

Title	User-centered Improvement of Entertainment Factors and Platform Transformation in Various Aspects
Author(s)	ANUNPATTANA, Punyawee
Citation	
Issue Date	2020-03
Type	Thesis or Dissertation
Text version	author
URL	<a href="http://hdl.handle.net/10119/16379">http://hdl.handle.net/10119/16379</a>
Rights	
Description	Supervisor: 飯田 弘之, 先端科学技術研究科, 修士(情報科学)

# **User-centered Improvement of Entertainment Factors and Platform Transformation in Various Aspects**

ANUNPATTANA PUNYAWEE



Supervisor: **Professor Hiroyuki Iida**

**A thesis submitted in partial fulfilment of  
the requirements for the degree of  
Master of Information Science**

**School of Advanced Science and Technology  
Japan Advanced Institute of Science and Technology  
Japan**

**February 2020**

## **Abstract**

Gaming technology has come a long way from pixelated days such as Pacman, Space Invaders, and old-fashioned games. Now the trend has become a source of entertainment for broadening its performance to that have more ubiquitous and accessible. Some game companies try to do rebranding of games consoles from simple devices to play games, to variety entertainment hubs. With such an example of changes in game platform, research in this field becomes interesting and has contribution to improve game communities. Entertainment factors are originated as a basis in this thesis, we conduct research and experiment based on user-centered study which discuss from the perspective of users in various aspects such as game mechanics, game preferences, and gaming devices. Otherwise, we focus on the game refinement theory and gamification in business model, education and finance.

This thesis has two directions, one is the analysis of the game element that discuss in Chapter 3 to Chapter 4. It will mainly conduct on application of game refinement theory from the game players viewpoint which the results are utilized for game development aspect. Whereas, we explain Chapter 5 to Chapter 6 mainly discuss from users' perspective in platform transformation for the second direction. We have figured out by using statistical analysis and contributing conceptual framework that sufficiently interpret the direction of platforms changes referring to users' demand.

Chapter 1 introduces the background of the study, then Chapter 2 provides the mathematical model of game refinement theory and necessary definitions and related works in platform transformation and game development field. Chapter 3 demonstrates application of game refinement to determine reasonable setting in Snake game in which the results can be measured the sophisticated level of the game by developing AI. Chapter 4 explores the evolution change and analyze its measurement of MOBA game from different platforms between mobiles and PCs, the result shows that mobile version can keep refinement measure in sophisticated zone while reduce game length. Also, we observes game elements in

business model of mobile version in which it earn higher revenue by using gamification as the PC version. Chapter 5 focuses on the user-centered study of platform transformation and game development, including proposing model of entertainment factors which has been constructed by perceived enjoyment framework, then we shows the prospective scheme that will apply to identify the direction of gaming platform evolution and further capitalize on educational context. Chapter 6 explores on financial literacy using gamification interpretation and some aspects from entertainment factors, then we implement stimulus model for mutual fund system to enhance users' engagement and learning capabilities. Chapter 7 gives the conclusion in which research question and problem statement are answered, and suggests possible future works with mainly discuss about three main keywords: entertainment factors, platform transformation, and game development.

## **Acknowledgements**

First of all, I would like to appreciate Professor Hiroyuki Iida for being my great advisor and supporting several things during my life as a master degree student at JAIST. Once in 2016, I had been at JAIST to conduct research under his supervision as an internship student. He was very kind and brilliant, he broadened my thinking process and milestones which makes me being a better researcher. Two years later, I decided to continue working under his supervision. He still gives me both theoretically and practically guidance, and teaches me meaningful lessons including being alive in Japan and how to contribute such an excellent research and academic paper. I sincerely appreciated his contribution especially for kindly support and suggest the way also provide financial support and round-trip air fares in every case. That makes me satisfied which I can go back to Thailand, my home country, and other new countries such as Indonesia and Singapore for the international conferences. It recovers my mental and encourage my motivation to face against the big step during being a master student. Without Profess Iida, I might not be able to receive my achievement.

I would like to appreciate my supervisor for minor research in Thailand, Asssistant Professor Wilawan Inchamnan, for kind hospitality and suggestions during that period. Also, gave me an opportunity to be the part of her project in Dhurakij Bundit University. Furthermore, I thanks everyone who help me during these two months for minor research project at Dhurakij Bundit University including all professors and staffs for kind welcome and support.

I would like to appreciate Professor Kokolo Ikeda, it is my pleasure to receive insightful comments and necessary suggestions for my research. I have received many things that I can improve myself as a researcher. Likewise, I would like to appreciate Professor Kazuhiro Ogata, it is my pleasure to be his advisee for my minor research project that gave me a lot of meaningful advice. Also, I have a pleasure and appreciation to work with Assistant Professor Mohd Nor Akmal Khalid who gives me many suggestive comments to make me a better researcher.

Besides these contribution, I would like to thank my seniors, my friends both from Thailand and foreigner. They fulfilled my life and spent such a wonderful time together in Japan. Especially, Mr.Nazhif Rizani, Ms.Htun Pa Pa Aung, Ms.Xiaohan Kang, and former student Ms.Sakshi Agarwal from our lab that we share a lot of memorable moments and distribute lively environment in our lab during staying in JAIST. Moreover, I would like to thank JAIST staffs for helping me and doing my favor becoming more convenient.

Finally, I would like to express my deepest thank to my parents and my sister for helping me to biggest challenge in my life which is studying abroad. They warmly support me at their best even giving me motivation speech and visiting me in Japan for taking care of me closely. Also, I would like to thank Ms.Tanjira Tongchum as well for putting me in good mental and giving me both lovely support and happiness. This accomplishment would not have been possible without them.

## Contents

<b>Abstract</b>	<b>ii</b>
<b>Acknowledgements</b>	<b>iv</b>
<b>Contents</b>	<b>vi</b>
<b>List of Figures</b>	<b>ix</b>
<b>List of Tables</b>	<b>xi</b>
<b>Chapter 1 Introduction</b>	<b>1</b>
1.1 Background .....	1
1.1.1 Game Theory and Game Refinement Theory .....	2
1.1.2 How Gamification relates to the Game Refinement Measure .....	5
1.1.3 Platform Transformation and Game Development .....	5
1.2 Problem Statements .....	8
1.3 Structure of Thesis .....	9
<b>Chapter 2 Literature Review</b>	<b>11</b>
2.1 An Overview of Game Refinement Theory .....	11
2.1.1 Introduction .....	11
2.1.2 Game Progress Model .....	13
2.1.3 Applications in Various Fields .....	16
2.2 An Overview of Platform Transformation and Game Development .....	17
2.2.1 Introduction .....	17
2.2.2 Perceived Enjoyment and Entertainment Factors .....	19
2.2.3 Gaming in Education .....	20
2.3 Chapter Summary .....	22

<b>Chapter 3 Finding Reasonable Setting in Games</b>	<b>24</b>
3.1 Introduction .....	24
3.2 Analysis of Snake Game .....	25
3.2.1 Overview of Snake game .....	25
3.2.2 Game Refinement Approach through Snake Game .....	27
3.2.3 Analysis of Snake Game Variants .....	30
3.3 Chapter Summary .....	33
 <b>Chapter 4 Evolutionary Changes of MOBA Games on PC and Mobile Platform Comparison</b>	 <b>35</b>
4.1 Introduction .....	35
4.2 Analysis of Realm of Valor: Mobile MOBA game .....	36
4.2.1 Overview of Realm of Valor .....	36
4.2.2 Game System and Monetization Model of ROV .....	37
4.2.3 Game Refinement Measure for Scoring Information Progress .....	41
4.2.4 Game Refinement Measure for Game System Progress: Arcana and Enchantment system .....	42
4.2.5 Game Refinement Measure for Monetization .....	44
4.3 Evolution of MOBA game and Its Interpretation .....	47
4.3.1 Platform Aspects .....	47
4.3.2 Business Aspects .....	48
4.4 Chapter Summary .....	51
 <b>Chapter 5 User-Centered Entertainment Factors</b>	 <b>53</b>
5.1 Introduction .....	53
5.2 Platform Transformation and Game Development .....	55
5.2.1 User-centered Entertainment Factors for Platform Transformation and Game Development .....	56
5.2.2 Interpretation of Entertainment Factors in Various Platform .....	58
5.3 Analysis of Gaming in Education .....	63
5.3.1 Classroom System with Technology to Enhance Engagement .....	64



5.3.2	Interpretation of Game Refinement Measure through the Classroom Possible Options .....	67
5.3.3	Analysis of Gamification Platform in Classroom .....	69
5.4	Ongoing and Prospective Works .....	70
5.5	Chapter Summary .....	73
<b>Chapter 6</b>	<b>Gamification Design Process for Financial Platforms</b>	<b>75</b>
6.1	Introduction .....	75
6.2	Gamification Stimulus Model for Mutual Fund .....	76
6.2.1	Mutual Fund .....	76
6.2.2	Gamification Mechanics and Workflow .....	78
6.3	The Financial Factors of Gamification .....	80
6.3.1	The Investment Factors of Gamification for Mutual Fund Investment .....	82
6.3.2	Gamification and Financial Literacy .....	82
6.3.3	The Conceptual Framework of Gamified Activity .....	89
6.4	Chapter Summary .....	90
<b>Chapter 7</b>	<b>Conclusion and Future Works</b>	<b>92</b>
7.1	Concluding Remarks .....	92
7.2	Future Works .....	95
<b>Bibliography</b>		<b>96</b>
1	Appendix A .....	112

## List of Figures

2.1 Decision tree of a two-person game	14
2.2 Technology Acceptance Model [66, 67]	19
2.3 Perceived enjoyment research model for continuous use [1, 37]	21
3.1 A screenshot of Snake game on Nokia 3310	26
4.1 Screenshot of Arcana system on ROV	38
4.2 Screenshot of Enchantment system on ROV	38
4.3 Screenshot of evolution skin features on ROV	39
4.4 Screenshot of evolution skin features on ROV	39
4.5 Game refinement measures among three types of players in Codex system analysis	47
4.6 MOBA games timeline and game refinement measures for each game	49
4.7 The approximate revenue of the ROV	50
5.1 Number of respondents and age range in questionnaire	57
5.2 A player enjoyment-based visualization for improvement of entertainment factors	57
5.3 Sample question and simplification from Likert-scale to positive-negative scale	58
5.4 Relationship of improvement factors among game platforms	59
5.5 Illustration of gaming platforms are currently getting the most support from game developers in 2019	63
5.6 Illustration of digital platforms using in the classroom [33]	65
5.7 Purpose of using platform technology in the classroom [33]	66
5.8 Illustration of classroom system in this study	66
5.9 Illustration of game refinement measure comparing two types of classroom	68
5.10 Conceptual relationship between uncertainty and time	71
5.11 A model of move selection in games	72
6.1 The mutual fund investment paradigm	77
6.2 The mutual fund investment gamification workflow design	87

6.3 The gamification workflow design process for mutual fund investment	88
6.4 Framework of the mutual fund investment gamified activity	88
6.5 Conceptual gamification stimulus model	89

## List of Tables

1.1 Fundamental game design elements	6
2.1 Measures of game refinement of major board games	15
2.2 Measures of game refinement of various games and sports	16
3.1 History of snake games in Nokia mobile phones	26
3.2 Human measures of game refinement for $SNG(15, 1, 240, c, 3)$	29
3.3 AI measures of game refinement for $SNG(15, 1, 240, c, 3)$	29
3.4 Measures of game refinement for $SNG(s, 1, 240, 1, 3)$	30
3.5 Measures of game refinement for $SNG(s, 1, m, 1, 3)$	31
3.6 Measures of game refinement for $SNG(15, a, 240, 1, 3)$	32
3.7 Measures of game refinement for $SNG(s, 1, 240, 1, l)$	32
4.1 Total prize pool for the tournaments	40
4.2 Measures of game refinement for ROV before 2017	42
4.3 Measures of game refinement for ROV after 2017	42
4.4 GR value of Arcana system	43
4.5 GR value of Enchantment system	44
4.6 The relationship between required evolution score, number of elements, accumulated price in each tier/level	45
4.7 GR value of evolution skins system of ROV	45
4.8 GR value of codex system of ROV	46
4.9 Trade-off between mobile and PC comparison	48
4.10 Measures of game refinement for each MOBA game and each platform	49

5.1 The result of t-test and p-value for interactivity factor	59
5.2 The result of t-test and p-value for variety factor	60
5.3 The result of t-test and p-value for challenge factor	61
5.4 A summary of impact of entertainment factors among game platforms	61
5.5 Timeline for Nintendo game platforms	62
5.6 Measures of game refinement of Kahoot in several cases fixed number of questions	70
6.1 Game mechanics and elements for gamified application in investment and stock trading area	81
6.2 The investment factors of gamification for mutual fund investment	83
6.3 The gamified experience for mutual fund investment	84
6.4 The gamification mechanics for mutual fund investment	85
.1 The general questionnaire for improvement factors evaluation	113

## CHAPTER 1

### Introduction

---

This thesis represents the conceptual framework to describe the technological impact in game industries and gaming platform changes in various aspects. In this chapter, we first explain the background of this study and brief definition of key point in this thesis. Then, we mention our problem statement and purpose of this study clearly. Finally, the structure of this thesis is explained.

### 1.1 Background

Nowadays, there are many definitions and interpretation on the play. There are many significant introduction both traditional and modern ways in various domains [1, 2, 3, 4, 5]. Psychologists defined 'play' as an activity considered as a valuable cultural transference in society, and as a part that can take place inside and outside of our physical reality with limitation of the medium and rule keeping [6].

The definition of play and recreations have explained on the key factor, based on the assumption that satisfaction as the crucial of an engaging experienced. [7] identified 27 fun factors based on a comprehensive literature review, they proposed Big Five [8] in game enjoyment (i.e., technology, game design, aesthetic, entertainment experience, and narrativity) and three threshold perspectives for elements of play (i.e., playability, enjoyability, and fun boosting factors).

The most importance in motivation of playing is that a player voluntarily enters to play without frustration and boredom [8]. Definition of play will change the quality of the activity and

experience. In addition, play has a repetitive nature: If the play is enjoyable, then it provide high redundancy of the enjoy experience. Therefore, element of play consists of voluntary and repetitive activity, provide a unique combination of features that are also essential to game developments and platform changes [1, 3]. There are several attempts to identify interaction between human and computer. Entertainment value can identify from descriptive statistics, in some ways, we are able to do research involving both computer science and psychology method to distinguish different player preferences and progress the user experience reaching the satisfactory point.

For those reasons, every player has their own differences in sense of strength, interesting, and expertise. The individual differences in playing relies on the behavior of the players. It can be seen clearly in our daily life that development of technology and advancement of internet have penetrated into daily works, entertainment stuffs including mobile phone games, videos, animations, software applications, and etc. Generally, we can observe a player's behavior in wider range. In order to understand such perceptions we need to consider the related potential contexts in which they can help us determine the characteristics and conceptual design. Utilizing collected data we may able to attain building models that would be valuable. The main objective of this thesis is to precisely evaluate and determine the users' desire and gaming innovation changes over the time.

Therefore, this thesis focuses on the entertainment factors from users' point of view, study from the past until present. Then, we propose background knowledge that we have studied; game refinement theory, gamification, and platform transformation. We believe that conceptual framework in this study can be one of essential ways to improve and contribute human and computer interaction. Also, we can determine the better opportunity to standardize new playing style and enjoyment experience even game context and non-game context.

### **1.1.1 Game Theory and Game Refinement Theory**

Game theory is one of the popular subject that apply into business, economics, and management areas, and then apply much larger range in other domains.

The brief history came from the publication of the 1944 book *Theory of Games and Economic Behavior* by J. von Neumann and O. Morgenstern, which included the method for finding mutually consistent solutions for two-person zero-sum game [9, 10], there is only one player win while the another lose. In early 1950s, J. Nash developed a new criterion, known as Nash equilibrium, to characterize mutually consistent strategies of players. Since it is applicable to non-zero-sum games [10], every user can win and gain the benefit, and marks forward in the development of non-cooperative game theory. Many important concepts of game theory were developed, such as the concepts of the extensive-form games [10, 11, 12], repeated games, and etc. Application of game theory to biology, i.e., the evolutionary game theory, was introduced by J. M. Smith and G. R. Price [13]. in the 1970s. In nowadays, game theory has been widely recognized as an important mathematical tool in many fields, such as economics [14], social sciences, biology, engineering, political science, international relations, computer science [15], etc., for understanding cooperation and interactions between individuals.

Nash equilibrium is a key concept to understand non-cooperative game theory [16], a game structure in which the players do not have the option of planning as a group in advance of choosing their actions.[16, 17]. Given a game where two or more players interactively make their decisions. The equilibrium where everyone plays the best strategy when taking decision-making of others into account. The existence of Nash equilibrium is quite general, but the uniqueness has to be analyzed case by case.

For the extension of this theory, evolutionary game theory (EGT) [18, 19] is presented for numerous behaviors include the interaction of different users in a population, and the success of any one of these users depends on how its behavior interacts with that of users. So the fitness of an individual user cannot be measured in isolation, or maybe it has got to be evaluated in the setting of the total population within the system.

To make this concrete, the payoffs in the evolutionary game represent fitness, the evolutionary game players inherit rather than choose their strategies. The focus of evolutionary games is on the dynamic of strategies more than the properties of strategies. It can tell us how rational player behave to approach a best strategy against a mutant users who do not follow the optimal strategy [19], and thus the EGT can better cope with the unpredictable events occurring in



the network system that to reach the equilibrium point called "Evolutionarily Stable Strategy (ESS)"

The motivation of game theory is to create the best decision making for each user, if player can predict the occurrences in the future based on cognitive knowledge background and evaluation of payoffs, the thinking process reflected through the benefit and loss, i.e. strategies. Every user always try to maximize of their own benefits and lead the improvements of performance in both ways.

On the contrary, game theory can redeem the problem of how to win the game by making a best response through various strategies of only players' side. Accordingly, [20] proposed game refinement theory in order to understand how to design an appropriate game structure with optimal sophistication. Both theory have been useful in the game development including computer games and general games. The differences between these theories has been spotted. For instances, like chess, game theory would focus on finding the finest response within the game no matter what another player does, which guarantees the optimal results based on the current positions. While game refinement theory determine how much attraction of a game to players, i.e. it is a theory that quantify the engagement and attractiveness of players to games based on the game elements, game structures, game contents and game itself [21]. Consequently, game refinement theory could be used to understand the development of game and evolution of game variants from the past until the present. We can extend game refinement theory to other domains such as sports, education, business models, and other non-game context which we can called serious game [5, 22]. Evaluation by using game refinement theory is to focus on how each activity can be engaging. To evaluate the targeted game, we have to determine the mapping of the game progress model which is fit for the evaluation purpose. Some kinds of games has very complex structures and elements during in game period, hence, that causes uncertainty and dynamics in the game. For this reason, it is essential for construction the core parameters for the game progress model when we apply game refinement theory. It can be seen that the potential of game refinement theory is still ongoing to improve game informatics field even in other domains to improve entertainment experience and create innovative ways for playing game.

### **1.1.2 How Gamification relates to the Game Refinement Measure**

Gamification is defined as the use of game elements and game mechanics in a non-game environment to improve and emerge as an innovative and effective solution [23]. It is about applying game-based thinking through both intrinsic and extrinsic motivation in which participation and the fun factor are essential [24]. For instance, points, objectives, levels, rankings, missions, challenges, notifications, and obstacles. Thus, gamification consists of game elements, game design, and non-game context leverages the intrinsic human motivations to keep gathering rewards and learning through play [25]. Several researches on gamification reveals the ability of its concept by enhancing engagement and motivational aspects, such as increasing users' satisfaction, increasing users' knowledge, and commitment of stakeholders.

According to game-design elements (see in Table 1.1) consist of dynamics, mechanics and components that are all incorporated each other [26]. They generate the user engagement and encourage user's enjoyment and curiosity. For example, ranking can be more competitive among user and other users. It is impossible to use all gamified elements within one gamified module, therefore before applying, it should be considered and figure out what goals is aimed to achieve. Furthermore, it should be care about creating an experience that user can feel engagement with service or product, motivate them to learn, and feel gamified experience.

As mentioned above, gamification is consisted of game elements and game design. However, early gamification strategies focus on how to increase attractiveness and engagement between users and products in business domain. But most businesses now have implemented gamification into their business model to keep customer retention while increasing the customer satisfaction [27]. They also prefer customer acquisition and determine the best monetization way. Game elements play as a virtual expression for players and game design approaches the feeling or experience to players.

### **1.1.3 Platform Transformation and Game Development**

Here we explain about platform transformation and game development. Twenty-first century games are much more complex and richer than the past. Modern games can hardly be

TABLE 1.1: Fundamental game design elements

<b>Dynamics</b>	<b>Mechanics</b>	<b>Components</b>
Constraints	Challenges	Achievements
Emotions	Chances	Avatars
Narratives	Competition	Badges
Progression	Cooperation	Collections
Relationship	Feedback	Unlockable contents
	Resources	Leaderboards
	Rewards	Dashboard
	Turns	Levels/Tiers
	Win-Lose status	Points/Scores
	Exchange	Virtual Goods

compared with the first generation of electronic games [28]. The changes of games has moreover increased significantly in terms of the existing elements sports that are being consolidated and transferred into the virtual game environments [29]. This not only relates to the simulation of well-known sport, but also incorporates aspects of human and computer interaction being part of a game. Given the increasing applications of advanced technology in traditional sports, the improvement of the versatile content has been supported by such as portability (mobility), accessibility (generality), and convenience (simplicity) [30]. Most studies have focused on the drivers of the initial acceptance of the games, and the users' continuance behaviors have been mostly ignored. Some paper examined the effect of factors on intention to continue playing, and some relevant research [3, 4, 5] showed the adoption of factor to quantify the social interaction and entertainment contribution in the view of developers and players. This concept has been promoted repeatedly and became to be essential driver for identifying in game design pattern. The direction of platform transition could be analyzed by using the concept of increasing enjoyment.

