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Japan Advanced Institute of Science and Technology

## **Doctoral Dissertation**

## Analysis of Game Elements in Fun Games and Serious Games

by

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submitted to Japan Advanced Institute of Science and Technology in partial fulfillment of the requirements for the degree of Doctor of Philosophy

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## Abstract

Recent years, mass-market consumer software has rapidly gained popularity and inspiration from video games. Usually summarized as gamification, this trend is associated with a sizeable body of existing concepts and research in game studies and human-computer interaction, such as pervasive games, serious games, alternate reality games, or playful design. However, it is not clear how gamification relates to these, whether it denotes a novel phenomenon, and how to define it.

Every game has its game mechanics. These are the rules and procedures that guide the player and the game responds to the players moves or actions and that is how game elements and game design work. Every game has "elements" or features that keep people engaged and the core of gamification is the game elements. Some games have a lot; others have very few. The choice of what to include should be deliberate. In this thesis we will explain why the concept of games is deeper than what most people realize, and how game elements serve as a foundation for gamification.

The "game informatics" has been established as a new research area in the field of information and computer science. This thesis focuses on the game refinement theory application and its development in MOBA game, business and education domain. The present contributions can be divided into two parts: fun game and serious game. This thesis has two directions, one is the analysis of the game elements by using different assessment, and the other is the application of game refinement theory. Previous work is mainly focused on the application of game refinement theory to sports game and board games. We noticed that these games usually have a pure game progress and share the same zone value. For sufficiently complex games like MOBA game and reality gamification case, we still don't know how to figure out the main game progress as this game may have two or three progress. Meanwhile, whether game refinement has a good universality is still an opening question. With such research background, we solve the question in the following way. Chapter 1 introduces the background of the study and the research question of this thesis. Chapter 2 presents the mathematical model of game refinement theory. Chapter 3 focuses on the evolutionary changes of a sufficiently complex MOBA game called DOTA2. Chapter 4 proposes a novel method to illustrate the entertainment impact of educational purpose game and discover the effects of game elements and course structure. Chapter 5 explores the benefits of a sales promotion in the aviation industry known as frequentflyer Program. Chapter 6 analyzes the case study of Starbucks with considering the gamification effect of loyalty program and its assessment using game refinement measure. Chapter 7 employs the game refinement theory, analytic hierarchy process and return on investment to comprehensively evaluate the game sophistication of hotel loyalty program in business domain. Chapter 8 gives the conclusion in which research questions and problem statement in this thesis are answered, and suggests several possible future works.

Keyword:Game Elements, Game refinement theory, Gamification, Fun Game, Serious Game, Business

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# Chapter 1

# Introduction

A game is a structured form of play, usually undertaken for enjoyment and sometimes used as an educational tool. Games are distinct from work, which is usually carried out for remuneration, and from art, which is more often an expression of aesthetic or ideological elements. However, the distinction is not clear-cut, and many games are also considered to be work (such as professional players of spectator sports or games) or art (such as jigsaw puzzles or games involving an artistic layout such as Mahjong, solitaire, or some video games). Games are sometimes played purely for entertainment, sometimes for achievement or reward as well. They can be played alone, in teams, or online; by amateurs or by professionals. The players may have an audience of non-players, such as when people are entertained by watching a chess championship. On the other hand, players in a game may constitute their audience as they take their turn to play. Often, part of the entertainment for children playing a game is deciding who is part of their audience and who is a player. Key components of games are goals, rules, challenge, and interaction. Games generally involve mental or physical stimulation, and often both. Many games help develop practical skills, serve as a form of exercise, or otherwise perform an educational, simulational, or psychological role.

Unfortunately, in a massive group of people's mind, the game is just for enjoyment or associate chair-warmer, and they think that the game is primarily for children and teenagers, therefore in university or academic area, few university or lab do the work related to the game science. In fact, a game called as "Ninth Art" which was a combined name with other 8 different arts – literature, painting, music, dance, sculpture, architecture, theater and film [54] [45]. A fantastic game would need a good storyline and background, good structure, mathematical balance and AI algorithm research, sophisticated coding and programming work, and wonderful painting and music design, being as complex as the operating system. Therefore, this study is dedicated to the development of a new academic research area in "Game Informatics" which has become apparent.

### 1.1 Game Theory

Typically, the academic concept in "game theory" comes from management and business. Sports such as soccer, basketball, table tennis, etc. are classified as to physical games. Of course, the board games and video games are the standard understanding in people's mind. In recent years, the concept of the game has been developed and changed into online games, cell phone games and serious games [24]. Game theory is a fascinating subject [19]. There are many entertaining games, such as chess, poker, tic-tac-toe, bridge, baseball and computer games, etc. In addition, there is a vast area of economic games, discussed in Myerson (1991) [47] and Kreps (1990) [40], and the related political games, Ordeshook (1986) [52], Shubik (1982) [64], and Taylor (1995) [69]. The competition between firms, the conflict between management and labor, the fight to get bills through congress, the power of the judiciary, war and peace negotiations between countries, that provide examples of games in action. There are biological games, the competition between species, where natural selection can be modeled as a game played between genes[65]. There is a connection between game theory and the mathematical areas of logic and computer science. One may view theoretical statistics as a two-person game in which nature takes the role of one of the players, as discussed in Blackwell and Girshick (1954) [16] and Ferguson (1968) [19].

Games are characterized by a number of players or decision makers who interact, possibly threaten each other and form coalitions, take actions under uncertain conditions, and finally receive some benefit or reward or possibly some punishment or monetary loss [70] [19].

In general game progress, typically involves several players; a game with only one player is usually called a decision problem. The formal definition lays out the players, their preferences, their information, the strategic actions available to them, and how these influence the outcome. Games can be described formally at various levels of detail [26]. A cooperative game is a high-level description, specifying only what payoffs each potential group, or coalition, can be obtained by the cooperation of its members. What is not made explicit is the process by which the coalition forms. As an example, the players may be several parties in parliament. Each party has a different strength, based upon the number of seats occupied by party members. The game describes which coalitions of parties can form a majority, but does not delineate, for example, the negotiation process through which an agreement to vote en bloc is achieved [26].

Cooperative game theory investigates such coalitions games with respect to the relative amounts of power held by various players, or how a successful coalition should divide its proceeds. This is most naturally applied to situations arising in political science or international relations, where concepts like power are most important. For example, Nash [71] [19]proposed a solution for the division of gains from an agreement in a bargaining problem which depends solely on the relative strengths of the two parties bargaining position.

The amount of power aside has determined by the usually inefficient outcome that results when negotiations break down. Nash's model fits within the cooperative framework in that it does not delineate a specific timeline of offers and counteroffers but rather focuses solely on the outcome of the bargaining process [19]. In contrast, the noncooperative game theory is concerned with the analysis of strategic choices. The paradigm of the noncooperative game theory is that the details of the ordering and timing of players' choices are crucial to determine the outcome of a game. In contrast to Nash's cooperative model, a noncooperative model of bargaining would posit a specific process in which it is prespecified to make an offer at a given time. The term "noncooperative" means that this branch of game theory explicitly models the process of players making choices out of their interest. Cooperation can, and often does, arise in noncooperative models of games, when players find it in their own best interests [26] [71].

Branches of game theory also differ in their assumptions. A central assumption in many variants of game theory is that the players are rational. A rational player is one who always chooses an action which gives the outcome he most prefers, given what he expects his opponents to do. The goal of game-theoretic analysis in these branches, then, is to predict how rational players will play the game, or, relatedly, to give advice on how best to play the game against opponents who are rational [19] [3]. In the following subsection, we will introduce some typical exciting cases.

John Nash proved that games with several players have a stable solution provided that coalitions between players be disallowed. Nash won the Nobel prize for economics for this critical result which extended von Neumann's theory of zero-sum games. Nash's stable solution is known as the Nash equilibrium. In game theory, the Nash equilibrium is a non-cooperative game involving two or more than two game players [25]. Each game player should know the concept of equilibrium solutions. While each player chooses a strategy, no player can change the strategy, while the other players keep their income unchanged, then the current strategic choices and the corresponding payoffs is a Nash equilibrium. The reality of a game's Nash equilibrium can be tested with an experimental economics approach [19].

Simply to say, PlayerA and PlayerB are in Nash equilibrium if PlayerA is making the best choice, taking into account PlayerB's decision while PlayerB's decision remains unchanged, and PlayerB is making the best decision, taking into account PlayerA's decision while PlayerA's decision remains unchanged [19] [26]. For Nash equilibrium, the most typical case is the prisoner's dilemma [19].

The prisoner's dilemma is a conventional example of a game analyzed in game theory that shows why two completely "rational" individuals might not cooperate, even if it appears that it is in their best interests to do so. It was originally framed by Merrill Flood and Melvin Dresher working at RAND in 1950. Albert W. Tucker formalized the game with prison sentence rewards and named it [57].

In a finite Prisoner's Dilemma super game the same game is repeated for a fixed number of times known to both players in advance. It is well known that such games have a definite game-theoretical solution which prescribes non-cooperative behavior in all periods of the super game [61].

### **1.2** Game Refinement Theory

Previously, we introduced the concept of game theory. However, game theory only can solve the problem of "how to win the game", it is the mathematical method with a focus on the players' side. In order to develop a new game theory from the game designer's point of view, Iida et al. [35] created game refinement theory in 2003.

Game theory and game refinement theory have played an essential role in the development of computer playing game and general games. So what is the difference between game theory and game refinement theory? How could those ideas be applied in our real life? As we have known that von Neumann is one of the researchers who formed the background for the modern game theory. From his idea of minimax, one of the most effective chess-playing algorithm, the minimax game-tree search algorithm was born. And what we can see in his theory is to find the best outcome in a game no matter what the other player does, also how to ensure the possibility of winning a game based on the understanding of current positions. On the other hand, in-game refinement theory, the focus is not on how to win a game but how much attraction of a game to players. In particular, in game refinement theory, they tried to quantify the engagement of players to games and based on that values, games are classified and analyzed to improve the attractiveness of the game itself.

Moreover, game refinement theory could be used to gain more understanding about the development of game history. Therefore, it gives us a more general and reasonable look at the evolution of specific game variants. In another way, game refinement theory provides us with another viewpoint of games from the entertainment aspect while game theory helps us understand the game's mechanism itself. From that viewpoint, we can extend the idea of game refinement into other domains in human life such as sports games, video games, education or business. The possibility of the extension comes from the core idea of game refinement theory that is quantifying the engagement. In many human activities, the engagement is usually used as one of the important standards to evaluate the effectiveness of those activities. We can extend models of game refinement and apply it into many fields as mentioned above. However, to evaluate the targeted games, we have to find the appropriate game progress. Unlike traditional board games such as chess and go, the game progress of some video games are very complicated and we could even find two or three game progress models during the in-game period. Thus, it is necessary for us to find the core game progress when we apply game refinement theory.

Although there are differences between game theory and game refinement theory, both

have contributed as a firmed base for the development of computer chess. Moreover, I believe that their potential would not be limited to game informatics field only but could be useful for many other domains as well from scientific research to daily life improvement.

## 1.3 Gamification

Gamification is the application of game design elements and game principles in non-game contexts. Gamification commonly employs game design elements to improve user engagement, organizational productivity, flow, learning, employee recruitment and evaluation, ease of use, the usefulness of systems, physical exercise, traffic violations and more. A collection of research on gamification shows that a majority of studies on gamification find that it has positive effects on individuals. However, individual and contextual differences exist. Gamification can also improve an individual's ability to comprehend digital content and understand a certain area of study such as music[29].

Early gamification strategies use rewards for players by completing their required tasks or competition to attract players. Reward types include points, achievement badges or ranks, fill progress bars or provide virtual currency to users. Rewarding to complete tasks visible to other players or to provide leader boards is a way to encourage players to compete. Another gamification method is to make existing tasks more like games. Some of the techniques used in this approach include adding meaningful choices, adding challenges and adding narratives.[28].

Gamification has been applied to many aspects in our daily life. The impact of gamification was soon evident to business practices where it had an impact both on marketing and learning. Typically, there are applications of gamification for customers or potential customers like marketing and sales context. The most successful application in the domain of customer engagement is the hotel loyalty program. As is mentioned above, gamification is the use of game elements and game design techniques in non-game contexts. There are three parts to that definition which are game elements, game design and non-game elements.

### **1.3.1** Game Elements

Here we consider game elements as the toolbox which are the pieces that we have to work with. If the game designers are trying to build some kind of service that uses the bits and pieces of games. Not the game themselves, but the regular design patterns that make up the games. The notion that there are these regular design patterns is something that is common across games as well as gamified services. Game elements are the pieces of game. We can find some game elements like the level, points, progression, promotions, and badges. If we surf the interface of hotel rewards program, and we can see the kind of graphical interface that we typically see in a game and the various kinds of pieces that offer us a game-like experience. Even though the interface is compact and commercial, we can still find some game elements like the level, points, progression and promotions. The loyalty program can send potential customers on quests to find missions where there exist a promotion, and they will get certain kinds of rewards. In this thesis, we will illustrate how game elements work with the proposed methodologies.

### 1.3.2 Game Design

Gamification technology is designed to take advantage of people's social, learning, mastering, competing, achievement, status, self-expression or simply their reaction to the contextual framework of a game or game. Early gamification strategies use rewards for players by completing the required tasks to attract players. Reward types include points, achievement badges or ranks, fill progress bars or provide virtual currency to players.

Games are things that are designed thoughtfully, artistically to be fun. Game design is a method that involves a way of thinking. Thus, gamification is game elements organized systematically and offers a game playing feeling to encourage the player to enjoy the activity. It is not just a set of practices, but is a way to approach the challenges that you have. Here is an example of a part of the Marriott loyalty program and we can observe the different treatment range from the member to platinum member.

### 1.3.3 Non-game Context

Here non-game context could be understood as anything other than the game for its purpose. When the players are playing a game, they are playing to have fun in the game. However, if the players are playing for reasons that relate to their basic need or business, they are playing because you are serving some objective of your company or trying to learn something that is relevant to their work. That is considered as a non-game context. The non-game context could be anything, where the objective is outside of the game. Thus, gamification is some social activities which involve some combination of game elements and game design that is for a purpose other than playing the game.

Gamification says that you are still in the real world, and you are still at your normal job, you are still on travel because you want to buy a product or stay in a hotel for a week. The motivation of gamification is to learn from the game and make the experience better, finding elements from games that can enhance the experience that the players are having. Gamification requires the game designer to find the meaningful core of those experiences and make them more rewarding, creating greater motivation, but not pull the player out of the real world.

### **1.4 Problem Statement**

H.Iida [32] has proposed a model of "Three Masters" about the game: *Master of Winning, Master of Playing, Master of Understanding.* Master of Winning focuses on how to win the game; therefore the game theory is critical. From "Master of Winning" to "Master of Playing", Iida established a mathematical psychology model "game refinement theory" to evaluate target games.

Three Masters model in game has been mentioned by Iida [32] which demonstrated the inner meaning of games with a focus on solving a game to know its true color, thrilling sense to feel when playing a game and uncertainty to imply the mind state of vanity including in game theory, game refinement theory and game information dynamics. The classical game theory focuses mainly on strategies of players during the game. The goal is to win the game, and its approach is applying algorithms which can generate best moves and optimize latency. This approach, however, will make the game less appealing due to lack of enjoyment and human sense. While in game refinement theory, the focus is to concentrate on the attractiveness and the sophistication of games. It considers properties that are essential for enjoyable games, including outcome uncertainty, game speed, game length, etc. However, game refinement theory is a relatively new model, which was mainly applied to the fun game and board games, the next challenge is to apply this theory to serious game domain.

Game theory has a deep relationship to games and therefore to gamification, however, they are different. Game theory is a set of algorithms and formulas and quantitative techniques for analyzing strategic decision making. Game theory is the study of strategic decision making, using mathematical models. So game theory uses stylized concepts of games, people competing or agents competing against each other. Game refinement theory and gamification idea both require us to think as the game designer.

Meanwhile, gamification and serious games offer similar benefits. They help to engage online learners, motivate them to succeed, and inspire them to achieve their true potential. There are notable differences between these two popular approaches, but they all need the basic game elements to improve users' experience.

**Problem Statement:** When comparing the game refinement value of sports game and board game, we notice that these games have pure game progress. The game refinement value of these games is usually located within the zone value from 0.07 to 0.08. However, we still have less knowledge about the sufficiently complex game like MOBA and loyalty program. Thus, it is inspiring to know how to evaluate these complex game with game refinement theory. Recent years we have received some feedback about the game refinement theory, the next challenge for us is to examine if this method could correlate with some other approaches to show that game refinement theory has a good universality.

**Research Question 1:** How to apply game refinement theory to MOBA game and analyze the evolutionary changes as this video game has a complex game mechanism? Is there any weak point of DOTA2 and how to solve the problem?

**Research Question 2:** By using the game refinement measure, what is the difference of these popular loyalty programs? With several approaches, what are their characteristics and how to enhance the loyalty program?

### 1.5 Structure of The Thesis

First of all, we will give a brief introduction of game refinement theory in chapter 2. In chapter 3, We will start by discussing the first issue, an analysis of a fun game by finding the appropriate game progress. With the historical perspective and game refinement measure, we could observe some remarkable changes of MOBA game. In chapter 4, we study the serious game case, a learning platform called Duolingo with focus on the course structure. Chapter 5 presents the game sophistication of the ancestor of the current loyalty program, frequent flyer program by analyzing the tier system and point system. Chapter 6 focuses on an analysis of gamification in business domain, in which Starbucks loyalty program was considered a test-bed. In chapter 7, we will list the several comprehensive evaluations of hotel loyalty program as the sample of gamification case. In chapter 8, we list the concluding remarks and some suggestions for different kind of games.

# Chapter 2

# An Overview of Game Refinement Theory

### 2.1 Chapter Introduction

From this chapter, we begin to discuss the concept of "Master of playing". In our daily life, we always meet such questions: "Which game is more interesting, chess or Go? Which sport is more exciting, basketball or soccer?" While people face these questions, they may answer by their experience then arguing without result. Actually, the concept of interesting or exciting is quite a subjective feeling or opinion, just like the great author William Shakespeare[63] said: "There are a thousand Hamlets in a thousand people's eyes." However, we would like to find a mathematical model to evaluate the interesting or exciting by nature science way, then Iida et al. [35] established a new method what was called *Game Refinement Theory*. Just like the game", therefore Iida et al. [33] defined it as *refinement*. In fact, the game refinement idea is strongly related with Newton mechanism and psychology; we guide from the process of Newton mechanism then get the data to evaluate the feeling in human's mind. In this chapter, we will explain the meaning of game refinement theory, use mathematical derivation process to show how it was born out, also some previous work will be introduced.

