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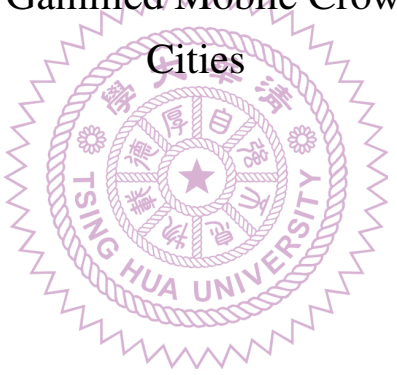
Master Thesis

在智慧城市中遊戲化手機群眾外包的用戶體驗

User Experience of Gamified Mobile Crowdsourcing in Smart Cities



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許愛倫 撰

106
6

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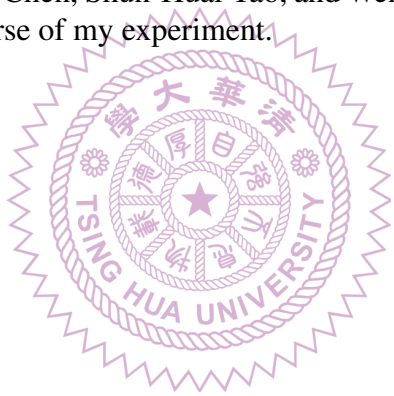

中文摘要

我們已知群衆外包是强大的收集資料方式之一. 隨著智慧城市概念的出現，公民也可以當作傳感器並參與感測任務. 但是若透過貨幣激勵的方式來吸引人來收集資料其所需付出的成本也視為一個問題; 因此，我們想通過遊戲化來代替它. 為了調查遊戲化對使用者的享受和參與有如何影響 我們做出來兩個APP,（i）普通APP（ii）遊戲化APP . 我們在NTHU校園進行了真正的使用者體驗實驗. 我們採用問卷來獲得使用者的感受與反應. 問卷包括（i）來自Intrinsic Motivation Inventory (IMI) 的7個問題，以評估參與者的享受，（ii）關於使用行為的4個問題，（iii）關於UI偏好的1個問題，以及（iv）1個待評論或其他反饋。結果，我們對遊戲化APP收到了更多的積極正面的反饋。

Abstract

We have learned that crowdsourcing is one of the powerful ways to collect sensory data in short period of time, broader coverage area, and at low expense. With the emerging of smart cities concept, the citizen can acts as sensor and participate in the sensing task. However, calculating how much to pay the crowd with monetary incentive is also seen as a problem; therefore, we wanted to substitute that by gamification. We have developed two versions of mobile crowdsourcing applications, (i) ordinary app and (ii) gamified app, to investigate how gamification affects user's enjoyment and engagement. We have conducted real user study experiment in our NTHU campus. We use questionnaire to get feedback from the participants. The questionnaire includes (i) 7 questions from Intrinsic Motivation Inventory (IMI) to assess the participant's enjoyment, (ii) 4 questions about usage behavior, (iii) 1 question regarding UI preference, and (iv) 1 open question for comment or other feedback. As a result, we have received more positive feedback on gamified app.

Contents

List of Figures

List of Tables


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Chapter 1

Introduction

1.1 Motivation

It has been predicted that by year 2050, world population will reach 9 billion where 85.4 percent of the population is living in the urban areas. Moreover, number of worldwide smartphone users will be as much as 2.5 billion in 2019 [3]. With this fact combining with the rapid growth of user-generated content in social networking sites, it is possible to integrate the concept of citizen sensing where people are acting as a sensor similar to physical sensors. From this scheme, we can encourage people to become part of smart cities.

The smart cities concept itself is still emerging where the market is forecast to be as high as 1.45 trillion US dollar in 2020 [5]. Smart cities utilize the information and communication technology in sensing and analysis that provide data for monitoring and create awareness in terms of running a city such as daily livelihood, environmental protection, public safety and city services, and industrial and commercial activities [27]. The information are collected from in-situ sensors but to install the sensors everywhere in the city are still considered very expensive. To increase the flexiblity in collecting sensory data, smart cities can considered using citizen as one of their sensors to collect data which normally involves in accessing smartphones sensors via mobile applications which is part of *mobile crowdsourcing* or *mobile sensing* [1]. The idea of mobile sensing is to be able to obtain local information such as location, personal and surrounding context, noise level, traffic conditions, and so on via mobile devices that are equipped with sensors (i.e. smartphones, wearable devices, and smart vehicles) [14].

The gist of mobile sensing is same as normal crowdsourcing which is to outsource and distribute the work or task to a large and diverse group of people in order to collect

[1]The difference between mobile crowdsourcing and mobile sensing is insignificant in this thesis and we will use the terms interchangeably.

large amount of data in a short period of time and at low cost [22][21]. We can say that crowdsourcing platform such as Amazon Mechanical Turk is one of the successful platforms with paid crowds. The tasks in MTurk are called human intelligence tasks where the tasks are posted by requester such as businesses and researchers and will be completed by online workers. The factor that leads to success for MTurk is because it can be access any time anywhere to a large and diverse type of online workers. This helps to reduce operational costs and get a quick result [11].

Yet, MTurk also provide payment as a reward which becomes an incentive that attracts people to participate in their crowdsourcing tasks. A payment reward does not limited only to monetary but it can also be snacks, goods, and virtual currency [31]. However, to compute the suitable reward for simple crowdsourcing task itself is not easy but might not be as tricky as the complex sensing or computing tasks. Determining monetary incentive itself is projected as difficult problem to solve. The monetary incentive calculation can also affect the quality of the result. The low rate of monetary incentives may affect the quality of the collected data from the crowd [11]. On the other hand, if the payment is high, it can cause a cheating behavior where some deceitful people can trick the system in completing the task but with useless results to earn the money [31]. Therefore, to avoid those issues, gamification has been introduced as a way to maintain user participation and engagement.

However, to develop a gamified crowdsourcing application is also not an easy task. The most essential key for gamification to work is how to maintain the motivation of the user. Many researches have studied that people participating in crowdsourcing caused by many reasons from intrinsic and extrinsic motivation [22]. We will describe more about motivation in Chapter 2.

From the aforementioned factors, we have developed mobile application where citizen can be a part of data collection with gamified elements that can boost their motivation and engagement. Therefore, we would like to investigate whether or not gamification can substitute other incentive in mobile sensing application.

1.2 Research Contribution

We have implemented the mobile crowdsourcing applications based on system prototype architecture (later discussed in Chapter 4). The mobile applications are developed in two versions, ordinary and gamified. The main contribution of this thesis is that we have conducted a real user study experiment to investigate the difference in user's enjoyment and behavior between ordinary app and gamified app.

From the user study experiment that we conducted, we have acknowledged the fol-

lowing:

- We have investigated the enjoyment of users while they are using both of our mobile applications. The enjoyment represents the fact that user has intrinsic motivation. The result from the investigation on enjoyment can signified the level of engagement and participation of the users.
- We found that 70% of the participant prefers gamified app in both user interface and usability aspects. From this result, we can be more certain that gamification actually worked.

1.3 Thesis Organization

The rest of this thesis is organized as follows. Chapter 2 defines concept of gamification, game elements, and motivation. Chapter 3 describes how we formulate the hypothesis and its purpose. We explain in detail about mobile applications system structure and their features and how we conduct user study experiment in Chapter 4. In Chapter 5, we present result analyses including quantitative perspective, qualitative viewpoint and hypothesis test result. Then, we end with conclusion in Chapter 6.

Chapter 2

Related Work

2.1 Smart City Platform

With the fact that world population is still growing and most of the people is living in the urban areas, there are many problems occurring in the urban cities that need to be attended and monitored. The problems in urban cities such as traffic congestion, energy consumption, and pollution can be monitored and ease up the current situation by integrating the smart city concept which involves three main components: (i) technology, (ii) people, and (iii) institutions [24]. The aim of smart city concept is to make use of the public resources while increasing the quality of services provided to the citizens at the possible lowest operational cost [34].

Previously, Liao et al [19] presented a system called the Smartphone Augmented Infrastructure Sensing (SAIS) which is a hybrid sensing platform with in-situ sensors and sensors from smartphones. The SAIS platform aimed for an efficient use of smartphone users in expansion of the stationary infrastructure sensors for an increase in awareness of the surrounding environment in smart cities. The idea of SAIS is for the smartphone users to participate in the sensing tasks where in-situ sensors are not able to cover. We took the SAIS platform and gamified it in order to raise user participation, improve overall productivity, and maintain the resource at minimum cost. The gamified SAIS platform aims to involve mobile user in performing the sensing tasks at a specific location to supplement the in-situ sensors [9]. Moreover, we will investigate the enjoyment in our user study experiment.