The study about platform has become progressively prevalent during past decades. The definition of platforms changes broadly between the general and specific. Some analysts characterized as technological building with essential functionalities to a system [31]. Some of them may refer to platforms as complementary innovative items and services [32]. In hardware viewpoints, a platform may refer to an operating system with hardware configuration and software system which several related components and services run [33].

At present, we cannot deny the fact that we use platform as one of the medium to connect and communicate with data, information, and sharing knowledge [34, 35]. Especially, advancement of technology supports and breakthrough the limitation of innovation. For example, WeChat, it provides a variety of complementary functions such as chatting, gaming, online shopping, and internet banking that create interaction between users and software in useful ways. Steam is one of the example in game industry, it is being as a game publishing station that users join and buy a game they prefer. On the other aspects, we can look ahead on the definition of platforms, they can be gaming console or devices which contains diverse functions and response the user's demand. Nintendo Switch (combination of Wii and Nintendo DS series) exhibits impact to players by providing interesting gaming experience and better flexibility. This provides sense of interactivity while feel with variety types of games. From our study context on entertainment platform, next generation platform would be a device that reduce border between reality and virtual world and combine all complementary functions based on the objectives and demands. In case of an education area, online platform and e-learning are introduced and very popular mediator that stakeholders and educators could enable absorbing and exchanging the knowledge [36].

When you think about the entertainment experience from the game, there are several stimulators in order to improve the experience and emotional impact while playing the game. For this reason, many studies [37] illustrated that now the game players are not only teenagers, games are widely get into adults and old persons. The purpose and objective would be considered to achieve and affect to players, if players can play interactively with games and enjoy with the functions inside both hardware and software, it will be effective and great contributions for the platform transformation and game development.

This studies presents the overview of enjoyment factor in game context, especially focusing on portable devices. Flow theory is a concept invented by Csíkszentmihályi [38] to represent the emotional state in which a person is fully engaged into the activities such as learning, thinking, playing, and etc [39]. People experience flow in a wide variety of daily activities such as sports, music, learning, working, and training. They described proposed concept that flow and playfulness are the most important intrinsic reward affecting player behaviours

in pleasant sensation. In the existing literature, flow theory is regularly comprised of four dimensions including attentiveness, curiosity, intrinsic motivation and control sense [40, 41]. [42] also mentioned that it has many of the same aspects of flow. Trying to convince and motivate people into comfortable zone which is equally between ability and challenge. Interactivity is also one of the recent trend that has been introduced to every domain not except in mobile game such as Pokemon Go!, virtual reality (VR) games, augmented reality game (AR) games, and etc. Other factors and information will be described in the chapter 5. This concept is one of the choice to understand perceived enjoyment, as widely applied and proven as the key essence in game and platform changes. Its definition and further details including methodology and scope of the study will be discussed in the chapter 2 and 5.

## 1.2 Problem Statements

According to overview from the previous section, different person has their own preferences to feel entertaining. Games have changed time after time, and they are affected by a player directly in which they performed mix of gaming behavior and interaction [8]. Many studies have analyzed on the game designer point of view. Recently, most of business company have tried to involve user-centered analysis and study to fully understand the user demand. In the advancement of technology, users could be more faster in sense of getting entertainment, boredom, frustration, and excitement experience. Also, we can see that there are several opportunities to take actions such as online education, online shopping, and etc. We are already known that engagement from user is necessary to create productively and effectively results [39], i.e. what users really want to acquire during they are immersed with. Problem statement is stated here as follow.

**Problem Statement** How to improve the entertainment factors and identify application into platform transformation and game development related to users' aspects.

So entertainment would be considered and entertainment factor is highlighted as a distinct emotion of enjoyment. When specific factors were found, they are likely to become great

directions to improve, leading to game development and platform transformation in a right path. Addressing this topic will give insight to adjust game features and business strategies.

The aim of this research is to investigate effective entertainment factors in various game platform. Likewise, it aims to improve the entertainment experience in game for driving platform transformation and game development in which can be useful in the game industries and other domains such as education and finance. We identify the most significant factors in each game platform through surveys and questionnaires, and conduct experiments to measure the entertainment impact of different platform by using game refinement theory and gamification perception.

In this thesis, we focus on many layers in game in order to fully perceive about the changes of game through gaming platform changes. For each chapter, we aim to use various methodology which will be approached to answer the research questions.

## **1.3 Structure of Thesis**

There are further 6 chapters in this thesis. We present the analysis of entertainment impact on mobile games, and then try to investigate the entertainment factors from game elements, game structures, and game platforms. Chapter 1 gives the background and the problem statement of this research.

In Chapter 2, we review and provide the related works. Game refinement theory and platform transformation are the important concept in this thesis. Thus, this chapter provides the their definition, application, and research gaps.

In Chapter 3, we reveal the first example of using game refinement theory. We show how this theory can be used for finding comfortable setting in the game, as we set up the family of game variants that could affect to the player's experience. Also, finding the entertainment impact and changes in game itself.

In Chapter 4, we present the another example of game refinement theory to mobile multiplayer online battle arena game (MOBA). Not only game context aspect, but also non-game context aspect such as monetization way. The first spot is to create game progress model in other domains. Another spot is to determine the differences from PC version and mobile version. Game features and game mechanics were changed to reach the appropriate game length. We show game refinement measure can improve entertainment impact of the game and provide new playing experiences.

In Chapter 5, we widely observe to the big spot. Platform transformation and game development are mentioned in this chapter. Based on perceived enjoyment, we construct proposed model and entertainment factors to verify the impact of each factor comparing to each platform. The significant statistics and perceptions are provided to fully understand the changes of games and platforms. Also, this chapter provide the brief application and conceptual scheme that will be used for creating entertainment educational classroom.

In Chapter 6, we present the example of gamification approach in the platform transformation. Mutual fund investment is introduced in this chapter, which we analyzed on how to increase engagement and interactivity by using entertainment factors and gamification driven factors.

At last, we give the conclusion of this thesis. According to the findings in previous chapter, we provide the possible best answer for the research questions and explain the contribution for this study.

## CHAPTER 2

### Literature Review

---

In this chapter, we first present the existing and related concepts which are inspired and applied into this thesis. We divide into two main topics, which is game refinement theory, and platform transformation and game development. This chapter gives sketch the fundamental idea of the concepts and their previous studies.

## 2.1 An Overview of Game Refinement Theory

### 2.1.1 Introduction

Several efforts have been made to explore the conceptual implications of the increasing attractiveness and sophistication of the game. Game refinement theory was invented by Hiroyuki Iida *et al.* and was proved by many publications [21, 43, 44, 45]. This theory has met a question of which game is more interesting, or more exciting. Exactly, the game refinement is established, which is strongly related to Newton Laws and the psychological aspect. According to the previous mention, game refinement theory focuses on playing game, not on how to achieve the best winning strategies. In this section, we will represent the interpretation of the theory, mathematical model representation, and also interesting previous work will be mentioned.

In fact, game designers often consider an important point, which is how to make the game more entertaining. From the player's point of view, they also want to have the best experience and balance between challenge and ability. The factors concerned should be discussed in terms of fairness and length of the game with regard to the uncertainty of the outcome. The



relationship between the duration of the game and the result is quite strong. If the duration of the game is too short, the outcome would be stochastic since the player might not be content. On the other hand, if the game duration is too long, the outcome would be visible and trigger boredom. Hence, the game duration or game length is essential parameter would be concerned. Appropriate game length provides fairness and attractiveness. In deeper detail, for example, we can use this theory to observe the evolution of game history.

A general game refinement model was formulated based on the concept of game-progress and game-information progression [21]. This bridges the gap between board games and sport games. The development of the 'game' is twofold. One is game pace or scoring amount, while the other is game information progress with a priority on the outcome of the game.. 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  $0 \leq t \leq t_k$  and  $0 \leq x(t) \leq x(t_k)$ , as shown in Equation 2.1.

$$x(t) = \frac{x(t_k)}{t_k}t \quad (2.1)$$

However, the game information progress given by Equation 2.1 is unknown during the in-game period. The presence of uncertainty during the game, often until the final moments of the game, makes game progress as exponential. Thus, the equation generates a precise description of progress in game information as Equation 2.2.

$$x(t) = x(t_k)\left(\frac{t}{t_k}\right)^n \quad (2.2)$$

Here  $n$  stands for a constant parameter that is given from the viewpoint of the observer of the game considered. The acceleration of the progress of the game information is achieved by deriving the Equation 2.2 twice. Solving it at  $t = t_k$ , we have Equation 2.3.

$$x''(t_k) = \frac{x(t_k)}{(t_k)^n} t^{n-2} n(n-1) = \frac{x(t_k)}{(t_k)^2} n(n-1) \quad (2.3)$$

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 subject to the forces and laws of physics. If there is less complexity in the game information, they may become tedious and feel unchallenged, while too much complexity outperforms the experience of entertainment being anxiety. Therefore, we expect that the larger the value  $\frac{x(t_k)}{(t_k)^2}$  is, the more the game becomes exciting, due in part to the uncertainty of game outcome. Thus, we use its root square,  $\frac{\sqrt{x(t_k)}}{t_k}$ , as a game refinement measure for the game under consideration. We call it  $GR$  value for short as shown in Equation 2.4.

$$GR = \frac{\sqrt{x(t_k)}}{t_k} \quad (2.4)$$

## 2.1.2 Game Progress Model

It is an essential and challenging task to construct a mathematical model of game progress and game information progress towards the main objective. from which a game refinement measure can be acquired. Below we present a brief description of three main game progress model, which have been often used to analyze game such as boardgames, sports, and computer games.

### 2.1.2.1 Board games

During in game period, there is always uncertainty until the very end of the game. That dynamics situation is a key factor in generating the entertainment including the unpredictable outcomes, then the decision option in the space has been investigated. Regarding to [46], the principle of seesaw game explain the game with uncertain outcomes. From the player's point of view, game information generally increases over the time. It means that increasing function should be derived. Game information progress displays how certain the outcome of a game is in a certain time or step. Let  $B$  and  $D$  be the average branching factor (number of possible options) and the average game length (average number of the whole game depth), respectively.

Figure 2.1[21] illustrated the interpretation of the game between available options and game depth. At each depth of the game tree, one will choose a move and the game will progress. The distance  $d$ , which has been shown in Figure 2.1, can be found by using Pythagoras theorem, this providing in  $d = \sqrt{\Delta l^2 + 1}$ .

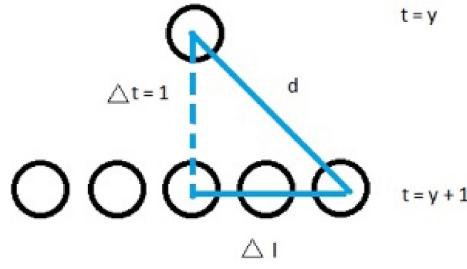


FIGURE 2.1: Decision tree of a two-person game

Assuming that the approximate value of horizontal difference between nodes  $\Delta$  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 it becomes smaller nearly 1 if we compared to  $B$ . The game length will be normalized by the average game length  $D$ . Then the game progress  $x(t)$  is given by  $x(t) = \frac{t}{D}d = \frac{t}{D}\sqrt{(\frac{B}{2})^2 + 1} = \frac{Bt}{2D}$ . Generally, we can get generalized as  $x(t) = c\frac{B}{D}t$  in which  $c$  is a different constant depending on the game considered. If we assume  $c = 1$ , then we have got a feasible game progress model for boardgames. Game information progress provides unknown situation during the game period. Thus, the game information progress is reasonably assumed to be exponential function as Equation 2.5.

$$x(t) = B\left(\frac{t}{D}\right)^n \quad (2.5)$$

Then, we derived as the same derivation as we did in the Equation 2.3. Therefore, GR value for boardgames can be obtained by using Equation 2.6

$$GR = \frac{\sqrt{B}}{D} \quad (2.6)$$

TABLE 2.1: Measures of game refinement of major board games

Game	$B$	$D$	$GR$
Western chess	35	80	0.074
Chinese chess	38	95	0.065
Japanese chess	80	115	0.078
Go	250	208	0.076
Mah Jong	10.36	49.36	0.078

We show, in Table 2.1, a comparison of game refinement for traditional boardgames [47].

### 2.1.2.2 Time limit sports

In the time limit sport domains such as football and basketball, game refinement measure was calculated by  $GR = \frac{\sqrt{G}}{T}$  [21]. By considering two parameters, let  $G$  and  $T$  express as the average number of successful shoots/scores and the average number of shoots/scores per game (number of attempts) respectively. Short description of this idea is twofold of game progress [21]. One is game speed or scoring rate, while another one is game information progress with focus on the game outcome. In case of time limit sports, we focus more on total score. Thus, the game speed is given by the average number of successful shoots divided by the average number of shoot attempts over the time. Therefore, GR value for time limit sports can be obtained by using Equation 2.7.

$$GR = \frac{\sqrt{G}}{T} \quad (2.7)$$

### 2.1.2.3 Score limit sports

In the score limit domains such as volleyball, badminton and table tennis, the game is regulated by a score. By considering two parameters, let  $W$  and  $T$  which express as for the average winner's score and the average total scores of entire game respectively. In case of time limit sports, we focus more on time or step to achieve the goal. Thus, the average number of total points per game may correspond to the steps to achieve the goal [48]. Therefore, GR value for time limit sports can be obtained by using Equation 2.8.

TABLE 2.2: Measures of game refinement of various games and sports

Game	$B$	$D$	$GR$
Western chess	35	80	0.074
Go	250	208	0.076
Football	2.64	22.0	0.073
Basketball	36.38	82.01	0.073
Volleyball (25pts)	25	44	0.114
Badminton (New system)	46.34	79.34	0.086
Table Tennis (Post-2000)	54.86	96.47	0.077

$$GR = \frac{\sqrt{W}}{T} \quad (2.8)$$

We show, in Table 2.2, a comparison of game refinement measure for various type of games. It can be seen that sophisticated games have almost a common factor, the same degree of acceleration, a feeling of engagement or anticipation, regardless of the various sort of games.

### 2.1.3 Applications in Various Fields

According to the basic idea of game refinement theory, we have applied the model of different areas. Many further investigation using this theory have been working both game context and non-game context.

The idea was proposed to the crane game [49], also digger or claw game. It is a type of arcade game which has been popular around the world. The game characteristics which is coin-operated, playing cost is defined as the enjoyment impact. They proposed  $c$  as cost per attempt normalized by the average cost per attempt of each country. Let  $P$  and  $T$  be the average number of prizes captured and average number of attempts, respectively. They derived function  $x(t) = \frac{P}{cT}t$ , then acceleration of game information progress is obtained as Equation 2.9

$$GR = \frac{\sqrt{P}}{cT} \quad (2.9)$$

Likewise, [50] applied game progress model in fighting game, which the player controls a character and engages in the combat. They defined  $G$  and  $T$  as the average number of successful damage and the average number of attack per game. The famous games were selected to collect the data and analysis. They determined the game rhythm that affect to the player. Also, this result can be used to identify the suitability for the competition in both sense of players' experience and audiences' engagement.

Another approach is to finding the comfortable setting in the game variants or game elements. [51] aim to determine the possible option in Pokemon Battle and appropriate number of Pokemon in the battle. They verified by using boardgames approach. There are several research on Pokemon [51] that determine the capabilities and effective settings for this game.

For non-game context, [52] tried to define the business model in various aspect such as digital games, tier system, point system, discount program, and loyalty program. They were trying to realize the link between game refinement interpretation in fun game context and serious game context. There are several attempts have been done in serious game domain. Also, in education aspect, [53, 54, 55] analyzed the education games and find the best definition of acceleration in education context that more concentrated on improving the ability of educators than the challenge.

## **2.2 An Overview of Platform Transformation and Game Development**

### **2.2.1 Introduction**

At present, we have been pointing at the progression of this gaming entertainment experience over the years, several ongoing improvements year after year is becoming almost casual gaming and available on accessible platforms. The growth of casual games has various reasons, mobile casual games are generally used by beginners or casual players to reduce boredom. Smaller screen size and input keyboard are a constraint on complex games, while they are reasonable for casual games. It usually simple and easy to play, and also are familiar

to a large segment of current owners of mobile devices and familiarity is an essential factor in the decision to buy a game [28].

Previous research suggests that screen sizes have a positive impact on task performance [56]. According to [57], there was no significant difference between learning and retrieval of information on smaller and larger screen devices. However, when users were asked to make a rationalization or to make decisions based on the information gathered, their performance decreased on smaller devices. This confirms finding of [58] that the performance of tasks on smaller screens is drastically lower than it does on larger screen sizes. Regarding to [57], they suggest that reducing scrolling interfaces on smartphones can improve performance. Researches have shown that smartphone users have a divided focus relative to desktop or laptop users. According to [59] found that smartphone surveys have taken longer to complete than PC surveys. Likewise [60], they found that people pay more attention to larger screen sizes and were more excited than smaller screens. However, not all tasks may benefit from larger screen displays [61].

There are some studies that showed the performance of user in the same tasks and compared the performance in both PC and mobile phone. For this reason, the effect of platform changes is be able to imply as the efficiency improvement of its application, also reaching the various experience during performing the tasks or activities [58, 61, 62]. As the prevalence of handheld devices continues to increase, people prefer the this one because of their high portability and simplicity [63, 64]. The characteristics of the portable platform show a significant difference in the experience of users. The majority of users ranked smartphones as marginally more optimistic than pessimistic, that was not relevant for personal computers. This finding strongly supports earlier studies that portability and simplicity have a huge impact on mobile device [64].

With the launch of the first generation of smartphone in 2007, the domain of mobile gaming has been becoming evolving. According to advancement of technologies, not only mobile games can be quickly accessed to play offline, but it can also be played online in real time with a wireless connection [30, 65]. It enables users to play anytime and anywhere, also stop and resume playing quickly in order to have a better gaming experience [65]. Game in this

decade have attracted many new users who likely to play simple or casual game in a short amount of game length, or just to pass time or escape daily life [37]. This fact leads that game development is essential issue to adapt time by time, also the platform that should correspond the changes in game to provide content experience during in-game period.

Consequently, in this section, we will determine entertainment factors as driving the gaming experience. In addition, we also try to characterize the drivers of entertainment factors in each platform and each game genre. Through studying the contributing factors to provide satisfaction, we intend to shed light on how enjoyable gaming experience promotes changing in gaming content and platform.

### 2.2.2 Perceived Enjoyment and Entertainment Factors

The previous study focused on considering the key drivers of perceived enjoyment and the degree to which perceived enjoyment drives persistent handheld game use. Technology Acceptance Model (TAM) has clearly been the most commonly used conceptual model and has been broadened to other factors relevant to gaming configurations. TAM has been demonstrated for independent decision-making on innovation in a setting. Through further advances, the final TAM design consists of perceived ease of use (PEOU), perceived usefulness (PU), behavioral intention to use and actual use as shown in Figure 2.2 [66, 67].

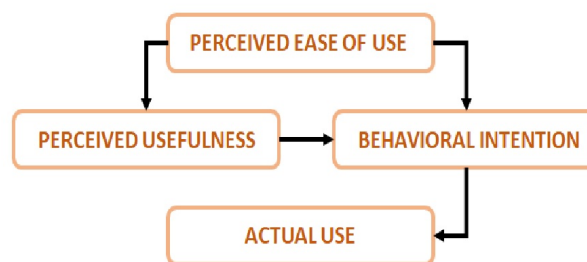


FIGURE 2.2: Technology Acceptance Model [66, 67]

In particular, the perceived enjoyment construction has been added to almost all of the research models. It has been identified as the most important predictor of the implementation



of mobile games [68, 69]. There are some researcher found another on point that perceived expectancy (PE) had a significant impact on attitude, but not directly on behavior intention [70]. Furthermore, attitude has also been found to be a strong predictor of use intention studied by [71, 72]. Another study [73] had also used Flow Theory to study the implementation of mobile games by users. Throughout this research, flow is seen as a blending between anxiety and relaxation [38, 73]. The finding shows that the flow experience had a very significant effect on the purpose of use. Once players feel high acceleration and enjoyment, they have a higher goal of playing games.