Moving on, game theory is a discipline which emanates from a game player's point of view, which revolves around how to win a game. However, game designers would consider another important aspect: how to make a game more exciting and immersive. This is what inspired a new game theory that is based on a game designer's point of view, called game refinement theory, which was proposed in the early 2000s. This theory is concerned about fairness and game length with respect to the uncertainty of a game outcome. If the game is too short, the outcome would be stochastic. If the game is too long, the outcome would be obvious and the game would be boring. Hence, it is essential to come up with an appropriate game length to maintain fairness and engagement. The measure of game refinement can also be used to obtain deep insight into the history of games. For example, it has been observed that the evolution of chess exhibits two different directions: one that increases the search-space complexity and another one that shifts to the comfortable degree of the game refinement measure. Hence, it gives a reasonable look at the evolution of specific game variants.

However, we need to recognize that the game refinement theory cannot explain everything of game, just like we judge a lady is beautiful or not, Body Mass Index(BMI, decided by height and weight) only can show some part of the target lady, we also need three sizes, face, skin and hairstyle, etc. to analyze how beautiful she is. On the other hand, we cannot deny the useful and scientific significance of BMI; therefore, game refinement theory still has a strongly positive meaning for game analysis and game design.

### 2.2 Game Progress Model in Boardgame

The dynamics of decision options in the decision space has been investigated and we observed that these dynamics was a key factor in gauging game entertainment. Then Iida et al. [35] proposed the measure of the refinement in games. The outcome of interesting games is always uncertain until the very end of the game. Thus, the variation in available options stays nearly constant throughout the game. In contrast to this, one player quickly dominates over the other in boring games. Here options are likely to be diminishing quickly from the decision space. Therefore, the refined games are more likely to be seesaw games. We then recall the principle of seesaw games [10].

Based on the principle of seesaw games, Iida et al. [34] proposed a logistic model of game uncertainty. From the players' viewpoint, the information on the game result is an increasing function of time (the number of moves) t. We further define the information

on the game result as the amount of solved uncertainty x(t). Game information progress presents how certain is the result of the game in a certain time or steps. Let B and D be the average branching factor and the average number of the depth of the game, respectively. If one knows the game information progress, for example after the game, the game progress x(t) will be given as a linear function of time t with  $0 \le t \le D$  and  $0 \le x(t) \le B$ , as shown in Equation (2.1).

$$x(t) = \frac{B}{D} t \tag{2.1}$$

However, the game information progress given by Equation (2.1) is usually unknown during the in-game period. Hence, the game information progress is reasonably assumed to be exponential. This is because the game outcome is uncertain until the very end of the game in many games. Hence, a realistic model of game information progress is given by Equation (2.2).

$$x(t) = B(\frac{t}{D})^n \tag{2.2}$$

Here *n* stands for a constant parameter which is given based on the perspective of an observer in the game considered. Then acceleration of game information progress is obtained by deriving Equation (2.2) twice. Solving it at t = T, the equation becomes:

$$x''(T) = \frac{Bn(n-1)}{D^n}t^{n-2} = \frac{B}{D^2}n(n-1).$$

It is assumed in the current model that the game information progress in any type of games is happening in our minds. We do not know yet about the physics in our minds, but it is likely and we propose that the acceleration of information progress is related to the force in mind. Hence, it is reasonable to expect that the larger the value  $\frac{B}{D^2}$  is, the more the game becomes exciting due to the uncertainty of game outcome. Thus, we use its root square, Equation (2.3), as a game refinement measure for the game considered [34]. We show, in Table 2.1, a comparison of game refinement measures for traditional boardgames [34].

$$GR = \frac{\sqrt{B}}{D} \tag{2.3}$$

Q			
	В	D	GR
Chess	35	80	0.074
Xiangqi	38	85	0.073
Go	250	208	0.076
Shogi	80	115	0.078

Table 2.1: Measures of game refinement for traditional boardgames

# 2.3 Game Refinement Model in Continuous Movement Game

For the next work [66], we expand the game refinement theory from traditional board game to the sports game successfully. Similarly, we consider two parameters G and Twhat express as the average number of successful shoots and the average number of shoots per game, then refinement value was strongly related with  $\frac{\sqrt{G}}{T}$ .

Similarly, we give a short sketch of the basic idea of game refinement theory from [66]. The "game progress" is twofold. One is game speed or scoring rate, while another one is game information progress with a focus on the game outcome. In sports games such as soccer and basketball, the scoring rate is calculated by two factors: (1) goal, i.e., total score and (2) time or steps to achieve the goal. Thus, the game speed is given by the average number of successful shoots divided by the average number of shoot attempts. For other score-limited sports games such as Volleyball and Tennis in which the goal (i.e., score to win) is set in advance, the average number of total points per game may correspond to the steps to achieve the goal [37].

Game information progress presents the degree of certainty of a game's results in time or steps. Let G and T be the average number of successful shots and the average number of shots per game, respectively. Having full information of the game progress, i.e. after its conclusion, game progress x(t) will be given as a linear function of time t with  $0 \le t \le T$ and  $0 \le x(t) \le G$ , as shown in Equation (2.4).

$$x(t) = \frac{G}{T} t \tag{2.4}$$

However, the game information progress given by Equation (2.4) is unknown during the in-game period. The presence of uncertainty during the game, often until the final moments of a game, reasonably renders game progress as exponential. Hence, a realistic model of game information progress is given by Equation (2.5).

$$x(t) = G(\frac{t}{T})^n \tag{2.5}$$

Here n stands for a constant parameter which is given based on the perspective of an observer in the game considered. Then acceleration of game information progress is obtained by deriving Equation (2.5) twice. Solving it at t = T, the equation becomes

$$x''(T) = \frac{Gn(n-1)}{T^n} t^{n-2} = \frac{G}{T^2}n(n-1)$$

It is assumed in the current model that game information progress in any type of game is encoded and transported in our brains. We do not yet know about the physics of information in the brain, but it is likely that the acceleration of information progress is related to the forces and laws of physics. Hence, it is reasonably expected that the larger the value  $\frac{G}{T^2}$  is, the more the game becomes exciting due to the uncertainty of the game outcome. Thus, we use its root square,  $\frac{\sqrt{G}}{T}$ , as a game refinement measure for the game under consideration. We can call it GR value for short.

Here we consider the gap between boardgames and sports games by deriving a formula to calculate the game information progress of boardgames. Let B and D be average branching factor (number of possible options) and game length (depth of whole game tree), respectively. One round in boardgames can be illustrated as a decision tree. At each depth of the game tree, one will choose a move and the game will progress. Figure 2-1 illustrates one level of the game tree. The distance d, which has been shown in Figure 2-1, can be found by using simple Pythagoras theorem, thus resulting in  $d = \sqrt{\Delta l^2 + 1}$ .



Figure 2-1: Illustration of one level of game tree

Assuming that the approximate value of horizontal difference between nodes is  $\frac{B}{2}$ , then

we can make a substitution and get  $d = \sqrt{(\frac{B}{2})^2 + 1}$ . The game progress for one game is the total level of game tree times d. For the meantime, we do not consider  $\Delta t^2$  because the value ( $\Delta t^2 = 1$ ) is assumed to be much smaller compared to B. The game length will be normalized by the average game length D, then the game progress x(t) is given by  $x(t) = \frac{t}{D} \cdot d = \frac{t}{D} \sqrt{(\frac{B}{2})^2} = \frac{Bt}{2D}$ . Then, in general we have,  $x(t) = c\frac{B}{D}t$ , where c is a different constant which depends on the game considered. However, we manage to explain how to obtain the game information progress value itself. The game progress in the domain of boardgames forms a linear graph with the maximum value x(t) of B. Assuming c = 1, then we have a realistic game progress model for boardgames, which is given by

Then, in general, we have Eq. (2.6).

$$x(t) = c\frac{B}{D}t\tag{2.6}$$

Where c is a different constant which depends on the game considered. However, we manage to explain how to obtain the game information progress value itself. The game progress in the domain of boardgames forms a linear graph with the maximum value x(t) of B. Assuming

c = 1, then we have a realistic game progress model for board games, which is given by

$$x(t) = B(\frac{t}{D})^n.$$
(2.7)

Equation (2.7) shows that the game progress in boardgames corresponds to that of sports games as shown in Equation (2.5).

To support the effectiveness of proposed game refinement measures, some data of games such as Chess and Go [35] from boardgames and two sports games [66] are compared. We show, in Table 2.2, a comparison of game refinement measures for various type of games. From Table 2.2, we see that sophisticated games have a common factor (i.e., the same degree of acceleration value) to feel engagement or excitement regardless of the different type of games.

<u> </u>			~
Game	B or G	D or T	GR
Chess	35	80	0.074
Go	250	208	0.076
Basketball	36.38	82.01	0.073
Soccer	2.64	22.0	0.073

Table 2.2: Measures of game refinement for boardgames and sports games

### 2.4 Chapter Summary

This chapter presented the basic idea of game refinement theory, then showed how it works in traditional board games with only one game progress. Later we have successfully used game refinement theory to analyze different types of game such as sports games. It has proof game refinement theory not only can be used in original traditional board games but also it can be used in the sports game (score limited and time-limited), video game (fighting game, Arcade catching game and Pokemon)[81][53].

We have done a lot of work in the application of game refinement theory in video games and some other sports like boxing and volleyball[68]. Therefore, game refinement theory could be a useful tool to analyze any target game, however, we also need to know, game refinement theory does not suitable for every game, it cannot explain every property in the game. Some time game refinement model is useful and most of the time, the mathematical model was not so affected. In a word, game refinement theory could be seen as the useful tools in some area, in the following chapter, one popular game type– MOBA game with a complex game mechanism will be evaluated by this measurement.

# Chapter 3

# Evolutionary Changes of MOBA game: From DotA to DOTA2

This chapter is an updated and abridged version of the following publications.

- Zuo, L., Xiong, S., & Iida, H. (2017, September). An Analysis of DOTA2 Using Game Refinement Measure. In International Conference on Entertainment Computing (pp. 270-276). Springer, Cham.
- Xiong, S., Zuo, L., & Iida, H. (2014). Quantifying engagement of electronic sports game. Advances in Social and Behavioral Sciences, 5, 37-42.
- Xiong, S., Zahi, H., Zuo, L., Wu, M., & Iida, H. (2015). Analysis of the "Heroes of the Storm". Advances in Computer Science: an International Journal, 4(6), 79-82.

### 3.1 Chapter Introduction

As a typical fun game, MOBA game has become the main trend of an online game. Most commonly, e-sports takes the form of organized multiplayer video game competitions, especially among the professional teams. Video games grow more popular every year and Real Time Strategy (RTS) is a sub-genre of strategy video games which does not progress incrementally in turns [9] [8]. Our research interest is to know a theoretical aspect of the attractiveness of such popular video games. However, any method or approach to quantify the engagement of target games is strictly limited. In other words, no mathematical theory has been established in this direction. The present study is an attempt to explore the game sophistication of MOBA games.

Many efforts have been devoted to the study of strategic decision making in the framework of game theory with a focus on mathematical models of conflict and cooperation between intelligent rational decision-makers or game-players. The game theory originated in the idea regarding the existence of mixed-strategy equilibrium in two-person zero-sum games [48], which has been widely recognized as a useful tool in many fields such as economics, political science, psychology, logic and biology [4].

However, little is known about mathematical theory from the game creator's point of view. Early work in this direction has been done by Iida *et al.* [35] [34], in which a measure of game refinement was proposed based on the concept of game outcome uncertainty. A logistic model was constructed in the framework of game-refinement theory and applied to many board games including chess variants. Recently a general model of game refinement was proposed based on the concept of game progress and game information progress [66]. It bridges a gap between board games such as chess and sports games such as soccer. The next challenge is to apply the game refinement theory to MOBA games.

### 3.2 MOBA Game

Multi-player Online Battle Arena (MOBA) [21], is usually a game in which a player controls a single hero or character at one side of two teams with the motivation of destroying the opposing team's main structure also with the assistance of periodically spawned computer-controlled units. The controlled character typically has some advantages and various abilities that could be improved throughout a game. A custom map for StarCraft called Aeon of Strife (AOS) is the ancestor of MOBA game. DotA (Defense of the Ancients), is a map based on Aeon of Strife for Warcraft III: The Frozen Throne and Reign of Chaos. At that time, it was the first MOBA game sponsored tournaments and one of the first major titles of its genre. Several years later, it was followed by two spiritual successors: "League of Legends" (LOL) and "DOTA 2". Generally, the Original MOBA game map is shown in [79]. From the Figure 3-1, we can see that MOBA game has developed over 20 years. However, DOTA 2 and LOL are very hard to learn that makes a lot of new players jump away from the game. This situation greatly limits the development



Figure 3-1: History of MOBA

of the MOBA game. In this case, a subversive game called Heroes of Storm came out in 2015.

## 3.3 From DotA to DOTA2

According to the previous review of the MOBA history, we could find that DotA is the ancestor of many successful MOBA games, and most of them have already become popular world champion. In this section, we will illustrate the whole evolutionary changes of each era.

### 3.3.1 The Remarkable Changes of DotA Era

In this subsection, we will start by discussing the remarkable changes of DotA including the new heroes and maintaining the fairness of the game. The success of the mechanism of DOTA2 cannot be without the support of DotA, as it established a fair and competitive basis for its developers.

#### New Heroes

Heroes are the essential element of Dota, as the course of the match is dependent on their intervention. At first, there were only about 20 heroes for players to enjoy when DotA was first released in 2004. The emerge of the new heroes has greatly made this game more enjoyable and competitive. More and more players were involved in this game. Now, DotA has over 100 heroes for ten players to choose and each of them has different abilities. This also accelerates the uncertainty of the game outcome which makes the game unpredictable.

#### Fairness

Equality and Fairness are the critical components of games. Without them, games will be selected and lose their charm in history. This is also suitable for MOBA games. In a game with the concept of turn to move, they may exist the advantage of the initiative. In this sense, the second player in a two-person game deserves compassion from the first player in order to maintain fairness. Though in MOBA games, victories mostly depend on the performances of players, before games begin, selecting characters to play a significant role in games' results, especially in tournaments. Thus the game designers, inspired by minimax equilibrium, created the ban and picked system.[80] The Captains mode is the standard format for tournament games. The captain forbids certain heroes and prevents any team from picking heroes. The captain could also select five heroes for their team. After the captain selects five heroes, each player chooses a hero provided by the captain. Ban and pick may take 30 seconds. The total reward time for each captain is 130 seconds and can be applied in any selection. If the time runs out during the ban selection period, no hero will be banned; if the time runs out during the selection process, the hero will be randomly selected.

### 3.3.2 Reborn: From DotA to DOTA 2

DOTA is a map based on Warcraft 3 which has a history for over 10 years. The WAR3 engine has limited to the game designer's creation, a lot of interesting skills and hero models are difficult to achieve. In this case, a new dedicated platform came out in 2011, that is, DOTA2.



Figure 3-2: The New Interface

### **New Interface**

DOTA 2 brings with a new interface, shown in Fig 3-2, new engine, and custom games. Everything in the dashboard has been redesigned utilizing a new UI framework and the engine that powers the game has been fully replaced. DOTA 2 is best enjoyed with friends. Several new tools have been built to make it easier for you to gather your friends for a match, and make the experience of communicating with them seamlessly.

### **Redesigned Hero Browser**

Heroes are the heart of Dota. The game designer has revamped the hero browser in order to create a single location for players to learn about, practice with, and customize their heroes. Hero pages now let the players quickly browse and try on every set and item available for that hero. If a player finds something he like, use the purchase button to buy directly from the DOTA 2 store or the Steam Marketplace. There's also more information to help the player determine if a hero is right for him, and a place to check out the community-written guides for that hero without needing to enter a match.

#### New Ways to Watch

Watching DOTA 2 is just as central an experience as playing. The Watch section has been redesigned to make it easier to find the matches which the players want to see and then
enjoy the game with a revamped DotaTV experience. The Watch section now presents a mix of live tournament games, those featuring high-skill players, and matches your friends are playing or spectating. The new live match previews will also give the players more information to help them decide which game to watch, including a detailed rundown of the state of the game, gold and experience graphs, and individual player stats.

### Learning DOTA 2

DOTA 2 is a game full of sophisticated heroes, items and mechanics. The game designer has built a new system of Guided Bot Matches, which allows a new player to jump right in and experience a full Dota game, all the while receiving guidance from an AI director.

### Improved Networking

The drop has been a serious problem for every player for a long time. DOTA 2 perfectly solve the problem and reconnection ensure that the game can continue in a fair and equitable manner. The game designer substantially improved the reliability of the game server network. By taking full advantage of Steam's expanding worldwide infrastructure and making use of a few new technologies, players will now have better connection quality and reduced service disruptions. In this case, we no longer need to worry about the drop or the sudden computer crashes.

## 3.3.3 The Remarkable Changes of DOTA 2 Era

The development of DOTA 2 began in 2009, when IceFrog, the designer of the original DotA mod, was hired by Valve. DOTA 2 has been praised by critics for its gameplay, quality of production and loyalty to its predecessor, despite criticism for its steep learning curve. DOTA 2 used the source engine until September 2015 when it was ported to Source 2, becoming the first game to use the new engine. DOTA 2 has achieved great success in the MOBA field in a few years, with more than 1 million online players. Here, we list the online players from 2012 to 2017.

	1	<u> </u>		<b>F</b>
Rank	Game	Prize	Pro Players	Tournaments
1	DOTA 2	\$31,018,392	979	220
2	League of Legends	\$7,697,750	1884	302
3	CS: Global Offensive	\$6,188,342	2996	700
4	Smite	\$3,709,088	252	42
5	StarCraft 2	\$2,815,882	493	668
6	Call of Duty	\$2,471,347	744	361
7	Heroes of the Storm	\$2,420,079	656	263
8	Hearthstone	\$2,336 161	547	237
9	World of Tanks	\$1,037,054	248	19
10	Heroes of Newerth	\$810,802	260	75

Table 3.1: Top 10 Game Awarding Prize money in 2015

#### **Tournament and Sponsor**

To ensure that enough DotA players can take advantage of DOTA 2 and demonstrate the game's capabilities, Valve sponsored 16 accomplished DotA teams to participate in the 2011 DOTA 2 specific tournament international competition, earning a million dollar prize. International became the annual championship competition. In 2012, the venue was changed to Seattle, Washington, and the United States. In the third year, the international increase in the prize pool through the interactive program, more than 2.8 million US dollars. Following the international competition, a number of e-sports competitions begin the transition from DotA to DOTA 2, including Electronic Sports World Cup. In 2015, DOTA 2 Asian Championships held in Shanghai, China, at that time a record prize pool of third parties more than \$ 3 million, by the compendium sales[17].