2.2 Crowdsensing

Crowdsening is considered as an extension of the crowdsourcing applications. In general, crowdsourcing applications can be divided into groups such as voting system, informa-

tion sharing systems, social games, and creative systems [33]. However, crowdsensing system is using the crowd especially for collecting sensory data which takes the opportunity from the widespread of smartphones in urban areas. Smartphones are equipped with many types of sensor including GPS readers, cameras, microphone, digital compass, and gyroscope which can sensed the surrounding environments and the data are essential and ideal for analysis in running smart city [7].

Mobile crowdsourcing also faced the same problems as general crowdsourcing applications. The challenges in crowdsourcing applications are, for instance, incomplete samples, user privacy, user credibility, and energy consumption [17]. Nonetheless, in this research we focus only the incentive part as in terms of using gamification to substitute the monetary incentives while maintain or increase the participation of the mobile users.

2.3 Gamified Crowdsensing Application

As the emerging growth of gamification in mobile crowdsourcing platform, many researchers are trying to prove that by gamifying the application can help increasing in motivation.

There are several applications that are similar to ours. These applications focus on crowdsourcing tasks and gamification. For instance, Geo-Zombie [25] is a mobile game application that designed for involving crowd in collecting geo-referenced data of urban accessibility. The game has been designed in a way that players will get ammunition to shoot the zombie if they successfully transmit the location of urban barriers and facilities to their server. The concept of Geo-Zombie is similar to our platform with a goal aiming for the citizen to participate in crowdsensing task while playing the game. However, Geo-Zombie let the player explore the area freely, while we will lead the crowd to the specific location to complete the tasks per requested.

PhotoCity [30] is another mobile game application that mixes crowdsourcing and gamification to accomplish the goal. The aim of this application is to create 3D building models from the pictures that are taken by the players which can be useful in other potential application such as urban planning, monitoring city infrastructure, and 3D modeling. PhotoCity also uses game mechanics to drive crowd to perform a meaningful task such that the player can feel achievement. The player can decide by themselves where or which building they would like to contribute to. Moreover, player can even initiate new building to be included in their system. The game will show at which location point of the building is still missing a photo which is quite similar to our platform where we have spot locator to guide the gamer to a certain spot of the destined location.

Another mobile game application that involves gamification mechanics into their non-

game context is the Alien vs. Mobile User game [28]. The main goal for Alien vs. Mobile User game is to encourage mobile user to participate in collecting Wi-Fi data in their university campus. The problem they want to address is that how to acquire Wi-Fi data covering all area including unpopular area in the campus, therefore, they did proposed a localized movement strategy for the aliens to move around the campus including the unpopular area for the gamer to track, chase and kill the aliens so they can cover broader area. They designed the game aiming for fast and efficient way to cover the large area; likewise, our application is also aiming for fast and efficient way to cover all the spots in which we have the nearest gamer assigner strategy.

Chapter 3

Background

In this chapter, we will explore more on the definition of gamification and the common game elements. Also, we will discuss about how gamification affects motivation and our focus on user experience.

3.1 Gamification

Video game has been a mainstream in pop culture for many decades. It has been use just for entertainment until in these past twenty years which the term gamification has been coined. The concept of gamification is introduced since early 2000s but did not become very popular until late 2010. Various business sectors such as productivity, finance, health, education, sustainability as well as news and media take interest in gamification because they see that game can continuously give interactive activities to players [13]. Presently, games have been used as means for entertainment, relationship-building, and training which will continue to have impact to our social and leisure lives [26].

According to SuperData Research, worldwide game industry revenue earned more than $90 billion in 2016 [2]. People are willing to pay and spend their time playing games. Game can also affect the mood of the player. Gamer will feel competence when they have accomplished missions or tasks in the game. Game offers challenges and goals; players are to engage in active learning process aiming to master the game mechanics [12]. Therefore, the above mentioned characteristics of game can attract many businesses to implement their product or service with a touch of gamification.

The term *gamification* is commonly defined as a combination of using game element in non-game context. The idea of gamification can be applied to all contexts, except for entertainment purpose. The context here represents the service or activity that is being gamified. It can be apply to those boring routine activities where gamification can play a role in increasing and maintaining users' engagement, for instance, point cards and

rewards membership [13].

We can also think of gamification as a process of combining game elements to some context that will transform it into a game. The game element is an element or component that makes a game playful which supports the following nine characteristics: (1) player, (2) environment, (3) rule, (4) challenge, (5) interaction, (6) goal, (7) emotional experience, (8) quantifiable outcome, and (9) negotiable consequences. These characteristics are set as a standard for determining gamefulness of the object. If none of these characteristics exist in the object, then it is recognized as not gameful [32].

3.2 Common Game Elements

When designing gamification, the use of game elements varies to the purpose and expected outcome from the application. We have listed game design elements that are commonly used [23][20].

1. Point System and Scores

   The point system acts as a measurement of success or achievement. There are many types of points that are used in the game; for instance, the so-called experience point (xp) such as points that earned by completing the given tasks and stream point such of those points that correspond to in-game currency.

2. Levels and Stages

   The level system functions as a way to show the user the progression in the game. Beginner levels tend to be easy and fast to level up; while, in more advanced levels, it require more effort and skills to achieve.

3. Badges

   Badges are one of the gamification techniques that present the task accomplishment during the process of goal achievement.

4. Leaderboards

   Leaderboards show the user where they rank in their peers or community and keep the user motivated and give sense of eagerness to climb up the rank.

5. Prizes and Rewards

   One example of in-game rewards is character upgrades, which can be seen as a way to motivate user by displaying their progress in the form of characters.

6. Progress bars

   Progress bars are used for tracking and displaying the overall progression. Progress bars can help motivate and encourage the user by showing how near or far they are from the goal.

7. Storyline

   Storyline is the narrative or story in the game where it also can provides context of learning and problem solving.

8. Feedback

   Feedback is main principle for performance and engagement.

9. Social Connection

   Social connection via social network which can be access anywhere anytime can help increase the level of engagement and interaction.

3.3 Gamification and Motivation

Gamification can also be expressed as a tool intended to increase intrinsic motivation of a user to participate in a given task [22]. Since motivation is a key to become successful in crowdsourcing application, we should be able to distinguish which game elements belong to intrinsic motivation and extrinsic motivation. To create gamified application that can keep or increase motivation of a user, we need to consider both intrinsic and extrinsic motivation [18].

Intrinsic motivation is different from extrinsic motivation in the aspects that intrinsic motivation comes from inside where a person did something just for enjoyment or other positive emotions. In contrast, extrinsic motivation is driven by rewards such as prizes or money that cause the change in behavior [18].

In designing gamification that focuses on increasing motivation, it is necessary to take both extrinsic and intrinsic motivation into consideration. In order to cultivate intrinsic motivation, the motivation theory such as self-determination theory plays an important role. Self-determination theory (SDT)[18] presents satisfied the basic psychological needs of human in order to foster well-being and evolve in the environment. The three basic needs are:

- *Competence*: The effectiveness of own actions in current environment (E.g. the urge to accomplish the mission and win the game)

- *Autonomy*: The internal need to be responsible for own meaningful choices (E.g. feeling responsible for making decisions during the game)

- *Relatedness*: The social involvement and the relation with others (E.g. MMORPG give sense of belonging in virtual community)

There are some organizations or companies that implement the use of gamification hoping that by embedding game elements such as points, badges, and leaderboard into their business can influence their workers and clients to have more engagement and motivation [32]. Badges and leaderboard are another element from game that might be helpful and commonly applied in gamification. Badges show the achievement progress; while, leaderboards promote engagement by compete in ranking. Nonetheless, there are researches arguing that the use of badges and rewarding systems might have a negative impact to user. With cognitive evaluation theory presuming that external events can manipulate one's intrinsic motivation based on that individual consider the events as informational or controlling [16].

Badges, rewarding systems, and leaderboards are the elements of extrinsic motivation where it can lead to demotivate individual. Therefore, when designing and implementing gamification, it is important to develop game elements and techniques that support both intrinsic and extrinsic motivation [18].

To motivate crowd to participate intrinsically, enjoyment plays an important role. People sometimes use applications to kill time even though it was not that fun to use. Therefore, if we can develop a crowdsourcing application that is fun, it can actually make the crowd participate and contribute. Moreover, habit and preference are also essential for intrinsic motivation. If the user interface for crowdsourcing application is too complicated and not user friendly enough, most of the people will not bother and will not take part in the crowdsourcing task [31].