A preliminary study on smartphone games shows a number of research gaps. A limited number of previous studies with significant use of TAM in the interpretation of human behavior in this area. Current studies have primarily focused on understanding the histories of the desire to foster at the pre-adoption phase, while ignoring post-adoption behaviors that are crucial to long-term success. Moreover, perceived enjoyment is continually confirmed as having a better impact on industry trends in game development, especially mobile gaming [68, 69, 74, 75, 76]. Perceived enjoyment has been promoted and became to be essential driver for identifying important game design [1, 37]. In this thesis, we believed that this theoretical framework can help identify and predict the direction of platform transition. Perceived enjoyment consists of five factors as design aesthetics, ease of usability, interactivity, variety/novelty, and challenge [1, 37] (see in Figure 2.3). In entertainment aspect, there are only interactivity, variety, and challenge. The main reason is that users can directly feel these intrinsic factor with common understanding. While perceptual factors need high understanding which is provided by developers. The definition of entertainment factor will be used as improvement factors for analysis the platform transformation. The proposed model and definition of each factor will be clearly described in the chapter 5.

### **2.2.3 Gaming in Education**

The higher progress of technologies and the evolution of gaming technologies have almost become part of our lives, our societies, and our homes. Technologies have helped to shape

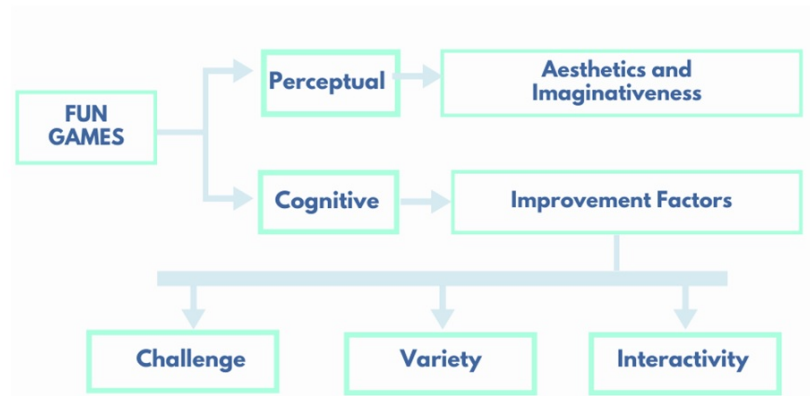


FIGURE 2.3: Perceived enjoyment research model for continuous use [1, 37]

the new ways in which people are learning, collaborating, and forming the technology-driven systems. Gaming technologies have become an essential role in most children's leisure activities and increasingly being integrated into the educational aspects. Even though these kinds of things have been considered as a disruption to the classroom, however, many experts and researchers show the application of gaming technology [77, 78, 79, 80, 81, 82] and game-based learning [83, 84, 85, 86] have been quite practical to enhance motivation and engagement as well as improve learning outcomes. Using gaming technology in the classroom is more than letting students in playing games, it also means allowing them to learn through play [87] which there are many studies that have been investigating terminologies and benchmarks [88, 22].

With a great combination of technology and education, A multitude of learning ways will be improved, and then the classroom will become more meaningful and enjoyable. It was revealed that the use of modern technology and tools would increase the learning rate and interactivity of students [89, 90]. The new type of technology devices or gaming technology might be useful to indicate the balance between traditional approach classroom and innovative classroom. Hence, one of the research questions is to address the positive impact of using technology in the classroom. Most studies have shown the benefits of the use of technology in the education field. The role of technology in education is quite vital; coming up with how to integrate and improve our use of technology to enhance the learning rate and engagement at

the same time. The challenge is therefore to create an effective condition which likely to learn in the classroom. Recently, advanced technologies link classroom and artificial intelligence (AI), it somehow changes and shapes our educational experiences at rapidly acceleration rate. For example [79, 91, 92, 93], AI may transform by bringing intelligent tutoring systems, virtual and augmented reality (VR and AR), and online learning systems.

However, its application way into formal education is scarce and different problems have been identified. First, there is a lack of acceptance of games as educational or learning tools. Besides, teachers and educators have no good way for integrating games into a regular classroom. Consequently, it requires determination such conceptual framework and critical factors that generate effective outcome for promoting students' engagement. For instance, games can be used as learning tools, motivation tools, assessment tools, skill-improvement tools, etc. Most game platforms implemented in the classrooms are platform-based. However, portable platforms have also been widely used as learning tools in the schools [33, 77, 90, 92]. Especially in mobile phones and tablets, they aim to use platform in science laboratory classroom based on concepts of try to understand hard subject by easier way, and the potential to studying vocabulary using supporting platforms [94]. Some schools conducted game platform into classroom based on concept of doing thing you cannot do in the real life. They also provide many different kind of applications to enhance quality of classroom and also enhance engagement of students. This is one of strong appeal of gaming technology, you can learn and improve your skill and experiences in real world by virtual world.

## **2.3 Chapter Summary**

As several previous works accomplished, it is obvious that game refinement theory can effectively be applied in many domains not only fun game context, but also non-game context like a serious game. Game refinement approach in boardgames and sports can be used to measure and quantify attractiveness and entertainment impact of a game, also encourage game development because this theoretical concept could make impact to game designers and game industries. It drives game designers to make a better, more sophisticated, more

entertaining experience game. This section provides fundamental aspect of game refinement theory and its recent works. According to literature review, we can found that game refinement measure converges around 0.07 to 0.08, that is sophisticated zone. It may imply in many various interpretation, but most of popular games and sports are represented game refinement measure around the zone. This zone is quite implied as the mixture of stochastic and skillful in which players will experience during in the game. However, we need to perceive that game refinement theory could not apply for every game. It depends on the mathematical model construction which affect to the objective of this measurement. In the next chapter, we will use this theory to analyze game elements and variants in the game to find the comfortable setting.

Moreover, we take a look wider for the platform transformation and game development which is related to user-centered study. Regarding to previous works, there is a gap that many research tried to analyze only continuance use. It is believed that we still have a chance to analyze the change of gaming experience by using perceived enjoyment concept. Not even in the game domain, education context and other domain would be considered. The platform plays as a education tools and knowledge-based system. If we change an element or a content, it might improve the efficiency of users. Also supporting technology could increase the performance of learning rate, and gaming technology could enhance engagement of students such as game-based learning, learn through play, and gamification. In chapter 5 and 6, we will describe what we have attempted based on using these concepts and existing literature.

## Finding Reasonable Setting in Games

---

This chapter is an updated and abridged version of work previously published in

- Punyawee A., Panumate C., Iida H. (2017) Finding Comfortable Settings of Snake Game Using Game Refinement Measurement. In: Park J., Pan Y., Yi G., Loia V. (eds) *Advances in Computer Science and Ubiquitous Computing. UCAWSN 2016, CUTE 2016, CSA 2016. Lecture Notes in Electrical Engineering*, vol 421. Springer, Singapore

### 3.1 Introduction

As we have explained in Chapter 2, application of game refinement theory could be used to determine the best setting of the game. Preference or setting in game is one of the essential factors, it can lead the game to the entertaining point or frustrating point. This is one of the reason why we can improve the entertainment experience of the game by finding the reasonable setting in games. Therefore, this chapter provides game refinement measure to analyze reasonable setting in games.

In this chapter, we aim to define the reasonable setting of Snake game. We discuss the idea for a new game refinement model that was used to analyze the progress of the game information which centered on the game information of the Snake Games. Game refinement theory is used to assess the sophisticated level of the game and define the appropriate setting. Basic AI was developed to gather data instead of human throughout this study. The results obtained show the reason why Snake Game has been so popular on mobile phones and people can feel

entertaining and excited. We select game progress model which is used for time limit sport to analyze it, the analytical results will be showed in this section.

## **3.2 Analysis of Snake Game**

### **3.2.1 Overview of Snake game**

Snake game is a type of arcade maze game originally developing from "Blockade" which developed by Gremlin Industries and published by Sega in October 1976 [95]. There are many similar game based on Blockade game inspiration, e.g. Bigfoot Bonkers, Surround, Dominos, and etc [96]. Blockade [95] is a black and white arcade maze game with using four direction buttons to control block while length of block is longer. A player must last longer than the opponent before hitting something, with the first person to hit something losing, the game ends after one player gains six wins. This game component is simple, and its simplicity has led to many implementations [95].

Snake games (see Figure 1) are considered to be a skillful game, players try to achieve for maximum score as much as possible. The basic regulation of snake games is to be controlled using the four direction buttons relative to the direction in which the snake's head operates. The snake is rising in velocity as it is getting longer, and there is only one life; one mistake means starting from the beginning. The player loses when the snake crashing with the screen border, obstacles or itself [97]. The most popular version have a regulation that snake's speed will go up when eat the fruit and snake can pass through the wall, then appear on the opposite side.

Nokia is well-known for putting Snake on the majority of their phones [95, 98]. Towards the end of the year 2000, Nokia released one of the most successful phones, Nokia 3310, which is improved to a snake pattern, introduction of bonus bugs, a 'Circumnavigate play area' and mazes (obstacle walls placed within the play area). It had a Snake hiding in its belly be a part of its success, this low-cost, compact design attracted people from all walks of life and it was here that Snake hit the big-time [98]. Snake games are still included on some new phones

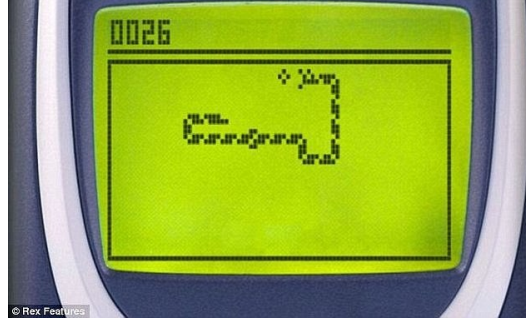


FIGURE 3.1: A screenshot of Snake game on Nokia 3310

from Nokia and available for all platforms. The history of snake games in Nokia mobile phones [96] as shown in Table 3.1.

TABLE 3.1: History of snake games in Nokia mobile phones

Year	Version
1997	Snake
2000	Snake II
2002	Snake EX
2003	Snake EX2
2005	Snakes
2005	Snake III
2006	Snake Xenzia
2008	Snakes Subsonic

In 20017, Snake game had been announced a new version for Messenger, which is incorporated as part of the instant games cross platform experience on Facebook [99]. It has been designed to play with groups of friends, this makes it even more enjoyable than it was the first time around. They enable the community to come together through a free game and encourage others to compete via instant games platform.

NOTATION 1. A family of Snake games are denoted by  $SNG(s, a, m, c, l)$  with the initial physical speed of snake in frame per second  $s$ , acceleration of snake when eating each fruit in frame per second  $a$ , size of the map  $m$  specifying in terms of total area (pixel x pixel), wall condition  $c$  specifying trigger between 0 and 1 which means no a wall and have a wall respectively, and initial length of snake in pixel  $l$ .

- **Physical Speed:** Physical speed is theoretically one of the considerations that usually affect the challenge of Snake game and make it more difficult for players.
- **Acceleration:** Snake games usually require acceleration, when the snake eats fruit and then it will be faster. Once the length of the snake is longer so that its speed is higher.
- **Map Size:** The size of map must be fit to the screen of mobile phone. There are many platforms supporting the snake game, e.g. Computers and Arcades. Size of map (or screen) should vary in size.
- **Wall Condition:** The snake's primary goal is to avoid running into the wall. Nokia 3310, [98] the most popular version, is the first version that change the regulation of the game, snake can pass through the wall and its primary goal will include avoiding to hit itself.
- **Snake Length:** The snake length will increase when the snake eat fruits, somehow if snake length is longer, players should avoid to control snake hitting itself. Players will carefully moving to required fruits.

### 3.2.2 Game Refinement Approach through Snake Game

We propose a new model of game refinement theory based on ratio of total scores and total move attempts. Finally, we can find the game refinement value of snake game. In time limit sport domains, the game refinement measure  $GR$  was calculated by  $GR = \frac{\sqrt{G}}{T}$  where  $G$  and  $T$  stand for the average successful scores per game and the average average number of total shoot attempts respectively. The values  $G$  and  $T$  correspond to  $x(t_k)$  and  $t_k$  in the section 2.1.2.2.

In a Snake game, we construct a game progress model with focus on average total scores per game called  $G$  and average of total number of moves (attempts) called  $T$  as shown in Equation 3.1.

$$GR = \frac{\sqrt{G}}{T} = \frac{\sqrt{(\text{average total scores per game})}}{\text{average total number of moves per game}} \quad (3.1)$$



In this study, we use computer players AI and human player for simulating a 250 games of the classical Snake game and show comparison of these two results.

We first establish AI for collecting the data, which is novice player. The version of the game used for this paper is a replica of the game as it currently exists on Nokia. The original screen size of the game is made up of 240 total pixel squares, 20 horizontals and 12 verticals. Snake generally begin at 4<sup>th</sup> position to 6<sup>th</sup> position of horizontal axis with long length of 3 pixel, and fruit randomly generates in the map except the origin of the snake. The parameters will be adjusted in each simulation. Due to the weakness that AI can not make a decision spontaneously like a human being and can not have a sense of learning, we were trying to implement the AI which can almost be considered to be a novice player as much as possible. The algorithm of the basic AI is shown in Algorithm 1.

---

**Algorithm 1** BasicPlayerAI

---

```

1: procedure DIRECTIONDECISION
2:    $i \leftarrow \text{random from } 0 \text{ to } 2$ 
3:    $\text{fruitPos} \leftarrow \text{random fruit position}$ 
4:    $\text{snakeX and snakeY} \leftarrow \text{position of snake's head}$ 
5:    $\text{headIndex} \leftarrow i$ 
6:    $\text{snakeX and snakeY} \leftarrow \text{headIndex}$ 
7:   if  $\text{snakeY} > \text{fruitPos}$  then
8:      $\text{direction} = \text{up}$ 
9:   else if  $\text{snakeY} < \text{fruitPos}$  then
10:     $\text{direction} = \text{down}$ 
11:   else if  $\text{snakeY} = \text{fruitPos}$  then
12:     if  $\text{snakeX} > \text{fruitPos}$  then
13:        $\text{direction} = \text{left}$ 
14:     else if  $\text{snakeX} < \text{fruitPos}$  then
15:        $\text{direction} = \text{right}$ 
16:   end if
17:   return  $\text{direction}$ 

```

---

We show, in Table 3.2, the human game refinement measures for  $SNG(15, 1, 240, 0, 3)$  and  $SNG(15, 1, 240, 1, 3)$  while using data from human players. We first consider the case of no wall and wall, the measures of game refinement for these two condition. As a result, snake games is played at a time and each game (or round) should generate different and various

results. The value of  $G$  and  $T$  which are collected from AI (see Table 3.3 might be different from human data because players can improve playing skill by themselves during in-game period.

TABLE 3.2: Human measures of game refinement for  $SNG(15, 1, 240, c, 3)$

c	G	T	GR
0 (no wall)	16.5	72.6	0.056
1 (wall)	6.1	31	0.080

TABLE 3.3: AI measures of game refinement for  $SNG(15, 1, 240, c, 3)$

c	G	T	GR
0 (no wall)	4.44	34.98	0.060
1 (wall)	2.18	17.03	0.087

With having a wall condition, game will be difficult in higher speed because we cannot control efficiency. By the way, game will quickly end than no wall condition because of survival situation. Score will be higher when we live in longer.

The concept of human-like AI is possibly due to randomness of snake direction moves. The basic objective of ordinary players is to eat fruits with low move and avoid hitting itself. Most players have your own mistaken control, so AI should be randomized in position of snake head for miss turning of snake to the fruits. This algorithm is to identify its own position time by time. It just calculates the shortest path, also avoid itself only  $i$  pixel which is randomized after the snake grabbed the fruit. As a consequence, if we approach this game progress model, the number of moves will be large once the snake becomes difficult to control. Otherwise the number of moves should be small at the beginning of the game. For the ideal player, they attempt to move as much as they can to stay alive and try to accomplish the target by focusing on eating fruit. For a beginner players, main objective is to eat a fruits with neglecting on any obstacles.

### 3.2.3 Analysis of Snake Game Variants

We present an analysis of game information of Snake game based on variants  $SNG(s, a, m, c, l)$  for finding reasonable setting. Regarding to what we mentioned in previous section, a computer player (AI) had done simulation of playing Snake game. We consider on the original popular version which is set the condition of wall as snake can pass through the wall and appear in the opposite direction of the map, i.e.  $c = 1$ . Because we observe that the condition wall  $c$  affects directly to the difficulty of the game. and the number of moves will be small.

#### 3.2.3.1 Analysis of $SNG(s, 1, 240, 1, 3)$ : Speed

We consider the first case with varying in snake's speed (see Table 3.4), the measures of game refinement for analysing on snake's speed with  $5 \leq s \leq 25$ . Generally, if speed is too high, the controlling is too difficult. In sense of activities and games, if the speed of the game is increased, player could feel excited and challenged.

In such case, it will increase the number of move for survivor. Basically, player can find a survivor way while speed is high level, so the main focus of some players would be changed to survive and less focus on eating the fruit. In the lower speed, players will get more score with less move. In the higher speed, players will get score with less move at the beginning, but moving will increase in very higher speed situation with less score getting. As we can see from Table 3.4,  $G$  and  $T$  is an inverse relationship as we mentioned about the speed. Both  $s = 15$  and  $s = 20$  are nearly represented the setting of Snake game in the sophisticated zone.

TABLE 3.4: Measures of game refinement for  $SNG(s, 1, 240, 1, 3)$

s	G	T	GR
5	5.51	12.8	0.183
10	4.28	11.8	0.175
15	2.18	17.03	0.087
20	2.54	19.46	0.082
25	2.34	20.072	0.076
30	2.06	20.24	0.071

### 3.2.3.2 Analysis of $SNG(s, 1, m, 1, 3)$ : Speed and Map Size

We consider the case with varying in size of the map (see Table 3.5), the measures of game refinement for analysis on snake's speed in different size of map. We focus in value of  $s$  and  $m$  with  $15 \leq s \leq 30$  and  $m = 160, 240, 336, 448, 960$  pixel x pixel. The size of map will control the game length. If the map is bigger, it likely means to be bored. In case of wall condition, the size of the map will be more likely as no wall condition because it will increase a survival way to players as if the speed is too low and the size of the map is too high.

TABLE 3.5: Measures of game refinement for  $SNG(s, 1, m, 1, 3)$

s	m	G	T	GR
15	160	1.80	12.8	0.112
20	160	1.96	13.7	0.102
25	160	1.91	14.23	0.097
30	160	1.96	14.50	0.096
15	240	2.18	17.03	0.087
15	336	2.50	20.33	0.079
20	336	2.30	19.92	0.076
25	336	2.40	20.90	0.074
30	336	2.52	21.67	0.073
15	448	2.44	22.40	0.070
20	448	2.62	22.43	0.072
15	960	3.12	27.80	0.063

### 3.2.3.3 Analysis of $SNG(15, a, 240, 1, 3)$ : Acceleration

We consider the case with varying in acceleration rate of snake (see Table 3.6), the measures of game refinement for analysis on snake's acceleration when it eats a fruit. In detail, the information about acceleration cannot clearly observe while playing because players should focus on their own turn in snake game. In game progress and case of higher speed, players will die quickly if they reaches at some point. In sense of entertaining, acceleration is quite less impact to this game progress model. When game is progressing for many games, the average number of move is the same on each value of acceleration.

TABLE 3.6: Measures of game refinement for  $SNG(15, a, 240, 1, 3)$ 

a	G	T	GR
0.2	2.26	16.85	0.089
0.5	2.31	18.62	0.082
1	2.18	17.03	0.087
2	1.96	16.024	0.087
3	2.43	18.88	0.083
4	2.32	21.92	0.079

### 3.2.3.4 Analysis of $SNG(s, 1, 240, 1, l)$ : Speed and Length of Snake

We consider the case with varying in length of snake (see in Table 3.7), the measures of game refinement for analysis on initial snake's length and speed. Each version of snake game has different length of snake and face against the higher speed level and the length is too long, players will have less choices to survive from hitting itself. If snake's length is too long, number of move will be depended on the decision of players. In that case, AI will random the choice of directions, and find the way to eat a fruit. This behavior will make the snake's length becoming less impact. In practical, snake length is difficult to see clearly in player's view because the screen does not show obviously pixel. However, a big gap in different length of snake will be affect to the difficulty but not in entertainment of the game.

TABLE 3.7: Measures of game refinement for  $SNG(s, 1, 240, 1, l)$ 

s	l	G	T	GR
5	3	5.51	12.80	0.183
15	3	2.18	17.03	0.087
30	3	2.06	20.24	0.071
5	6	4.79	11.09	0.197
15	6	1.25	10.18	0.110
30	6	1.16	10.23	0.105
5	9	4.55	10.48	0.200
15	9	0.92	17.40	0.130
30	9	0.82	8.90	0.102

### 3.3 Chapter Summary

In conclusion, this chapter reveals an approach to find the reasonable setting of the game while analyze the game variants that leads the game become famous for a decade. Computer player (AI) has been developed for simulated playing of Snake game. We analyzed the primary factors that have effect to the entertainment experience of player. We explored that the appropriate setting in snake game for  $SNG(s, a, m, c, l)$ .

According to the assumption of game refinement theory for sophisticated zone, the results show game refinement measure of the classical Snake game that are around the sophisticated zone of range 0.07-0.08. The objective of the game is simple, move for eating fruits which get score as high as possible. While another objective is to survive from the dead. The simplicity of regulation helps game designer that prefer to design this game on mobile phones platform because it is portable and easy to implement a game in many tricks. Snake game is a casual game launched on a mobile phone that has been a success.