DOTA 2 has a wide range of professional stages, with teams from around the world participating in a variety of competitive leagues and tournaments. The largest professional competition is called the International, hosted by Valve and will be held once a year. The 2015 edition of the International (TI) created the largest prize pool in eSports history, totaling more than \$18 million. Also starting in 2015, Valve began sponsoring smaller but seasonal tournaments, including a fixed prize pool called Professional. The professional form is based on Valve's eponymous series sponsored by its first-person shooter "Counter Strike: Global Offensive". The first of these was hosted and produced by the E-Sports Alliance, which was held at Frankfurt University in Frankfurt, Germany from November 13th to 21st, 2015. The next Major will be held at the Mercedes-Benz Arena in Shanghai from March 2nd to 6th, 2016. The third and final major events of the 2015-2016 season before the 2016 International 2016 will be held in Manila in June 2016. Here we show the list of the top ten prizes for 2015 in Table 3.1. There is no doubt that DOTA 2 has become the most profitable game for professional players after 2010. In this case, many professional players participated in the game and competed for the prize.

### Matchmaking

Matchmaking is the process through which the system groups players into opposing teams for public games. With the exception of bot games, matchmaking is mostly determined by matchmaking ratings. Matchmaking Rating or MMR is a value that determines the skill level of each player. This value is used in matchmaking. Winning increases a player's MMR while losing decreases it. All PvP matchmaking is based on an MMR similar to the Elo system. Players of roughly equal skill will be placed in the same game. The  $S_i$ follow the Elo rating algorithm, it means the MMR of a hero.  $N_i$  means the number of the *i*th ranking hero the player uses and *n* stands for the total number of the hero player use.

$$MMR = \frac{\sum_{i=1}^{n} S_i N_i}{\sum_{i=1}^{n} N_i} (n \ge 30, N_i \ge 2)$$
(3.1)

### Smoke

The most critical changes in the mechanism of DOTA 2 are the emerge of the smoke item, new rune system and the scanning system of the minimap. The new mechanism accelerates the game progress and accelerate the uncertainty during the game. The new mechanism offer more chance for both teams to win or make a mistake in the game. Thus, the game becomes more and more uncertain until the very end of the game. The Smoke of Deceit is an item purchasable at the Main Shop, under Consumables. It turns the user and nearby ally heroes invisible, letting them slip by wards and creeps undetected. Upon activation, the user and all nearby allied player-controlled units gain invisibility and bonus movement speed for a brief time. Minimap icons will also be hidden. Attacking, or moving within 1025 range of an enemy hero or tower, will break the invisibility.



Figure 3-3: Sceen shot of special boosters that spawn on the map

## Rune System

Runes are special boosters that spawn on the game map, shown in Fig. 3-3. Picking up a non-bounty rune grants the player a powerful effect for a short time[58]. Runes spawn at two points in the river. Two Bounty Runes spawn on at the beginning of the game, which is twice as effective as Bounty Runes that spawn afterwards. After this first spawn, one Bounty Rune and one random non-bounty rune spawn every two minutes. If a rune is not picked up, it is replaced by a new rune at the next spawn time. Other than Bounty Runes, runes of the same type cannot spawn at consecutive spawning intervals. This means that if a Haste Rune spawns at 2:00, the non-bounty rune that spawns at 4:00 cannot be a Haste Rune.

## Scan Ability on Minimap

Players can use the Scan ability on top of the minimap UI to detect any enemy heroes in an area, shown in Fig. 3-4. Scans a targeted 900 AoE for 8 seconds. Indicates whether there are enemy heroes in that area during the 8 seconds. When a hero is detected, the green minimap indicator turns red. However, it does not show how many heroes there are, just if there are any enemy heroes. Meanwhile, it does not give vision or reveal anything and the enemies do not know when your team casts it. This mechanism significantly makes the game more exciting and add an extra level of uncertainty.



Figure 3-4: Screen shot of scan ability to detect any enemy Heroes in an area

# 3.4 Analysis of DOTA2 by Using Game Refinement Theory

This section presents the analyzing results and DOTA2 series using the game refinement measure and discusses its rule changes with a focus on the prize in a championship.

## 3.4.1 Game Progress of DOTA2

DOTA 2 is a combination of RTS including perspective and a substantial requirement of tactics and team coordination and RPG including itemization and leveling up. Players are split into two competing teams (Radiant and Dire), each consisting of up to five players. The primary objective in DOTA 2 is to destroy the enemy Ancient inside their stronghold. These strongholds are protected by multiple towers down 3 lanes. The player controls a Hero, a strategically-powerful unit with unique abilities and characteristics, which fights for them and gains strength by leveling up and buying items with gold. Experience is earned when creeps and heroes die. Gold is gained passively over time, by killing creeps, by killing enemy heroes and by destroying buildings. In this section, we will discuss the game progress of DotA. As a MOBA game, the motivation of two teams is destroying the opponents' base. however, to reach this goal, the players need to make their heroes powerful by purchasing items and unique skills.



Figure 3-5: Screen shot of level-up

### Game Progress of Level-up

DotA is a game with a remarkably diverse number of viable strategies. There are also multiple ways to look at strategy within DotA, which makes it a complicated matter to discuss. The strategy can be talked about on a Hero specific scale, concerning lane partner pairing, positioning, and roles, as well as at an overall team level. It is very commonly accepted that DotA has a continually evolving metagame which changes the usability rapidly. Each level of division builds into the next, creating huge amounts for permutations and combinations.

Abilities are unique skills that heroes and creeps have access to on the battlefield. They range from simple passive effects to devastating explosions of energy, to sophisticated, terrain changing feats. All heroes have four or more abilities, three or more basic abilities, and an ultimate ability, that they can assign ability points to every time they level up. Every level in ability makes it more powerful, sometimes increasing its mana cost as well. Every time a hero levels up, they earn an ability point which they can use to upgrade any of their abilities or learn a new ability. At the start of the game, heroes know none of their abilities but are given a free ability point to learn one. Abilities cannot be used and do not have any effect if they have not been learned. After an ability is learned, it can be upgraded several times. Basic abilities can be upgraded 3 more times, for a total of 4 levels, and a hero's ultimate ability can be upgraded 2 times, for a total of 3 levels. In version 7.00, a new talent system involved in this game. Talents are traits unique to each hero. They are chosen every 5th level starting at level 10, offering a permanent choice between two distinct bonuses. A special sound Play is played when you have reached the

Table 5.2. Gr of Lev	ennig up	
Average Branching Factors	Depth	GR
2.2	25	0.059

Table 3.2: GR of Levelling up

level required to choose talent. These bonuses range from increases to hero attributes, additional gold or experience gain, and boosts to hero abilities. Once talent is chosen, its counterpart is discarded and the selected bonus is gained for the remainder of the match.

### Game Progress of the Tower

Towers are the main line of defense for both teams, attacking any non-neutral enemy that gets within their range. Both factions have all three lanes guarded by three towers each. Additionally, each faction's Ancient have two towers as well, resulting in a total of 11 towers per faction. Towers come in 4 different tiers:

- 1. Tier 1 towers, located at the end of each lane.
- 2. Tier 2 towers, located halfway through each lane.
- 3. Tier 3 towers, located on top of the 3 ramps at each base.
- 4. Tier 4 towers, located in pairs in front of each Ancient.

There is also a game progress of the destroying the tower as DOTA2 is a game related with the defense. In this chapter, we mainly focus on the killing progress.

#### Game Progress of Gold and Experience

Gold is the currency used to buy items or instantly revive your hero. Gold can be earned from killing heroes, creeps, or buildings. The main purpose of gold is to purchase items. The player with the most gold can buy the most powerful items and therefore has a powerful hero. The items each player buys depend on their role in the team and many other factors. Items can be sold back to the shop for half the price unless they are sold within ten seconds of being bought and their acting ability has not yet been used. Items are in-game equipment that provides heroes with bonus attributes and special abilities. They can be purchased from several shops on the game map. Lower tier items are combined into higher tier items, usually with the help of a recipe. Heroes have six item slots in their inventory, three in their backpack, and six more in their stash. Items



Figure 3-6: Screen shot of Gold and Experience

can be picked up and delivered to their owner with a courier.

Experience allows heroes to level up, which makes them stronger and allows them to learn new abilities. Experience is earned by being within a 1300 range radius of a dying enemy unit. It takes more experience increasingly to level up as a hero's level progresses. Units can be denied by other allied units to reduce the experience given from dying. Each hero starts the match at level 1, with one ability point to spend. A hero levels by acquiring a certain amount of experience. When a hero levels, its attributes get increased according to that hero's individual attribute bonuses, and it gains ability point. The ability point can be spent on an ability which has not been maxed out, or on a Talent. Ability points do not need to be spent immediately, a hero can level up multiple times while saving the ability points. Usually, during the in-game period of DotA, there are two elemental game progress patterns shown below.

1. Seesaw Game: One team leads, then the other team leads, and this will repeat several times alternately. The game keeps its uncertainty until the very end of the game.

2. One-side Game: One side is much stronger than the opponents and dominates the whole game.

Usually, we select the seesaw game as the sample to figure out the game sophistication. The progress of tower, gold and experience are also the game progress during the in-game period. However, to figure out the appropriate game refinement value, we take killing as the main progress for this sufficiently complex game. Thus, we skip these progress and

### Game Progress of Killing

Hero kills grant reliable gold to the killer. Bonus gold is awarded for stopping kill streaks. The first hero that is killed in a match gives a bonus 150 reliable gold to the killer. DotA players would first concern about how to develop themselves and limit the development of the enemy. Different game players have different roles in the game. In this way, they have to choose different kinds of heroes in order to cooperate towards the victory. Usually, there are three roles in DotA: "ganker", "supporter" and "carry". The charm of DotA lies in gank and usually we care about the killing and how the hero escapes in a crisis or kill the ganker with the support of teammates during the game. When a hero dies to enemy creeps or an enemy tower and has not been damaged by any enemy heroes in the last 20 seconds, the kill gold is split among all enemy heroes. When a hero dies to enemy creeps or an enemy tower and is assisted by only one enemy, that enemy is credited with the kill. When there are multiple enemies within 1300 range, the gold is split equally amongst all heroes that assisted. Every time a hero kills an enemy hero, the killer is awarded reliable gold using the following formula:

$$Gold = 110 + SteakValue + (KilledHerolevel \times 8)$$

$$(3.2)$$

Streak Length	Streak Value
Zero, One, Two kill in a row	0
Killing Spree (3 kills in a row)	60
Dominating (4 kills in a row)	120
Mega Kill(5 kills in a row)	180
Unstoppable (6 kills in a row)	240
Wicked Sick (7 kills in a row)	300
Monster Kill (8 kills in a row)	360
Godlike (9 kills in a row)	420
Beyond Godlike(10 kills in a row)	480

Table 3.3. Hero Kills

## 3.4.2 Game Refinement Measure

In order to apply the game refinement measurement to DOTA2, we need to consider a model of DOTA2 game progress. As DOTA2 has very complex game information, we take the killing heroes as the main game progress to figure out the game refinement value

of this game. In the middle of the top of the interface, we can find the score of killing board for each team instantly, each killing is considered as 1 score. Thus, the main game progress can be measured by two factors: the successful number of killing heroes and the attempts. Let K and T be the average killing of a game and the total amount of attempt within a game, respectively. Here K is collected by the official client and T is collected by watching the replays carefully, as the final may usually have 4 or 5 games in total. Thus, the game progress model is given by Equation (3.3).

$$\frac{K}{T} \tag{3.3}$$

Thus, according to the previous knowledge of game refinement theory, we can get the acceleration of game information progress for DOTA 2, shown in Equation (3.4)

$$y''(T) = \frac{Kn(n-1)}{T^n} T^{n-2} = \frac{K}{T^2}n(n-1)$$
(3.4)

Hence, it is reasonably expected that the larger the value  $\frac{K}{T^2}$  is, the more the game becomes exciting due to the uncertainty of game outcome. Thus, we use its root square,  $\frac{\sqrt{K}}{T}$ , as a game refinement measure for the DOTA 2. Thus, the game refinement measurement can be shown in Equation (3.5)

$$GR = \frac{\sqrt{K}}{T} \tag{3.5}$$

To obtain the latest GR of DOTA2 series, we collect the data from the historical TI championships. For this purpose, we download all the replay of the final to calculate its GR values. We show, in Table 3.4, GR value of each TI championship, together with prize money compared [17]. Table 3.4 and Figure 3-7 shows that from 2011 to 2014 GR value

Table 3.4: Measures of game refinement for DOTA2 series and prize at TI championship

Year	Championship	K	T	GR	Prize (US dollars)
2011	TI1	51.3	93.0	0.077	1,600,000
2012	TI2	32.5	76.3	0.075	$1,\!600,\!000$
2013	TI3	36.6	81.8	0.074	$2,\!874,\!380$
2014	TI4	30.0	77.3	0.071	$10,\!925,\!709$
2015	TI5	39.8	89.4	0.074	18,429,613
2016	TI6	54.0	94.3	0.078	20,746,930

decreases. The rules of DOTA2 have been changed for that period to be more competitive

as the prize became higher. However, such rule changes (decreasing of GR value) made DOTA2 boring for the viewers.<sup>1</sup> On the other hand, the designer of DOTA2 has attempted many rule changes with an expectation that DOTA2 would have more uncertainty while adding new items and incorporating the unexpected factors which mean that a lower rating team would win against a higher rating team with higher probability than before. Thus, after 2014 until now, GR values are increasing.



Figure 3-7: GR values and prize pool of DOTA2 in 2011-2016

## 3.4.3 Rule Changes in 2011-2013: Towards More Skillful

The TI championship series is the most significant and profitable annual event for DOTA2 since 2011. The game designer has attempted to modify the rules as described in Table 3.4. In 2011, Smoke was introduced for DOTA2 Ver. 6.70. The Smoke of Deceit is an item purchasable at the Main Shop, under Consumables. It turns the user and nearby ally heroes invisible, letting them slip by wards and creeps undetected. Upon activation, the user and all nearby allied player-controlled units gain invisibility and bonus movement speed for a brief time. Thus, many new tactics were explored after the emerge of Smoke items. Then the team behavior became conservative after the only three Smoke items were included during the in-game period. In 2012 the nerfed numerous heroes in Ver. 6.74 has established the foundation for the TI championship to enhance the game rigorism since DOTA2 has become a game to be played not only for fun but also for prize seriously. The

<sup>&</sup>lt;sup>1</sup>Actually many people complained about the conservative game progress.

appearance of the new captain mode in 2013 of Ver. 6.79 has contributed to maintaining fairness at the initial with the expectation that the rule of the ban and pick system greatly would influence the game result. For both teams, it is no longer easy to choose an unbalanced hero and relatively hard to successfully kill the enemy as before. For the period 2011-2013, the average number of killing, denoted as K in the game progress model, has decreased year by year. This implies that GR value has become lower. As a result, DOTA2 has become more skillful and competitive. Note that DOTA2 mainly focused on hero development and less gank or battle.

### 3.4.4 Rule Changes in 2014-2016: Towards More Popular

A highly skill-based game would not become popular since skill itself is unfriendly to the beginners. In 2014 the new rune system in Ver. 6.82 came out and added bounty rune. Runes are special boosters that spawn on the game map. Picking up a non-bounty rune grants the player a powerful effect for a short time. Runes spawn at two points in the river. The emerge of bounty rune makes the supporter or carry get money easier and the player can purchase the items earlier than before. This also accelerates the game progress. In 2015 the game designer reworked the gold and experience mechanism in Ver. 6.84. The new mechanism encouraged two teams to take part in more battle activities as they can get more gold and experience than before. The new rules focus more on gank and push issue instead of hero development. Another interesting mechanism of scan appeared in 2016 of Ver. 6.87 and we can comprehend this mechanism as a strategic skill for both teams. Players can use the Scan ability on top of the minimap UI to detect any enemy heroes in an area. This mechanism greatly made the game more exciting and added an extra level of uncertainty as the players do not know the exact number of enemies. To summarize all these new mechanisms accelerated the game progress and enhanced the uncertainty during the in-game period. The new mechanism offers more uncertainty for both teams to win or make a mistake in the game. Then, the game has become more uncertain until the very end of the game. Thus, we see that GR value has increased after 2014 and it is supposed that DOTA2 will become more and more popular in the future. We see that the balance between skillfulness and popularity is so important for the survival of a game.

## 3.4.5 High Prize

As we have mentioned above, DOTA2 has over one million concurrent players while being the most profitable sports in the world. It seems that DotA was first designed only for fun, however, with the contributions of sponsors and game designer, DOTA2 has become a main trend of e-sports. The dynamic changes of each version and high prize made DOTA2 the most successful and profitable e-sports even in its short history. Now DOTA2 has lack of popularity as this game is still unfriendly to the novice players and has relatively complex game information to learn, as there are totally over 110 heroes and 150 items. However, compared with other sports, we see that DOTA2 is now at the peak, as shown in Table 3.5[17].

rabie 0.0. Fouritamente prize in sportes, inina sportes ana e sportes compared				
Event	Sports	Prize (US dollars)	1st Prize	
Australia Open	Tennis	$35,\!530,\!000$	1,040,000	
NBA	Basketball	$14,\!000,\!000$	4,100,000	
FIFA Club World Cup	Soccer	28,000,000	5,490,000	
Ing Cup	Go	650,000	400,000	
S6	League of Legends	5,070,000	2,130,000	
TI 6	DOTA2	20,746,930	9,140,000	

Table 3.5: Tournament prize in sports, mind sports and e-sports compared

## 3.5 Weak Point and Improvement

As a popular MOBA game and the highest e-sports game, it seems that DOTA2 is successful. However, based on the historical overview if this game, we still find some weak point which needs to be improved.