In addition to intrinsic motivation, extrinsic motivation is also important. The most effective and easiest way to motivate extrinsically is payment. Payment can be in forms of money, virtual currency, goods or even food. However, payment only helps in increasing participation but not in improving the quality [31]. If possible, both intrinsic and extrinsic motivation should be implemented together to maximize the effect.

3.4 User Experience

The term user experience (UX) has various definition. In this thesis, user experience for us is "the quality of experience a person has when interacting with specific design" [6]. Generally, UX is concerned with how user feels about a system, product, or service. For

us to evaluate our mobile applications, we are focusing on measuring the enjoyment as user experience. Enjoyment is a pleasurable feeling responding to the media use which supports emotional satisfaction and can lead to stimulation that is a need for acquiring new knowledge and skills [8]. Enjoyment satisfies the intrinsic motivation from SDT that can result in several outcomes that will increase the interest, satisfaction, and enjoyment of the activity [29]. We will assess the user enjoyment by using a questionnaire from Intrinsic Motivation Inventory (IMI) which a multidimensional assessment tool aiming to evaluate user subjective experience toward the activity such as using our mobile applications [10]. We believe that the level enjoyment represents the state of emotion that met intrinsic motivation which may result in higher engagement and participation.

3.5 Discussion

With these knowledge about gamification, we have selected some of the game elements and designed our gamified crowdsourcing application. When we are designing the gamified app, we have considered to include many game elements into our application. However, not all of the game elements are applicable in our app.

We have decided to use first person shooting/collecting type of game that is played by users via their smartphones while moving around the area as guided by the NPC (non-player character). The NPC is any character that existed in the game that is not controlled by the player. Our player character is a silent protagonist which it will have no dialogue in the game [4]. As this is developed as a proof of concept, we keeps things simple but clear. We did have a very clear goal for our gamified app which is for the player to complete the sensing task by recording a video at the requested location.

We have designed the game rule and story to go accordingly with our goal. The story of the game is that the player has to follow the NPC, which in the game appears as a corgi dog, to find food for their survival. The NPC will lead the player to the sensing location which is where the food will appear. After the player has completed a task, they will gain a score. The score system is just a mean for the player to feel achievement. We also implement a leaderboard for the player to compete with each other. However, with the design of our experiment, leaderboard is not applicable. We are expecting that if gamification works, it will have effect on motivation even with a small amount of game elements implemented.

Chapter 4

Hypothesis

We will describe what is the research problem and why is it significant enough to become our hypothesis in this chapter.

4.1 Research Problem

Gamification has been viewed as a method that can maintain user participation and increase positive user experience when use the service or application [15]. Gamification borrows the elements found in game and applies to the context other than entertainment which is expected to produce the same effect as playing game. Game elements and mechanics are implemented to increase intrinsic motivation of users so that they keep participating in the activity [22].

We want to investigate that by applying gamification in our mobile application can increase user enjoyment while using the application. Enjoyment is considered as an intrinsic motivation which means that the user will enjoy playing our gamified app and will keep participating in the crowd sensing tasks. It is important to know that gamification works in our mobile application.

Moreover, we want to examine how the participants perceived toward monetary incentives as we use gamification to maintain user engagement in substitution of monetary incentive. We assume that by applying game elements and mechanics to our mobile application can help increase enjoyment and maintain user participation but up to what extend does the gamification works.

4.2 Hypothesis Formulation

In order to evaluate that mobile sensing application in form of mobile game can take place as alternative incentive for mobile crowdsourcing, we have formulated two hypotheses.

We design user study experiment that examine the behavior of mobile users enjoyment and perception towards monetary incentive. The first hypothesis is to assess enjoyment which by means can measure intrinsic motivation.

> *Null Hypothesis,* H_0: There is *no* difference in terms of enjoyment between the ordinary and gamified version of the mobile applications.
>
> *Alternative Hypothesis,* H_1: There is a *significant* differences in terms of enjoyment between the ordinary and gamified version of the mobile applications.

The second hypothesis is to investigate how our participants perceived toward monetary incentive. As monetary incentive is an extrinsic motivation, we want to understand that if we have applied gamification, will monetary incentive be more effective in motivating engagement. Therefore, we have formulated the second hypothesis to assess that.

> *Null Hypothesis,* $H2_0$: There is *no* difference in monetary incentive perception between the ordinary and gamified version of the mobile applications.
>
> *Alternative Hypothesis,* $H2_1$: There is a *significant* difference in monetary incentive perception between the ordinary and gamified version of the mobile applications.

Our independent variable is the change in condition of the application, from ordinary version to gamified version. The expected outcome from the change in independent variable is positive difference in user's enjoyment which is the dependent variable. The enjoyment will be measure by using the Intrinsic Motivation Inventory (IMI) that is specialized in assessing subjective experience of a user towards a given activity [10]. The purpose of this field study is conduct as a proof of concept that gamification have effects on enjoyment.

Chapter 5

User Study Design Process

In Chapter 4, we will explain the system prototype that works behind the mobile applications. We also will describe the features and how to use our two versions of mobile application. The last part of this chapter will discuss about how we conduct the experiment.

5.1 Mobile Application System Architecture

We would like to investigate the difference in user's engagement and enjoyment between the ordinary application and the gamified application. From this curiosity, we have developed two versions of mobile applications that serve the same purpose which is to gather sensory data from mobile user.

We have designed the prototype system that works behind the mobile applications to have three main parts: (i) mobile app, (ii) broker, and (iii) dashboard [9]. The first part is the mobile application where we implement the user interface as ordinary and gamified. The ordinary application has simple user interface with the implementation of Google Map API. The user will be guided by the pins that mark target locations on the Google map interface in the app. On the other hand, gamified version is more fancy. We develop the application by game engine called Unity. Not only the game elements that are included into this version of application, we also apply the 3D map. There is also an integration of augmented reality when the app turns into camera mode. We also implement the *NPC path generator* here to guide the gamer to the spot where the task is available. Both version of the application collect the sensory data from the tasks that are completed by the user/gamer.

The second part is the broker server. The broker includes database, task manager, *spot locator*, and *game assigner*. The database is where all the data such as the sensory data, the requested tasks, and status of gamer are being kept. The task manager manages and

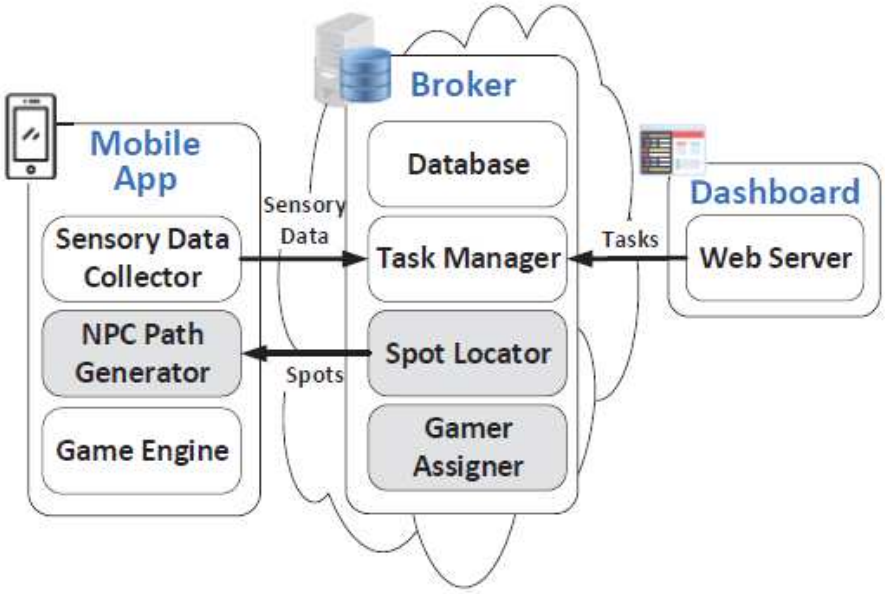


Figure 5.1: The design of our prototype system.

keeps track of the gamers and their assigned sensing tasks. Yet, another two important algorithms in the broker are *spot locator* and *game assigner*. The *spot locator* is the algorithm that calculates and generates the location where the gamer should be when performing the task. While the *gamer assigner* algorithm is the process where the nearest gamer is assigned to the nearest available task.

The last part in our system architecture is the dashboard. The dashboard is basically the Web interface where the sensory task requests are submit, configure, and retrieve the results. Currently, the dashboard is being monitored by the administrator in this project but it is meant for the smart city application developer to use in the real implementation.