Based on the experiments, firstly,  $s$  is around 25-30 for  $SNG(s, 1, 240, 1, 3)$ . Second,  $SNG(15, 1, 240, c, 3)$  can play both either  $c = 0$  and  $c = 1$ , condition of the wall indicates the difficulty of the game. In the same manner with  $SNG(15, 1, m, 1, 3)$ , it is best to play with appropriate map size as same as a mobile phone. For other analysis sections, we explored that acceleration  $a$  and length of snake  $l$  are less impact to game entertainment, i.e. these two variants are subsection of speed, physical speed usually is mainly involved with difficulty by itself.

Consequently, while increasing speed can make entertainment impact during the game. However, player might not want to increase until becoming too excited. Even the classical one is the most popular. Snake game also provides the challenge for player by adding condition wall, or gamification techniques like the leaderboard and achievements. Nowadays, Snake game has been launched on smartphone with high speed of internet in order to compete with others. For this reason, interactivity and variety would be improved even though the main objective of the game might ignored.

In conclusion, it has been showed that AI of snake game is simple with no complicated condition, but all this results can answer why this game was becoming famous. Also, results show the game information which is supportive reason of favouring in Snake games. In the future works, we might analyze the game by deriving a reasonable game progress model and a strong AI performance [100] to quantify another issues or other contexts.

## CHAPTER 4

# **Evolutionary Changes of MOBA Games on PC and Mobile Platform Comparison**

---

This chapter is an updated and abridged version of work previously published in

- Anunpattana, P., Khalid, M.N.A., Yusof, U.K., Iida, H. 2018. Analysis of Realm of Valor and Its Business Model on PC and Mobile Platform Comparison, Asia-Pacific Journal of Information Technology and Multimedia, vol. 7, no. 2-2, pp. 1–11.

## **4.1 Introduction**

As we have explained in Chapter 3 about the application of game refinement theory that could be also use to study the evolutionary changes of game elements from the past. There are several popular game has decide to import their own game to other platforms in order to increase the market base and provide new experience of game playing. The game characteristics is one of the essential considerations, game designers and developers must keep the original game experience while provide new contents that suitable for each platform. People perceives different enjoyment aspects and each platform provides different experiences. Therefore, this chapter provides game refinement measure approach to find the comparisons of reasonable game setting for both PC and mobile platform.

In this chapter, we aim to analyze the game information of MOBA game through PC and Mobile platform. We discuss the idea for a new game refinement model that was used to analyze the progress of the game information which centered on the game information of the Realm of Valor (ROV). Game refinement theory is used to assess the sophisticated level of the



game and the appropriate setting can be defined in both senses of gameplay and monetization. Data collection is set by recording from international tournament and in-game information. We select game progress model which is used for time limit sport to analyze it, the analytical results will be showed in this section.

## **4.2 Analysis of Realm of Valor: Mobile MOBA game**

In this section, we explore the attractiveness and sophistication of Realm of Valor (ROV) using game refinement theory and analysis its business model by focusing on gamification. ROV is one of the most attractive and popular MOBA games in mobile platform. It is free-to-play (F2P) game which is the most popular business model for mobile platform. The findings are used to compare the platform transformation of the MOBA genre, which is the consequence of the quick time combat characteristics. We also show the impact of the evolution skin revenue and battle pass revenue for this game, which has increased substantially over the year due to the number of mobile users.

### **4.2.1 Overview of Realm of Valor**

REALM OF VALOR (ROV) or global name as ARENA OF VALOR (AOV) is a type of 5v5 multiplayer online battle arena (MOBA) game that has been released on smart phone iOS and android platform by Tencent Games. It was originally developed from LEAGUE OF LEGENDS (LOL). ROV has over 80 million daily active players and 200 million monthly active players, which is the world's most popular and highest grossing game in mainland China, as well as the most downloaded app globally [101, 102].

Without using Intellectual Property (IP), despite Tencent owning the developers of League of Legends, Riot Games. However, there are a number of differences made to the game to make it more accessible for mobile users. Given the incredible success of LEAGUE OF LEGENDS and DOTA on PC platform, MOBAs mainly require a critical mass of players in order to have short match waiting times and gain competitive experience for each player [44, 103].

ROV is one of the best examples bringing MOBA to mobile platform, whereas it is a highly competitive game played by two teams: Red and Blue team, each consisting of five players. The main goal is trying to destroy the opponent's main tower/ancient located in the opponent's base. Due to the implementation on mobile platform, ROV is True 5 versus 5 MOBA with 3 battle lanes with quick battle time per game, approximately 15-20 minutes. The battle contains minions which are computer controlled characters that automatically spawn at the generator and make their way towards enemy's generator along the three lanes [102, 104]. The key point as corresponding to our research question, ROV has own characteristics for mobile platform and aim to provide entertainment not only for children, but also every group of people.

#### **4.2.2 Game System and Monetization Model of ROV**

ROV is a Free-to-Play (F2P) game which can be essentially downloaded, installed, and played for free. However, the basic concept of every business has to consider the customer is how to make the profit as much as possible [105], these type of games should include an option that player or user for spending their own money to get in-game purchasable items and privileges including the battle pass [106]. Common examples can be categorized into two types as below: functional items and decorative items.

##### **4.2.2.1 Functional Items :**

Theses items help boost the character and directly affect the win-rate and balance of the gameplay. In ROV, players can play free hero and it will be rotation in weekly. However, if player needs to get permanent hero, they have to pay real money for purchasing. Basically, hero can also purchase by virtual currency, but it is not affordable and take a lot of time to collect money, that is how the company increases the profit. There is a temporary boost item that helps players increase virtual money and player's experience point. Moreover, ROV provides one feature that makes various style the gameplay that strengthen initial abilities of the characters and can be various adapted in each type of the character called "Arcana system" as shown in Figure 4.1 and Figure 4.2 [107].



FIGURE 4.1: Screenshot of Arcana system on ROV

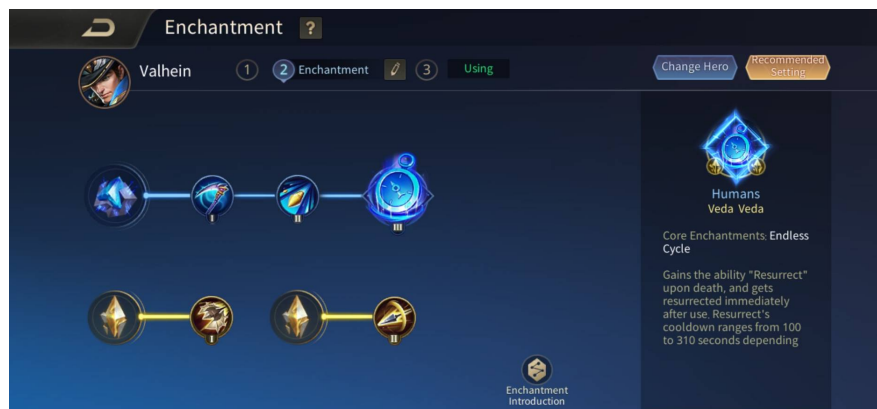


FIGURE 4.2: Screenshot of Enchantment system on ROV

#### 4.2.2.2 Decorative Items :

These items do not affect the gameplay or win-rate, but they will increase to money rate and experience point of players (not heroes). They are solely for appearances also known as skin in ROV, and player has an option to purchase with real money or get from Gacha (lucky draw). Tencent Games has a partnership with DC Comics, one of the largest and oldest American comic book companies that produces iconic heroic character, to create the special heroes and skin. Moreover, there are evolution skin that player can experience special animation, effect, and sound based on tiers system. Player has to accumulate a total evolution point to obtain

higher tier of evolution skin and reach privileges from the skin which is different in each tier, as shown in Figure 4.3 [102, 107].



FIGURE 4.3: Screenshot of evolution skin features on ROV

However, the battle pass (see Figure 4.4) is the one gamification approach to get higher revenue from users like [108]. Players just pay only one time and possibly get the privileges and cosmetics from the battle pass, but players have to pay a bit more to get all privileges including the limited items. In ROV, they called Xeniel's Codex, that players need to achieve the quests in weekly and get the points. Then we exchange the points for items in the pass. Items in roulette in the battle pass contains the limited item, player have to achieve every quest to get, if not, players might have to pay more to acquire the item [107].



FIGURE 4.4: Screenshot of evolution skin features on ROV

### 4.2.2.3 Tournaments and Prize Pool

There was an official tournament in 2017 organized by Tencent Games, which was the first major tournament as Arena of Valor International Championship (AIC 2017) in Seoul, South Korea on November 2017 [102]. This competition have awarded for a total prize value of an incredible \$500,000.

In 2018, they will have a first time of Arena of Valor World Cup 2018 (AWC 2018) in Los Angeles, the United States of America. Garena, sponsor and organizer of this competition, has stated that the tournament's prize pool has been set at total over \$550,000. This breaks the previous world record that Arena of Valor set during AIC 2017. Prize will be awarded to teams and players for various accomplishments in the tournament. There are many famous in Chinese Taipei, Hong Kong, Macau, Thailand, Vietnam, Singapore, Malaysia, Philippines, Indonesia, South Korea, North America, South America and Europe. Previous two tournament, AWC 2109 and AIC 2019, have been recorded as having the most prize pool for MOBA mobile game. Since 2018, they also have competition in Asian Games 2018 and Southeast Asia Games 2019 (SEA Games 2019). Table 4.1 shows the prize pool for the existing major tournaments

TABLE 4.1: Total prize pool for the tournaments

Tournaments	Total Prize Pool
AIC 2017	\$500,000
AIC 2018	\$600,000
AIC 2019	\$650,000
AWC 2018	\$550,000
AWC 2019	\$600,000
Pro League Thailand 2019	\$400,000
Honor of King Championship 2019	\$2,100,000

In the next part, we first give a sketch of the basic idea of game refinement theory and apply to ROV and its business strategy for monetization.

### 4.2.3 Game Refinement Measure for Scoring Information Progress

This section presents the analyzing results of ROV using the game refinement measure to figure out the entertainment and attractiveness of this game. ROV is a game with complex game information, so we need to consider the game progress for this game as same as general MOBA game. We focus on killing progress (contains kills/deaths/assists) because this is the only scoring information that two teams both know during the in-game period and they do not know the other information the opponent achieved. Thus, we need to figure out an appropriate game progress model to apply game refinement theory. We assumed that ROV is similar to sport domain with no score limited game. With this idea, we construct a game progress model with a focus on the average number of successful kills per game called  $G$  and average of total number of attempts (or assists) per game called  $T$  as shown in Equation 4.1.

$$GR = \frac{\sqrt{(average\ number\ of\ successful\ kill\ per\ game)}}{average\ of\ total\ number\ of\ attempt\ per\ game} \quad (4.1)$$

To obtain the game refinement value of ROV, we collect the data from video recording of AIC 2017, ROV Major League Playoffs Knockout Round, and ROV Pro League Season 1 Grand Final [109]. For this purpose, we download all the replays to calculate GR values. We show, in Table 4.2, GR value of each match and calculated the average of GR value of these tournaments. We can see that the refinement value signifies and gradually remain in range of the sophisticated zone and exciting zone. As we have mentioned above, it is developed from LOL and the platform transformation is compulsory thing that company should concern. Mobile MOBA requires the quick time battle to feel excited in short time. We can observed that game refinement measure indicates excitement increase and influence to GR value is more likely to Dota 2 [44, 103]. Therefore, ROV is a well designed game with a good balance between entertainment and competitiveness, which is suited for competitions and every participant as we compared with original PC platform (LOL). Then, short game time provide the best fit for mobile platform and competition. Thus, we see that GR value has decreased from only entertainment to more competitive after 2017 and supposed that ROV will become more and more popular in the future.

TABLE 4.2: Measures of game refinement for ROV before 2017

Tournaments	G	T	GR
AIC 2017	24	53.8571	0.091
ROV Major League 2017	25.5714	58	0.08719
ROV Pro League Season 1	25.3	62.95	0.0799

Moreover, in the competition after 2017, game mechanics and features have been updated as same as the way they improved the game. They have included the new system in the game called "Enchantment system" which increase the challenge and variety of the game. We can see from the Table 4.3, the comparison of game refinement value after 2018. They has made the game become more competitive for introducing in E-sports and beginner players have to take much time to understand the game. The game length becomes a bit longer than the previous, but the GR values is maintained in the sophisticated zone (around 0.07-0.08). We can say that the after the game has been updated, gameplay is now balanced between skillful and luck. Even the speed of the game is higher, but the time is still almost the same and fit for playing in mobile platform.

TABLE 4.3: Measures of game refinement for ROV after 2017

Tournaments	G	T	GR
AWC 2018	26.78	66.91	0.077
AIC 2018	29.03	70.2	0.076
AWC 2019	30.5	70.78	0.078
AIC 2019	35.22	74.2	0.079

#### 4.2.4 Game Refinement Measure for Game System Progress: Arcana and Enchantment system

In this section, we explain about the game system that enhance the variety of the game. Before 2017, this game provide only the arcana system (In this game, we called Rune system), that players can make a combination of power element to upgrade initial abilities before the game. We would like to observe the appropriate number of arcanas which players can add before starting in each game. Fairness is one important point, if players said this system is not unfair for them, they would become boring and frustration easily.

A progression system known as arcana system which is very similar to the Rune system in League of Legends (LOL). As you progress through the game, heroes can be equipped with arcana which strengthen their initial abilities. New slots are unlocked every time the player levels up, and the player can also gain access to multiple arcana pages. Before that, arcanas in the game has only 54 arcanas, but players can make a combination of 66 arcanas in maximum 30 slots for each arcana page now. They can only use virtual money earned after game ending to purchase arcanas from the shop. We construct a game progress model to find GR with consider to number of available arcana slots for each arcana page (30 slots) and total number of arcanas in the game (54 and 66 arcanas) as shown in 4.2, this concept corresponds to boardgame approach.

$$GR = \frac{\sqrt{(\text{number of available Arcanas slot for each page})}}{\text{total number of Arcanas in the game}} \quad (4.2)$$

This system shows the decreasing of refinement value due to increasing of number of arcanas. GR converges to the sophisticated zone that player can experience excited (see Table 4.4. Player can make a combination and lead create various strategies and tactics, thus it can be challenging for layers. GR value indicates the fitness for competition and professional players. This accelerate and various aspect of entertainment in game itself, i.e. it does not affect to the gameplay, but we can say that it expand various dimensions of playing styles.

TABLE 4.4: GR value of Arcana system

Version	Number of slots	Total arcanas in the game	GR
2016-2017	30	54	0.1014
2017-Present	30	66	0.083

For the enchantment system, this system has been updated in 2018. This makes game become more complex, and it almost similar to Arcana system in case of upgrading the initial ability of the character. Players can combine 31 enchantment in maximum 5 slots. Therefore, we also use boardgame progress model to analyze the fairness of this system. We construct a game progress model to find GR with consider to number of available enchantment slots for each player (5 slots) and total enchantment in the game (31 enchantments) as shown in 4.3.



We can see the result of game refinement measure from Table 4.5. GR value shows in fairness area, and means that this system can be useful for competition in professional tournaments.

$$GR = \frac{\sqrt{(\text{number of available Enchantment slot for each page})}}{\text{total number of Enchantment in the game}} \quad (4.3)$$

TABLE 4.5: GR value of Enchantment system

Version	Number of slots	Total enchantment in the game	GR
2018-present	5	31	0.072

#### 4.2.5 Game Refinement Measure for Monetization

We first focus on the cosmetic items called as evolution skin. Game company aims to get money back from this strategy, they released this content to respond the demands of customers and set it as higher cost. Every player has a decision to purchase using real currency to get the unique designed evolution skin as they want to.

Basically, evolution skin originally made up from tiers system even in-game called as evolution level. The maximum level is Level 5, which consists unique effect, sound, animation, and appearances. Let we assume that the initial Level 1 must earn 360 evolution points, such that the score can be purchased by evolution element. One element can vary the points from 10, 20, and 50 respectively. The opportunity to get higher points is less possible, thus we assume that it can get only 10 points for each element in this study.

The game progress of this model is figured out by the ratio of the price of elements obtained over the accumulated price as shown in Equation 4.4.

$$GR = \frac{\sqrt{(\text{price of elements obtained})}}{\text{total or accumulated price}} \quad (4.4)$$

Table 4.6 shows the relationship between required evolution score, number of elements, accumulated price in each tier/level. The price of evolution elements is worth that \$1 each in

the game. Regarding to worth \$1 each , since the price of elements obtained and accumulated price has to be equal.

TABLE 4.6: The relationship between required evolution score, number of elements, accumulated price in each tier/level

Level	Required Point	No. of Elements	Accumulated Price
1	360	36	\$36
2	500	50	\$86
3	760	76	\$162
4	1140	114	\$276
5	1500	150	\$426

In general, MOBA game do not get much money from player basis due to their extremely competitive nature. Cosmetic items (character skins on ROV) as the main source of revenue since they have no effect on the gameplay even though heroes also one revenue, but we focus only F2P concept (does not influence gameplay).

TABLE 4.7: GR value of evolution skins system of ROV

Level	Items	Accumulated Item	Accumulated Price	GR
1	36	36	\$36	0.1667
2	50	86	\$86	0.1078
3	76	162	\$162	0.07857
4	114	276	\$276	0.0602
5	150	426	\$426	0.04845

In Table 4.7, we can see the result which is tabulated the refinement values vary as the evolution skin tier/level. If players decide to pay money, they will be excited for the first tier because it encourages player to try and obtain the privileges. So on, refinement value decreases when it is higher level because the distance (i.e. evolution point) is too wider, so players have to spend too much and feel less exciting. Mostly, reaching to Level 3 and Level 4 have already consisted of unique skill effect, unique animation, unique appearances, thus the player can experience satisfaction at this tier [107].

Furthermore, extension of selling cosmetics in the game has been included in the battle pass (Xeniel's Codex). Some of limited characters and skins are consisted in the Codex. This codex is available to all users, free or otherwise. Generally, players level up their codex with

points, either earned by achievements in game or purchased with money. The codex levels up after players collect 50 points, the rewards unlocked after reaching the certain levels [107]. After reaching the maximum level of codex (approximately 60), players can spin a roulette for limited prizes. The points to spin a wheel is incremented by 10 every single time, starting from 50 points until 110 points. There are 12 prizes in the roulette, so it finally requires 1,110 points for this roulette. There are two types of players, paid players and free players. Paid players will begin at level 21, and free players will exactly begin at level 1. Normally, free players surely could not hit the roulette and end up at level 40. Paid players can spin the roulette, but probably would not get all prizes if they had not achieved all quests.

In this study, we assume that 50 points for 1 level is worth \$1. Paid players would play approximately \$16 to get shortcut way reaching level 21 while free players who want to get the elite prizes need to pay \$8, but it will begin at level 1. For pure free players, they do not need to pay anymore, but they will only get the free type of the prizes. We use the same approach as we used for analysis evolution skins system as Equation 4.5. The main game progress can be given by two factors: the number of successful leveling up and the total accumulated price of codex.

$$GR = \frac{\sqrt{(the\ number\ of\ successful\ leveling\ up)}}{total\ or\ accumulated\ price} \quad (4.5)$$

TABLE 4.8: GR value of codex system of ROV

Level Obtained	Accumulated Price (Free Players)	GR	Accumulated Price (Elite Free Players)	GR	Accumulated Price (Elite Paid Players)	GR
21	\$21	0.2182	\$29	0.1580	\$37	0.1239
30	\$30	0.1823	\$38	0.1441	\$46	0.1191
45	\$45	0.1490	\$53	0.1266	\$61	0.11
60	\$60	0.1290	\$68	0.1139	\$76	0.102
72	\$82.2	0.1032	\$90.2	0.094	\$98.2	0.0864

As a result in Table 4.8, we can see the analysis which is tabulated the refinement values vary as codex level. Refinement values decrease over the time, but the elite paid players will reach nearly the sophisticated zone. As a consequence, if player paid for the shortcut

way, they would not feel too excited. Free players will get nervous and frustrated when they hit the higher level. The trendline of this result is decreasing if the range of level is extended regarding to Figure 4.5. Paid players actually satisfy and have a will to pay for the prizes. In case of some types of players, they want to achieve the quests, but the motivation is important in this moment. At least they might have no doubt to pay for \$8 or \$16 to enhance the motivation.