## 3.5.1 Complex Game Information

For most of the MOBA players, the most intuitive feelings are DOTA 2 is a hard game and takes relatively long time to learn compared with other MOBA games like HoS(Heroes of Storm) and LOL(League of Legends). If the skill of two players are close together, they are considered good candidates to put into a match together. Players who are far apart are considered a poor match. The typical career trajectory of a player new to DOTA 2 as he gains experience and moves towards the right is to move upwards as their skill

increases gradually. When skilled players create new accounts, they follow a bit different trajectory[82]. Usually it costs about 600 matches for the novice player to get enough game information to become a skilled DOTA 2 player. Thus, we could say the DOTA 2 itself takes a long time to learn.

Though DOTA 2 has already made a breakthrough, some weakness still exists. The tutorial is still too simple which is hard for the novice to get the main point of DOTA 2. Also, the game interface and hero models are European styles which are unfriendly to female players. That s the key reason why League of Legends attracts so many female players and become the most popular MOBA game which the number of simultaneous online players are over 8 million.

## 3.5.2 Improvement of Maintaining the Diversity of Heroes

As we know that DOTA2 has over 110 heroes, however, the primary trend of some players only fight for the victory and choose the strong hero. This situation greatly blocks the diversity of the game. In this case, the new MMR system based on the picking rate of all the heroes could solve the problem entirely. Thus, we offer a possible enhancement of this rule. We suppose the  $R_n$  are the picking rate of five players of the Radiant side and  $D_n$  are the picking rate of five players of the dire.

Table 3.6: Radiant: Team 1				
Hero	Matches Played	Pick Rate		
Phantom Assassin	33,911,769	33.05%		
Pudge	33,215,734	32.37%		
Legion Commander	28,862,718	28.13%		
Slark	26,084,171	25.42%		
Invoker	$25,\!448,\!195$	24.80%		

Table 3.7: Dire: Team 2			
Hero	Matches Played	Pick Rate	
Lone Druid	2,098,663	2.05%	
Brewmaster	1,887,946	1.84%	
IO	1,847,492	1.80%	
Visage	1,010,347	0.98%	
Chen	1,005,135	0.98%	

### The Proposed MMR Mechanism Equation

If the Radiant win the game, the result is shown below.

$$\Delta M M R_R = 50 \times \left(1 - \sum_{i=1}^5 X_n \frac{100\%}{\sum_{i=1}^5 X_n + \sum_{i=1}^5 Y_n}\right)$$
(3.6)

If the Dire win the game, the result is shown below.

$$\Delta MMR_D = 50 \times \left(1 - \sum_{i=1}^5 Y_n \frac{100\%}{\sum_{i=1}^5 X_n + \sum_{i=1}^5 Y_n}\right)$$
(3.7)

#### The Proposed MMR Mechanism Example

Take this as an example. According to the data of the last 3 months (From Jun. 2016 to Sep. 2016). The Radiant choose the five highest picking rate heroes as a team and the Dire choose the five lowest picking rare heroes as the opponent side. Thus, according to the new system, if the radiant team win the game and they will get 2.53.

$$\Delta MMR_R = 50 \times (1 - 143.77\% \frac{100\%}{143.77\% + 7.66\%}) = 2.53$$
(3.8)

However, if the dire team win the game and they will get 47.47.

$$\Delta MMR_D = 50 \times (1 - 7.66\% \frac{100\%}{143.77\% + 7.66\%}) = 47.47$$
(3.9)

## **3.6** Chapter Summary

Unlike other sports, whose rules are defined in eras of years and decades, for example, chess has not had a significant patch change in a thousand years, DotA and DOTA2 are unrecognizable from the game it was even months ago. Patch changes put the community in a constant state of learning, the rhythm of which seems to hit its peak at a Major or The International tournament.

In this study, we evaluated the DOTA2 series using the game refinement measurement. By using the same idea of the evaluation of sports games, we successfully extended game refinement theory from simple game to sufficiently complex game with focus on the main game progress. We have found that the game refinement value of DOTA2 and some board games are same, however, these two games are different types of game. The results indicate that DOTA2 has a similar zone value with sophisticated sports and board games. In addition, the DOTA2 championship of every year during 2011-2016 was analyzed. The results show that the game refinement value has stayed within 0.071-0.077, which is slightly lower than DotA. The prize of the championship has strongly influenced the development of DOTA2. Higher prize enforced the players to be more conservative and the game refinement value became lower which implies that DOTA2 became more skillful. However, such a direction of game evolution was not accepted in the DOTA2 community due to the lack of entertainment. Later, the direction of DOTA2 evolution was shifted to be more popular while taking stochastic elements into consideration. According to our previous research and result, we found that some well-designed game,especially the game of competitiveness usually have the game refinement value within the zone value. Thus we see that a good balance between skillfulness and popularity is essential to survive.

The results of computer analysis confirmed MOBA game has the similarity of game entertainment impacts like sports games and board games. It means that multi-player game also follows the principle of seesaw games. Game refinement value cannot prove this game is successful, but it can illustrate the balance of the game with the game designer's perspective, it is a parameter offered to game designer to find the appropriate setting from the evolutionary changes and also with the balance of skillfulness and unexpectedness.

## Chapter 4

# Analyzing Gamification of Language-Learning Platform Duolingo

This chapter is an updated and abridged version of the following publication.

- Huynh, D., Zuo, L., & Iida, H. (2016, December). Analyzing Gamification of Duolingo with Focus on Its Course Structure. In International Conference on Games and Learning Alliance (pp. 268-277). Springer, Cham.
- Huynh, D., Zuo, L., & Iida, H. (2018, August). An Assessment of Game Elements in Language-Learning Platform Duolingo. In 2018 4th International Conference on Computer and Information Sciences (ICCOINS) (pp. 1-4). IEEE.

## 4.1 Chapter Introduction

Gamification is a term that refers to the use of game-based elements such as mechanics, aesthetics, and game thinking in non-game contexts aimed at engaging people, motivating action, enhancing learning and solving problem [13] [38]. The benefit of game and game-based approaches in education has been investigated since 1980s [62] [23] [39]. In recent years, there is a growing interest in gamification as well as its applications and implications in the field of education since it provides an alternative to engage and motivate student during the process of learning. While gamification is gaining ground in some fields such

as business, marketing, management and wellness initiatives, its application in education is still an emerging trend. In this study, we aim to investigate the attractiveness of *Duolingo*, which is one of the most popular language learning platforms by applying game refinement theory. Due to the lack of research on the gamification in the education domain, numerous questions arise as to clarify how gamification can be used and how it benefits us the most. Therefore, the research question for this study is "How do game elements make an effect when applying it into an education situation?". To answer this question, we try to quantify the attractiveness of the language course based on the game refinement theory. Specifically, we analyze the game refinement value zone of *Duolingo*.

Game refinement theory has been proposed earlier by Iida to measure the attractiveness and sophistication of games under consideration. A game refinement measure is derived from a game information progress model and has been applied in various games. Classical game theory concerns the optimal strategy from the viewpoint of players, whereas game refinement theory concerns the optimization from the game developer's point of view. In fact, there are many challenging questions, especially applying this theory to gamification of serious games.

This chapter is organized as follows. We will first present the previous studies in gamification in education and a short sketch of free language-learning platform-*Duolingo* which is our case study in this paper. Then, we present the basic idea of game refinement theory and show our analysis using this way. Moving on, we discuss about our experiment and a structure of *Duolingo* language course. Finally, concluding remarks and some future works are given.

## 4.2 Gamification and Education

In this section, we first show the previous study of gamification in education. Then, we give a short sketch of the gamified free language-learning platform *Duolingo*.

## 4.2.1 Related works

We review literature related to the use of gamification in education. Although some researchers are working on it, there currently is still few works on this subject. Gamification, as a term, was mentioned for the first time in 2008. There are works which have been done, and many papers are written on this topic [20]. Unlike game-based learning which is clearly a game, the essence of gamification is that it occurs in a non-game context; therefore, it would be applied in such a way that would not change the existing practice of learning, and instead focus on making it more engaging and challenging for student. There are increasing number of case studies and researches dealing with gamification in general [30] and in education contexts.

Besides, some successful gamification applications, many studies presented a gamification mechanic and its effect when applied into the system. Muntean[46] has shown a theoretical analysis of gamification as a tool to engage users in e-learning platforms. In Fogg's Behaviour Model, gamification mechanics is used to motivate and trigger desired behaviours on learners. He has provided a list of gamification elements and explained how they could apply into an e-learning course. Recently, Snezanal Scepanovic also give a discussion and evaluation of gamification mechanics based on literature review and analysis of implementation the concept of gamification in Higher Education learning. While majority of studies report overall positive results of applying game elements and mechanics into the system, and their effects in motivating and engaging learners. Our study aims at analyzing and measuring the attractiveness of game elements and its effect when combined with a language course's structure. By applying game refinement theory as an assessment method, we could figure out specific factors, which directly make an effect on a platform, and a degree of their effectiveness.

By those factors mentioned above, we could adjust them to increase their attractiveness and their making motivation in a platform. Moreover, we could compare the impact between the elements based on a degree of their attractiveness to list elements, which make the most effectiveness in a platform, and enrich them. Those are different points of this study compared to previous works. This contribution will lead to a better understanding of the effects of gamification in learning domain.

## 4.2.2 Duolingo

*Duolingo* is a gamified free language-learning platform created by professor Luis Von Ahn and his graduate student Severin Hacker. The system is designed so that users could learn languages, while helping *Duolingo* to translate documents. *Duolingo* became publicly available in 2012 with more than 300000 users. As of April 2016, it offers 59 different language courses across 23 languages[15]. The authors of *Duolingo* skillfully apply gamification into their system in order to engage and motivate their users. They have used some game-elements in their system. They are shown as follows:

- Reward: In *Duolingo*, lingot is a reward. Users can easily collect dozen of lingots by completing their lesson or skill.
- Leader-board: which shows users how they are doing compared to their friends, these are some great motivators to help the users coming back and learning.
- Level-system: providing a way to track users daily activity and compete with their friends, XP (experience point) also determines users language "level", which is displayed on their profile page and above their comments in discussions.
- Badges: *Duolingo* has some achievement tokens which are the skills a user has gained. They are displayed on user's profile. Badges is an excellent tool for making people to feel invested in their study.

Although *Duolingo* has used many game elements in their platform, we specifically analyze only "badges" in this study because the important part of successful gamification is content and learning material. The game element "badges" are combined in harmony with a learning content to construct the main structure of a language course. The structure of a language course including some elements as follows. The core element in a course is its lessons. The lesson is well-designed, drilling skills of user with several different kinds of challenges. They do not get too repetitive, and they are just easy and fun to do. They are categorized into small sets which are called skills by part of speech or lesson vocabulary meaning such as: verb, adjective, sport, food, etc. Each skill has a strength bar, which will be full only when users have passed all lessons in the skill. However, the strength will be decreased overtime to represent "words fading from memory". At the beginning, only basic skill is available, another skills are locked. To unlock other skills, users have to complete all their available skills. The skills in a skill-tree are split into check-points which represent for stages or the milestones of user study process. Although there is no

reward is given when users reach each milestone, we could see the expression of milestones in the skill-tree after users have completed the number of skills.

# 4.3 Quantifying the Game Sophistication of Duolingo with focus on Course Structure

Duolingo is different from sports and boardgames. It is gamification product, which means that they use game elements to create enjoyment points in learning environment. Therefore, in this study, we highlight a gamification structure in each language course as the main aspect. As we mentioned in the previous section, the structure of language course is constructed by some core elements such as lesson and skill. Furthermore, following the basic idea of game refinement theory, game progress is twofold, which known as goal and time or steps to archive the goal in sports and boardgames [66]. In a language course, the goal of learners is to complete their study by getting all badges in the skill-tree. To archive a badge, users must complete all lessons in a skill. Therefore, the game process of *Duolingo* language course can be measured by skills.

Let S and L be the average number of skills and the average number of lessons in the same language courses. If one knows the game information progress, for example after the game, the game progress x(t) is given by Eq 4.1.

$$x(t) = \frac{S}{L}t\tag{4.1}$$

Hence, a model of game information progress is given by Eq. 4.2.

$$x(t) = S(\frac{t}{L})^n \tag{4.2}$$

Where n stands for a constant parameter which is given based on the perspective of an observer in the game considered. Only a very boring game would progress in a linear function, but most of games do not. Meanwhile, we reasonably assume that the parameter would be  $n \ge 2$  in many cases like balanced or seesaw games. Then acceleration of game information progress is obtained by deriving Eq. 4.2 twice. Solving it with t = L, the equation becomes

$$x''(L) = \frac{Sn(n-1)}{L^n} t^{n-2} = \frac{S}{L^2}n(n-1)$$
(4.3)

Therefore, the refinement value of a language course in *Duolingo* can be described as the Eq. 4.4.

$$R = \frac{\sqrt{S}}{L} \tag{4.4}$$

Duolingo has 120 million users around the world and currently teaches 19 distinct languages. The most popular courses are available for speakers of a variety of languages: for example, we can learn English from 21 different languages [11]. In order to make the data more objective and reasonable, we collect the statistics by observing a structure of each popular language courses in *Duolingo*. Based on information that has been shown in the skill tree, we can easily get the number of skills and the number of lessons in a skill.

Table 4.1. 1 optial languages in Dublingo			
Language	Number of courses	Total number of enrolment	
English	21	181,412,000	
Spanish	5	66,199,700	
French	6	45,724,000	
German	6	28,083,200	
Italian	3	18,483,000	
Portuguese	2	9,870,000	
Others	1	11,532,000	

Table 4.1: Popular languages in *Duolingo* 

Following the popular languages as shown in Table 4.1, we calculate game refinement values. For instance, to calculate GR of English courses, we have to calculate the average number of lesson L and the average number of skills S of 21 English courses. As a result, GR could be calculated by Eq. 4.4, which is shown in Table 4.2.

Table 4.2: Measures of game refinement for *Duolingo* language course

Language	S	L	GR
English	55.619	291.958	0.0259
Spanish	64.142	319.571	0.0250
French	72.222	346.333	0.0243
German	89	381.25	0.0243
Portuguese	68	379	0.0204
Italian	66	385	0.0200

## 4.3.1 Data Collection

In the previous studies, the GR of sophisticated games like sports and boardgames often fall into the range between 0.07 and 0.08. However, we noticed that the results of *Duolingo* show much lower. Here we take English language as an example, there are 55.6 skills and 291.9 lessons on average, so the GR of this language is 0.0259. To achieve 55.6 skills, learners must complete more than 291 lessons. Moreover, the GR of Portuguese is lower than English for the average number of skills and lessons are 68 and 379. According the Eq. 4.4, the GR increases when the number of lessons decreases, which means that the goal is easy to achieve. This is similar to increasing the number of skills. The GRfalls into the range between 0.020 and 0.025, which shows that the "game" in language course will be too challenging. As we introduced, *Duolingo* is a learning platform, which means that it is a serious environment and game elements are used to increase motivation and engagement of learners, they are not used to make a course becomes entertaining or relaxing as fun games. Hence, the GR range is reasonable.

However, with the degree of challenging which is indicated by GR, the "game" in language course only increases the motivation for advanced users or who learned with a purpose. With novice users or nonnative-language learners, they give up easily their study. There is a reason why *Duolingo* authors have applied a creating milestones technique, to respond learner's efforts. Like as a game, the skills in course are structured so that learner have various "levels" of goals. Generally, the requirements of each "level" of goal gets increasingly harder from completing the initial tasks until completing the course. This allows learners to learn and practice skills. We made a brief analysis of the most popular language course "English for Spanish speakers" (EFSS) to see the obvious effect of the creating "milestone" technique. We assume that each milestone in a course is a sub-game. Next, we calculate GR in each sub-game in a course, which is shown in Table 4.3. The GR of each milestone shows that the milestone is designed for various types of learners. For instance, in the first milestone, GR is 0.081. This value is higher than the results of sophisticated sports and boardgames, which implies that the "game" in the first milestone is so exciting and attractive for beginners. The increase in the requirement is to give more challenging and exciting to learners since their skill gets better at every milestone. To prevent the course from getting bored, the number of lessons and skills should be lower,



Figure 4-1: GR when starting from Milestone 1

then the performance of learners would be higher. Moreover, after going through many challenges, learners need enjoyments in order to avoid the drop-out from the course. Therefore, in later milestones, the GR tends to increase to be a higher value such as 0.094, which is shown in Table 4.3.

Milestone	S	L	GR
1	10	39	0.081
2	12	56	0.062
3	15	97	0.039
4	14	79	0.047
5	8	30	0.094

Table 4.3: Measures of game refinement for each milestone in EFSS course

We collect the data of each milestone to quantify the GR. In general, the player usually start from the first milestone and accomplish the final goal. Thus, the GR for normal player is depicted in Fig. 1. We noticed that the GR goes down sharply and maintaining the low value after the 4th milestone. However, for some expert players, they can start from the third milestone by ignoring the first and the second milestone. In that case, we also calculate the GR for the players who start at the third milestone. If the player is the expert player who start from the third milestone, he will not enjoy the entertainment, for the game is maintaining the low value, as shown in Fig.2.



Figure 4-2: GR values when starting from Milestone 3

## 4.4 Chapter Summary

In this study, we extended this theory to the gamification of *Duolingo*. By using the same idea of the evaluation of board games, we successfully extended game refinement theory from simple game to sufficiently complex game with focus on the main game progress. A brief sketch about *Duolingo* shows that there are many game elements which have been applied to this platform. As a result, data analysis shows that the game refinement value falls into the range between 0.020 and 0.025 which is much lower than other fun game. It is reasonable because *Duolingo* is used in a serious environment or non-game context. We also quantified the attractiveness of each milestone and made a comparison between the players who start at the first and third milestone. It is assumed in this study that every milestone in a course is a sub-game. After the brief analyzing, the game refinement value shows that the *Duolingo* is enjoyable for new players who start from the first milestone, however, less enjoyable for expert players who start at the third milestone. In this case, it is essential to increase the degree of gamification of *Duolingo* by decreasing the number of lessons or increasing the number of skills in the target courses.

Future works will focus on the analysis of the other game elements which have been applied into *Duolingo*, and perform more experiments to understand the effects of "milestone" technique. Additionally, we will apply game refinement theory in more learning platforms to find the most effective structure from the perspective of gamification.