5.2 Mobile Applications

In the following section, we are going to describe in details of how our mobile applications worked. Even though, both version of the mobile applications serve the same purpose which is for the user/gamer to collect sensory data, but the user interface and how the app works are different. We can categorize how the app works into three main parts which are (1) receiving the task, (2) walking to the location and (3) recording the video.

- *Receiving the task* is after the user/gamer starts the app and is connected to the internet where the server will get the current location of the user and send back the nearest available tasks.

- *Walking to the location* is when the user/gamer will walk to the location of nearest available task.

- *Recording the video* is once the user/gamer arrives at the location, they will conduct the task by recording the video at the location.

5.2.1 Ordinary App

The user interface of ordinary app is simple and straightforward. Fig. 5.2(a) shows the first screen when the user open the app and they have to click **START** button to begin using the app. We can feel that it has old school design. Once the user gets into the app which is shown in Fig. 5.2(b), they will see three main menus at the bottom of the screen. The first one is the **Map** which we implement with Google map API. The **Map** menu is to show the current location of the user and the location of all nearest available tasks. The second menu is the **Task** menu which will show a list of all nearest available tasks. The last menu is the **Setting** menu where the user can configure some settings.

While the user is at the **Task** menu, they have to tap slightly on the screen and pull down to refresh the connection to *receive the task*, as a result the list of nearest available tasks will appear as demonstrated in Fig. 5.2(c).

After the list is refreshed and showed on the screen, the user will touch the **Map** menu; they will see their current location represented in blue user-location icon and the nearest available tasks indicated in red location-pin icon, Fig. 5.3(a). From this map, user can see where they are and to which task they are close to so they can start *walking to the location*.

Fig. 5.3(b) presents a sample screen when the user walks closed enough to the location task. They can tap on the red location-pin to begin *recording the video*. Once the user has selected the red location-pin, there will be a pop-up window asking for confirmation as in Fig. 5.4(a), if the user is going to perform the task, they will have to click **Start** or if they click **Cancel** and it will go back to the map. So when the user clicked **Start**, the camera will open and is prompt for video recording. The user just has to click at the **Capture** button to start the recording, Fig. 5.4(b).

Fig. 5.4(c) and 5.4(d) give signals when the camera starts rolling and when it is done. The camera will keep on recording for about four seconds and the user can film anything because we did not indicate where and what exactly the user has to record in the video.

Once the user has completed one task, they can continue to perform the rest of the nearest available task depending on their interest and time.

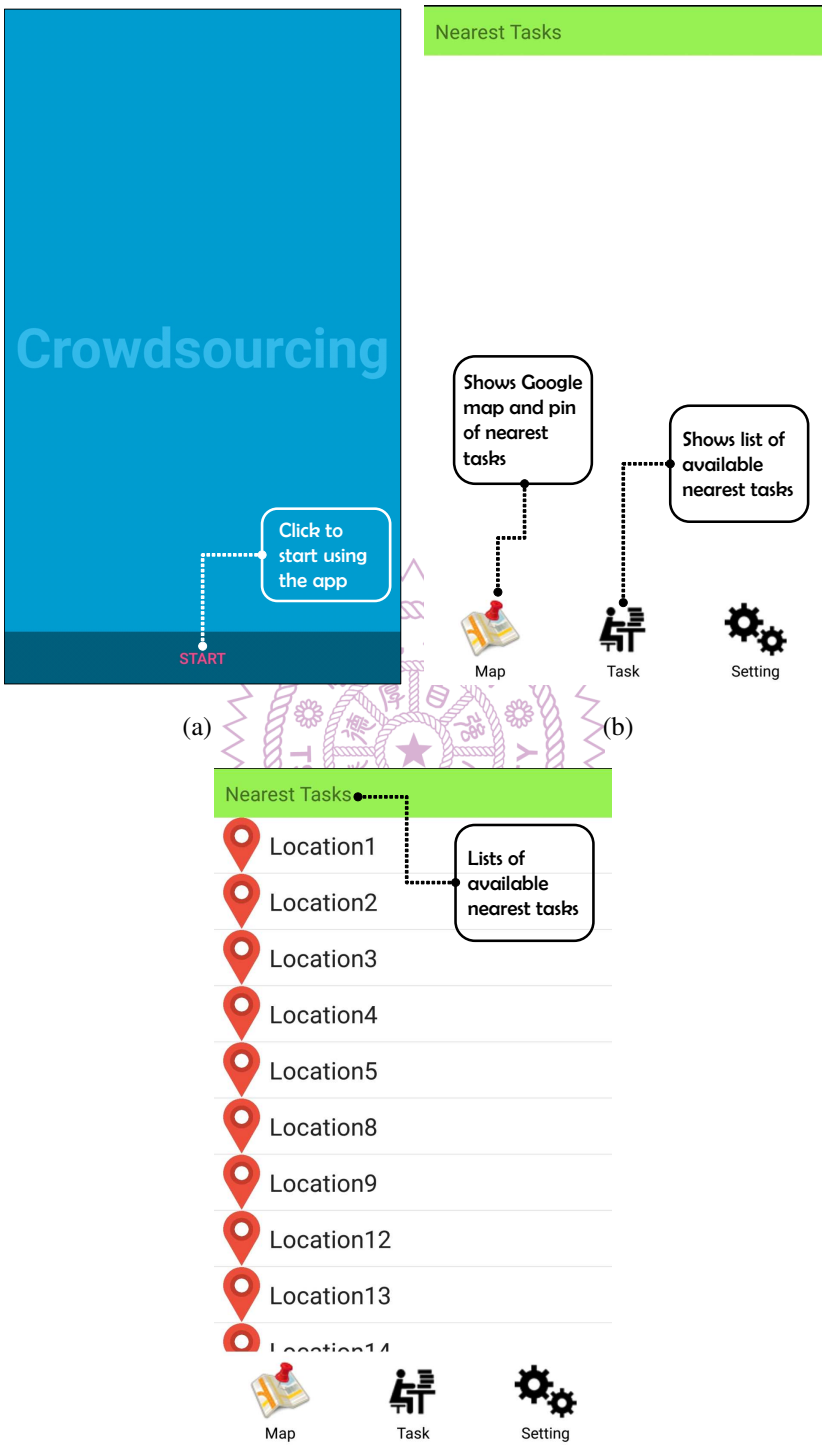
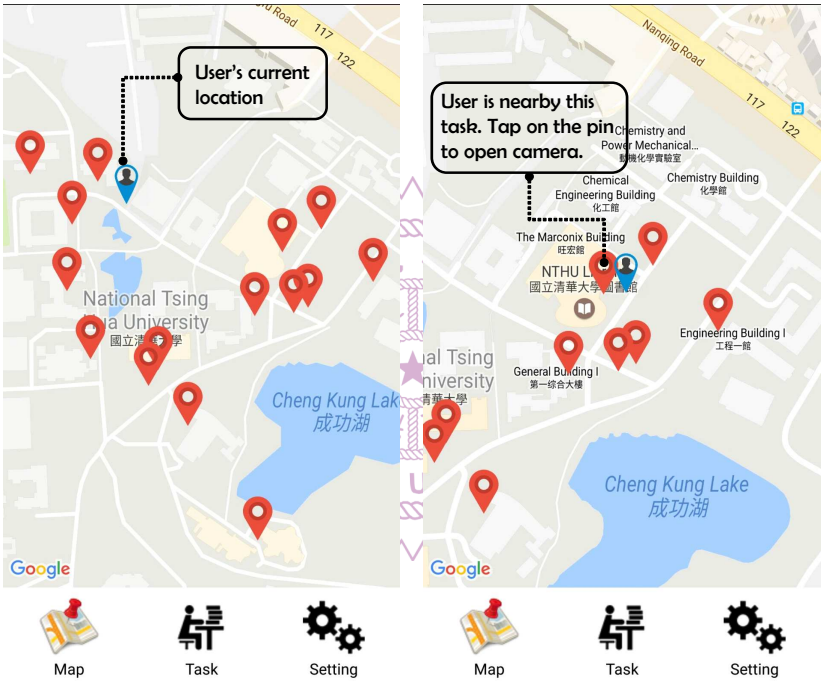


Figure 5.2: Ordinary app - Get task



(a) (b)

Figure 5.3: Ordinary app - Walk to task location in Map mode

Figure 5.4: Ordinary app - Record the video in Camera mode

5.2.2 Gamified App

Our gamified mobile application is implemented with the same purpose as ordinary app, however, we have include the game elements into the app assuming that gamification can helps increase user's motivation and engagement. The platform we use to develop our gamified app is Unity, the user interface will look more like a game with 3D map, user avatar, and corgi dog. The story of this game is that the gamer has to find food in order to keep their pet dog survive. The HP bar of the dog is showed at the bottom right corner. The dog will guide the gamer to where the food is. The various kind of food will randomly appear and the gamer must collect it to gain badges. Furthermore, the score system is implemented for the gamer to feel somewhat achievement.