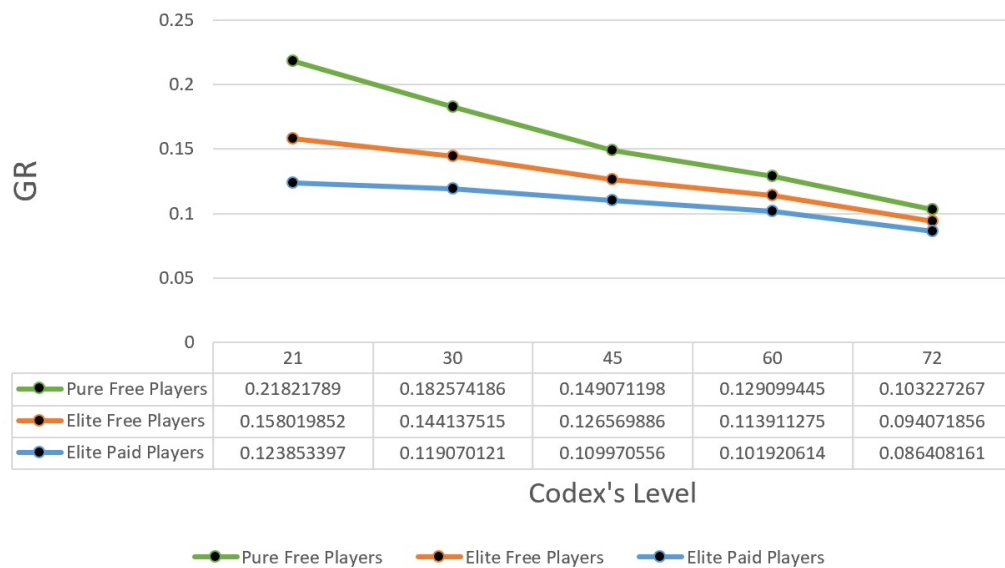


FIGURE 4.5: Game refinement measures among three types of players in Codex system analysis

## 4.3 Evolution of MOBA game and Its Interpretation

### 4.3.1 Platform Aspects

One crucial factor for mobile platforms is the length of the game, which, although shorter but capable of presenting excitement and competitiveness, enables beginners and stakeholders to play and understand less sophisticated details than PC platforms. The trade-off between the two platforms is typically based on technological improvements. Most game companies would launch modern mobile games with such high-performance and emerging entertainment types that lead to how technology and innovation will change in the future.

TABLE 4.9: Trade-off between mobile and PC comparison

	<b>Mobile</b>	<b>PC</b>
<b>Game Length</b>	Short	Long
<b>Technology</b>	Supportive	Supportive
<b>Convenience</b>	More	Less
<b>Design/Implementation</b>	Easy - Moderate	Moderate - Difficult
<b>Specification Requirement</b>	Less	More
<b>Special Features</b>	Various	Various
<b>Equipments and devices</b>	Only mobile phone	Many devices

Table 4.9 shows the trade off between this platform transformation, it is the reason behind of developer perspective, mobile phone is dominant in convenience, design, game length and specification. Even though PC can perform higher performance but user can experience excitement no matter think deeply. Many game industries trendily begin to penetrate huge market with easy to implementation, developing, launching and make impression to their customer experience. Table 4.10 shows the comparison of game refinement measure among MOBA games in PC and mobile platform [44]. It can be seen that the trend in mobile game platform and e-sport competition[107] is now introduced in many major tournament and sports festival. Therefore, MOBA mobile game can provide sense of entertainment and competition. The visualization of average game refinement measure as shown in Figure 4.6

### 4.3.2 Business Aspects

Games are usually developed to be fun and enjoyable. F2P games are in a tough situation in this way, as they need to convince the user to pay money during the game, but it would also be possible to continue playing for free [105].

Generally, the difference business model between PC and mobile platform is how they sold the game, and also how they develop to sustain the game's lifetime. Getting to purchase an expensive game without a chance to try it first was frequently criticized by gaming experts. It has been noticed that F2P games are a more optimal way to bring good revenue. Mobile platforms offer free downloadable games, while PC platforms, especially offline games, need to be purchased first. They have recently introduced modifications and extra content that

TABLE 4.10: Measures of game refinement for each MOBA game and each platform

Games	Versions	G	T	GR
ROV	AIC 2017	24	53.8571	0.091
	AIC 2018	29.03	70.2	0.076
	AIC 2019	35.22	74.2	0.079
DOTA	Version 6.48	69.2	110.8	0.075
	Version 6.74	62.4	102.6	0.077
	Version 6.77	62.8	102.8	0.077
	Version 6.80	68.6	106.2	0.078
DOTA2	TI1 2011	51.3	93	0.077
	TI2 2012	32.5	76.3	0.075
	TI3 2013	36.6	81.8	0.074
	TI4 2014	30	77.3	0.071
	TI5 2015	39.8	89.4	0.074
	TI6 2016	54	94.3	0.078
LOL	Version 6.6	37.65	44.26	0.138
HotS	Sky Temple	77.68	79.9	0.110
	Battlefield of Eternity	99.3	168.8	0.082
	Cursed Hollow	69.55	100.7	0.083

MOBA EVOLUTION VERSUS GR

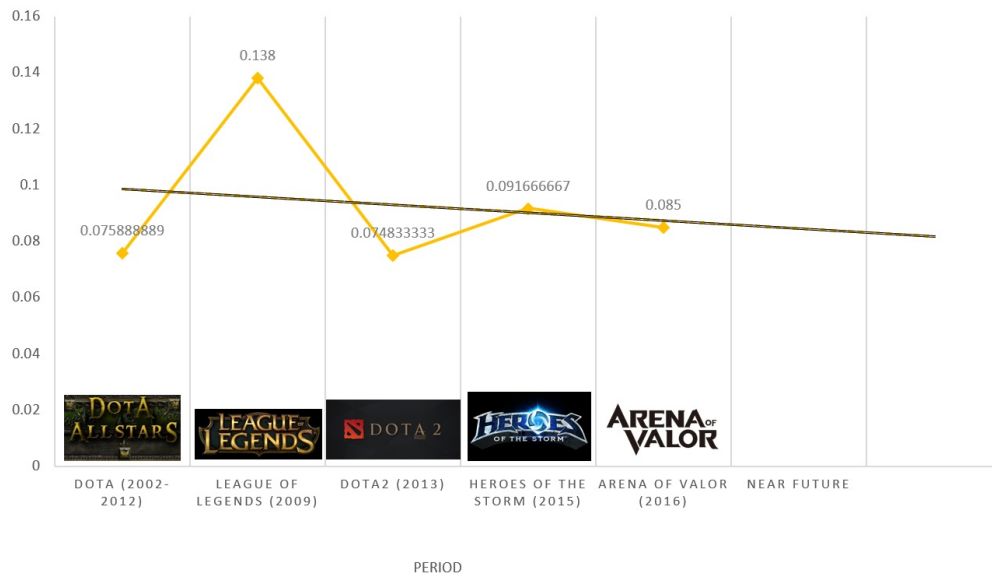


FIGURE 4.6: MOBA games timeline and game refinement measures for each game

players can pay for. Most players are allowed to have a trial version or to get it for free. However, if they want to get more extra content, players will have to pay through the nose.

Codex system is one a good example in this context because it played as same as battle pass (compendium) in DOTA2 [108].

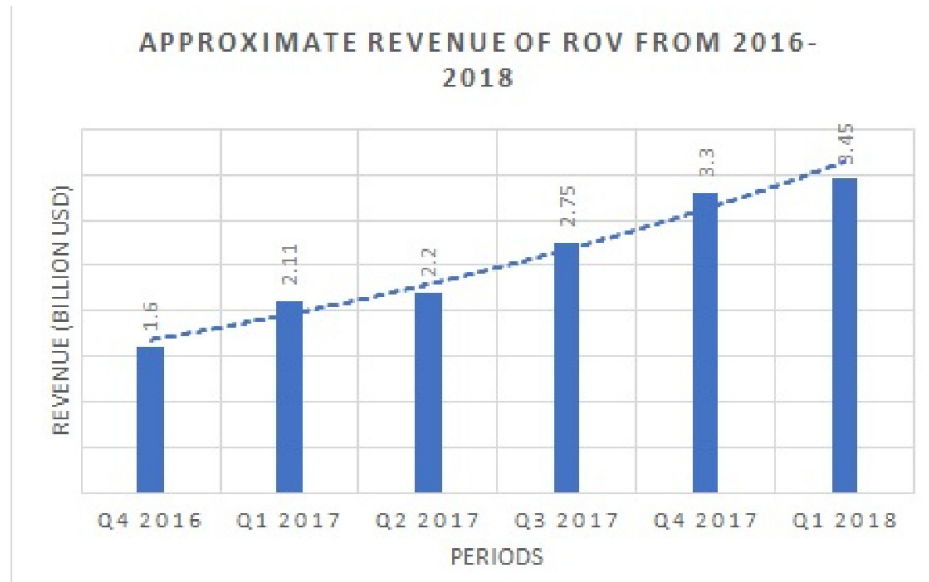


FIGURE 4.7: The approximate revenue of the ROV

As we observed in Figure 4.7 [110]. The approximate revenue of the ROV gradually increase since 2016. The main source comes from cosmetics and in-game purchasable items as we have analyzed evolution skins system and codex system. Tencent Games focus on marketing target which mainly penetrates in China and distribute around the world. It is important to note that the market continues to evolve and grow as smart phone adoption and development increase. This is the significant sign that F2P model acquires higher revenue because ROV represents a very specific genre of MOBA business model due to mobile platform.

Another one concerns is Pay-to-Win facet, they should not develop Pay-to-Win monetizing model even though it can ruin player experience because of imbalance when most heroes cannot be played for free [102]. But they have to put a confidence to those groups of players to be perceived and persuaded. Therefore, it is ready to pay for the privileges that they offer. Platforms have also played and will have a major role in the future. If the platforms change the industry is also strongly influenced. One reason for optimism was that the limit of paying money inside the game would be reduced. This would take the conversion rate for F2P games to a better level, also monetization rate will be changed [105]. The influence of F2P model is

suitable more for every MOBA game and it obviously make player familiar at the beginning and provide long lifetime of mobile game.

## 4.4 Chapter Summary

In this study, we have analyzed on ROV and platform transformation by using the application of game refinement measurement, and studied its business model using gamification. The results indicate that ROV is in sophisticated zone that the game refinement value has significantly converged within 0.07-0.08. Then ROV is a well designed with good balance between competitiveness and entertainment, it implies skillful play with quick time battle per game. Particularly after they have included the enchantment system the performance of game score information provides better-calculated values. Although increasing the number of successful kills and overall attempts in the game, there is no significant effect in the duration of the game, but it could be said that the match is quicker due to the additional system which appears to be smoother in the view of the player.

Therefore, we can say that reducing of game length in mobile platform does not affect the excitement of the game in which their characteristics can improve player satisfaction and the entertainment impact. This popularity has strongly influenced the development of ROV and mobile phone game development industry. Most mobile phone user usually like stochastic game with competitiveness, and game system progress has been introduced to make new entertainment experience. Players do not feel imbalance but they can feel the various playing styles instead. We have analyzed by using boardgame approach model to quantify number of possible (appropriate) options, that mean number of arcanas and enchantments in this context. The result shows the well-organized of these two systems. Therefore, mobile platform transformation try to concise the system into suitable design when we compared to PC platform and design new prototype characteristics in order to get player satisfaction in new entertainment point of view. In fact, the near future probably promises a number of opportunities for PC as well as for mobile games depending on technology development and



support. It means that we will be able to enjoy high quality gaming content no matter what device is used.

ROV continually improved to increase their revenue over the years. The direction of Tencent Games is to keep customer retention and aim to Asia market before distribution around the world. The concept of F2P has been introduced in the mobile platform because number of mobile users obviously increase every year and also are obviously more than PC users so that number of active users of ROV is so high. ROV has specific monetization model, evolution skin is one that this study interested, as GR value of level 3 and 4 are in sophisticated zone, hence company can get revenue approximately \$200 per player, if players is willing to pay for privileges at this tier. Similarly, the enchantment system will definitely get revenue from player at least \$16, and they will be forced to get the limited prizes and pay at least around \$20 when player reached at level 60. They can improved a better their tier systems and provide a much significant reward in the future that influence to increase worth of in-game items. It will improve the excitement for player and revenue of this business model each other.

Further works can be conducted to analyze the motivation on how fully mobile platform would work in the future. However, we can analyze on fairness mechanism by using game refinement theory on ban-pick system and hero picking strategy that interpret whether imbalance or not. Moreover, the prospect of the F2P games looks pretty good, both for designers and players as both gameplay and behavior are expected to improve. Nevertheless, while the confidence in better more versatile and environmentally less controversial games was high, it may not be simple to get there. F2P players are in a considering spot: balancing between a fun game and getting revenue and rising the conversion rate are tough future challenges [105].

## CHAPTER 5

### User-Centered Entertainment Factors

---

This chapter is an updated and abridged version of work previously published in

- Anunpattana, Punyawee & Khalid, Mohd Nor Akmal & Iida, Hiroyuki. (2019). User-centered Entertainment Factors for Platform Transformation and Game Development. Proceedings of the 1st International Conference on Informatics, Engineering, Science and Technology (INCITEST2019), Bandung, Indonesia.

#### 5.1 Introduction

As in the past year, both hardware and software gaming technology is making fast and omnipresent change. In terms of entertainment experience, platform transformation and game development technology allows users to encounter thrilling sensations. The new approach gains from technical improvements and provides high performance. Researchers and psychologists have begun exploring the factors that drive the entertainment experience of playing games [28, 111]. Game diversity has also expanded with respect to the current gaming components that are being integrated and applied to the virtual game environments. Given the increasing applications of digital technology in traditional sports, critics can mention that the worlds of virtual and non-virtual sports are approaching and merging [5].

Successful of mobile game industry and versatile game development have provided and expanded the line between casual, free-to-play mobile games and traditional console games has been becoming beyond recognition. Big game companies have entered the game market with the primary question, which seems to have been crucial until now. Why are games

fun? What makes any game fun? When a group of developers or companies creates a new game, their primary goal is to make the game fun and lead the players to satisfaction point of experience. However, not every new game is fun, because the facts are ignored: What kinds of games are fun? Why are these games fun? What makes people perceive enjoyment? Answering these questions in a statistics and scientific way are the objective of this study. We considered evolution of this gaming entertainment experience over the years, many ongoing changes year by year nowadays it becomes almost casual game and launches in portable platforms. Earlier mobile game researches have mainly focused on implementation and development in sense of developer perspective. Additionally, while intrinsic factors are often considered important in affecting gameplay, little research has attempted to understand their kinds of characteristics that reach satisfaction of users [1] and psychology of user based on emotion and attention [112]. Based on the assumption, developers should focus on demands of customers in how to improve gaming experience. Consequently, users can drive the direction of future gaming experience. To fill these gaps, our study focus on the role of improvement factor as a driver of mobile game's continued use, and the antecedents of perceived enjoyment [1, 3].

There are two research objectives in this study. The first is to visualize improvement factors to perceive an enjoyment experience. The analysis of improvement factors is to determine the overall structure of game design for developing fun games, which is perceived enjoyment [1, 37]. This leads to further investigation of the improvement factors that are used in educational aspect to improve and enhance in both sense of learning and engagement. Also, we have been tried to incorporate these factors as a basis to develop fun games in the near future. Therefore, the second objective of this study is to suggest entertainment and playing trend in the near future.

In this chapter, we will show the statistical visualization of our results that acquired from scale-rating questionnaires. Then we had analyzed based on the proposed model, which has been introduced to identify the key concept that was related to the perceived enjoyment and users' behavior, to determine the improvement factors that largely effects different gaming platforms. The second part is to represent the possible interpretation of key improvement

factor in educational facet, most focusing on how to apply the gaming technology and example of use of game elements in genuine classroom. Lastly, we have reviewed the prospective works which possibly to promote and study in various ways and approaches.

## 5.2 Platform Transformation and Game Development

In this section, we explore entertainment environment that focuses on platform transformation based on the response of the user's demand. Improvement factor has been introduced to identify the key concept that was related to the perceived enjoyment. Perceived enjoyment consists of five factors as design aesthetics, ease of usability, interactivity, variety/novelty, and challenge [1, 37]. In entertainment aspect, there are only interactivity, variety, and challenge. The main reason is that users can directly feel these intrinsic factors with common understanding. While perceptual factors need high understanding which is provided by developers. The definition of each factor is described as following below.

- Interactivity is one of the most important factors that response and activate the interaction between player and game. Most descriptions are typically defined as how system respond and provide real experience for user [1, 37], when user feel great practical situation and positive impact during in-game period. In point of developers, they evaluate as providing positive impact on the users' gaming experience by facilitating the casualness.
- Variety or novelty can be referred as the extension for the system and gaming experience. Users always need to meet variety during in-game period. Thus, the term variety or novelty refer to the aspects of system attributes that users perceived surprising and unfamiliar [1, 37]. To maintain users' enjoyment, variety in system will increase the users' interest towards the game.
- Challenge is defined as the sense of user face against positively situation and capability to use individual skill including stochastic decision and outcome [1, 37]. Challenge is of great relevance in gaming context, typically presents the difficulty of

the game. The user is likely to lose interest in the game if the challenge is too easy. On the other hand, if it is too hard, the user might be frustrated and boredom.

These factors are adopted to quantify the interaction and entertainment contribution in the view of developers and players. This concept has been contributed to be essential driver for identifying important game design and game development. Therefore, we have been trying to observe the impact of each factor in various platform to propose the attempt for future progress and development in game industry.

### **5.2.1 User-centered Entertainment Factors for Platform Transformation and Game Development**

In this section, a scale-rating questionnaire was proposed in order to survey and collect data, statistical analysis can be conducted to test our hypotheses. It has been used to gather importance of improvement factors among platform based on users. Coming up 15 questions in total which each question (See in Appendix 1) consisted of a pairwise comparison of three improvement factors. For each question, the respondents were asked to mark the relative importance of those factors and categorization. The questions were developed in Likert-scale items (1 to 5) for each factor to describe users' attitude regarding a subject. The resolution of the scale range is to include possibility to provide neutral answer. 350 respondents can be anyone and intentionally game player or entertainment relative person. Half of respondents are in 15-22 age range, and separated group of respondents every 7 years referred to users' personality changes [113], as shown in Figure 5.1.

The dimensional focus of perceived enjoyment consists of interactivity, variety, and challenge. These three factors are not independent, but they uniquely combine together to improve enjoyment and perceive by player. The proposed visualization for improvement of entertainment factors in Figure 5.2 showed that variety, interactivity, and challenge are defined as low, balance, high complexity respectively. The intersection points are curiosity, competitive, determination, and finally attractiveness and enjoyment [111] which are the player's feeling,

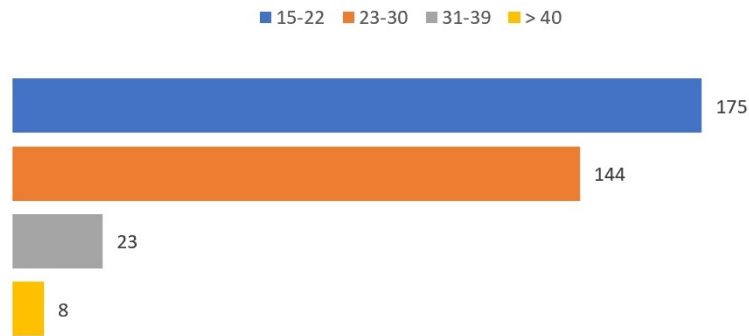


FIGURE 5.1: Number of respondents and age range in questionnaire

emotion, and state when they reach at that equilibrium. Notice that this proposed model was constructed based on the definition and interpretation of [1, 37].

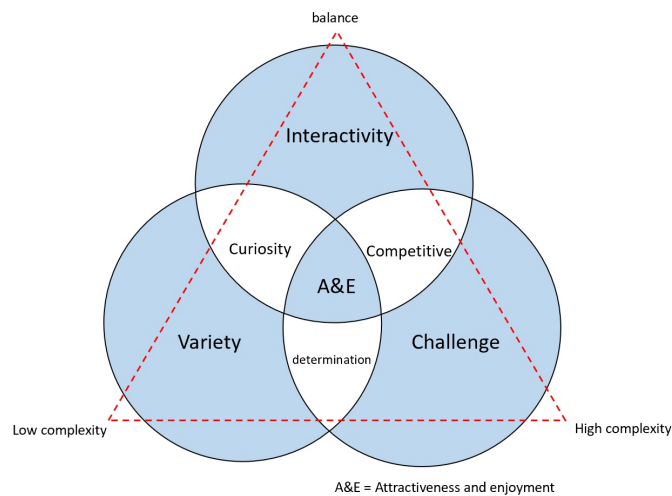


FIGURE 5.2: A player enjoyment-based visualization for improvement of entertainment factors

The data collected were reduced into three columns—positive (+1), neutral (0), negative (-1) in order to easily identify the general trends. Figure 5.3 shows the sample question and simplification Likert-scale into positive-negative scale. The score values were grouped into 1-2 score value as a negative set, 4-5 score value as a positive set, and others as the neutral set. The reliability test is conducted using the t-test to compare the mean scores of two or more groups of significant differences. The significance  $p$ -value was set at 0.05 in this analysis.

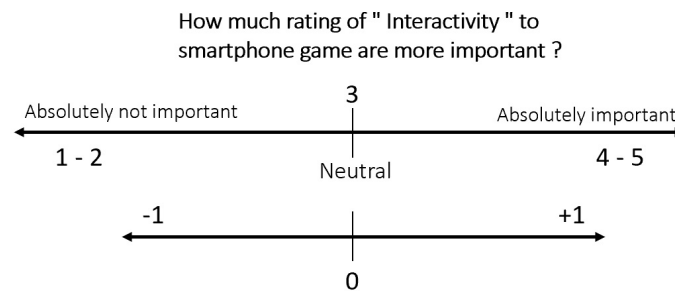


FIGURE 5.3: Sample question and simplification from Likert-scale to positive-negative scale

This study investigates the improvement factors that are perceived as important in platform transition and observe the game contents changes based on user perspective. To see more clearly, the scale from Likert-scale was derived into a positive-negative scale to identify the percentage ratio of the respondents results for each platform (Figure 5.4). 54.57% in variety is the highest in smartphone platform followed by hybrid console and fun games. Interactivity is strongly fit for home console and VR platform, which accounted for 48.57% and 48%, respectively. However, for the challenge factor, the percentage ratio for each platform were in close proximity between one another where home console is the lowest one. However, pre-surveying did not provide obvious results, most of people tend to be satisfied by including all the factors in each platform as much as possible, Significant result and virtue test should be investigated more in the next section.