## Chapter 5

# An Analysis of Gamification Effect of Frequent-Flyer Program

This chapter is an updated and abridged version of the following publication.

 Zuo, L., Xiong, S., Wang, Zhichao., & Iida, H. An Analysis of Gamification Effect of Frequent-Flyer Program. 12th Edutainment Conference. Xian, China, June 28-30. (In Press)

## 5.1 Chapter Introduction

This chapter explores the benefit of a sales promotion in aviation industry known as the frequent-flyer program. The Frequent Flyer Program is considered as a successful application of gamification in the business domain. Four famous FFP in China was employed as a benchmark to illustrate the game sophistication and game experience with the proposed game refinement theory. We present a data-driven approach for discovering these two systems and the results show that the range of game refinement value of the two mechanics is reasonable in such a business environment. The features of FFP allow us to explain the tiers system offers a fun game experience while the point system shares a serious game experience. The theoretical framework makes it possible for us to illustrate how these two mechanics work.

A frequent-flyer program (FFP) was the first gamification case when American Airlines introduced its AAdvantage FFP in 1981[7]. FFP is a loyalty program offered by an airline and it is considered as the world's most significant gamified service from the historical perspective. It is the critical strategy for the airline company in attracting business to its properties and this program commonly consists of two mechanics which are the tier system and point system. Many airlines have frequent flyer programs designed to encourage airline customers participating in the program to accumulate points (also known as miles, kilometers or segments) and then redeem air travel or other rewards. Points earned based on the FFP may be based on the fare class, the distance of the airline or the amount paid. Frequent-flyer programs describe how travelers accumulate and redeem their frequent flyer miles in the program, and determines the amount of benefits travelers can receive from the program[43].

The history of FFP programs, considered to have started with the AAdvantage program, has been characterized by a series of inventions that improved airlines revenue streams, reduced customer switching tendencies, improved the effectiveness of direct marketing campaigns and increased customer recognition[12]. Their purpose is simple: reward customers with airlines and increase future customer loyalty. Americans started the program using their customer database. They tracked the member's flight miles and developed a reward system of one mile for a mile. Such innovation has been extremely successful.

Then, the hotel industry entered the game. Initially, they only participated as partners in the airline program. However, considering the cost of their role as airline partners, most hotel chains have started their permanent residence plan today, although most hotels do have frequent stops, they are still partners of all significant airlines because It can bring higher sales. Previous work has already been done by Zuo and Xiong with a focus on the hotel loyalty program.

However, FFP has also been understood as the ancestor of the loyalty program. In this chapter, we ask, what were the characteristics of this program and how it works? We will start by defining the gamification in FFP and introduce the two mechanics of it. With the assessment methodology, we could observe the game experience and sophistication of these two systems.

## 5.2 Gamification

Gamification is about engaging customers actively by applying game-based thinking. Gamification leverages the intrinsic human motivations to keep gathering rewards or miles. Gamification is the constructs of rules that ensure enjoyable game using positive feedback like points, badges, status to build up the users motivation and to ensure that the engagement is continuous. Based on incremental levels of activity, gamification helps increase engagement without incurring additional spend[5]. It can be defined as a service quality attribute that consists of two systems which are the tier system and point system. With the literature review, we first give a strict definition of gamification in FFP.

**Definition 1. Gamification in FFP** The enhancement of service and miles bonus when the customer is promoted to a higher membership status with the well-organized game elements for gameful experiences to retain customer loyalty to the airline brands.

## 5.2.1 Tier System

One gamification of FFP is the tier system which is the application of progression levels or difficulty levels just as video games. This tier system commonly represented by four levels, member, silver, gold, and platinum. The different status enjoys the different level of rewards, additional points, priority check-in and availability of the lounge depending on the different airlines. Here we list the requirement of the tier system of four FFP in China. <sup>1</sup>

Table 5.1: Eastern MilesTierMiles/SegmentBonusSilver40,000/2515%Gold80,000/4030%

160,000/90

50%

Platinum

China Eastern Airlines frequent flyer program is called Eastern Miles. Shanghai Airlines and China United Airlines, China Oriental subsidiary are also part of the plan. The registration is free for every customer. Eastern Miles members can earn miles through airlines and using Eastern Airline credit card spending. After collecting enough miles,

 $<sup>^1\</sup>mathrm{All}$  company names, loyalty rewards names, trademarks, and pictures are properties of their respective owners.

members can upgrade to Elite. The elite membership of East Miles can be divided into three levels: Platinum Card, Gold Card and Silver Card. Elite members can enjoy additional benefits.

Table 5.2: Phoenix Milles			
Tier	Miles/Segment	Bonus	
Silver	40,000/25	25%	
Gold	80,000/40	30%	
Platinum	160,000/90	50%	

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Phoenixmiles is a frequent flyer program designed for Air China and its subsidiaries, including Shandong Airlines, Shenzhen Airlines, and Dalian Airlines. Phoenixmiles is the first frequent-flyer program launched in mainland China. It is designed to reward frequent flyers traveling internationally and domestically with Air China and its partner airlines.

Table 5.3: Sky Pearl Club				
Tier	Miles/Segment	Bonus		
Silver	40,000/20	15%		
Gold	80,000/40	30%		

The frequent flyer program of China Southern Airlines is called Sky Pearl Club. The Pearl Club allows its members to earn FFP miles, not only over the southern China domestic flight but also from other SkyTeam member airlines within the SkyTeam global network. Besides, Pearl Club members can earn and redeem miles by partnering China Eastern Airlines, Sichuan Airlines, and China Airlines flights. Sky Pearl Club members are divided into three levels: Sky Pearl membership card, Sky Pearl Silver Card (Sky League Elite) and Sky Pearl Gold Card (Elite Plus).

Table 5.4: Fortune Wings Club Tier Miles/Segment Bonus Silver 30,000/2025%Gold 5,0000/4050%Platinum 100,000/8055%

Hainan Airlines's frequent-flyer program is called Fortune Wings Club. The airlines' subsidiaries Hong Kong Airlines, Lucky Air, Tianjin Airlines, Beijing Capital Airlines, Fuzhou Airlines and parent company Grand China Air are also parts of the program. It is also possible for passengers to collect miles on Alaska Airlines, Etihad Airways and the

airlines which have codeshares with Hainan Airlines. Members can earn miles on flights as well as through consumption with Hainan Airlines's credit card. When enough miles are collected, members can be upgraded to Elite members which are divided into four tiers: Fortune Wings Platinum membership, Gold membership, Silver membership, and Flying Card membership. Elite membership gets extra services.

The frequent-flyer program of Hainan Airlines is called the Fortune Wing Club. Airline's subsidiaries including Tianjin Airlines, Beijing Capital Airlines, Hong Kong Airlines, Lucky Air and Fuzhou Airlines are also part of the rewards program. The customers can also collect miles at Alaska Airlines, Etihad Airways and airlines that share code with Hainan Airlines. Members can earn miles by taking the flights and the credit card spending through Hainan Airlines. When enough segments or miles are collected, members can upgrade to Elite members in four levels: Fortune Wings Platinum, Gold, Silver and Flying Card. Elite members receive additional services.

## 5.2.2 Points System

The points system is a virtual currency that is primarily used in the game. It can be regarded as a type of virtual currency, a one-way flow of money to purchase miles, but not exchanged money. As a new player, you can get a qualified segment through the system and get quick reward points for immediate satisfaction. Here the terminology segment means that how many times the customer takes the flight. The programs award bonus revenue to senior cabin passengers and their elite members based on the status of the class; obtaining an additional 15%-55% flight miles is a common reward. There are other ways to earn points. For example, in recent years, the use of co-branded credit and debit cards has earned more points than through the air travel. Another way to earn points is to spend money at a relevant retail store, car rental company, hotel or other related company. Points/miles can be redeemed for air travel, other goods or services, or upgrades, the availability of airport lounge and priority booking.

## 5.3 Analyzing Gamification Effect

FFP can be defined as a service quality attribute that consists of some redemption of free flight miles and can determine the selection of airlines [43]. So, how do they reward customers? The basic concept is "the more frequently you fly with them, the greater your rewards become." The concept behind FFP is that the airlines want their passengers to maintain the loyalty or finally become the lifetime customers.

### **Tiers System**

The tiers system is an effective and proven way of encouraging repeated business. We determine the game progress model of an FFP based on the action of qualifying segments of membership tiers. The main game progress can be defined by two factors: the number of successful qualifying segments and the total number of segments within a year. Here, we consider the normalized model that the customer can usually get one segment in one day. As the total number of days in a year is 365, the measure of game refinement for the tiers system (say  $GR_T$ ) is given by Eq. (5.1), and the results are shown in Figure 5-1.



$$GR_T = \frac{\sqrt{Qualifying\_Segments}}{Total\_Segments}$$
(5.1)

Figure 5-1: Measures of game refinement for tiers system from four FFPs

**Definition 2. Game Experience** is defined as the relationship between the player and the game. Experience includes both the process and the outcomes of the interactions between a player and the game's design. It focuses on the personal challenge that the user experiences from interacting with the application during the entire gaming process.

Every airline company has almost the same strategy of membership management, with the membership consisting of four tiers, except Sky Pearl Club that has three tiers excluding the platinum tier. Here, maintaining or promoting the status could be considered as tackling a challenge in a game.

*Remark.* The trend of these four FFPs is statistically significant to observe that  $GR_T$  tends to increase with the tier promotion, which implies that the tiers system is offering fun-game experience.

### **Points System**

The points system describes how travelers accumulate and redeem their miles[67]. In this study, data is collected by considering the flight distance. As game refinement requires the highest level (corresponding to the skillful player) to make the result more objective, we take the most senior membership as a sample to figure out the measurement denoted as  $GR_P$  in Eq. (5.2). Table 5.1-5.4 show that the higher status customers take, the more miles/points they obtain. Meanwhile, the points for redeeming free segments differ dramatically from a distance, which highlights the consideration of the distance issue when we apply  $GR_P$  to the free segments. Thus, we choose three kinds of ranges: short, medium and long. Here, we figure out the impact of a free segment for the highest membership of Fortune Wings Club, considering the distance issue within a year to illustrate game sophistication and game experience.

$$GR_P = \frac{\sqrt{Free\_Segment}}{Qualifying\_Segment}$$
(5.2)

Thus, the total points one can earn within a year with considering the 80 segments (XIY-PVG) of the domestic with the point bonus are about 170,000. Then, we collect the data on the official website to check the points required for a free flight [72]. Table 5.5 shows that the highest  $GR_P$  is 0.045, which is similar to the previous result in the hotel

loyalty program [83]. When assuming that each free segment is a sub-game, we would look into the in-game period to illustrate the game experience as shown in Figure 5-2.

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Segment	Poins Required	Free Flights	Qualifying Segment	$GR_P$
Short (XIY-PVG)	13,000	13	80	0.045
Medium (XIY-NRT)	28,000	6	80	0.031
Long (XIY-CDG)	45,000	3	80	0.022

Table 5.5: Measures of game refinement for points system in Fortune Wings Club



Figure 5-2: The trend of  $GR_P$  with increasing number of free segment redemption

*Remark.* The more free segments one redeems, the less challenge he/she meets, which implies that the points system is offering serious-game experience.

## 5.4 Chapter Summary

The loyalty program is a marketing activity whose primary objective is to encourage customers' loyalty by rewarding them. The rewards usually take the form of reward currency or point. Airline companies which run loyalty programs can get more information about the customers' data including behavior, consumptive habits, and attitudes. Gamification is to learn from the game and make the experience better, finding elements from games that can enhance the experience that the players are having and make the activity more rewarding. The FFP uses the notion of gamification with the points, badges, and progression bar, and shows how to structure them systematically with rules and challenges. Despite the theoretical grounding in the gamification domain, few studies have empirically investigated the exact mathematical model of the fundamental mechanism in gamified systems. The proposed mathematical model solves the problem efficiently. More empirical, mixed method research that employs statistical analysis, in-game period dynamics and experience is necessary to substantiate the initial positive effect on game players.

In this chapter, a game refinement measurement has been used to obtain novel insights into the benefit of FFP with a focus on the tiers system and points system. It is observed that the measurement of game refinement for the tiers system tends to increase with the tier promotion, which implies that the tiers system offers fun-game experience. The analysis of game refinement for the points system tends to decrease with the increasing number of free flight redemption. It indicates that the more free segments one redeems, the less challenge he/she meets, which implies that the points system offers serious-game experience.

The game sophistication of FFP for the tiers system ranges from 0 to 0.026 and offers a fun game experience. On the other hand, we have figured out the  $GR_P$  based on the distance issue and found that the zone value ranges mainly from 0.022 to 0.045 but shares the serious-game experience. Specifically, according to the previous review, we have made it possible to illustrate the interpretation of the relationship between the tier system and point system.

This chapter has shown a promising approach to evaluate the various gamified services such as a sales promotion in the aviation industry known as Frequent-Flyer Program. However, it is nascent, so there is a pressing need for further exploration of a broader range of games including serious games and the investigation of the subjective feelings of some passengers in the future. However, FFP should adopt new strategies to enhance the relationship with the members and to keep pace with the latest developments in the hospitality market and customer entertainment needs.

## Chapter 6

# Measuring the point system in the Starbucks Loyalty Program

This chapter is an updated and abridged version of the following publication.

 Xin, O. W., Zuo, L., Iida, H., & Aziz, N. (2017, November). Gamification Effect of Loyalty Program and Its Assessment Using Game Refinement Measure: Case Study on Starbucks. In International Conference on Computational Science and Technology (pp. 161-171). Springer, Singapore.

## 6.1 Chapter Introduction

This chapter explores the advantage of loyalty program in the domain of business, while Starbucks is chosen as a case study. It focuses mainly on the point system that provides a certain degree of gamification effect. It considers a game progress model of My Starbucks Rewards to derive a game refinement measure for the assessment of gamification impact. The assessment results indicate that the game element of the point system in My Starbucks Rewards shows motivations towards the normal purchasing activities. On the other hand, the point system shows the decreasing motivation effect on customers' purchases over time. In short, customers are experiencing simple game experience in a point system which is proved to be a short-term incentive that is useful to motivate customers in an early age for a short period. Starbucks incorporates both point system and tier system in its loyalty program, targeting to attract new customers as well as retain them for a long time to come. However, the current study only examines the point system of Starbucks. Further research might explore more on the structure of the loyalty program in the restaurant or food industry.

## 6.2 Research Background

Coffee statistics report shows that coffee shops make up the fastest growing part of the restaurant business, checking in with a 7% annual growth rate [1]. In today highly competitive marketplace, customer retention increasingly becomes the attention of businesses. Customer retention refers to the activities and actions of companies and organizations which take to reduce the number of customer defections [59]. Retention of customers stands out to be so crucial because the cost of finding a new customer is about 5 to 10 times more than to keep the existing one. Loyal customers often know exactly what they want when purchasing from a certain brand and tend to spend more as well. Current customers tend to spend 67% more than new customers. Unfortunately, companies tend to lose around 13% of their customers every 5 years [41].

Therefore, the loyalty of a customer is critical to the success of a business. Generally, the loyalty program is defined as a reward program offered by a business to customers who frequently make purchases [55]. Loyalty program typically requires customers to register with their information and customers will be given a unique membership ID or physical membership card to be used when making purchases. From the perspective of the business owner, the loyalty program works to track customers' purchase behavior and history in order to recognize the loyal customers and hence reward them. Meanwhile, customer engagement is further improved when the feeling of appreciation by the company is established in the customer.

According to a statistic [2], there is a 26% rise in profit and an 11% total revenue lift when Starbucks introduced the My Starbucks Rewards program. A spokesman in Los Angeles Daily News announced that coffee chain's most loyal customers visit 18 times a month. Maritz Study in 2016 reported that more than 45% of consumers buy a product to gain rewards in a loyalty program [22]. Starbucks loyalty program had always been known to be a successful gamification mobile marketing strategy. Gamification is defined as the employment of game elements in non-game context to improve user's engagement.
Early works had been done by Zuo et al. [83] on the analysis of hotel loyalty program, identifying the game experience of loyalty program in the world's largest hotel chain. In this paper, we aim to investigate the gamification effect of the Starbucks loyalty program, specifically across its evolution as well as comparing among Starbucks US and Starbucks China.

This paper begins with an overview of the Starbucks loyalty program and follows by reviewing the basic idea of game refinement theory. Next, we implement the game refinement assessment in the Starbucks loyalty program. Finally, the conclusion gives a summary and critique of the findings.

# 6.3 Starbucks Loyalty Program "My Starbucks Rewards"

The first Starbucks was opened in 1971 in Seattles Pike Place Market with just a narrow storefront. With the growing numbers of stores worldwide, Starbucks launched "My Starbucks Rewards" loyalty program in 2009. Currently has more than 24,000 stores in 70 countries and 13 million of "My Starbucks Rewards" active members [18]. "My Starbucks Rewards" is a free loyalty program introduced by Starbucks that gives exclusive member offers and allow customers to earn rewards such as free drinks, foods and refills. To earn rewards, customers simply need to pay for any Starbucks product with a registered Starbucks card. Each time a purchase is made, the customer will earn a specific amount of stars that can be redeemed for free Starbucks treat. The terms and conditions of "My Starbucks Rewards" vary according to different countries. As of 2016, the number of Starbucks licensed stores globally is ranked by United States (US) as the first with 5,292 stores and follows by China with a total of 1,110 stores. In this paper, we observe mainly "My Starbucks Rewards" in two countries: the United States (US) and China.

#### 6.3.1 US

Starbucks US had always been a great example for its loyalty program over the years. The evolution of its loyalty program is so successful that it is able to recognize and retain its loyal customers. Starbucks makes changes and improvements to its loyalty program



Figure 6-1: Evolution timeline of Starbucks loyalty program

by listening to their customers' feedback and ideas. Figure 6-1 illustrates the evolution of the Starbucks loyalty program.

In 2009, December 26, Starbucks US officially launched its loyalty program, "My Starbucks Rewards", a visit-based rewards system which consists of three levels. By opening an account and registering a Starbucks card, the customer will be automatically enrolled in "My Starbucks Rewards" at the Welcome Level. The customer can earn a star each time visit Starbucks. The rewards in Welcome Level includes a free birthday beverage, and up to two continuous hours of free Wi-Fi access daily. After successfully collected five stars, the customer will reach the Green Level where the customer is qualified for the; benefits in Welcome Level, free beverage customization, free brewed coffee refills, free tall beverage of choice with the purchase of one pound of whole bean coffee, and special offers. Customer who earns at least 30 stars will be promoted to Gold Level to enjoy all the benefits in Welcome Level and Green Level, besides receiving a personalized gold card and a free drink with every 12 additional star.