Fig. 5.5(a) shows the screen after the gamer open the app. The gamer can navigate every menu just from this screen. The user is the avatar with rectangular head in the center of the screen. Next to the user avatar is the corgi dog which will act as a navigator in this application. At the bottom right corner, there is a hambone which represents the list of nearest available tasks. On the top left corner shows a score the gamer earns when completed a task.

When the hambone at the bottom right corner blinks, it means that the game has *received the task* and there is new task available. When the gamer taps at the blinking hambone, it will shows the list of nearest available tasks, Fig. 5.5(b).

Once the gamer choose the task, the screen will show a command telling the gamer to follow the pet dog to find food as shown in Fig. 5.5(c). The dog will guide the way as the gamer is *walking to the location*. The food will appear on screen when the gamer is closed to the location.

After the gamer taps at the food, the AR mode will be activated as well as the camera, Fig. 5.5(d). As the rule of the game, the gamer has to find the food by following the dog (Fig. 5.6(a)) which the gamer will not know where the dog is so the gamer has to pan the camera around to find the dog first. Then, the dog will run to the food as in Fig. 5.6(b). The moment that both the dog and the food are in the camera, the gamer has to tap at the food as a mean to finish the task and the screen will shows text **Gotcha** to inform the gamer that they have completed the task, Fig. 5.6(c). The gamer will earn score from finishing a task.

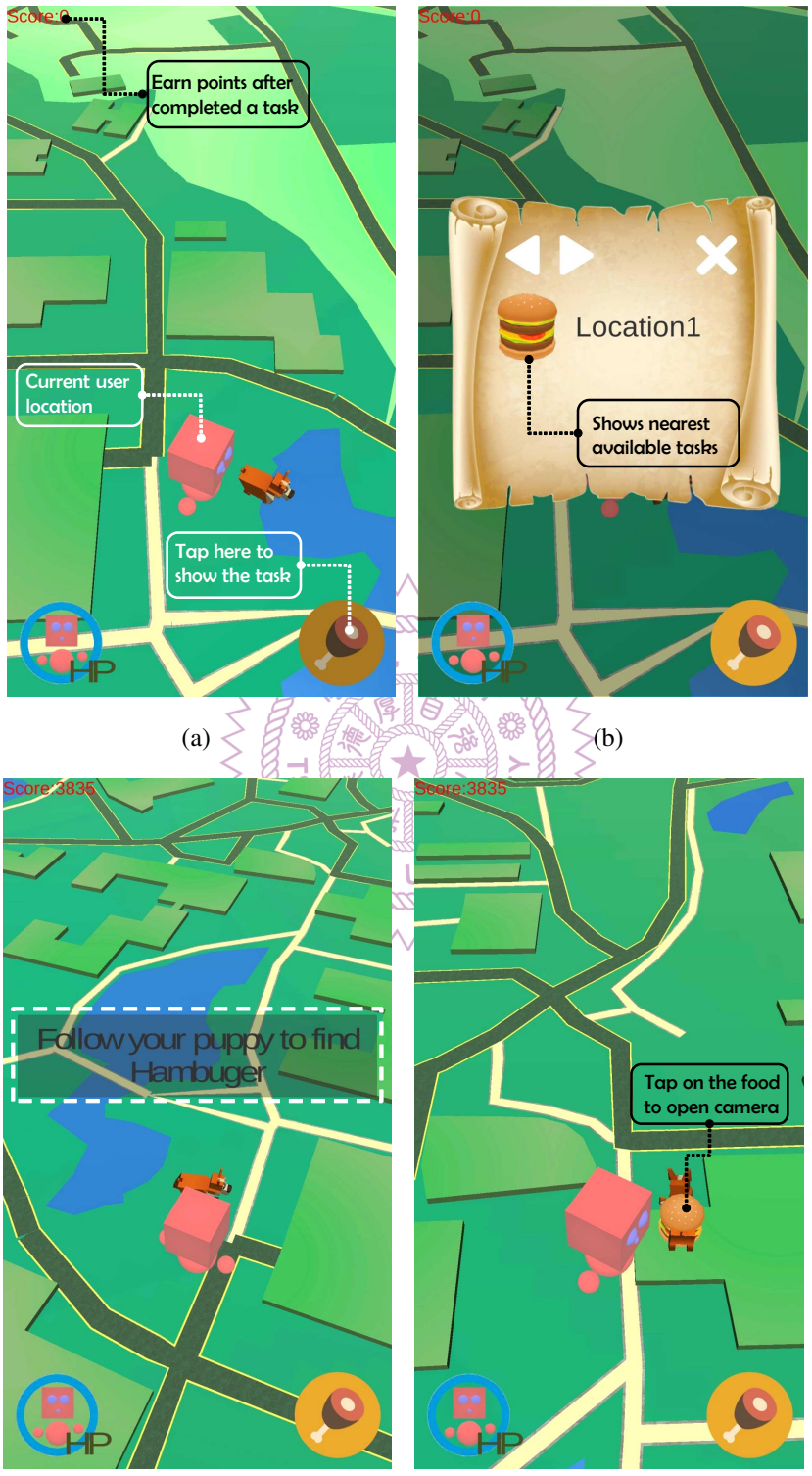


Figure 5.5: Gamified app - Get task and walk to task location in Map mode

(a) (b)

(c)

Figure 5.6: Gamified app - Record video in AR mode

5.3 Experimental Process

Our experiment is conducted as a proof of concept that gamified elements have effect on user's engagement and enjoyment. The field experiment is conducted in the area of NTHU campus. We have set 20 locations in campus to simulate the situation (Fig. 5.7 and Table 5.1 shows the lists and location of the pre-defined task locations) and the coverage area is approximately 570m x 600m; however, the task location in the real implementation can be anywhere in the world depending on the requester.

The participants are to conduct the experiment in both versions, ordinary and gamified. We use the within subject design approach to conduct our experiment because it required few participants. However, the downside of within subject design is the order effect which can caused the performance to be better when the participant already knows what to do. While on the other hand, the performance can become worse if the participant is tired.

Therefore, we divide the participants equally into two groups: (1) Group A will perform with ordinary app first then gamified app and (2) Group B will start with gamified app follows by ordinary app and conduct the experiment. We use this repeated measures with counterbalancing method to help reduce the order effect which can affect the performance of the participants. The results will balance out the order effect [1].

List of Task Locations			
Item	Location	Item	Location
1	Delta Building	11	Food court
2	Physics Research Center Library	12	Shui Mu
3	EECS Building	13	Feng Yun
4	Material Science & Technology Building	14	Skate Rink
5	Basketball Court	15	Auditorium
6	Engineering Building III	16	Smile Cafe
7	Education Building	17	Grass field
8	General Building III	18	Chemistry building
9	Art Center	19	In campus bus stop
10	Cafe de Socrates	20	Engineering Building I

Table 5.1: List of Task Locations

Each of the participants is given an Android device with data plan and pre-install of our apps. The data plan we used in the experiment is sponsored by Industrial Technology Research Institute of Taiwan (ITRI). ITRI is developing the 5G network and they have one base station in the Computer and Communication Research Center (CCRC) located

at General Building II in our NTHU campus. The current specifications of the base station are as follow:

Hardware: BBU:RBS6601

Software version: L16B

Frequency band: FDD Band3 1870MHz-1880MHz

We use the sim cards provided by ITRI to connect the internet when conducting the experiment. The connection is only work for LTE network. The signal is not very stable and only strong in the area around General Building II.

Before the participants go out to perform the experiment, we asked them to sign a consent form which informs them that while they are in the experiment, everything will be tracked and recorded. After each run, they will come back and fill in the questionnaire about the enjoyment and feedback. The participants are to return the device when they finished the experiment.

Figure 5.7: Task Locations

The questionnaire is designed to assess the enjoyment, usage behavior, and preference of the user/gamer while using the app. We use 5-point Likert scale to assess how participant feels about our applications where 1 = Not true at all and 5 = Very true. First part of the questionnaire comes from Intrinsic Motivation Inventory (IMI) which is specialized in assessing subjective experience related to the performed activity of a user [10].