### 5.2.2 Interpretation of Entertainment Factors in Various Platform

In this section, we have more analyzed by using t-test analysis, each platform was compared by testing a hypothesis based on improvement factors which resulted into 30 hypotheses. The expected score from the respondents were used for comparing platform demand for each factor. Table 5.1, 5.2 and Table 5.3 showed the result of both the t-test and the  $p$ -value for each hypothesis classified based on the factor of interactivity, variety, and challenge, respectively.

Firstly, we consider the interactivity which maintain engagement between players and games. The result for interactivity term regarded home console, smartphone, and VR platform are

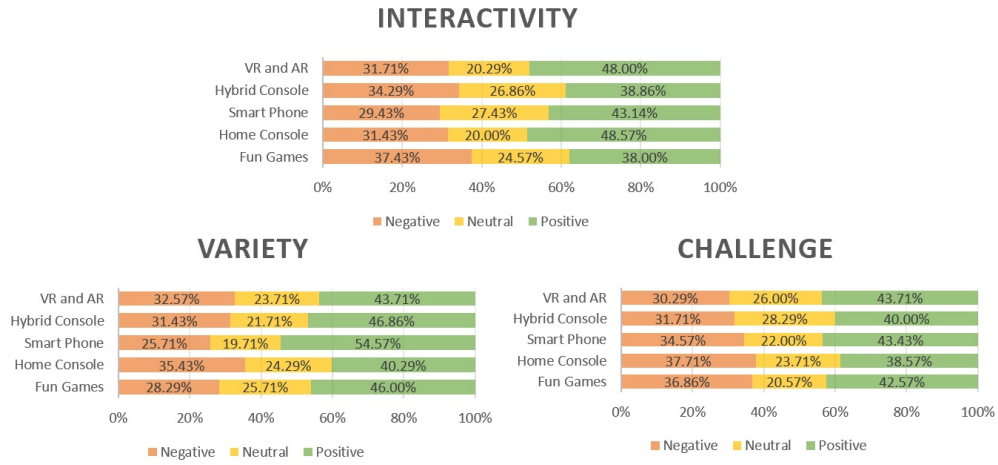


FIGURE 5.4: Relationship of improvement factors among game platforms

TABLE 5.1: The result of t-test and p-value for interactivity factor

	Hypotheses	t	p
<b>Interactivity</b>	Fun games - Home console	-1.69	0.05
	Fun games - Smartphone	-1.98	0.02
	Fun games - Hybrid console	-0.20	0.42
	Fun games - VR	-2.83	0.00
	Home console - Smartphone	-0.26	0.40
	Home console - Hybrid console	1.52	0.07
	Home console - VR	-1.19	0.12
	Smartphone - Hybrid console	1.81	0.04
	Smartphone - VR	-0.96	0.17
	Hybrid console - VR	-2.68	0.00

significantly different to other platforms (see in Table 5.1). The hypothesis of importance of interactivity between each platform are justified by using t-test analysis. We can see that fun games like boardgames are least dominant in interactive sense. For instance, fun games and VR platform has  $t = -2.83$  which minus sign means expected score of interactivity in VR platform is more than fun games, and  $p = 0.00$  which is less than 0.05 means the difference is significant. Comparing to other platforms, t-test analysis provide negative value of t for fun games. Virtual reality (VR) platforms also provide the better sense of interactivity based on game players' view. Other justified hypotheses which are fun games - home console ( $t = -1.69$ ,  $p = 0.05$ ), fun games - smartphone ( $t = -1.98$ ,  $p = 0.02$ ), smartphone - hybrid console



( $t = 1.81$ ,  $p = 0.04$ ), and hybrid console and VR ( $t = -2.68$ ,  $p = 0.00$ ) have been proved by significance level  $p = 0.05$ . As we mentioned about the definition of interactivity in this study, it depends on player experiencing the true sense of system or software, and on developers preparing casualness that enhance interaction between player to player or player to the game. Therefore, home console and VR games could basically generate such an experience during in-game period than others.

TABLE 5.2: The result of t-test and p-value for variety factor

	Hypotheses	t	p
<b>Variety</b>	Fun games - Home console	1.69	0.05
	Fun games - Smartphone	-2.10	0.02
	Fun games - Hybrid console	0.60	0.27
	Fun games - VR	0.67	0.25
	Home console - Smartphone	-3.84	0.00
	Home console - Hybrid console	-1.09	0.14
	Home console - VR	-0.98	0.16
	Smartphone - Hybrid console	2.72	0.00
	Smartphone - VR	2.74	0.00
	Hybrid console - VR	0.08	0.47

For variety factor (see in Table 5.2), smartphone is the dominant that need variety to improve entertainment aspects.  $p$  value showed the absolutely difference among other platforms. Variety in smartphone platform is more important than hybrid console ( $t = 2.72$ ,  $p = 0.00$ ). In order to support and improve gaming experience in smartphone platform, variety is rich important in view of users to keep customer engagement and gather several numbers of downloading. However, developer might claim that hybrid console consists various function and features in case we studied on platform design perspective. In case of fun games, they are required variety as well to enhance the players' engagement in-game period. Other justified hypotheses which are fun games - home console ( $t = 1.69$ ,  $p = 0.05$ ), fun games - smartphone ( $t = -2.10$ ,  $p = 0.02$ ), home console - smartphone ( $t = -3.84$ ,  $p = 0.00$ ), and smartphone and VR ( $t = 2.74$ ,  $p = 0.00$ ) have been proved by significance level  $p = 0.05$ .

The proximity of challenge factor was analyzed between home console and other platforms (see in Table 5.3). only two justified hypotheses are significant different which home console - smartphone ( $t = -2.25$ ,  $p = 0.01$ ) and home console - VR platform ( $t = -2.50$ ,  $p = 0.01$ ).

TABLE 5.3: The result of t-test and p-value for challenge factor

	<b>Hypotheses</b>	<b>t</b>	<b>p</b>
<b>Challenge</b>	Fun games - Home console	1.10	0.14
	Fun games - Smartphone	-1.08	0.14
	Fun games - Hybrid console	-0.42	0.34
	Fun games - VR	-1.32	0.09
	Home console - Smartphone	-2.25	0.01
	Home console - Hybrid console	-1.59	0.06
	Home console - VR	-2.50	0.01
	Smartphone - Hybrid console	0.70	0.24
	Smartphone - VR	-0.26	0.40
	Hybrid console - VR	-0.96	0.17

Corresponding to players point of view, they do not need higher challenge for home console than enjoyment, otherwise need challenge to reduce boredom in game contents. Challenge is one the factors that appear in every part of the game in which to perceive the continuance of the game and increase capability of players. Therefore, we can roughly mention that challenge affects all platforms in better way of increasing enjoyment and attractiveness. Table 5.4 shows the summary of entertainment factors among game platforms while we are focusing on users.

TABLE 5.4: A summary of impact of entertainment factors among game platforms

	Fun games	Home console	Smartphone	Hybrid console	VR and AR
Interactivity	Less	High	Less	Less	High
Variety	High	Less	High (game)	High (platform)	Less
Challenge	High	High	High	High	High

By investigating and studying the history of the way of Nintendo developed various game platforms [114] (Table 5.5), a good example of the future trend can be examined. Nintendo usually has platform transition cycle every 5-7 years due to hype cycle of technology. Most game companies begin with the home console which high interactivity. However, the progress of support technologies drives development of game platform in both sense of aesthetic and cognitive. Nintendo had developed Virtual Boy in 1995 that is the prototype of virtual reality nowadays. They also released the first portable console Game Boy in 1989 which got highly famous and still ongoing development until Nintendo 3DS in 2011. Portable console is the motivation that many game companies started launching game to mobile platform and smartphone due to more ubiquitous and more accessible.

The level of improvement factors for those platforms should be improved in game industry, Nintendo release Wii in 2006 that drives the profit in the company. It can be inferred that interactivity is the main concern in home console, and Wii can respond to players in such direction by providing positive impact on practical gaming experience. For example, many sports in real world are implemented in platform so that players can enjoy sport without going outside. Even though Wii U is not successful for earning revenue, but Nintendo applied this idea into Nintendo Switch which is the first hybrid console to make more variety and interactivity for players.

TABLE 5.5: Timeline for Nintendo game platforms

Platform	Year	Type
Nintendo Entertainment System (NES)	1983	Home Console
Game Boy	1989	Portable Console
Virtual Boy	1995	Virtual platform
Nintendo 64	1996	Home Console
Game Boy Advanced	2001	Portable Console
Nintendo DS	2004	Portable Console
Wii	2006	Home Console
Nintendo 3DS	2011	Portable Console
Wii U	2012	Home Console
Nintendo Switch	2017	Hybrid Console
Nintendo Switch Lite	2019	Portable Console

Recently, it can observe that Nintendo Switch (combination of Wii and Nintendo DS series) had improved impact to players by providing interesting gaming experience and better flexibility. Nintendo also offer another choice for player who needs more portable so that they released Nintendo Switch Lite (portable console) that try to reach satisfaction of variety, and justify the concept of more ubiquitous and more accessible. This justifies our findings on platform transformation as a primary concern with respect to the variety and interactivity factors. Nintendo Switch is now highly successful new hybrid console and also considered very interesting by the developers community.

However, few developers are already working on games for this console as shown in Figure 5.5 [115]. In case of smartphone, considering the huge installed base and the relatively low effort involved in making smartphone games, it is reasonable that developers try to carry on

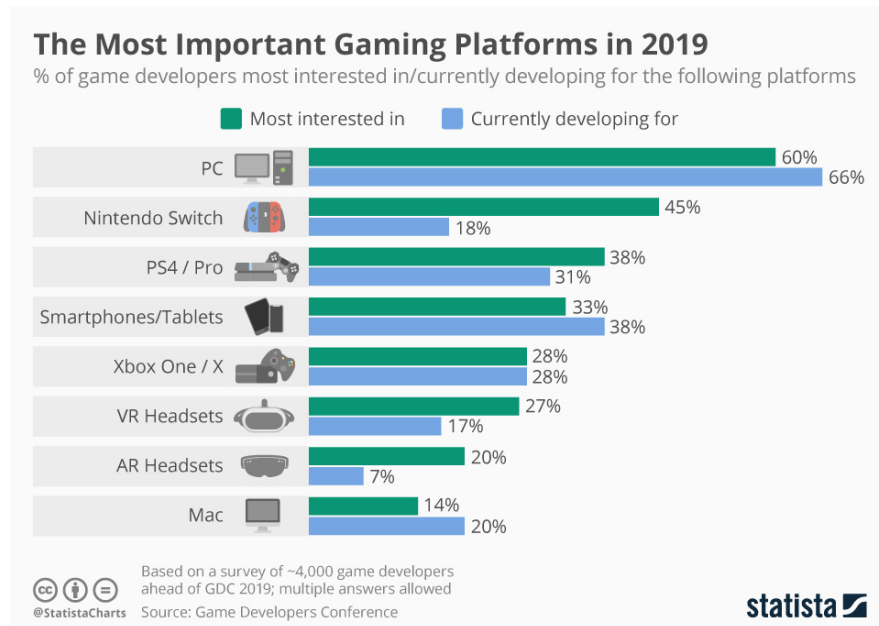


FIGURE 5.5: Illustration of gaming platforms are currently getting the most support from game developers in 2019

that opportunity. From our study context on entertainment platform, next generation platform would be a device that allows accessibility which reduce border between reality and virtual world based on the traditional play and sport. Additionally, new platform will also capitalize the improvement factors for creating a new playing style and a new playing experience which maximizes user entertainment and enjoyment.

## 5.3 Analysis of Gaming in Education

In this section, we considers gaming technology in the classroom by comparing it with the traditional classroom. Nowadays, portable and high mobility devices are more advanced with the increasing variety of features and more user-friendly [92]. They have also implemented and supported educational game software for classroom learning [82, 116, 117, 118]. Therefore, portable game platforms may provide the best suitable for a learning environment. Hence, these digital game platforms can utilize to enhance motivation and engagement of user depending on users' purpose. However, we have to understand and observe the capabilities and performance of various platforms. It may make contribution in particular aspects and

contexts. Hopefully, this study can be used as a guideline for teachers, educators, and stakeholders in order to develop suitable game platforms and improve effective learning condition while increasing of better educational environment.

This study is organized as follows. First, we give a short sketch of the related work and preliminary studies in this field, also basic idea of game refinement theory and apply to the classroom systems to quantify the attractiveness between regular classroom and innovative classroom. Second, we have been trying to investigate the suitability of applying game platform, and indicate the feasible solution for analysis attractiveness and engagement in the classroom. Ongoing works will describe about the conceptual framework for analysis of examination fairness and the approach on how to enhance intelligent skills [119], such as linguistic, mathematics, spatial, and etc, with progress technology by using game refinement approach.

### **5.3.1 Classroom System with Technology to Enhance Engagement**

Here let begin observing at the preliminary study and survey on incorporating gaming technology in the practical classroom. There are existing studies which evaluate and assess the performance of the gaming platform in educational purposes. [77, 120] have done the comparative study between mobile-based learning game and traditional game since the result showed significant differences between the two groups. M-learning [86] might influence the learning outcomes of the students more than the traditional learning. Moreover [81], Nintendo has done many investigations on the design and assessment of educational games and educational platforms. Their objectives are to focus on how to use gaming technology to provide motivation, dynamics, and technological transfer through games. Types of the platform are a necessary point to concern. This research mainly focuses on the handheld platform between Playstation Portable (PSP) and the Nintendo Dual Screen (NDS) [82]. This study proposed a conceptual model of adopting these two kinds of the platform in the learning environment, and then the result shows that these two platforms can generate integration way for stakeholders and educators. Nintendo Labo [121], the extension and complement of

Nintendo Switch, has been used into the classroom for management and improvement of fundamental skills for children.

According to this research, they focused on how to integrate games and technologies as a part of the classroom. They surveyed in which platforms that game-using teacher usually use in the classroom, and purposes of using the platform in the classroom. Figure 5.6 and Figure 5.7 show the pre-result of this survey, and this shows a variety of devices and possible purposes by using gaming platforms [33].

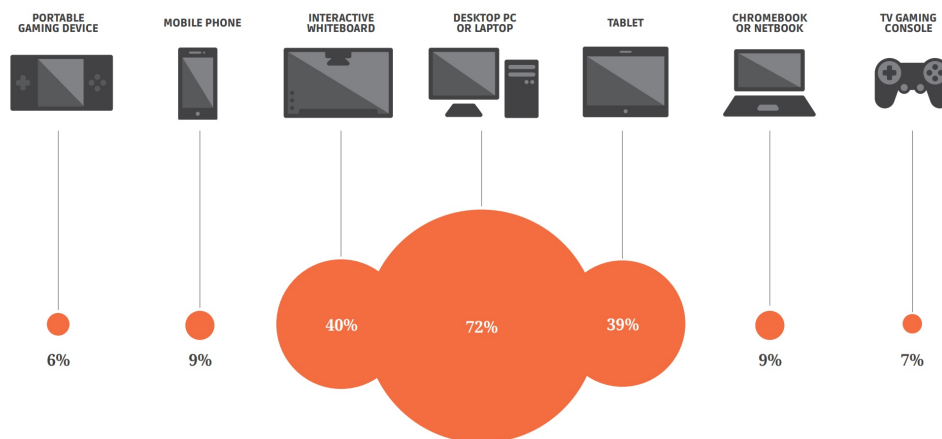


FIGURE 5.6: Illustration of digital platforms using in the classroom [33]

We can see that 72 % of respondents in this survey prefers to using personal computer, which can be observed from programming class, problem solving subjects, and game authoring class [122]. While tablets and interactive whiteboards (accounted for 39 % and 40 % respectively) are also keen to visualize for learning in specific context. Most of teachers usually use in a way of giving rewards and complimentary after the class or in-during class. Some of them have willing to introduce new material and enhance interactivity in the class by using games and technologies.

Due to the application of gaming technology into the classroom, it essentially provides more possible options for students which are useful to increase engagement. Figure 5.8 has shown the possible options of students in the regular classroom and innovative classroom. Students have basic possible options in this study. The number can be varied corresponding on the

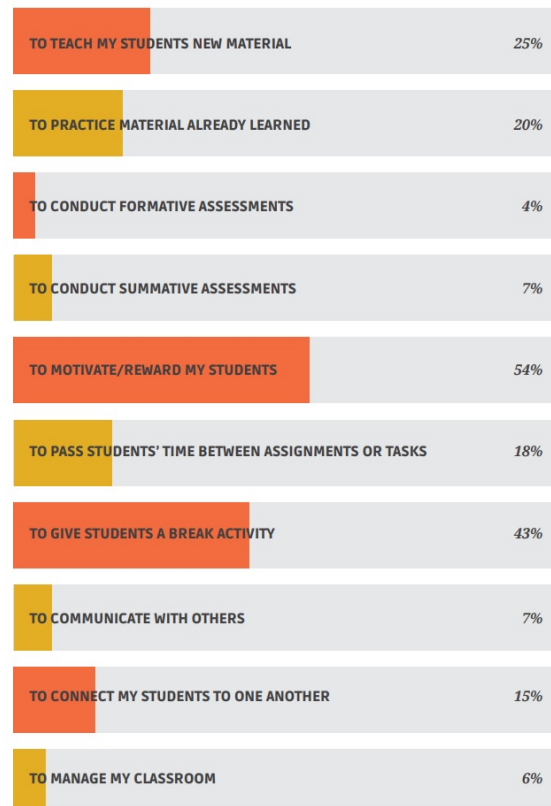


FIGURE 5.7: Purpose of using platform technology in the classroom [33]

instructors. Otherwise, it depends on classroom regulation and teaching styles. These potential options were surveyed referring to [33].

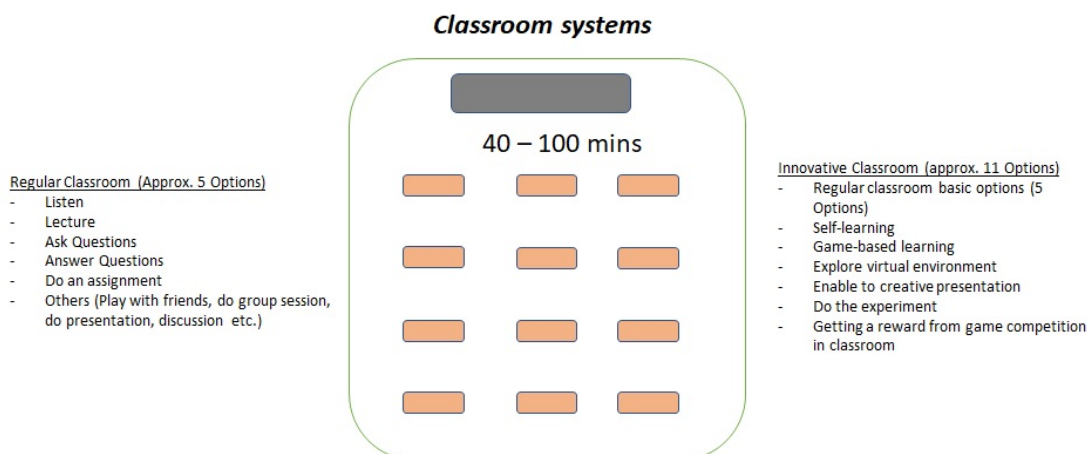


FIGURE 5.8: Illustration of classroom system in this study

### 5.3.2 Interpretation of Game Refinement Measure through the Classroom Possible Options

This study supposes the classroom system as a board game, where the students have possible options to keep engagement in the classroom. However, there are two crucial differences between board game and classroom system. A board game is likely fun-game context, whereas the classroom system tends to be a more serious game. Thus, some interpretation of students probably means in different facets when comparing to board game approach. Another point is game length, which the board game approach focuses on the whole game decision tree while the classroom system should be expressed as classroom time because we do not need only one winner in the classroom.

To summarize the progress and engagement of student in the classroom, it is general to analyze the student perceptions to keep maintaining the engagement based on the attempt of possible tasks which is considered as a game action in educational aspect. Then, game refinement theory can be applied by using the idea as same as approach we used in [54, 52]. Thus, we find  $GR$  value by using possible options  $B$  and class length  $D$ , with an equation  $GR = \frac{\sqrt{B}}{D}$ . The classroom system progress model is defined as equation 5.1.

$$GR = \frac{\sqrt{\text{number of possible options of students}}}{\text{average classroom time}} \quad (5.1)$$

Two lines are plotted in order to show the differences in refinement value with respect to the class time between the regular classroom and innovative classroom (see Figure 5.9). Regular classroom shows quite less engagement in each period. The innovative classroom truly shows high engagement in each period due to various option providing and implementing in the classroom. Based on the proposed classroom model, if a classroom can provide variety and more educational contents that useful for students, then refinement measure can be increased and the engagement can be increased. The illustration shows that students begin with high engagement in the class, but at each time, engagement will be decreased depending on the regulation and contents provided by teachers.