In 2012, October 16, Starbucks made some modifications on "My Starbucks Rewards" that launched in 2009. This improvised version of "My Starbucks Rewards" basically eases the free redemption process where postcards evolve into email notification, and rewards can be used for food and drink redemption and 12 stars for a free item redemption instead of 15 stars [36].

In 2016, April 12, Starbucks introduced another "My Starbucks Rewards" which is a spending-based rewards system. This rewards system has the same benefits as the old system. However, the main difference with the previous system is that this rewards system consists of only two levels, namely the Green Level and Gold Level. Customer will be automatically qualified as a Green Level member once successfully registered. With each dollar spent, the customer will earn two stars. Customers are required to earn 300 stars to be eligible for Gold Level promotion. In the Gold Level, customers need to earn an additional of 125 stars in order to trade for a free item. Customers can enjoy the redemption of the unlimited number of free items with every 125 stars earned during the year of Gold Level membership.

#### 6.3.2 China

In January 1999, Starbucks entered the mainland China market by opening the first store in the China World Trade Building, Beijing [51]. "My Starbucks Rewards" in China consists of three levels, somehow similar to the old "My Starbucks Rewards" in the US, that is Welcome Level, Green Level, and Gold Level. Released in the middle February of 2011, "My Starbucks Rewards" had gained high popularity in China.

The star or point in "My Starbucks Rewards China" is rewarded with every spending of RMB50. In Welcome Level, members will receive several e-coupons during the membership year which includes three pieces of "buy one get one free" handcrafted beverage, one piece of free morning complimentary tall-sized beverage before 11 am and one piece of a free upgrade from tall to grande or grande to venti. After earning five stars, Welcome Level members will be promoted to Green Level where members can enjoy a free birthday beverage and one piece of "buy three beverages get one free" e-coupon. Within the 12 months of membership period, Green Level member will be upgraded to Gold Level after earning 25 stars, else will be downgraded to Welcome Level. In Gold Level, members are eligible for one free birthday beverage, Gold Level My Starbucks Rewards card, one free tall size beverage during account anniversary and one piece of "10 purchases get one complimentary beverage".

By comparing "My Starbucks Rewards" in the US and China, there are some differences in term of structure and the rules of the loyalty programs. The primary interest is to identify the main successful core structure which made up of point system that has been used in both loyalty programs which will be further discussed in Section 6.4.

Table 6.1:  $GR_P$  values of different versions of Starbucks US loyalty program (point system) in earning a free item in Gold Level

Year	Version	F	С	$GR_P$
2009	My Starbucks Rewards (Visit-based)	1	15	0.067
2012	My Starbucks Rewards (Visit-based)	1	12	0.083
2016	My Starbucks Rewards (Spending-based)	1	16	0.063

## 6.4 Assessment Methodology and Data Collection

This section presents the game refinement theory to derive a measure of game sophistication which will be used for the assessment of game elements of Loyalty Program "My Starbucks Rewards".

In this paper, the game progress is studied from the perspective of the point system in "My Starbucks Rewards". The game progress in point system can be measured by two factors: the number of free items redeemed, and the total number of items consumed. In order to get the game refinement value, Eq. (6.1) is proposed, where F and C represents the number of free items redeemed and a total number of items consumed, respectively.

$$GR_P = \frac{\sqrt{F}}{C} \tag{6.1}$$

This section starts by analyzing the different versions of the point system in Starbucks loyalty program specifically in the US, then follows by analyzing point system implemented that in "My Starbucks Rewards" in both US and China.

# 6.5 Evolution of Point System in Starbucks US Loyalty Program

In the evolution of "My Starbucks Rewards" since 2009, Starbucks US had continuously made minor changes on the rules in redeeming free items. Hence, the game refinement  $(GR_P)$  value of different versions of "My Starbucks Rewards" from the perspective of the point system in Gold Level is analyzed.

As shown in Table 6.1, the point system of "My Starbucks Rewards" in the US from

2009 until 2016 shows the  $GR_P$  value in the range of 0.063 to 0.083. The  $GR_P$  value is calculated and tabulated by assuming the very first free item redeemed by the customer, Fand the required number of item consumption, C is computed based on the average price of a cup of Starbucks coffee which is \$4 and RMB27 in the US and China respectively. The higher the  $GR_P$  value indicates the lower the required number of consumption in order to redeem for the free item.

The changes of rules in "My Starbucks Rewards" of 2012 had shown an increase in the value of  $GR_P$ . This means that customers in Gold Level are required to spend lesser than previously for a free item redemption. On the other hand, comparing the visit-based "My Starbucks Rewards" in 2012 with the spending-based "My Starbucks Rewards" in 2016, the  $GR_P$  values show a decrease of 0.02, from 0.083 to 0.063. This result may be explained by the fact that Starbucks requires its customer to spend more in order to get a free item. Before introducing the spending-based "My Starbucks Rewards", the customer can spend less than \$4, which is the average price of a cup of Starbucks coffee, in a transaction for 12 times to earn a free item. However, Starbucks values its loyal and high-spending customer, hence changes are made that star is earned based on the amount of spending. These changes are less entertaining and more challenging for the customer who spends a minimum amount to earn stars or free items.

# 6.6 Analyzing the Point System

This section is mainly focusing on the point system in Gold Level of "My Starbucks Rewards" in both the US and China. When a customer reaches the Gold Level to enjoy the benefit of free item redemption, the effect of repeating redemption for free items on the  $GR_P$  value is observed.

Table 6.2: Differences between My Starbucks Rewards in US and China

Country	US	China
Number of level	2	3
Requirement to reach or stay in Gold Level	$38 \mathrm{~cups}$	$47 \mathrm{~cups}$
Requirement to get one free item in Gold Level	$16 \mathrm{~cups}$	$10 \mathrm{~cups}$

The differences between "My Starbucks Rewards" in the US and China is tabulated



Figure 6-2: Game refinement value for point system in Gold Level with increasing number of free cups redemption

in Table 6.2. Firstly, the difference can be seen from the number of levels, where "My Starbucks Rewards US" consists of only 2 levels, but a total of 3 levels in "My Starbucks Rewards China". Secondly, in order for a customer to reach or stay in Gold Level, the customer is required to at least be consumed 38 cups of coffee in the US and 47 cups in China during the membership year, taking the average price per cup is \$4 and RMB27 respectively. Thirdly, the requirement for a customer to redeem for a free item in Gold Level is 16 cups in the US and 10 cups in China. From the differences, we found that the requirement for a customer to get one free item in Gold Level is higher in the US as compared to China. With these differences, the redemption of a free item for My Starbucks Rewards US and China in long-term is observed in Figure 6-2.

In economics, Hermann Heinrich Gossen [27], a Prussian economist explains that a consumer's utility which is the satisfaction derived from consuming a service or product decreases with the increasing consumption of that particular service or product. In other words, the first unit of consumption of a service or product yields more utility than the second and subsequent unit. This decrease in marginal utility with the increase in consumption is known as the Law of Diminishing Marginal Utility. Mathematically, it is represented by Eq (6.2).

$$MU_1 > MU_2 > MU_3 \dots > MU_n \tag{6.2}$$

Where  $MU_i$  stands for the marginal utility with the frequency  $i \in \mathbb{N}$ . The marginal utility

may decrease into negative utility, as it may become entirely unfavorable to consume another unit of the product. Therefore, the first unit of consumption for any product is typically highest, with every unit of consumption to follow holding less and less utility [27].

From the graph in Figure 6-2, the  $GR_P$  value for China is relatively high which yields the value of 0.1, whereas US starts with the  $GR_P$  value of 0.063. Nevertheless, both curves in the US and China show the downwards sloping trend which indicates that the  $GR_P$  value is decreasing with the increasing number of free item redemption. This inverse relationship is identical to the Law of Diminishing Marginal Utility in economics if we assumed that the game refinement relates to the satisfaction of a person. For instance, a person feels less excitement with lower  $GR_P$  when the number of free item redemption increases.

Hence, the points system is concluded to be a normal rewards or incentives system that can attract new customers to purchase and join the point system loyalty program. Eventually, the  $GR_P$  value or customer's satisfaction will decrease. Thus, the point system seems to be suitable for a business that has frequent, and short-term purchases.

The Law of Diminishing Marginal Utility directly relates to the concept of diminishing prices. As the utility of a product decreases as its consumption increases, consumers are willing to pay smaller dollar amounts for more of the product. Same goes to the case of free items redemption, customers become less willing to purchase the same amount of item in order to get another free item which will give less satisfaction.

# 6.7 Chapter Summary

Generally, the game element of the point system in "My Starbucks Rewards" shows motivation towards the normal purchasing activities. From the case study on Starbucks, the  $GR_P$  zone value of point system is observed to be ranged from 0.063 to 0.1. "My Starbucks Rewards" in China demonstrates the highest  $GR_P$  value of 0.1, whereas "My Starbucks Rewards" in the US shows the lowest  $GR_P$  value of 0.063. Meanwhile, the  $GR_P$  value of point system in both the US and China will eventually decrease as the number of free item redemption increases. Hence, we concluded that the point system shows decreasing motivation effect towards customers' purchases over the time. In short, the customer is experiencing unsophisticated game experience in point system which is proved to be a short-term incentive that is useful to motivate customers at an early age for a short period of time. Starbucks incorporates both point system and tier system in its loyalty program, targeting to attract new customers as well as retain them for a long time to come. However, the current study only examines the point system in the case of Starbucks. Further research might explore more on the structure of the loyalty program in the restaurant or food industry to determine the appropriate or universal comfortable zone for loyalty program in the business domain.

# Chapter 7

# Comprehensive Evaluation of the Game Elements of Hotel Loyalty Program

This chapter is an updated and abridged version of the following publication.

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- Zuo, L., Rizani, N., Iida, H., & Xiong, S. (2018, October). An Analysis of Points System of Hotel Loyalty Program Based on the Return on Investment. In 2018 International Conference on Electrical Engineering and Computer Science (ICECOS) (pp. 357-360). IEEE.
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# 7.1 Chapter Introduction

Gamification is the application of game design elements and game principles in non-game contexts.[14] Gamification commonly employs game design elements which are used in

non-game contexts to improve user engagement, organizational productivity, flow, learning, crowdsourcing, employee recruitment and evaluation, ease of use, the usefulness of systems, physical exercise, traffic violations and more. A collection of research on gamification shows that a majority of studies on gamification find it has positive effects on individuals. However, individual and contextual differences exist. Gamification can also improve an individual's ability to comprehend digital content and understand a certain area of studies such as music, language or business domain. In this chapter, we will employ the hotel loyalty program as the sample to evaluate the mechanism of game elements of gamification effect.

A hotel loyalty program is aimed at enticing business travelers and other frequent hotel guests to prefer a particular brand or group of hotels over others. The hotel loyalty program will generally have multiple levels. New members are offered such privileges as free internet access to encourage them to join the scheme. This ensures that guests have an incentive to use their loyalty cards, even if they do not anticipate reaching the next rewards level. Besides, joining such a scheme and staying nights in a hotel will typically accrue points, which are similar to frequent flyer miles. The customers could accumulate their points by getting the qualifying nights and sale promotion provided by the hotel rewards, and these points could be redeemed to the free nights, room upgrade and some services. Higher tiers or levers in the scheme will generally offer multiple benefits including free room upgrades, bonus points, rolling 24-hour check-in, and free access to more of the hotel's facilities, which may include buffet breakfasts, executive lounges, spas, and other features. Higher tiers will usually be reached by staying a certain number of nights during the membership year, for example, 75 qualifying nights to reach the platinum status. The world's largest hotel chains, including Marriott, Starwood, Hyatt, Hilton, IHG and several others, offer reward programs. To make the resulting objective, the selected hotel rewards are all very popular and has a sound system. To make sure we could have a comprehensive evaluation of these five great hotel rewards, we will select three approaches:

- (1) The analytic hierarchy process.
- (2) Game refinement theory.
- (3) Rerun on investment.

The analytic hierarchy process (AHP) is a structured technique of organizing and

analyzing complex decisions, based on mathematics and psychology. This technique has a particular application in group decision making and is used around the world in a wide variety of decision making situations in such fields as government, business, industry, healthcare, shipbuilding and education. In this chapter, we will start by discussing the comparison of five famous hotel groups and figure out the weight of each one based on the AHP.

The game refinement theory helps us view games from an entertainment aspect while game theory helps us understand a game's mechanism. It can be used to evaluate to the attractiveness of board games and sports game. Based on that viewpoint, the idea of game refinement can be extended into other domains in human life such as the gamification effect of educational game and business. The possibility of doing that comes from the core idea of game refinement theory, which quantifies how engaging a game is. In many human activities, engagement is usually considered to be one of the important standards of evaluating the effectiveness of such activities. Basically, staying in a hotel is usually related to the customers' need which is based on their business and only when some game elements and design are involved, this activity will become a gamified activity, say hotel loyalty program. Thus, this chapter explores the benefit of gamified sales promotion with a focus on the hotel loyalty program, which is the essential strategy for the hotel companies in contributing sales volume to its properties and commonly consists of two mechanics: tiers system and points system. We will present a data-driven approach for discovering the two mechanics of the world's largest hotel chains while analyzing the game sophistication level using a game refinement measurement. With the previous knowledge presented in Chapter 1, we initially define the gamification of hotel loyalty program in the following way. Thus, we could apply game refinement theory to understand the information on the extent of gamification effect of the hotel loyalty program.

**Definition 3. Gamification in hotel loyalty program** is defined as the enhancement of service and points when the customer promotes to a higher membership status with the well-organized game elements for gameful experiences to retain customer loyalty to the hotel brands.

Then the next contribution may illustrate how the points system works and the return on investment from the perspective of marketing. It also shows an advantage of its harmonious combination to attract more potential customers and retain the frequent customers. Thus, it is critical to consider from the perspective of the economy. In business, return on investment (ROI), a measure on return rates of invested funds to a certain economic entity over time, is utilized to determine if an investment should be made. It is also an indicator when comparing different investments in a portfolio. Priority is normally granted to the investment with the largest ROI, with this method, we make it possible to rank the benefits for customers of each hotel loyalty program.

## 7.2 Overview of Five Hotel Loyalty Programs

Loyalty programs in the hotel space have evolved as a reflection of larger societal trends and some unique hotel trends [44]. In this section, we give a short sketch of the historical overview of the hotel loyalty program and introduce the selected hotel loyalty programs. Then, we discuss how loyalty program has worked with the tiers system and points system.

Following airline deregulation in the United States in 1978, airlines were compelled to market their services more aggressively. That, combined with increased computing power and data-storage capabilities, led to the first frequent flyer program from a major air carrier, American Airlines, which launched AAdvantage in 1981 [49]. Two brands lay claim to first involving frequency programs in the hotel industry. Holiday Inn started its hotel loyalty program in 1983, followed by Marriott of the same year.

In the beginning, the schemes of hotel loyalty program were merely similar to the airline frequent flyer programs: the points earned in the hotel programs could be traded for free flights on participating airlines. However, the hotel loyalty program evolved so quickly that the points accrued could also be used for free room nights. Some brand companies continue to refine their loyalty schemes and add some compelling rules such as the availability of the lounge access and the breakfast for two for the elite member. The world's famous hotel companies: Hilton Worldwide, InterContinental, Marriott and Starwood Hotels & Resorts Worldwide recently made some remarkable changes to their points programs, raising the thresholds for members to receive free-night benefits [6].

#### 7.2.1 Comparison of Hotel Loyalty Program

In this section, we will make a comparison of different loyalty program in details so that we could make a questionnaire for the analytic hierarchy process. For most of the customers, the number of hotels, retention time of their points, free night and if the points could be transferred are the four main criteria when they choose the hotel loyalty program. We selected five famous hotel loyalty programs as a sample to analyze the gamification effect. The selected hotel loyalty programs offer the tiers system and points system. For some hotel, like APA hotel in Japan, they only offer the points system or stay 10 get 1 free night promotion. Without the tier system, these hotel rewards could be regarded as the promotion, not the loyalty program. Thus, we take IHG, Starwood, Hilton, Marriott and Hyatt, known as the Big 5 in hotel industries as the sample to compare the tier system and point system. With the assessment methodology, we could make it possible to illustrate their strategy and characteristics.

Hatal	Comparison Items				
noter	Distribution	Retention	Transferbility	Points System	
шс	4900 Hotels	1 Voor	Y	1\$ = 10 Points	
ШО	100 Countries	1 i ear		10000 Points = 1 Free Nights	
Hilton	4000 Hotels	1 Vaar	V	1\$ = 10 Points	
Hilton	90 Countries	1 i eai	I	5000 Points = 1 Free Nights	
Stampia d	1300 Hotels	1 Year	Y	1\$ = 3 Points	
Starwood	100 Countries			3000 Points = 1 Free Nights	
Morriott	4500 Hotels	2 Voora	V	1\$ = 10 Points	
Marriott	87 Countries	2 rears	Ĩ	7500 Points = 1 Free Nights	
Hyatt	600 Hotels	2 Voora	V	1\$ = 5 Points	
	50 Countries	2 rears	Ĩ	5000 Points = 1 Free Nights	

Figure 7-1: Comparison of five famous hotel groups

#### 7.2.2 Gamification Mechanics

In an attempt to provide long-term sustainability of the customer, many of the world's major hotel brands are considering how loyalty is recognized and rewarded. The best ways to maintain the repeat business is to establish an attractive and well-organized guest loyalty program. On the other hand, to make customers feel more enjoyable after joining the loyalty program, the hotel company has to recognize the importance of the appropriate characteristics of good game elements and design.

The hotel loyalty program which is the critical strategy for the hotel chain commonly

consists of two mechanics: the ties system and points system. Generally, the successfulness of gamification has commonly been quantified by the overall retention of users and sales volume. However, if we accept that gamification aims to create gameful experiences, then the successfulness of gamification could also be measured by some mathematical measurement as games are [31].

#### Tiers system

A typical hotel rewards program has four tiers. The new customer may start with the regular member with the register with their names, address and contact information, and they could enjoy some basic benefits such as Internet access. Customers at this base level may make some discretionary purchases to earn points. The middle level is a segment of customers who stay regularly, say twice a month and the top level is reserved for platinumthose frequent customers who stay in a hotel over 60 nights per year. [56]. Here we show part of the tier system including member benefits of the Marriott Hotel.