We extract the subscale enjoyment/interest of IMI and apply to our questionnaire. The full set of IMI actually consisted of 7 subscales with total of 45 questions. The 7 subscales include (1) interest/enjoyment, (2) perceived competence, (3) effort/importance, (4) pressure/tension, (5) perceived choice, (6) value/usefulness and (7) relatedness. However, just only with the interest/enjoyment subscale, we can measure the intrinsic motivation. Therefore, we apply only interest/enjoyment subscale to our questionnaire. The interest/enjoyment subscale has total of 7 items as follows:

1. I enjoyed doing this activity very much.
2. This activity was fun to do.
3. I thought this was a boring activity. (R)
4. This activity did not hold my attention at all. (R)
5. I would describe this activity as very interesting.
6. I thought this activity was quite enjoyable.
7. While I was doing this activity, I was thinking about how much I enjoyed it.

The item with (R) such as question 3 and 4, is a negative question which we have to reverse the score when use in statistic calculation as a whole set. When use for individual interpretation, we want the score to be low; for example, ”I thought this was a boring activity” and the participant give score of one in Likert scale, that can be interpret as ”I don’t think this was a boring activity at all”.

We also asked 4 questions related to usage behavior, 1 question about UI and usability preferences, and 1 open question for other comment or feedback. The 4 questions are (1) I discovered new route while I was using this app, (2) I went out from my daily route while using this app, (3) I find the app difficult to use and (4) I think I will be more motivated if presented with monetary reward. In total, we have 14 questions in our questionnaire excluding those personal information questions. The results will be analyzed in the next chapter.

Chapter 6

User Study Results Analysis

In this chapter, we will present the results in both quantitative and qualitative perspective plus hypothesis test from the experiment that we conducted with 14 participants.

6.1 Basic Statistics

In this user study experiment, we have recruited total of 14 participants. The population of the participants are 7 male and 7 female. They are all in their twenties and are students at National Tsing Hua University. From the 14 participants 43% are international students and 57% are local Taiwanese students.

We have divided the participants into two groups in order to avoid the order effect. Group A will perform with ordinary app then gamified app, while Group B is vice-versa. Each group has seven participants. The population in Group A consists of 4 male and 3 female and 2 are international students. On the other hand, Group B is composed of 3 male and 4 female and 4 of them are international students. As a whole population, 5 out of 14 participants own iPhone which may or may not influence user experience because they are not familiar with Android operated smartphones that we give them to use for performing experiment.

	Group A	Group B
Male	4	3
Female	3	4
Domestic	5	3
International	2	4
iOS	2	3
Android	5	4

Table 6.1: General information of participants

6.2 Quantitative Results

We have tracked and recorded the data as the participants performed the experiment. We extract the logged data and analyze as follows:

- *Completion time*. The time the user/gamer takes to finish all the tasks.
- *In-app usage time*. The time the user/gamer spend in using our app while completing all the tasks.
- *Video duration time*. The duration time of the video recorded by the gamer.
- *Walking distance*. The distance that the user/gamer walked during the experiment.

There are some complications happened with the logged data. Therefore, we are left with data of 10 participants to process and analyze for quantitative results.

The total time spend in completion time is twice more than of in-app usage time. Fig. 6.1 shows the total time spend to complete all the pre-defined tasks and the in-app usage time for both ordinary app and gamified app. Table 6.2 and 6.3 presents the total, minimum, and maximum time spend in completing the tasks and using the app.

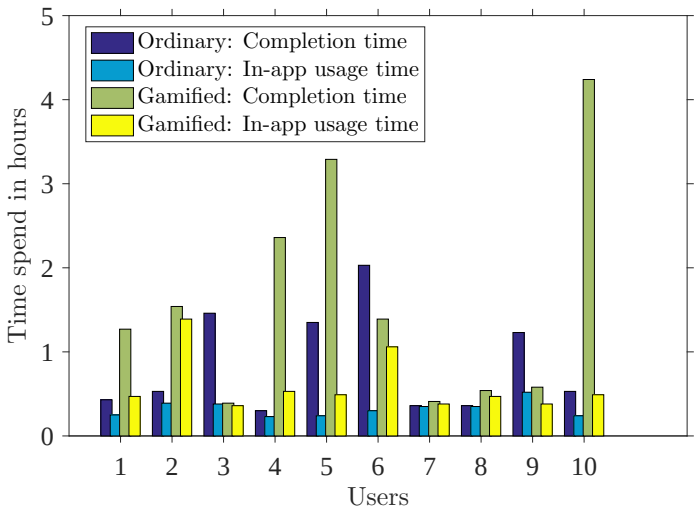


Figure 6.1: Comparing completion time and in-app usage time between ordinary app and gamified app

For ordinary app, participants took in total of 11:39 hours to complete the task while they only spend 5:33 hours using the app. The total completion time is twice as much of in-app usage time. In gamified app, the total time took to complete the tasks is 18:46 hours but the in-app usage time is only 8:47 hours. Again, the completion time is more than twice the time of in-app usage. Therefore, from this fact, we can analyze that most of

Version	N	Total	Minimum	Maximum
Ordinary	10	11:39:20	00:30:37	02:03:58
Gamified	10	18:46:52	00:39:58	04:24:04

Table 6.2: Completion time (hh:mm:ss)

Version	N	Total	Minimum	Maximum
Ordinary	10	05:33:41	00:23:55	00:52:55
Gamified	10	08:47:48	00:36:45	01:39:49

Table 6.3: In-app usage time (hh:mm:ss)

the participants did use the app while carrying out their usual routine. However, of course there are some that concentrate just on using the app and finish all the tasks.

However, the total completion time and in-app usage time spend in gamified app is approximately 1.6 times more than of ordinary app. This might cause by the fact that in ordinary app, the participants can plan their own walking route to the nearest available task, while in gamified app, the user will not know where the location of the task is, in which they cannot really manage their walking route.

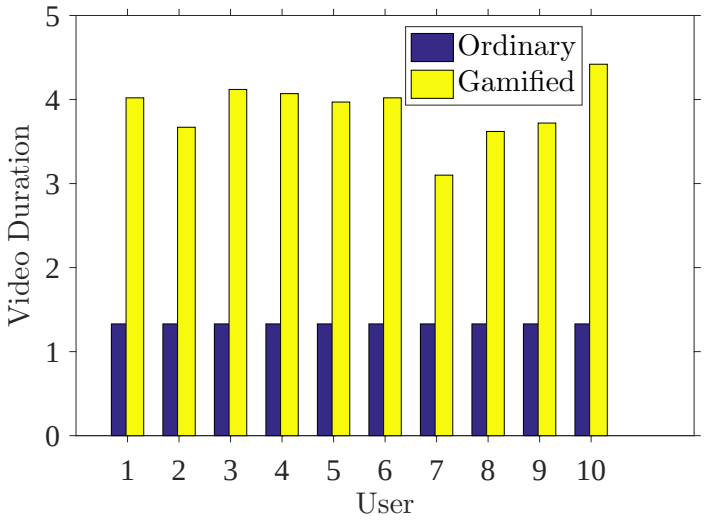


Figure 6.2: Comparing video recording duration time between ordinary app and gamified app

Video recording time in gamified app is 2.5 times greater than ordinary app. Fig. 6.2 and Table 6.4 presents the total video duration. We have total of 200 videos per app (10 users x 20 videos). In ordinary app, we implement with fixed video recording time which is 4 seconds per task. While in the gamified app, we design with the mechanic that gamer has to search for the pet dog and the food, so the recording time will varied

Version	N	Total	Minimum	Maximum
Ordinary	200	15:30	00:04	00:04
Gamified	200	39:10	00:01	00:35

Table 6.4: Video duration (mm:ss)

depending on how fast a gamer can find the dog. The total video duration for gamified app is 2.5 times more than ordinary app. 19% of the videos in gamified app is recorded at 14 seconds.

In-app usage time is correlated with walking distance and speed. Table 6.5 shows walking distance in kilometers and in-app usage time. The total distance walked in this experiment is 34.22 km. The shortest route walk is at 2.21km which has the same user as the minimum time spent in using the app. While the longest route walked 6.65km with the longest in-app usage time. Therefore, from this investigation, we can examine that the longer route the user walked, the longer time they spent. In generaly, walking distance in average is measured at 0.06km per minute; however, the walking distance and time spent for each participant differs depending on how fast each person walks. Moreover from this fact, the user might feels fatigue from walking in long distance and time which might caused an effect to participation.

	N	Total	Minimum	Maximum
Walking distance	10	34.22	2.21	6.66
In-app time	10	08:47:48	00:36:45	01:39:49

Table 6.5: Comparing walking distance (km) and in-app usage time (hh:mm:ss) for Gamified app

6.3 Qualitative Results

We use questionnaire as a tool to measure subjective point of view and to get feedback from the user/gamer.