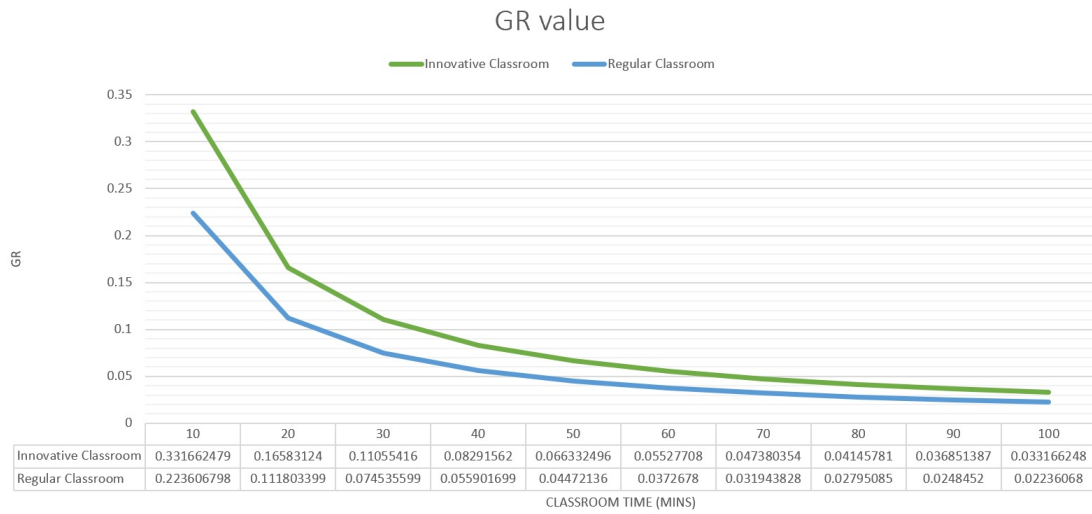


FIGURE 5.9: Illustration of game refinement measure comparing two types of classroom

As we observed from Table, students will get boring after passing around 30 to 50 minutes in a regular classroom which contains refinement value around 0.074 to 0.044. During 30 to 50 minutes in the innovative classroom, refinement values are 0.011, 0.083, and 0.066 respectively. That means the innovative classroom provides high engagement during the time in the classroom based on game refinement assumption. But after an hour, students will be getting bored in case that teacher provided a fewer variety of contents in the classroom, and refinement value becomes less than 0.05. Therefore, time is one factor which we can set a proper time, and instantly, the innovative classroom can provide engagement to the student for longer.

There are exceptions can be considered; the regulation and the teaching style is also important. Some of the teachers do not have enough knowledge to establish innovative classroom, i.e., applying educational game or gaming platform in the class. Therefore, the figure shows only a simple matter, which, at every single moment in the classroom, offers as many choices as an instructor might. Through introducing gaming approaches, student engagement can be varied and changeable on the basis of teaching style. Throughout our study, the use of gaming technology and network could be a justification and a way to improve interaction.

Furthermore, the figure shows the result in the individual student point of view. There may be cases in which students in the same class have a different willingness and motivation in the class. Engagement can start at a lower or higher stage, depending on the student in this case. Intuitively, we assumed that the student was a class player voluntarily and without negative emotion and attitude towards the class. Control variables like students sample group should be discussed in future work. [54, 52]

### 5.3.3 Analysis of Gamification Platform in Classroom

One of the good example of gamification platform is Kahoot, a free tool that educators can create their own quizzes for educational purposes or others. Variety, interactivity, and challenge are included in this platform and participants can visit directly to website kahoot.com where you will find all the details on how to use it. It is really fast and easy to create quizzes. You can both add a picture or a video to go along with your questions, and also choose how much time the players will have to answer the questions from 5 seconds to 120 seconds per each. Each question is worth up to 1000 points. It can be created 4 choices for each and each time a player gets points from correct answer that are also based on how quick the answer was; the faster the questions are answered, the higher the obtained scores are [123]. After everyone has answered the results are shown on the screen and you can see how many right and wrong answers players gave and a small leaderboard with players with the most points on it [124].

We apply game progress model to quantify engagement impact of this session for analysis the gamified experience over the time. To summarize the progress and engagement of this tool, then game refinement theory can be applied by time limit progress model. Normally, we find  $GR$  value by using average amount of time using to answer the questions  $G$  and game length as total amount of time of whole quiz  $T$ , with an equation  $GR = \frac{\sqrt{G}}{T}$ . The game progress model is defined as equation 5.2.

$$GR = \frac{\sqrt{\text{average amount of time using to answer}}}{\text{total amount of time of whole quiz}} \quad (5.2)$$

TABLE 5.6: Measures of game refinement of Kahoot in several cases fixed number of questions

Question time	Number of questions	Total time	Average time using	GR
5	20	100	60	0.078
10	20	200	116	0.054
20	20	400	208	0.036
30	20	600	308	0.029

Analysis result has been briefly showed in this thesis (see in Table 5.6), we analyzed Kahoot by focusing on time given and time spent in each question. Table shows the game refinement value of each case, from 5 seconds to 120 seconds. We did the experiment in the classroom, 27 elementary kids were participated and questions are based on logical and mathematical questions, and difficulty had been increased while we analyzed in each case along the session from easy to difficult. The distribution of question is monotonous and could express linearly increasing of challenge and ability at the same time. The difficulty might affect the result depending on the students skills. GR is literally decreasing , whilst increasing the time per each question. Further study is needed to particularly focus on determining difficulty and distribution order in each question. That may affect the fairness and in-class engagement.

## 5.4 Ongoing and Prospective Works

Recently, we are trying to link between education context and entertainment context, and then find the relationship between each characteristics and definition. We believed that if players can learn and solve complex information, it will increase the satisfaction and solved uncertainty to make players being comfortable. Therefore, there are two methods which we can be able to apply for further analysis. Firstly, game refinement theory has been useful to determines how much attraction of a game to players.

Besides, it is necessary to relate the improvement factor that users feel experience in positive way, i.e. that make educators or students feel appropriate circumstances which provide balancing between motivation and learning. The essential factor of play is to voluntarily do by several time (redundancy) while maintaining the will and improving of learning

performance. This research will be a bridge by combining the explicit knowledge and existing results between fun game context and non-game context, it may be a new interpretation of educational context that approaches the perception of mind from various point of views.

There are several studies to realize the link between game refinement interpretation in fun game context and non-game context [26, 45, 52]. Also, in education aspect, analyzed the education games and find the best definition of acceleration in education context that more concentrated on improving the ability of educators than the challenge. Using technological development and gamification approach would represent the new paradigm shift and contribution of education research field including perspective of using technology to enhance both performance and engagement efficiently and perspective of justify the concept of genuine educational process in practical. Requisition of diversity in learning perhaps increase the learning performance while driving entertainment for innovative classroom.

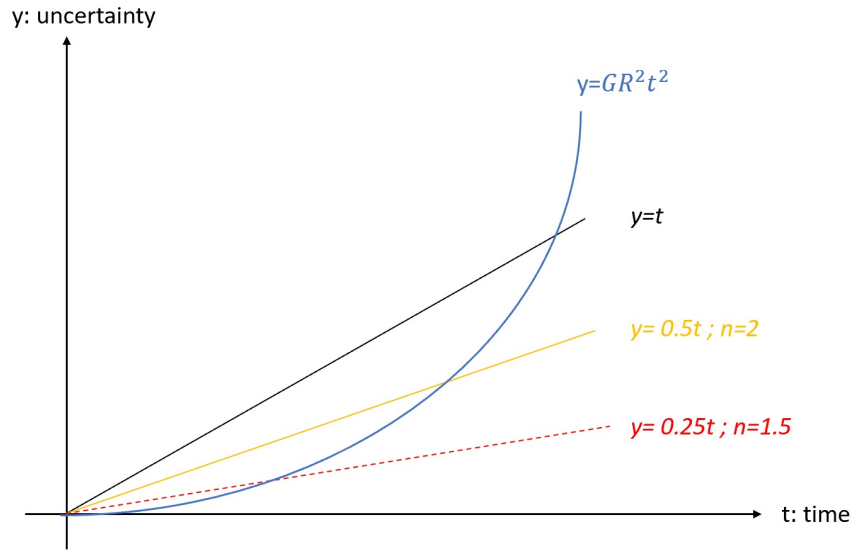


FIGURE 5.10: Conceptual relationship between uncertainty and time

Figure 5.10 shows the concrete example between uncertainty (risk taking) and time (game length).  $y = GR^2t^2$  implies the sense of thrill where  $GR$  corresponds to acceleration in the sense of dynamics in the game refinement theory. Technically, we define a sophisticated game with good balance between fairness, playability and sense of thrill is concentrated near the intersection of  $y = GR^2t^2$  and  $y = 0.5t$ . If we could further define the position of educational

context in case that the intersection between  $y = 0.5t$  in a competitive game based on regular players, and  $y = 0$  in deterministic certainty game, it becomes contribution to verify the game elements and justify the deployment in educational practice which we would expect  $y = 0.25t$  referring to educational context should be between sense of fun and serious activity that related to two necessary terms between effort and achievement.

Let us consider to define the mass-in-mind in educational context, we focus on the reduction rate of a progress tree. According to what we mentioned in Chapter 2 about the branching factor. Other enhancements and strong programs can reduce the effective branching factor. For instance, masters would consider feasible moves or have higher chance to reduce the decisions. In other words, they are able to reduce the size of game tree if they have enough information and learn every nodes (all possibilities). As we shows in Figure 5.11, the branching factors  $B$  can be reduce by obtaining the skills and learning which would be selected in a deterministic way and be followed by a stochastic way [125]. That is the framework we would like to use for analysis examination fairness and thrilling sense of student in practical classroom. Students could learn until the branching factors, i.e. possible answers, are reduced and get the best answer when branching factors are small (nearly to 1). It is expected that further study is needed to establish the way to determine the reasonable interpretation for the education domain.

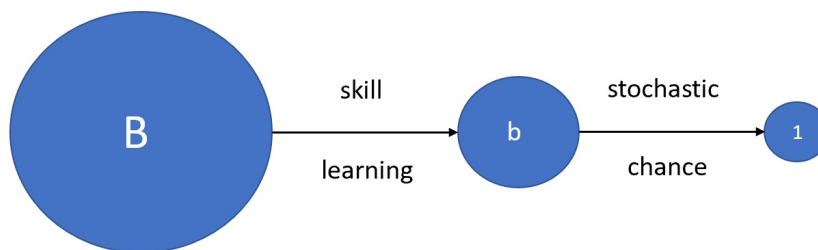


FIGURE 5.11: A model of move selection in games

## 5.5 Chapter Summary

In this study, the relationship among improvement factors was described in user-centered entertainment model. The proposed model was justified using questionnaire and statistical analysis. It was found that home console, smartphone, and VR platform need high interactivity in playing style. However, smartphone needs more variety to enjoy and satisfy in short game length. Furthermore, VR platform needs challenge to make users feel more interesting and more competitive. Further generalization of the model to other domains (such as platform transformation of education [5, 126], business, and financial literacy) may be an interesting direction to investigate. Since this study focused on users, the findings may be limited and exposed to bias. In addition, respondents might have different preferences and acquiring data in the psychological way is difficult to analyze quantitatively. Thus, future study should be conducted to specific respondents and exposed to specific purposes.

Another context is educational context, this investigated the engagement of student by comparing two types of classroom, the result might be attributed to fact that innovative classroom widely become dominant and to be used as standard in the near future. Results suggested perception of implementation and introduction technology in the classroom. The suitable time for regular classroom can manipulate students as long as 20 to 30 minutes. On the other hand, innovative classroom can extend more than 10 to 15 minutes. As an assumption, technology can make contributions to the classroom if we capitalize systematically and efficiently to determine the solution. In future classroom, we should conduct robust research about the usefulness and effectiveness of gaming platform and technology solution and clearly show how game platforms can be managed for improving learning process. We also show entertainment impact using Kahoot based on game progress model. The results pointed that it could enhance engagement under time limitation and number of questions in which time using is affecting to obtained score and game length is bound by number of questions in each session. However, the limitation and future studies are still interesting point that we should consider about the strategies which enhance engagement, and also diversity of quiz and subject applied differently through classroom.

Standardization of game into the curriculum and integrating into the classrooms is still ongoing. Some of them provide only pure technology into the classroom, otherwise, a few school has tried to use gaming technology [33, 121]. The results tend to clarify that portable gaming device, mobile phone, and TV gaming console can be implemented into the classroom with edutainment purpose by using educational games and virtual reality, so that the classroom for the future is going to offer more possible options for students. Future works can be varied in many different ways, this study can continue on how to introduce the gaming technology into curriculum and also observe further possibilities of gamified activities to keep maintaining or enhancing engagement level.

## **Gamification Design Process for Financial Platforms**

---

This chapter is an updated and abridged version of work previously published in

- W. Inchamnan and P. Anunpattana, "Gamification in Mutual Fund Knowledge-Based Systems," 2019 17<sup>th</sup> International Conference on ICT and Knowledge Engineering (ICT&KE), Bangkok, Thailand, 2019, pp. 1-7.

### **6.1 Introduction**

With the recent advancement of technologies, there is a need to adapt driven methodologies to make games much more interactive and attractive in order to motivate people's attention in terms of behavior changing. With an increasingly progress of digital technology that widely affects many industries, both products and services have to be changed along the period. Nowadays, there are many ongoing application software developments released on portable devices and platform to enhance engagement and interactivity between user and software which we called human and computer interaction [127, 128]. It is now playing an essential role including learning by doing which therefore provide valuable experience as a gamification while we are in the learning phase. For instance, gamification may encourage positive impact in many domain such as financial literacy practices in Thailand. However, the existing research indicates that gamification can help people to change their behavior by using persuasive, usable technology and the motivation for engagement. Although, gamification activities could be designed by using new technology to offer free choices for autonomy, rewards and feedback, and the outcomes can be measured during the activities. They are lack of the way to design how people are stimulated from new technologies.



Nowadays, financial literacy is education and recognizing whether money is being made, invested and saved. The skills are the ability to use financial resources to make decisions. The concept of financial literacy decisions includes how to generate, invest, spend, and save money. There is growing evidence that individuals who possess higher financial literacy have better economic outcomes as it improves financial decision making [129]. Current financial training providers in Thailand are small-scale, targeting learners and/or potential users of structured financial products [130]. Surveys on financial literacy in Thailand revealed that, on the whole, the overall score for financial literacy is broken down into the three main components, i.e., financial knowledge, behavior, and attitude [131]. The survey also found that areas with fewer financial transactions typically have lower financial literacy scores [130]. Financial literacy can be supported by technology for life-long learning. Thais also know that budgeting can help people to keep track of how much money they can spend by using educational game technology [130].

This study aims to determine the gamification workflow design which encourages people to conduct their lives using advanced technology and how the activities can stimulate the behavior that focuses on the financial issue. Then, the awareness in the literacy will use for influencing a persuasive behavior gamification design.

## **6.2 Gamification Stimulus Model for Mutual Fund**

### **6.2.1 Mutual Fund**

An investment is an asset or item acquired with the goal of generating income or appreciation [132]. The investment is a risk that relies on the market and economics. One of the small stake in all investments is a mutual fund. A mutual fund is a collective investment that pools together the money of a large number of investors to purchase a number of securities like stocks, bonds etc. Technological advancements may help people to understand an investment concept. Most people do not have enough knowledge about an investment, which effects to ordinary people who wants to start investing without relying on luck and other media.

Mutual Funds are designed for every individual investor diversification and money management, even for small investors who invest low amount of money. Mutual funds are an appropriate investment option to consider for investors who just began investing, if you do not have a lot to invest, or if you want diversification in your portfolio [133]. This fund is responsibly secured by a fund manager and financial securities organization who will use the fund to invest in various assets according to the investment objectives of each fund [134]. Investors will approximately earn money from the dividend, capital gain, and profit from each asset unit. It is a chance to develop gamification software for people (see Figure 6.1).



FIGURE 6.1: The mutual fund investment paradigm

For instance, it is trying to invest in an application before investing in the capital market or expanding into an international investment. The mutual fund has been introduced in this research because it helps beginner user with less investment experience, not much budget, and not much time to follow up with information. Therefore, this research will help general

investors interested in this type of investment units; furthermore, it can be a model for further international investment development.

Nowadays, there are many ongoing application software developments released on portable devices to enhance engagement and interactivity between user and software [127, 128]. Human and computer interaction is playing an important role, such as learning by doing which therefore provide valuable experience as a gamification while we are in the learning phase. Therefore, this study focuses on the area of investment to increase engagement of using technologies and intelligent systems, and helping out people feels enjoyable experience through gamification software.

### 6.2.2 Gamification Mechanics and Workflow

According to game-design elements [26] (see in Table ?? in Chapter 1) consist of dynamics, mechanics and components that are all incorporated each other. They generate the user engagement and encourage user's enjoyment and curiosity.

For example, ranking can be more competitive among user and other users. It is impossible to use all gamified elements within one gamified module, therefore before applying, it should be considered and figure out what goals is aimed to achieve [135]. Furthermore, it should be care about creating an experience that user can feel engagement with service or product, motivate them to learn, and feel gamified experience. Gamification brings benefits to users. These benefits include, but are not limited to, reducing stress, maintaining an active lifestyle, and regular planning activities which may be behavior change agents [136], and regular planning activities which may be behavior change agents. The agents are technologies that are used to assist individuals in achieving goals, including helping them for self-monitoring behaviors and encouraging commitment.

*NOTATION 2. Gamification is one such technical way that generates rewards, competition, social comparison, goal setting, challenge, self-monitoring, feedback, and entertainment to promote certain behavior [137]. Users can develop activity plans and continuous feedback*

*and suggestions are provided on how to achieve goals, monitor behaviors and obtain rewards for the achievement of the set goals [136].*

- **Rewards:** Gamification combines two motivations using extrinsic rewards such as levels, points, badges to improve engagement, and striving to raise feelings of achieving mastery, autonomy, sense of belonging [138], as intrinsic rewards. Motivation has been employed by both persuasive and gamified system designers, and reward is the most frequently used [136]. Motivation is demonstrated by an individual's choice to engage in an activity and the intensity of effort or persistence in that activity [139]. The efficacy of persuasive technologies, like gamification in financial literacy, relies on the human potential to do better and foster their intrinsic motivation to seek a better quality of life [136]. While the goal is to create and maintain intrinsic motivation, gamification is the application of extrinsic motivators [140].
- **Goals:** Achievement goal orientation is a general motivation theory that refers to the fact that the type of goal toward which a person is working has a tremendous impact on how they pursue the goal. Designing a good model of a mastery-oriented by goal setting, learner can do in learning environments [141]. In order to evaluate whether a game goal or sub-goal has been achieved, some kinds of cognitive processing need to occur [142]. Users can achieve goals, monitor behaviors and obtain rewards for the positive achievement.

One of the main issues in mutual fund application is engagement with and commitment to start investment. In such a situation, gamification can be applied in order to enhance motivation through intrinsic rewards and feedback. However, there is not yet any clear application of gamification. From this review, it is possible to spot possibilities regarding the gamification in several type of elements. For example, knowledge-based system tends to focus on self-learning and self-training in order to improve and understand the concept of mutual fund. There is a focus on simplicity, positive rewards and positive outcomes. This indicates that the system might require an implementation of gamification which denotes as user-centred design to get the gamification driven: positive feedback, capable of mastering tasks, free choices

for autonomy, and good communication [143]. The workflow can apply to the GSM model in terms of the gamification driven that stimulates the motivation. The stimulus is positive feedback, capable of mastering tasks and free choices for autonomy.

### **6.3 The Financial Factors of Gamification**

The potential impact of gamification can be used to encourage investment. Many relevant applications use gamification concept to enhance incentive and provide knowledge in financial and economics terminology. The gamified application must be able to demonstrate the potential reward as well as the risks of investing. For example, allowing potential investors to understand about investing through gaming processes rather than overwhelming them with technical requirements and complexity [26]. Especially amongst young people, it must be simple and relatable to the main point. Once they feel comfortable and satisfied, they can be open-minded to learn new things smoothly [32]. In the sense of investment, there is no application which simulates the investment situation refer to GAC - Government Application Center. Most of them provide only one-sided information for investment such as trends of investment, guides for investment, sharing center, etc. For example, investing.com gives the user about stocks, bond, and debenture based on the economic world calendar function. eToro social trading has been the sharing center for investors that are seeking for techniques, portfolios, and guidelines.

By the way, some of them have tried to combine with gamified elements and set up a game for the interested user. Stock trading is famous for simulating the situation. Table 6.1 shows the game elements which are included in this stock trading game. ChartGame.com uses the mechanics of randomization trading graph and modifying challenges by given initial budget. This game reveals feedback by virtual cash detail and profit-loss percentage on the dashboard. Tradeaminute.com simulates the stock trading by providing an initial budget, and users can try to make the decision by themselves or follow the mentor suggestion in the game. The game will collect the record and proceed to make portfolios which indicate the transactions between game period. The Business application called FuteBank is mutual funds portfolio

TABLE 6.1: Game mechanics and elements for gamified application in investment and stock trading area

<b>Games</b>	<b>Mechanics</b>	<b>Elements</b>
ChartGame.com	Challenges Chances Stochastic	Achievements Dashboard
Tradeaminute.com	Challenges Feedback	Achievements Dashboard
FuteBank	Challenge Competition Feedback	Avatars Achievements Badges Leaderboard Dashboard Points/Scores
Bull Ranger	Resources Win-Lose status Rewards	Unlockable contents Leaderboards Levels/Tiers Points/Scores

management using an animated model of a football league. The relationship between a football team with a portfolio investment funds and the positions of the players on the field are the gamification approach that are assigned for users with mutual funds in their portfolio with the main objective to transform a complicated process of choosing, selecting and funds, in a simple way [135]. Furthermore, Bull ranger is also a fun game which provides knowledge of the technical word in investment and economics domains for rookie players. Interests, capital gain, and dividend are included as game elements which are calculated for point or score. This research aims to seek the gamification approach for simulating and demonstrating the investment situation for gamified application.