Benefits	Member	Silver	Gold	Platinum
Qualifying Nights	0	10	50	75
Rewards points earned per dollar spent	$\checkmark$	$\checkmark$	$\checkmark$	$\checkmark$
Additional bonus points	0%	20%	25%	50%
Guaranteed room type			$\checkmark$	$\checkmark$
Complimentary room upgrade			$\checkmark$	$\checkmark$
Enhanced in-room Internet access			$\checkmark$	$\checkmark$
Late checkout			$\checkmark$	$\checkmark$
Guaranteed lounge access			$\checkmark$	$\checkmark$
Free breakfast for two			$\checkmark$	$\checkmark$
Arrival gift				$\checkmark$
48-hour guaranteed room availability				$\checkmark$

• The tiers system is the base of the whole structure of a hotel loyalty program. Some benefits are highly related to this system. However, staying in a hotel for business or traveling is still an activity which is based on the basic need of customers. Thus, the real entertainment feeling comes from the free night by redeeming the points.

#### Points system

The points awarded by the hotel loyalty program were meant to tip the balance towards frequent customers with hotels. For each qualifying night, a customer would accumulate points. When a threshold was reached, the customer could trade those points for a free night. While higher level tiers give the customer a greater ratio of points (for example, 50% extra points). The attractiveness of free night is so compelling as every customer wants to enjoy a night without any payment also with the high-level services[56].

Hotel groups	Qualifying nights	Additional points
IHG [75]	75	100%
Hilton [73]	60	50%
Starwood [77]	100	50%
Marriott [76]	75	50%
Hyatt [74]	60	30%

Table 7.1: The elite membership requirement and benefit: five hotel groups compared

## 7.3 Analytic Hierarchy Process

Rather than prescribing a "correct" decision, the AHP helps decision makers find one that best suits their goal and their understanding of the problem[60]. It provides a comprehensive and rational framework for structuring a decision problem, for representing and quantifying its elements, for relating those elements to overall goals, and for evaluating alternative solutions.

Users of the AHP first decompose the decision problem into a hierarchy of comprehensible sub-problems, each of which can be analyzed independently. The different elements on the hierarchy can relate to any aspect of the decision problem tangible or intangible, carefully measured or roughly estimated, well or poorly understood anything that applies to the decision at hand.

Once the hierarchy is built, the decision makers systematically evaluate its various elements by comparing them to each other two at a time, with respect to their impact on an element above them in the hierarchy. In making the comparisons, the decision makers can use concrete data about the elements, but they typically use their judgments about the elements' relative meaning and importance. It is the essence of the AHP that human judgments, and not just the underlying information, can be used in performing the evaluations.

The AHP converts these evaluations to numerical values, which can then be processed and compared over the entire range of the problem. A numerical weight or priority is derived for each element in the hierarchy, allowing diverse and often incommensurable elements to be compared to each another in a rational and consistent way. This capability is what distinguishes the AHP from other decision-making techniques. In the final step of the process, numerical priorities are calculated for each of the decision alternatives. These numbers represent the alternatives' relative ability to achieve the right decision. This allows for a straightforward consideration of the various courses of action.



Figure 7-2: AHP modeling of hotel rewards selection

Thus, to solve the proposed problem, the AHP can be implemented in three consecutive steps as depicted in Fig 7-2:

- (1) Computing the vector of criteria weights.
- (2) Computing the matrix of option scores
- (3) Ranking the Options

The AHP commonly starts creating a pairwise comparison matrix A for the purpose of figuring out the exact weight of different criteria. A is an  $m \times m$  real matrix, where m is the number of the evaluation criteria to be considered. Each entry  $a_{jk}$  of matrix Arepresents the importance of the jth criterion relative to the kth criterion, and the entire  $a_{jk}$  and  $a_{kj}$  satisfy the following constraint:

$$a_{jk} \ast a_{kj} = 1 \tag{7.1}$$

Obviously,  $a_{jj} = 1$  for all j and the relative importance between two criteria is measured according to a numerical scale from 1 to 9.

Value of $a_{jk}$	Interpretation
1	j and $k$ are equally important
3	j is moderately important than $k$
5	j is strongly important than $k$
7	j is more strongly important than $k$
9	j is extremely important than $k$

Table 7.2: Table of relative scores (2, 4, 6, 8 values in-between)

Hence, with the previous review in Figure 7-1, we can derive the relative scores of each option. We released the questionnaire on the website and collected the result based on the comparison items<sup>1</sup>. There are totally 138 participants respond to our questionnaire. Here, we show the results of the consolidated decision matrix. The exact scores were given by judgment based on the previous review.

Another issue we would like to highlight is that some inconsistencies will arise when many pairwise comparisons are performed. The AHP incorporates an effective technique of checking the consistency of the evaluations made by the decision maker when building each of the pairwise comparison matrices involved in the process. A perfectly consistent decision maker will always get the result as 0. However, if the value of inconsistency is lower than 0.1, it can be tolerated. Eventually, we get the final result of the experiment in which we list the number of customer membership together with the weight of each hotel loyalty program.

In the final step of the process, numerical priorities are calculated for each of the decision alternatives. These numbers represent the alternatives' relative ability to achieve the decision goal, so they allow a straightforward consideration of the various courses of action. According to the result of our survey in the previous review, we could get the weight of each hotel groups, shown in Table 7.3.

# 7.4 Game Refinement Theory

The decision space is the minimal search space without forecasting. It provides a conventional measure for almost all board games. The dynamics of making decisions in

<sup>&</sup>lt;sup>1</sup>https://www.wjx.cn/jq/23856935.aspx



Figure 7-3: Consolidated decision matrix

ambiguous situations has been proved and observed to be a significant factor in estimating a games degree of recreation and entertainment. The consequence of amazing games has always been uncertain until the end of such games. As a result, switching between available options is commonplace when playing a game. Hotel loyalty program also has such search space in a specific city. However, players know that these options become limited in the space of a decision. In a situation like this, seesaw games are easier to refine.

Rank	Hotel	Weight
1	Intercontinental Hotels Group	0.306
2	Marriott International	0.263
3	Hilton Hotels & Resorts	0.254
4	Starwood Hotels & Resorts	0.090
5	Hyatt Hotels Corporation	0.088

Table 7.3: The Result of Computer Simulation by AHP



Figure 7-4: Breakdown by each node and consistency check

#### 7.4.1 Evaluation of Search Space for Customers

In an attempt to promote customer retention, many of the world's major hotel brands are concerned about how loyalty is recognized and rewarded. The best way to keep existing customers is to establish an attractive and well-organized guest loyalty program. On the other hand, to make customers feel more satisfied with after joining a loyalty program, hotel companies have to make use of the most remarkable characteristics of good loyalty programs. If we list the tiers system of different hotel loyalty programs, we will find that each hotel has different reward strategies. Here we show the tier system of each rewards program and their requirements for the qualifying nights.

The hotel loyalty program, as an application of gamification in the business domain, has been in existence for over 30 years. However, how do these guests enjoy the loyalty

Hotel groups	Number of hotels $(B_H)$	Game length $(D_H)$	$GR_S\left(\frac{\sqrt{B_H}}{D_H}\right)$
IHG	40/3/23	75	0.084/0.023/0.064
Hilton	4/5/2	60	0.033/0.037/0.026
Starwood	16/3/14	50	0.080/0.035/0.075
Marriott	26/6/17	75	0.068/0.033/0.055
Hyatt	12/5/5	60	0.058/0.037/0.037

Table 7.4: Measures of game refinement GR for hotel groups in different locations (Shanghai/Tokyo/Paris)

program? We will tackle that problem relative to what happens in board games. Here, we take the Marriott platinum as an example, where the length of the game is 75, same as the 75 nights guests have to stay within a year so as to qualify for the rewards. Then, the branching factors of the program mainly vary with location. In this case, it can be the exact number of hotels in a specific city that is available for guests to select from. This means that even though customers are playing the same game, the length of the game may vary. Nevertheless, the diversity in the number of hotels may also lead to different outcomes, which highlights the importance of the location when applying the game refinement measure. Consequently, we chose three big cities: Shanghai, Tokyo, and Paris. Then, we figured out the impact of free nights for the highest membership status depending on the location. Let us take  $B_H$  and  $D_H$  as the number of hotels with a hotel loyalty program in a specific city and the depth of the game respectively. Based on previous literature review, we can get the GR of five famous hotel groups in these three cities.

Table 7.5: Tiers system (Qualifying nights)

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Hotel groups	Silver	Gold	Platinum
IHG	10	40	75
Hilton	10	40	60
Starwood	25	50	100
Marriott	10	50	75
Hyatt	10	30	60

#### 7.4.2 Evaluation of Tier System and Point System

Compared with our previous approach of game refinement theory, this time we consider the tier system as the score and time-limited game, whereas the points system as the score limited game. For the tier system, the customer has to accomplish 75 qualifying night within a year to become a platinum member of Marriott Rewards. Moving on, when 75 qualifying nights was reached, the customer has usually accumulated enough points to redeem several free nights.

#### Tiers System 1: Game Design

We figure out the game progress model of hotel loyalty program based on the game design of qualifying nights of membership tiers. The main game progress can be given by two factors: the game design of the qualifying nights and the total number of days within a year. As the total number of days in a year is 365, hence, the measure of game refinement for the hotel loyalty program is given by Eq. (7.2) and the results are shown in Figure 7-5.



$$GR_T = \frac{\sqrt{Qualifying_Nights}}{365} \tag{7.2}$$

Figure 7-5: Measures of game refinement  $(GR_T)$  for hotel loyalty program with focus on qualifying nights: five hotel groups compared

Here maintaining a status could be considered as a social activity which is not a game behavior based on the need for business or traveling. However, game refinement measure can still be applied to this activity by observing the appropriate progress.

#### Tiers System 2: Action of the Customer

Meanwhile, there exists another tier system if we consider the real game progress which is based on the action of the player.

$$GR_T = \frac{\sqrt{PotentialQualifying_Nights}}{365}$$
(7.3)

As this data may vary individually, we ignore this quantification. However, from the perspective of the hotel companies, they could predict the potential qualifying nights by collecting the previous performance of last year. Thus, they could offer the personalized promotion offer to each customer. This is a brilliant idea that IHG rewards club is now using this method to keep the membership loyalty.

*Remark.* Basically, every hotel has almost the same game design of membership management and the membership tiers consisting of four tiers. However, there is still some slight difference between them. It is noteworthy that more frequent customer would enjoy more with the status promotion. However, we notice that Marriott hotel has a higher requirement for the silver status. It means that Marriott requires customers to spend more on its loyalty program. By observing the  $GR_T$  values, we may conclude that the zone between 0 to 0.027 would be the activity zone for the hotel loyalty program.

#### **Points System**

There still exists another system based on the tiers system that is rewarding the free night with the points earned. In this method, data is collected by considering the location. As game refinement requires the highest level (skillful player) to make the result more objective, we take the most senior membership as a sample to figure out the  $GR_P$  value. In Table 3.2, the higher status a customer takes, the more points he/she will get. This means that even the customers are playing the same game. Nevertheless, the diversity of the membership may also lead to the different outcome. Meanwhile, the points for redeeming free nights dramatically differ from the location and brands, which highlights the consideration of location issue when we apply the game refinement measure  $GR_P$ to different cities. Thus, we choose three big cities: Shanghai, Tokyo, and Paris. Here, we figure out the impact of free nights for the highest membership with considering the location issue within a year.

$$GR_P = \frac{\sqrt{Free\_Nights}}{Qualifying\_Nights}$$
(7.4)

Table 7.6: Measures of game refinement  $(GR_P)$  for hotel loyalty program in Shang-hai/Tokyo/Paris with focus on free nights: five hotel groups compared

Hotel	Price (\$)	Redeem Points	Free Nights	$GR_P$
IHG	75/208/148	18421//50000/34778	6/6/6	0.033/0.033/0.033
Hilton	125/190/190	31400/55400/55000	3/3/3	0.029/0.029/0.029
Starwood	115/247/335	6900/16000/19769	12/10/10	0.035/0.032/0.032
Marriott	143/208/285	13026/36250/32800	15/7/10	0.052/0.035/0.042
Hyatt	146/336/233	13285/20667/18000	4/6/5	0.033/0.040/0.037

*Remark.* The results of  $GR_P$  show that the average price and redeem points differ from the location. However, IHG and Hilton have the same  $GR_P$  regardless of the location. It means that these two hotel groups have the same strategy when dealing with the free nights' issue. The  $GR_P$  of Starwood and Hyatt slightly vary with the location. On the other hand, the result of Marriott greatly differs in location, which highlights that Marriott considers more about the urban development. We also find that both Starwood and Marriott provide a higher game element in Shanghai. There is no doubt that China is now becoming the largest hotel market and Marriott is dedicating to China by providing a more enjoyable experience in Shanghai.

With the improved benefits and guest-friendly rules, hotel loyalty programs are increasingly becoming one of the primary reasons for selecting a particular hotel. The two mechanics seem to be irrelevant, however, looking back to the whole structure of the hotel loyalty program, we find that they are correlated with each other. The elite member could accumulate their points much faster with the additional points policy which also means that they could get more free nights, as shown in Table 7.2.2.

Gamification is about learning from games, not just in the sense of learning about the games themselves and understanding what makes the games successful. Game theory solves the problem from the game player's point of view. However, both game refinement theory and gamification require thinking like a game designer. Game theory has a deep relationship to games and therefore to Gamification, however, they are different. Game theory is a set of algorithms and formulas and quantitative techniques for analyzing strategic decision making. So the game theory is more about defining formal models and mathematical structures to analyze different kinds of behaviors.

Gamification requires the game designer to find the essential core of those experiences and make them more rewarding, creating greater motivation, but not pull the player out of the real world. Gamification can provide that motivation. As in the other cases, gamification can encourage people to participate when they otherwise might not. Gamification says that you are still in the real world; you are still at your normal job, you are still on travel because you want to buy a product or stay in a hotel for a week. The motivation of gamification and game refinement theory is to learn from the game and make the experience better, finding elements from games that can enhance the experience that the players are having.[78]

As depicted in Figure 7-5, we see that the GR line of these five hotel groups is similar. For the highest class membership, Starwood has the highest value 0.027, InterContinental and Marriott are at the same level at 0.024. The GR value of Hyatt and Hilton is 0.021 which is lower than the others simultaneously, and the gap between these five loyalty programs is not so noticeable. The GR value for maintaining the elite status is ranged from 0.02 to 0.03, which is lower than the sophisticated zone ranged from 0.07 to 0.08. This is because the hotel loyalty program itself is an activity organized with gamification but not fun games such as video games. However, the strategies of the points system of these five loyalty programs are different, which makes the variation of  $GR_P$ . Meanwhile, we highlight that  $GR_P$  may be changed with the location and we find that the highest value in Shanghai is 0.052. It means that one customer can enjoy much more only when he/she becomes the elite status membership. Thus, we may recognize the hotel loyalty program as a kind of skill-based games.

#### 7.4.3 Effectiveness of Points System

The points system is the most critical game elements of a hotel loyalty program, as the entertainment feeling mostly comes from the free nights or service. To confirm the effectiveness of gamification, the online report on hotel ranking and the ranking by the measure  $GR_P$  are compared. Very recently the US News & World revealed the best hotel loyalty programs of 2016-2017 [50], as shown in Table 7.8. The U.S. News & World Report travel rankings are based on the analysis by experts and user opinions. This unbiased approach makes the rankings more useful than merely providing editors' personal opinions. Compared with the ranking by the measure  $GR_P$ , presented in Table 7.7. We see that the two rankings are almost the same. The results show that Marriott provides a more enjoyable hotel rewards system and focuses more on the Chinese market. After the acquisition of Starwood in 2016, Marriott became the world's largest hotel chain to make a significant lead regarding locations (over 6,000 hotels and more than 1 million rooms), brands (over 30) and locations (122 countries). The motivation of offering a ranking is not to prove which loyalty program is better, instead show that the points system has a strong influence (i.e., game element) on the satisfaction of a hotel loyalty program.

Table 7.7: The ranking of points system based on  $GR_P$  values with considering the location

Rank	Hotel Rewards	$GR_P$
1	Marriott Rewards	0.043
2	Hyatt Gold Passport	0.037
3	Starwood Preferred Guest	0.033
3	IHG Rewards Club	0.033
5	Hilton Honors	0.029

 Table 7.8: The hotel loyalty program satisfaction of the US News & World Report 2016 

 2017

Rank	Hotel Rewards
1	Marriott Rewards
2	Hyatt Gold Passport
3	Hilton Honors
4	IHG Rewards Club
5	Starwood Preferred Guest

The results indicate that the range of game refinement value of these two mechanics is meaningful and reasonable in such business domain. The tiers system provides the frequent hotel guests with a fun game experience, whereas the points system allows them to identify which hotel rewards are more attractive and rewarding. In this chapter, we have evaluated the gamification of the hotel loyalty program and made a comparison of five well-known hotel groups in the world. Using the proposed definition, we identified two possible mechanics of hotel loyalty program. The game refinement measure of tiers system of the hotel loyalty program is ranged from 0 to 0.027. This is considered an activity in social life and offers a fun game experience compared with educational purpose game. On the other hand, we figure out another measure, denoted as  $GR_P$ , based on the location issue which is considered as the core game element of the hotel loyalty program and it is found that the zone value is mainly ranged from 0.03 to 0.05.

Gamification is an idea to make the activity more attractive and enjoyable to offer a better feeling which would encourage the players to do more. Thus, it is reasonable that the value of  $GR_P$  is much lower than fun games. Meanwhile, the entertainment impact of gamification may also vary with the location, and we observed that Marriott Rewards offers a better game experience with a higher game attractiveness. However, hotels should adopt new strategies to enhance the relationship with their members and to keep pace with the latest development in the hospitality market and customer's entertainment needs. Future work may focus on the mileage program and OTA(Online Travel Agencies) loyalty program.

## 7.5 Return on Investment

The main motivation of this section is to find the exact ranking of ROI of these famous hotel rewards which makes it possible for us to have a comprehensive evaluation of hotel rewards and explain that the relationship between the tier system and point system of the hotel rewards program. The program schemes, or specifically, the approaches of accumulating and redeeming loyalty points, will generally decide how attractive the loyalty program is, for they may affect how many benefits travelers will receive from these programs[67].