The overall IMI scores present that users are more satisfied and enjoyed gamified app. Fig. 6.3 shows the average score from total of 14 participants in each item. Each bar in the figure represents one of the 7 questions from IMI. As an overview analysis of this subscale, we can say that gamified app did perform better in interest/enjoyment. Let's observe into more detail for each item.

In question 1 and 2, for ordinary app, 49% of participants enjoys using the app but only 44% feels that the app was fun to use while in gamified app 71% like playing the

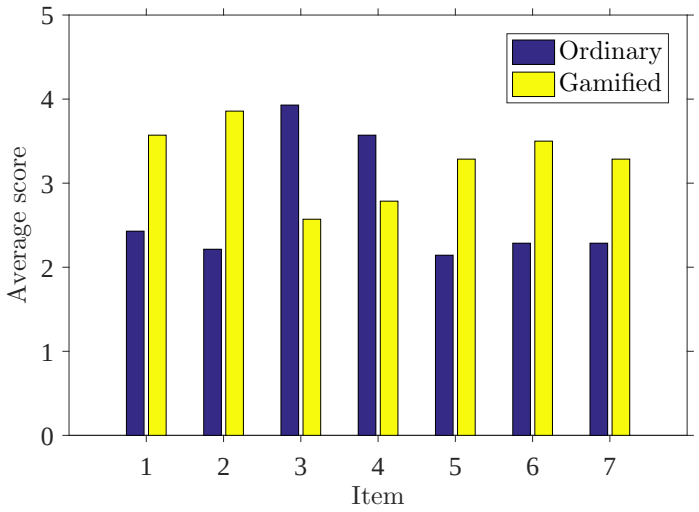
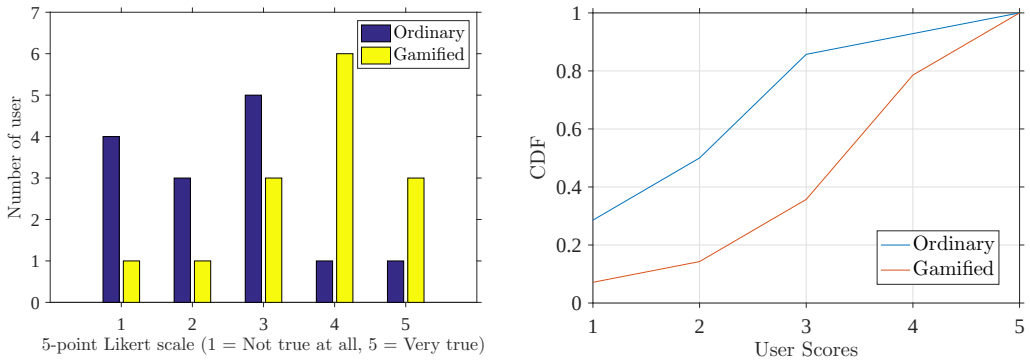


Figure 6.3: The average score from IMI

game and 77% thinks that the game is fun to play.

For the question item 3 and 4, it is reasonable that gamified app will has a lower score than ordinary app as the questions are in negative form. Therefore, we can say that participants feel that ordinary app is more boring and did not hold their attention that much comparing to gamified app.

The last three questions can be analyzed as 43% of participants thinks that ordinary app can be described as interesting app but only 46% thinks that they enjoyed using the app. On the other hand for gamified app, 66% will describe gamified app as interesting and 68% enjoyed playing the game.

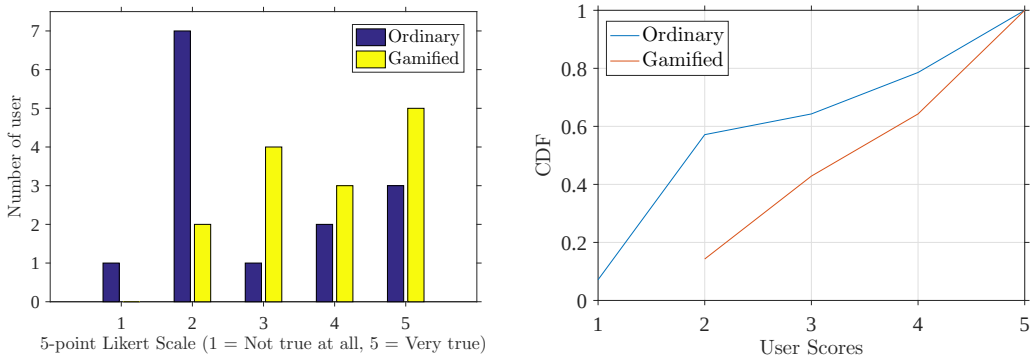


(a) (b)

Figure 6.4: User's feeling on item "I discovered new route while I was using the app".

With gamified app, the users discovered new route more than using ordinary app. Fig. 6.4(a) reports the answer from question "I discovered new route while I was using this app/game". 50% of the participants does not feel that they discovered new route

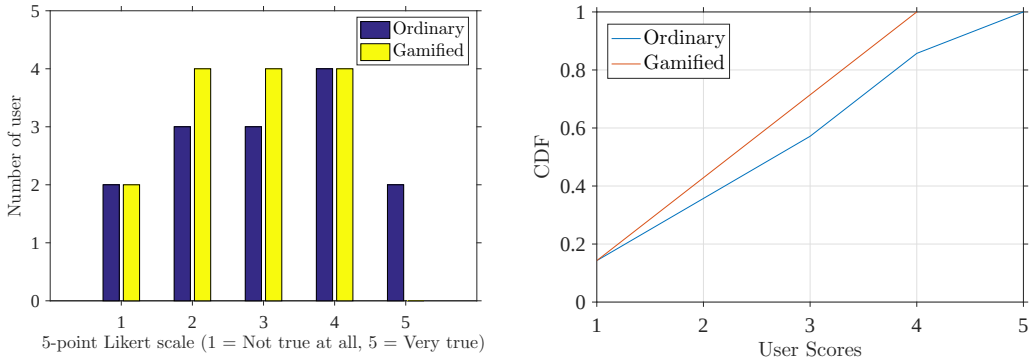
while using the ordinary app. One of the participants mentioned that he can manage his own route because in ordinary app, all the available tasks and user location are display on the map. On the other hand, around 65% of the participants agreed that did found new route while using the gamified app.



(a) (b)

Figure 6.5: User's feeling on item "I went out from my daily route while using this app".

Most of ordinary app users did not change the daily route while using the app. Another question that we asked about route is that "I went out from my daily route while using this app/game" and the response is showed in Fig. 6.5(a). About 57% of the participants did not went out from their daily route to use the ordinary app. Yet, in gamified app approximately 57% of the participants did went out from daily route while playing the game. Two participants complained that they could not find the right way to go as in terms of they get lost in sense of direction.

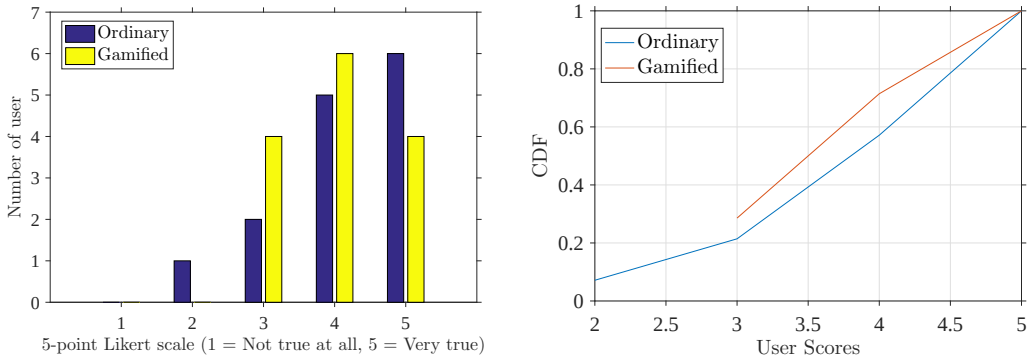


(a) (b)

Figure 6.6: User's feeling on item "I find the app/game difficult to use".

Majority of the users feel that gamified app is easier to use than ordinary app. Fig. 6.6(a) shows the answer from question "I find the app/game difficult to use". Around 43% of the participants think that ordinary app is difficult to use. While only 28% of

the participants consider gamified app difficult to use. I assume that it is because the instability of the network connection that we provide.



(a) (b)

Figure 6.7: User's feeling on item "I think I will be more motivated if presented with monetary reward".

