral intention to use the application, we found that there are users' internal and external factors influencing the behavioral intention to use. Most of the internal factors come from user habits that affect BI. This is consistent with the findings of Tam et al. [28], which habits affect the decision to continue using mobile applications, as it has become an automatic behavior for them. User habits also affect on PU, which is clearly seen in the decision not to use them for reasons such as not being used to taking notes and rarely buying many stocks of the ingredient so that the application is not useful for them, also the trait of getting bored easily makes gamification unattractive. As for those who want to use the application, they have a habit of forgetting frequently, often throwing food away, and rarely managing food waste, or self-awareness and self-motivation. In addition, the factor of self-hobby, which likes to do activities such as taking notes, controlling, and monitoring, encourages the desire to use the application.

While the external factors are in the form of the situation and environment, such as having a lot of food needs and less systematic storage, which causes a lot of food to be wasted, so they want to use applications or easy access to shopping which cause them no need to buy a lot of stock, as well as social factors that influence the excitement of gamification. Further research can be examined with those variables. The effect of external factors aligns with the research by Tom et al. [28], in which users that have convenient access to a set of facilitating conditions will willing to continue using the mobile applications themselves. User interface and application appearance also affect the perceived ease of use of the application.

The user-friendly and appropriate design, and clear also pleasing appearance made it easier to use the applications [27].

h) Recommendations

All participants provided suggestions regarding the FLW application. The suggestions are regarding user interface improvements, adding information, content, and features, and developing gamification, such as adding food waste history reports and notifications, also adding badges and social features. Social features can potentially be included in future investigations. In Tony et al. [20] research, social influence significantly impacts BI. Points of view of other users may influence someone to use the mobile application and community involvement can help to boost users to accomplish their tasks, therefore social influence can be considered an essential factor in determining users' intention to use mobile applications [20].

4. CONCLUSION

To conclude, the FLW application that was developed received a positive response and has the potential for daily use in helping users reduce food waste, especially for younger adults. The perceived usefulness of the application (PU) has a major influence on the user's decision to use the application (BI), therefore Hypothesis 1 is supported. On the other hand, perceived ease of use (PEOU) significantly affects the behavioral intention to use the application (BI) and indirectly also affects perceived usefulness (PU), therefore Hypotheses 2 and 3 are supported. The developed application received a positive response, especially regarding benefits. Adding gamification supports the function and emphasizes the goals of the application to reduce wasting food habits. Gamification can help increase motivation to use applications and engage in reducing wasting food habits. With gamification, the use of applications becomes more interesting and exciting. The daily chores that used to be mundane become more enjoyable and rewarding to the user.

Although widely accepted, this research has certain limitations. Based on the previous explanation, the numbers of participants in each characteristic are not distributed equally, hence larger sample size will be more sufficient to analyze in further research. In addition, the research can be improved with additional features from the provided suggestions by the participants. Also, the internal and external factors and variables that are mentioned in the previous statement can be observed in further research for better understanding of implementation gamification in reducing and managing household food waste. Further research also can be conducted by reviewing the effects of gamification engagement in applications on users, which is a follow-up study from Cechetti et al. [11].

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