ROI is the ratio of net profit to cost generated by resource investments and performance measures, which assesses the investment efficiency or compares that of various investments. Return relative to cost for investment is calculated, and the higher the ROI, the more profitable the investment. The efficiency of an investment or those of a series of different investments can be evaluated or compared via ROI the performance measure. It actually links the profits to invested capitals from a purely economic point of view. ROI formula, which compares customers benefits with their investment, is utilized herein to measure the revenue of a hotel loyalty program. **Definition 4. ROI of Hotel Loyalty Program** Let subscript t represent a qualifying stay where a customer accumulates within a year (t = 1, 2, 3, T). For a customer whose main destination (exact city) is c, and b is the hotel rewards. The amount of benefit that the customers can realize by using hotel loyalty program within a year in which T qualifying nights are made by the customers (denoted as  $ROI_{b,c,t}$ ) To calculate ROI of hotel rewards, the result is defined as a ratio or a percentage.

$$ROI_{b,c,t} = \frac{\sum_{t=1}^{T} Return_{b,c,t}}{\sum_{t=1}^{T} Investment_{b,c,t}}$$
(7.5)

The motivation of hotel loyalty program all share one goal: to create a close and strong relationship with clients to retain constant loyalty. The points system concerns about the benefit for customers who may feel a kind of game experience (a good balance between customer's capacity and challenge) but related to the popularity. The free nights in this paper is considered as the return and this return is so attractive as every customer desires to get a free breakfast and night or lounge access also with the high-level services. Thus, the motivation of this gamified services organized systematically is to create a program to maintain customer loyalty [42].

Hotel Groups	Silver Member	Gold Member	Platinum Member
$ROI_{IHG,shanghai,t}$	0%	6.1%	8.1%
$ROI_{IHG,tokyo,t}$	0%	6.2%	8.3%
$ROI_{IHG, paris, t}$	0%	6.4%	8.5%
$ROI_{Hilton,shanghai,t}$	0%	7.2%	8.0%
$ROI_{Hilton,tokyo,t}$	0%	6.2%	6.9%
$ROI_{Hilton, paris, t}$	0%	6.2%	6.9%
$ROI_{Starwood,shanghai,t}$	5%	5%	13.9%
$ROI_{Starwood, tokyo, t}$	4.6%	4.6%	9.3%
$ROI_{Starwood, paris, t}$	0%	5.1%	9.3%
ROI <sub>Marroitt,shanghai,t</sub>	13.2	16.5%	20.3%
$ROI_{Marroitt,tokyo,t}$	0%	8.6%	10%
$ROI_{Marroitt, paris, t}$	10.4%	10.9%	14.6%
$ROI_{Hyatt,shanghai,t}$	0%	6.6%	7.1%
$ROI_{Hyatt,tokyo,t}$	0%	9.8%	10.6%
$ROI_{Hyatt, paris, t}$	0%	7.8%	8.4%

Table 7.9: ROI of hotel loyalty program in Shanghai/Tokyo/Paris for different membership: five hotel groups compared

The loyalty program is a marketing activity whose primary objective is to encourage

customers' loyalty by rewarding them. Thus, based on the literature review in the previous section and the new approach, we could have a clear understanding of the evaluation of a hotel loyalty program. We collected the data via the official website and calculated the ROI via the computer software[75][73][77][76][74]. The three approaches (hotel rewards, city and tier) are different but critical to the hotel loyalty programs. Here we list the result of our evaluation based on the proposed definition, shown in Table 7.3. We could observe that the point system is related to the tier system and it seems that the point system is specially designed for the customers of the highest tier.

The result of ROI can illustrate which hotel rewards are more attractive. This makes it possible for us to have a comprehensive understanding of the evaluation of hotel rewards. We could clearly find that Marriott has a high ROI among the five rewards program, especially in the Chinese market.

With the previous result, the Table 7.10 lists the name of five famous hotel rewards and several results of our previous investigation including the quantity of customers(Q), the weight(the result of AHP), GR,  $GR_P$  and the proposed ROI. The Table 7.10 shows the comprehensive result of five hotel loyalty programs with the proposed approaches considering the location issue.

Table 7.10: Evaluations of a hotel loyalty program with the quantity of customer membership(Million), AHP, game refinement measure 1, game refinement measure 2 and ROI in Shanghai/Tokyo/Paris: five hotel groups compared

Rewards	Q	Weight	$GR(\frac{\sqrt{B_H}}{D_H})$	$GR_P(\frac{\sqrt{F}}{Q})$	ROI
IHG	92m	0.306	0.084/0.023/0.064	0.033/0.033/0.033	8.1%/8.3%/8.5%
Hilton	52m	0.254	0.033/0.037/0.026	0.033/0.033/0.033	8.0%/6.9%/6.9%
Starwood	21m	0.090	0.080/0.035/0.075	0.035/0.032/0.032	13.9%/9.3%/9.3%
Marriott	54m	0.263	0.068/0.033/0.055	0.052/0.035/0.042	20.3%/10%/14.6%
Hyatt	20m	0.088	0.058/0.037/0.037	0.033/0.040/0.037	7.1%/10.6%/8.4%

Gamification notions like points, badges, and progress bars can be applied in a hotel loyalty program under a systematic structure with certain rules and challenges. Despite the theoretical basis, there is seldom empirical investigations or accurate evaluations about the fundamental mechanism of gamification, but this issue is effectively tackled with the proposed mathematical model. ROI is selected as a benchmark to explain the popularity of particular hotel rewards. In this study, novel insight into hotel rewards economic benefit is obtained via applying a game refinement measurement with a focus on the points system. It is shown that Marriott provides customers with better strategies, especially benefiting the Chinese market. The versatility and simplicity endow ROI, a rudimentary gauge for investment profitability, with great popularity. Such calculation wins at low complication, natural interpretation, and extensive application. Negative ROI or potentially higher ROI in other opportunities are signals of elimination or better choice during investment decision.

The result of ROI can illustrate which hotel rewards are more attractive. This makes it possible for us to have a comprehensive understanding of the evaluation of hotel rewards.

- The result of AHP and the *GR* are the two approaches to evaluate the attractiveness or preference of the customers before they join the scheme. The weight of AHP for each hotel rewards are related to the number of customers while the *GR* is the evaluation of the search space for the customers when they stay in a specific area. We could say that IHG rewards are the most popular rewards and friendly to new customers. Meanwhile, the Starwood also has an excellent performance for the game sophistication
- These two approaches illustrate the sophistication of the point system during the in-game period. The  $GR_P$  and ROI are mainly determined by two factors: the free nights and the qualifying nights. We could find that the Marriott has an outstanding outcome for the ROI and  $GR_P$  which indicates that this hotel reward focuses more on the frequent customers.

## 7.6 Chapter Summary

This Chapter has shown a promising approach to evaluate the various gamified services such as a sales promotion in the hotel industry known as the hotel loyalty program.

We conducted three approaches to evaluate the hotel loyalty program. With the game refinement methodology, the result of the GR in these three cities for five famous hotel groups is entirely different. It means that even the customers are enjoying the same loyalty program, the decision complexity will also vary with the location. Compared with the previous work in sports and board game domain, the GR of hotel rewards is lower than the sophisticated zone from 0.07 to 0.08. However, such value is also reasonable in the marketing domain, as hotel rewards are the application of gamification. By using game refinement measurement, the value of the tiers system is too low. The long game length makes this activity boring, as it takes a year to distinguish the membership. One possible solution is to change the game length.

we have evaluated the gamification of the hotel loyalty program and made a comparison of five well-known hotel groups in the world. Using the proposed definition, we identified two possible mechanics of hotel loyalty program. The game refinement measure of tiers system of a hotel loyalty program is ranged from 0 to 0.027. This is considered as an activity in social life and offers a fun game experience compared with educational purpose game. On the other hand, we figure out another measure, denoted as  $GR_P$ , based on the location issue which is considered as the core game element of the hotel loyalty program and it is found that the zone value is mainly ranged from 0.03 to 0.05.

With the AHP method, we figured out the weight of each hotel rewards with four items as the critical options when customers select specific hotel rewards. The paper empirically evaluated the game sophistication of the hotel loyalty program in a particular city, and the result of the AHP based on the four selected comparison items is inspirable which offers a new perspective for customers to select a hotel reward. The result of AHP indicates that IHG rewards have a better performance and that is the main reason why IHG has over 90 million customers join the scheme.

The result of ROI could make it clear to explain how the tier system and point system related and illustrated that points system is specially designed for the highest membership. Thus, we could explain how hotel rewards work and maximize the customers' benefit. Meanwhile, we could find that these hotel groups strategic focus is mainly in China. However, the hotel rewards still need to develop new benefits and strategies to sustain the loyal customers and attract new customers to keep pace with the customer entertainment needs and hospitality marketing.

Now, we have several results of the evaluation of hotel loyalty program, including the quantity of the customers, result of the AHP, GR based on the location issue,  $GR_T$ ,  $GR_P$  and ROI. Thus, with the computer software, we made a correlation analysis to observe if there is any positive correlation among these data.

From the Fig 7-6, two positive correlation was found. We could observe that the

		Q	Weight	GR	GR <sub>T</sub>	GR <sub>P</sub>	ROI
Q	Pearson Correlation	1	.929*	.214	032	.065	079
	Sig. (2-tailed)		.023	.730	.959	.917	.900
Weight	Pearson Correlation	.929*	1	046	150	.283	.101
	Sig. (2-tailed)	.023		.941	.810	.645	.872
GR	Pearson Correlation	.214	046	1	.784	.140	.306
	Sig. (2-tailed)	.730	.941		.116	.822	.616
GRT	Pearson Correlation	032	150	.784	1	.223	.547
	Sig. (2-tailed)	.959	.810	.116		.719	.341
GR <sub>P</sub>	Pearson Correlation	.065	.283	.140	.223	1	.922*
	Sig. (2-tailed)	.917	.645	.822	.719		.026
ROI	Pearson Correlation	079	.101	.306	.547	.922*	1
	Sig. (2-tailed)	.900	.872	.616	.341	.026	

Figure 7-6: Correlation Analysis

quantify of the customer was positively correlated with the result of  $AHP(r = 0.929, p \le 0.05)$ . Meanwhile, the  $GR_P$  was positively correlated with the result of  $ROI(r = 0.922, p \le 0.05)$ .

The hotel loyalty program has a good marketing performance. It still has some weak point, for example, the lack of the usage of the badges. Few rewards program offers the targeted sale promotion based on the customer performance of last year. If we could offer such promotion, this will make the customer enjoy the sense of flow as this promotion is specially designed for them. Meanwhile, we also suggest hotel offer the all brand plan to maintain the diversity of the hotel brands, it means that the customer will get a significant amount of points if he successfully stays all the brands of a reward program. As we mentioned, maintain the diversity of the brand is also critical for hotel chains. The hotel loyalty program is still changing and made some breakthrough, for example, for the new customer, they have the stay 2 get 1 or stay 4 get 2 promotion. However, the hotel organizations need to follow the new trend of the customers' need to sustain the loyalty customers.

By analyzing the learning platform and loyalty program, we also summarize the difference between these two kinds of games. Gamification and serious games offer similar benefits by using game elements. However, serious games follow the typical game structure, but also have some form of training value. Gamification deals with using game mechanics in a non-game context in order to enhance motivation and influence behavior. So, gamification is more than creating a serious game.

# Chapter 8

# **Conclusion and Future Work**

In this chapter, we list the contribution and innovation of this thesis and illustrate the mechanism of loyalty program by two figures. We answer our research questions and problem statement. Then, some future work are discussed.

# 8.1 Concluding Remarks

The previous work in board games and sports games have illustrated how to apply game refinement theory to simple game which has a pure game progress. In this thesis, we focus on two directions, one is the analysis of the game elements by using different assessment, and the other is the application of game refinement theory. We start by discussing the application of game refinement theory to sufficiently complex game called DOTA2. Then, we extend this idea for learning platform by finding the appropriate structure. The two experiment have proved that game refinement theory has a good universality by finding the reasonable progress even this game is sufficiently complex. Thus, our first innovation is to extend game refinement theory from the simple board game and sports game into the sufficiently complex game.

Meanwhile, we never ignore other approaches when dealing with the loyalty program. To analyze the game elements, we have adopted three methods including game refinement theory, AHP and ROI to comprehensively evaluate the hotel loyalty program. With the data analysis of the result of these three methodologies, two correlations were found which has proved that game refinement theory can be reasonably applied to evaluate the



Figure 8-1: Interpretation of the Contribution(Grey Area)

attractiveness of a game and appropriate setting (Game length and possible selection). That is the second contribution and innovation for game refinement theory by correlating other assessment. The Figure 8-1 illustrate the innovation of this thesis.

Thirdly, with the comprehensive evaluation of hotel loyalty program, we make it possible to illustrate how game elements and design work. The motivation of loyalty programs all shares one goal: to create a close and strong relationship with clients to retain a constant loyalty. Figure 8-2 demonstrates the relationship between the tiers system and points system, assuming that the guest is already aware of the loyalty program. The grid provides an overview of the various types of program members. Targeted marketing efforts (in compliance with individual needs) should be made to steer program members towards a higher level of loyalty, depending on their characteristics. Hence, the aim is to turn new joined customers into frequent guests, frequent guests into potentially loyal guests, and potentially loyal guests into loyal ones. Thus, we provide an overview of the mechanism as two different kinds of gamified services: tier-based game (red-color path) and point-based game (blue-color path). The tiers system gives customers fun-game experience; this idea gives people the motivation and challenge to promote a higher status or maintain the status. This leads to the win-win scenario: customers improve their loyalty and companies increase their revenues. One dimension is the frequency of tiers system which means the sustainability of the frequent customer. Another dimension is the profitability of points system which indicates the popularity of the gamified service, as profit may encourage more customers involved in. The points system concerns about the benefit for customers who may feel serious-game experience (a good balance between customer's capacity and challenge) but related to the popularity. The free ticket is so compelling as everyone desires to enjoy a flight without payment also with the high-level services. Thus, the motivation of these two gamified services organized systematically is to create a program to maintain customer loyalty [42].



Figure 8-2: Interpretation of the relationship between tiers system and points system. Both systems aim to bring customers to Loyalty Guest position in a different path.

# 8.2 Answer to RQ1 and RQ2

Above all of the contents in this thesis, thus we answer our research questions as below.

#### • Research Question 1

We evaluated the DOTA2 series using the game refinement measurement. The results indicate that DOTA2 has a similar zone value with sophisticated sports and board games. In addition, the DOTA2 championship of every year during 2011-2016 was analyzed. The results show that the game refinement value has stayed within 0.071-0.077, which is slightly lower than DotA. The proposed measurements offer us a new perspective when dealing with the complex game. The prize of the

championship has strongly influenced the development of DOTA2. Higher prize enforced the players to be more conservative and the game refinement value became lower which implies that DOTA2 became more skillful. Meanwhile, to maintain the diversity of the heroes selection, we proposed a new matchmaking system based on the picking rate.

#### • Research Question 2

We successfully broad the game refinement theory in business domain which is completely different from the previous research. With the game refinement measurement, we figured out the game refinement value of three loyalty programs and proposed to calculate the tiers system and points system separately. Meanwhile, we also apply AHP and ROI to analyze the game elements to comprehensively evaluate the hotel loyalty program. With the data analysis of the result of these three methodologies, two correlations were found which has proved that game refinement theory can be reasonably applied to evaluate the attractiveness of a game and appropriate setting.

Game	$GR_S$	$GR_T$	$GR_P$
Hotel Loyalty Program	0.033-0.084	0-0.027	0.033-0.052
Frequent Flyer Program	N/A	0-0.026	0.022 - 0.045
Starbucks Loyalty Program	N/A	N/A	0.063-0.100

Table 8.1: The Range of Game Refinement Value

The tiers system and points system are the two critical systems of the loyalty program. With the proposed methodology, we make it possible to illustrate how to retain constant loyalty and which one is more enjoyable. From the perspective of a game designer, we pointed out some weak point of loyalty programs, such as the no use of badges or the unattractive badge system. With the result of different approaches, we could observe the different strategies and advantage of each rewards program. The result of return on investment could make it clear to explain how the tiers system and points system related and points system is specially designed for the highest membership. Thus, we could explain how hotel rewards work and maximize the customers' benefit. Meanwhile, we could find that these hotel groups strategic focus is mainly in China. The IHG rewards possess the largest participants and take
the lead position in the AHP results. The ranking of return on investment, GR, and  $GR_P$  demonstrate that Marriott rewards have a strategy more appealing to the customers in points system and are especially beneficial for the Chinese market. The results indicate that in such business domain, the range of game refinement value of the tiers system and points system is simultaneously meaningful and reasonable.

#### 8.3 Answer to Problem Statement

Game refinement value is one parameter or property of the target game. Therefore, game refinement theory can judge how exciting and how interesting a game is. However, high interesting level does not mean that it can attract more population to enjoy the game. The researchers have found a regular and the samples are all fun games such as sports, video games and board games. Game refinement theory could be the benchmark to explain the tendency of the game progress from the historical point of view. Meanwhile, according to the previous knowledge, the "successful" games usually share the zone value from 0.07 to 0.08. The research of gamification breaks this rule which highlights the consideration of the game category. These are the main reasons we employed related algorithms and different methods of computation to evaluate the proposed games.

With the comprehensive evaluation of loyalty programs, we have illustrated the mechanism of points system and tiers system. These two systems possess critical game elements of loyalty programs. Game elements and rewards serve as a starting point to understand gamification effectiveness. The model of player motivations provides the basis to understand and consider how players differ from one another and how motivations of play relate to rewards patterns and in-game behaviors. By this, we strengthen the link between game refinement theory and other established approaches.

## 8.4 Future Work

The thesis proposed several approaches to evaluate the game elements of the fun game and serious games. To have a better understanding of gamification effect of loyalty program, game refinement theory, AHP and ROI were employed to evaluate the targeted programs. However, we have noticed that the OTA(Online Travel Agency) like Booking, Agoda and Airbnb have become more and more popular among the young. Usually, these OTAs offer simple loyalty programs compared with the traditional loyalty programs. However, OTA loyalty programs are not challenging the traditional rewards system as they are not targeting the business travelers. Thus, it is meaningful to investigate why OTA loyalty program become so popular rapidly with some evaluation in the future.

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