Ordinary app users felt that they can be more motivated if monetary reward is given. For the last question from the questionnaire is "I think I will be more motivated if presented with monetary reward". Almost 80% in ordinary app and 70% in gamified app of the participants agreed that they will be more motivated with reward and the result is shown in Fig. 6.7(a). As we can see from the result, monetary incentive is still a powerful way to attract participants regardless of how much they will get paid.

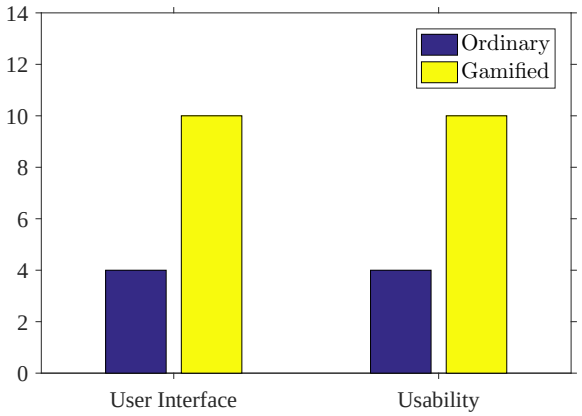


Figure 6.8: User preference in UI and usability between ordinary app and gamified app

About 70% of the users prefer gamified version in both UI and usability. The result in Fig. 6.8 confirms that most of the participants prefer gamified app in terms of user interface and usability. One participant likes the UI of gamified app but prefer the usability of ordinary app as she has commented that she can plan her own route when she

sees the entire available tasks showing on the map. Nonetheless, many participants have commented that the idea of using the dog is cute but should have more dog selection.

6.4 Hypothesis Test Result

For our first hypothesis where *null hypothesis* is "There is *no* difference in terms of enjoyment between the ordinary and gamified version of the mobile applications", we use the score from IMI to calculate and run in t-test to test the significant of our hypothesis. A paired t-test is conducted to compare the difference in effect of gamification on enjoyment. We compute with 0.05 significant level, which if p <0.05 then we can reject our null hypothesis.

	Mean	N	Std. Deviation	Std. Error Mean
Ordinary	15.8571	14	4.4177	1.1806
Gamified	24.1429	14	4.7208	1.2616

Table 6.6: Paired Samples Statistics

Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval	t	df	Sig. (2-tailed)
8.29	1.728	0.4618	(-11.8376, -4.7338)	-4.2044	13	0.001031

Table 6.7: Paired Samples Test

We reject *null hypothesis* where our p-value is 0.001031 which is less than 0.5. Table 6.7 shows the detail results from t-test. A paired t-test was conducted to compare enjoyment of user while using ordinary app and gamified app. There was a significant difference in the scores for ordinary (M = 15.8571, SD = 4.4177) and gamified (M = 24.1429, SD = 4.7208); t(13) = -4.2044 and p = 0.001. Our p-value is less than 0.05; therefore we can reject null hypothesis and saying that *"There is a significant difference in terms of enjoyment between the ordinary and gamified version of the mobile applications"*. From this statistical calculation, we can prove that user enjoyed using gamified app more that ordinary app.

Our second hypothesis is to investigate the difference in perceived monetary incentive between ordinary and gamified app. The *null hypothesis* is "There is *no* difference in monetary incentive perception between the ordinary and gamified version of the mobile applications". We also run paired t-test to get statistical result.

There is no statistically significant differences between ordinary and gamified app. Table 6.9 shows the detail results from t-test. A paired t-test was conducted to

	Mean	N	Std. Deviation	Std. Error Mean
Ordinary	4.1429	14	0.9493	0.2537
Gamified	4	14	0.7845	0.2096

Table 6.8: Paired Samples Statistics for H2

Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval	t	df	Sig. (2-tailed)
-0.14	0.3291	0.087955675	(-0.5336, 0.8194)	-0.563093	13	0.582954

Table 6.9: Paired Samples Test for H2

compare perception of user on monetary reward while using ordinary app and gamified app. There was no significant difference in the scores for ordinary (M = 4.1429, SD = 0.9493) and gamified (M = 4, SD = 0.7845); t(13) = -0.56309 and p = 0.582, in which our p-value is greater than 0.05; therefore we do not reject null hypothesis.

6.5 Summary

We will summarize all of our findings in this section.

In **qualitative** point of view, we have found that (1) the total time spend in completing all the pre-defined tasks is twice more than of in-app usage time, (2) in gamified app, video recording time is 2.5 times longer than ordinary app, and (3) in-app usage time is correlated with walking distance and speed.

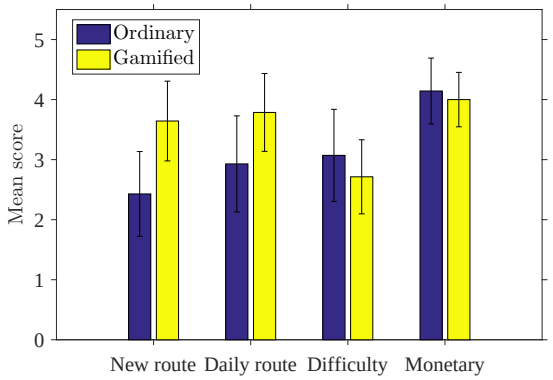


Figure 6.9: Mean score from 4 questions with error bar

For **quantitative** perspective, we analyze and summarize that gamified app users (1) tend to discover new route more than using ordinary app, (2) are likely to get out from their daily route to use the app, (3) feel that gamified app is easier to use, and (4) are less

sensitive to monetary incentives. To conclude, users are more statisfied and prefer using gamified app.

As for **hypothesis** test, we reject the first *null hypothesis* and conclude that there is statistically significant difference in enjoyment in gamified version of mobile crowdsourcing application. However, we fail to reject *null hypothesis* for the second hypothesis and admit that there is no statistically significant difference in monetary incentive perception between ordinary and gamified app.

Chapter 7

Conclusion and Future Work

7.1 Limitation

The limitation of this user study experiment is that we have few participants and the period of experiment is considered short. Due to the fact that our mobile crowdsourcing applications are for outdoor usage, the weather is the biggest obstacle. The participants are not willing to do the experiment in rainy day, cold day, nor very sunny day. This is one observation that we need to take in consideration.

Moreover, many participants provide the feedback about GPS accuracy and how the NPC guide to the wrong direction which have direct effect towards the enjoyment of the user because they walked to the wrong direction and got re-route back. This is another point that we need to improve so that it will not cause negative feeling toward enjoyment.

7.2 Future Work

For future work, we will implement a better routing algorithm and more accurate GPS location for the NPC to guide the mobile user to the best walking route with accuracy. Also, we will have more choice of selection in the NPC guiding dog and the food to collect. We can also consider to have special event such as time attack mode, players compete with each other to complete the task at the same time but the problem will be we need many participants to use the app at the same time.

In addition, we are considering to lessen the number of tasks for the participant to complete as they might get too tired from completing 20 tasks for each applications in one day due the heavy mental efforts. The participants need to learn how to use the application plus while conducting the experiment they have to multitask walking and operating the unfamiliar application which might not be easy for some people. We should consider user friendly interface with easy instruction so that it will not tired out the users.

As in the part of questionnaire, we have focused on enjoyment as user experience in this thesis; for future work, we can include other aspect in measure UX as in overall usage satisfaction, flow of the game and so on. Also, we can have more questions in testing our second hypothesis which we wanted to investigate how participants perceived toward monetary incentive. We currently have only one question to run the hypothesis test which is not solid enough. We should have more questions related to how our participants feel about monetary incentive.

For the result analysis part, if we have more participants we can analyze the differences between Group A and Group B participants. Group A participants are to conduct ordinary app first then gamified app and Group B is the opposite. Since we only have 7 participants per group, the analysis might not be very different.

7.3 Conclusion

In this thesis, we develop mobile crowdsourcing applications based on the SAIS platform. We have the mobile applications build in two versions, the ordinary app and gamified app. We have discussed how gamification can affects user engagement; therefore, we apply game elements into our application to investigate the effect as a proof of concept. An experiment is conducted to examine the difference in enjoyment from the two versions of the mobile applications. From our investigation, 70% of the participants agree that they preferred the UI and usability of gamified app; therefore, we can ensure that gamification can help in increasing the enjoyment of a user which in consequence leads to more engagement and participation in using our gamified crowdsourcing application.

Even though, we got a positive feedback from the experiment but it might be because of the novelty of the application. The bottom line is that user should contain intrinsic motivation in their behavior or action; gamification is only a mean to quantify that but once the novelty becomes old, the magic of gamification wears off. Therefore, designing application with gamification is not easy and should consider many elements related to gamification and user experience.

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