Some researches address the way of gamification in terms of financial. Gamified application has a positive impact on the acceptance in financial technology. The positive technology bases on the ease of use, enjoyment and usefulness [135]. The gamification can be powerful experiences, leveraging both motivation and engagement. The recent trend toward “gamifying” applications depends on the complexity of a well-designed and balanced game down to its simplest components, such as badges, levels, points, and leaderboards to generate both a

technical toolset and a set of best practices for implementing successful gamified experiences in educational contexts [138, 144], such as the financial literacy.

### **6.3.1 The Investment Factors of Gamification for Mutual Fund**

#### **Investment**

We have briefly reported literature on gamification of mutual fund investment and learning through game in section 6.2.2. We have analyzed gamification in investment contexts in terms of how the gamification has been implemented and what kind of possibilities it has been expected to lead to. The findings of the analyses indicate that the gamification studies in the context of investment strongly considers with the general research on gamification with regards to enhance engagement and provide perceptions of investment. The findings can be analyzed into 3 parts: investment factors, gamified experience, and gamification mechanics (See in Table 6.2, Table 6.3, and Table 6.4).

### **6.3.2 Gamification and Financial Literacy**

In spite of gamification can be applied in order to enhance motivation through intrinsic rewards and feedback. However, there is not yet any clear application of gamification. From this study, it is possible to spot possibilities regarding the gamification in several type of elements. For example, knowledge-based system tends to focus on self-learning and self-training in order to improve and understand the concept of mutual fund. There is a focus on simplicity, positive rewards and positive outcomes [154]. This indicates that the system might require an implementation of gamification which denotes as user-centred design to get the gamification driven: positive feedback, capable of mastering tasks, free choices for autonomy, and good communication [143]. Thus, a conceptual framework of gamification in investment of mutual fund is introduced in Figure 6.2.

This study aims to examine the gamification design process for mutual fund investment by encouraging use of application and investment of people through knowledge-based system. Figure 6.3 shows that the investment factors are addressed to enhance engagement while

TABLE 6.2: The investment factors of gamification for mutual fund investment

Factors	Contexts	Game Design
Capital Initial budget	Mutual Funds are designed for every individual investor and money management, even for small investors who invest low amounts [133]. It is a strong predictor of attitudes toward users to start and have intention with related services. It should be set for any user to make the developing investment skills.	Provide the initial budget depending on the risk and investment unit
Type of Funds	Mutual funds varieties are categorized on the base of investment objective, structure, and schemes. The investment objective mutual funds can be equity or growth funds, fixed income funds or debt mutual funds, tax saving mutual funds, money market or liquid funds, balanced funds, gilt funds, and exchange-traded funds (ETFs) [133].	Provide knowledge of each type of fund and structure or strategy for earning revenue.
Risk	The rate of risk can be implied as the rate of profit or loss at the same time [145]. Generally, when the rate of risk increases, the potential return also increases. It is an indicator and strong motivative factors in order to convince new investors. The mutual fund has the level of risk with their own risk depending on the objectives of the fund.	Survey the user behavior and objectives to assess the risk and investment unit
Mindset	There are many different facets and investment mindsets which primarily consider beforehand. Mutual fund is just to collect money from investors, sometimes these kinds of investors intend to do by taking all responsibility to fund manager. Some people can consider about the budget, and in the light of those people want to learn invest systematically to have a plentiful retirement and be financially independent. Therefore, people can have their own mindset before using application and we can design various types of game depending on the user's objective and mindset.	Survey the behavior and objectives to design suitable game situation that reach achievement.



TABLE 6.3: The gamified experience for mutual fund investment

Experiences	Contexts	Game Design
Simplicity Accessibility	The diversification has also increased in terms of the existing gamified elements are being incorporated and transferred into the virtual environments [146]. Human and computer interaction being part of a game. The development of the application software and hardware industry has been supported by such as portability, accessibility, and convenience (simplicity).	User interface should be friendly and reliable. Moreover, it should be implemented on portable devices or supported technology platform to satisfy user's experience.
Motivation, Incentive, and Engagement	Motivation and engagement can be varied in different aspects. In terms of education [147], engagement may be considered as the 'behavioral intensity and emotional quality of a person's active involvement during a task'. In term of uses, we can define perceived enjoyment for users such as challenge, variety, and interactivity [127]. Users look for positive feeling, and likely to seek for difficulty to maintain interesting. Application should increase the users' interest towards the game.	Gamification can motivate user by changing behavior and maintain engagement in terms of continuing use. For learning investment knowledge, users should feel attractive and be able to use their own skills varied on the challenges.
Persuasive	Persuasive technologies can be used for enhancing a user's behavior and decision without forcing the change [148]. They have various aims: some want people to lose weight based on fitness trainer software, others are designed to promote energy efficiency through neighborhood peer pressure based on smart home applications [27].	Games are the dominant choice for simulating investment situation, and we also express investment in sense of fun game rather than serious game.

encourage the use of application. The gamification approach is focusing on market fund base, amount of capital fund, type of funds, mindset of investors, time limit, and assessment of risk.

Many investors are concerned on the initial budget so that mutual fund investment can redeem this problem. Investors should accept and assess the risk by themselves in order to do investment in the right direction. On the other hand, people have a bit gap to start investment due to lack of knowledge and incentives. Therefore, giving background knowledge

TABLE 6.4: The gamification mechanics for mutual fund investment

<b>Mechanics</b>	<b>Contexts</b>	<b>Game Design</b>
Goals	Games are rule-based playing concentrated on achieving goals [149]. Refer to that, gamification is mostly focused on incorporating game elements pursuing various goals, from motivation to engagement. The most important is to identify user's goals and to build an application related to their interests. Game progressing should be incorporated into user experience, they should be represented by short or long-term goals to keep users engaged [146].	After assessment and survey of the user's characteristic, application may set the goal and progress board like that user will have an incentive to carry on.
Badges	Badges are used in order to convince users and change behavior [128]. For example, finishing a level or achievement, these badges serve to unlock other aspects of the game, or use these badges to exchange virtual stuff into real stuff such as privilege in frequent flyer program [23] or permission for activities [150].	Users are allowed to get the badge if they can reach achievement. Badges can be represented as a certificate in practice when users need to do real practice
Time	Users feel motivated to look for positive outcomes, but they might lose engagement over the time [151]. If the time is too short, user will not satisfy experience of the game. If the time is too long, user will get boredom until they lost desire to play. Engagement can be measured by the time people spend on a specific task [108].	In each mission or task, time can depend on the difficulty and type of investment unit. Game usually start with lower acceleration until desire acceleration at some point during game period.
Rewards	Rewards is simply notation for enhancing engagement and persuade the people [23, 150, 152]. Motivation can be examined in two different psychological space. Rewards can affect both intrinsic and extrinsic that arouse certain feelings such as curiosity, competitiveness, frustration, happiness, etc [153].	Rewards can be used in real life even in form of money or privileges. Login rewards system can be also included to keep user retention. Contest, mission, and points can be used in which creating competitiveness, attractiveness, dynamics during game period.

Feedback	<p>Feedback notifies the evaluation of user's performance during the game or activity. It is easy to report the performance and is targeted to player to improve their approach for better, more desirable results [145]. For example, LiveOps utilized gamification to improve workers' performance and customer satisfaction by implementing elements such as avatars, mission, leaderboards, and points [145]. Kahoot applications are easily observed by providing leaderboard to get exciting environment together with competitive feeling [145].</p>	<p>Introduce the sense of competition by ranking and letting people know their standing among their peers. Introduce dashboard by showing the information and transaction which people have done, then give users suggestions and recommendations.</p>
Challenges	<p>Games can have different levels, and engagement can be considered by the user interactions [1, 127]. Gamification in DOTA2 can be represented as a battle pass, users were trying to get level to get a bonus item and special unlockable achievements [108]. In the educational games, most of them use level to quantify players' knowledge and increase according to player's skills [25]. It is implied about balance between challenge and skill as mentioned in flow theory which can describe emotion and motivation of players [38].</p>	<p>Difficulty features should be included for improving user's learning rate. Users can choose what they want to learn while the difficulty has been increased based on their skills. To make more competitive, stochastic the case happened in practice will be helpful to enhance the sophistication of the game.</p>

in investment field is important while we use gamification approach in the system, users require information to make a better decision. Moreover, the gamification issues are addressed to enhance users' motivation and engagement by considering on simplicity, accessibility, and gamification elements such as rewards, badges, challenging and clear tasks [155]. In this

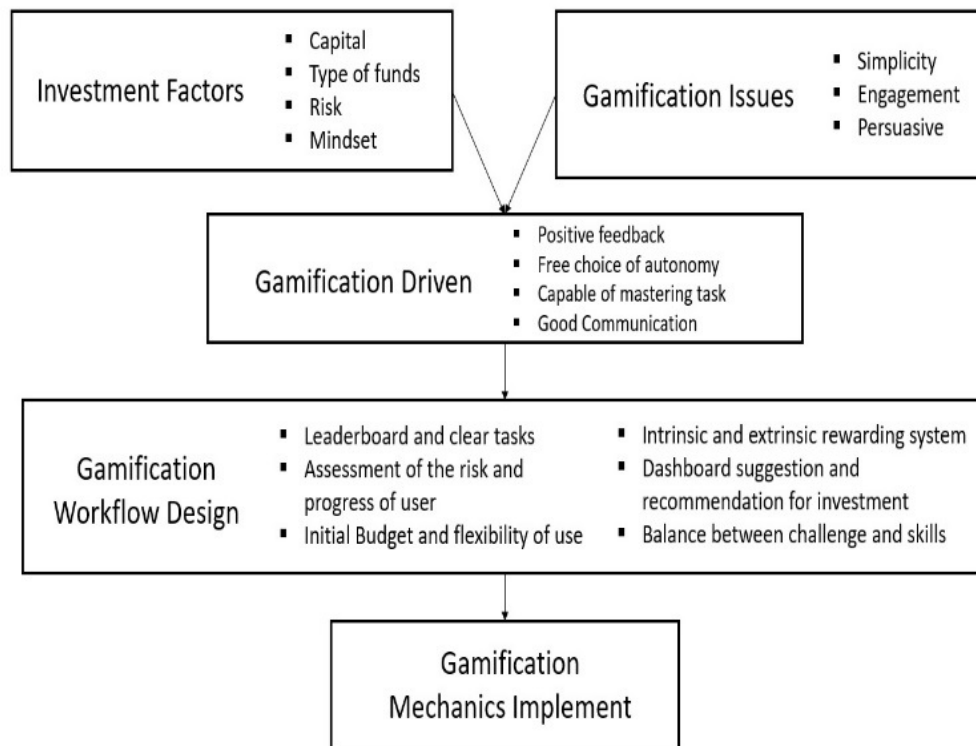


FIGURE 6.2: The mutual fund investment gamification workflow design

context, the findings allow the researcher to design the workflow and gamification mechanics for mutual fund investment in Thailand. This workflow is expected to achieve the objectives that enhances user's motivation.

Refer to Figure 6.4, this system tries to simulate mutual fund investment within safe condition. Based on the practical one, assessment of risk will be done by user that starts with doing survey and choosing the risk in each investment unit. Then, the application will proceed based on the survey data and provide the information which is used to design gamified activity in the game. Gamification elements will be selected according to the information to satisfy and enhance user's engagement, even provide feedback and investment plan based on mathematical model which will be future studies.

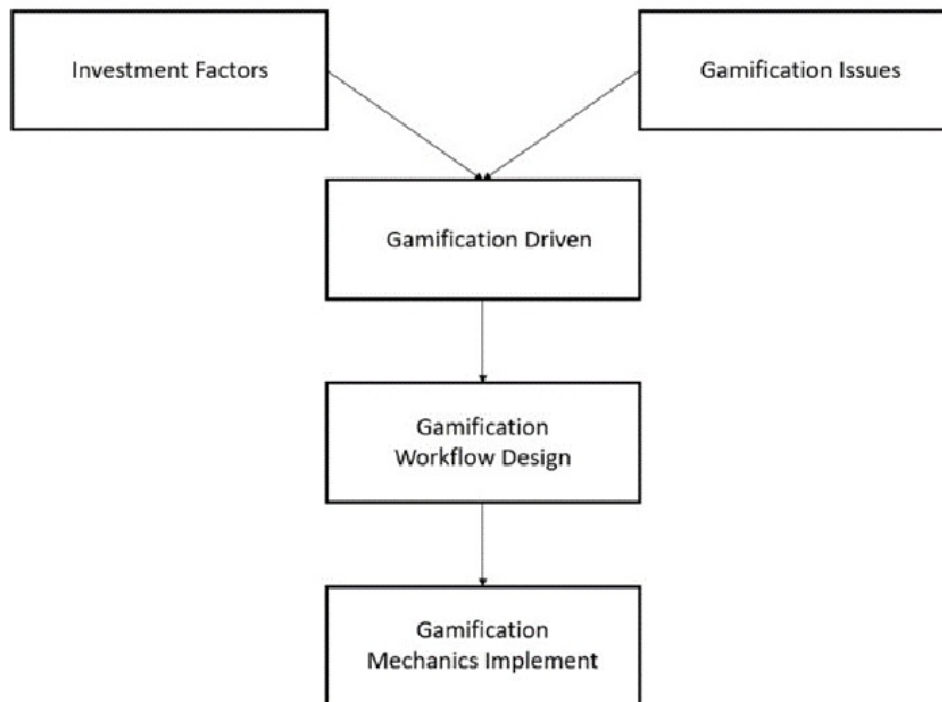


FIGURE 6.3: The gamification workflow design process for mutual fund investment

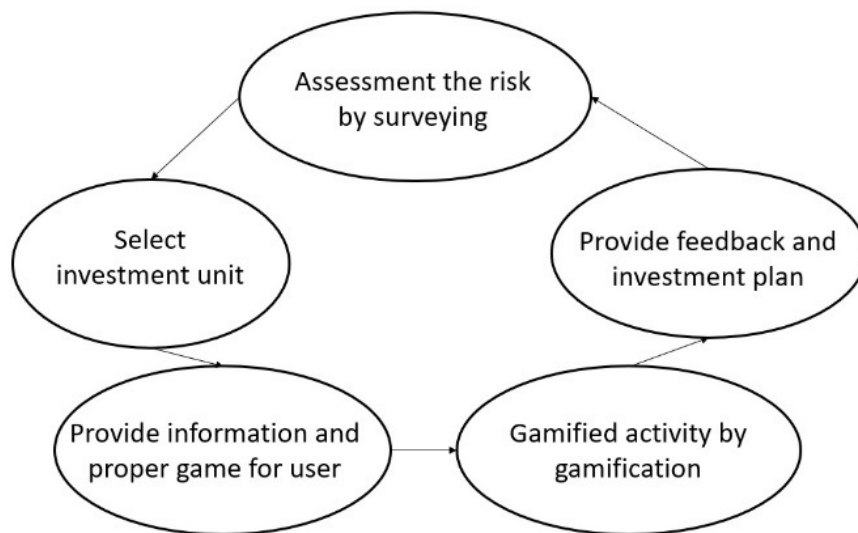


FIGURE 6.4: Framework of the mutual fund investment gamified activity

### 6.3.3 The Conceptual Framework of Gamified Activity

The gamified activities can influence behavior through the mastery of tasks and organizing financial goals. The design process of gamification driven for the financial literacy. The design workflow will be implemented in different contexts. The workflow designs to provide tasks that will help people trust the activities. This study examines gamification strategy by establishing a technology-driven trust relationship with players, and then determining the best way to encourage the players to set goals in terms of financial literacy. Gamified activities will be designed to provide positive feedback by using a saving and expense activity. This positive feedback will persuade players to change their behavior in terms of financial literacy. From the research background, the gamification stimulus model (GSM) is focused on the persuasive behavior. The behavior influences from the sense of achievement. The achievements are stimulated from motivation that drive by the cognition. The knowledge cognition defines as the mental action or process of acquiring knowledge and understanding through thought and externalization of enhanced learning circumstances, experience, and the senses. Gamification plays a stimuli role including a goal setting, challenges, and feedback activity. This model shows the stimuli activities that provides by game mechanics.

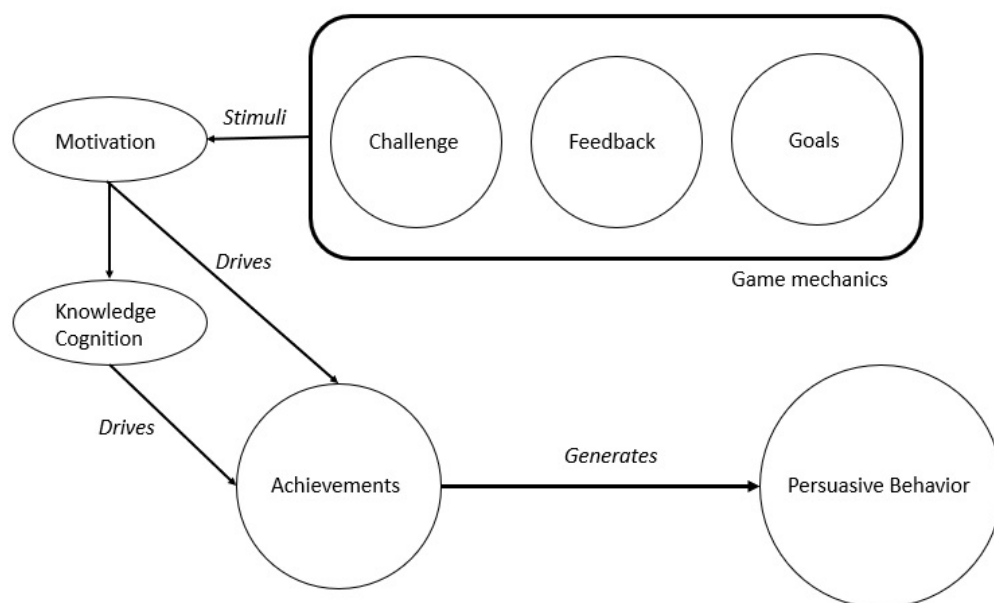


FIGURE 6.5: Conceptual gamification stimulus model

The illustration shows (see Figure 6.5) the relationship between the game element and the sense of achievement. It is impossible to use all gamified elements, it should be considered and figure out what goals is aimed to achieve. The technologies that are used to assist individuals in achieving goals, including helping them to self-monitor behaviors and encouraging commitment. Gamification employs rewards, competition, social comparison, goal setting

## 6.4 Chapter Summary

This chapter presents a review of investment factor and gamification that addressed issues regarding to financial issues with the aim to illustrate and explore the conceptual framework. The gamified experience can be justified the concept of entertainment factors including interactivity, variety, and challenge. Then, it shows that gamified elements vary according to each game mechanic. Most of the mechanics are utilized for engagement, education, motivation, monitoring, persuasion and productivity. They involve rewarding systems, points, time, leaderboards, clear goals, and badges which is expected to help users enhancing their learning activity through serious gaming activity. If it works successfully, gamification can be a tool for enhancing gamified experience. However, challenges might rise, particularly in terms of data analytics. As most of the applications acquired user data, there is a need for analysis of such data, including behaviors and investment factors. Thus, gamified application requires a technology-driven of gamification itself. Therefore, this study has also presented a gamification model a stimulus tool with positive feedback. The model is applied from the crucial characteristics of financial literacy. The gamified activities can influence behavior through the mastery of tasks and organizing financial goals. The data have provided a better understanding as to how to improve gamified activities that influence a player's behavior through engagement in and mastering activities and learning from the feedback and experience.

In future works, the author will explore the outcome of the gamified design. The design model will guide game designers to produce activities that can change people's behavior and teach skills in regard to financial literacy. Furthermore, the proposed method will be

applied and evaluated in the gamified development to support learning. For further research in this area, gamification involves fun, entertainment, engagement, learning and data driven decision making, knowledge-based system, and big data analysis issues could be more studied, integrating not only all the financial areas but also all stakeholders involved in the process in a more engaging way and promoting innovative outcomes in the era of digital transformation.



## Conclusion and Future Works

---

This thesis present various approaches and aspects to investigate effective entertainment factors in various game domains and platform perspectives. In this chapter, we will give answering our research question and problem statement. Then, some future work are discussed.

### 7.1 Concluding Remarks

We summarize our research finding of each three main contents as below:

- **Entertainment Factors**

In chapter 2, we revisit the application of game refinement theory. Intuitively, we present the mathematical expression and infer mathematical model to get the refinement measure. We provide several examples of its application in various domain including boardgames, sports, digital games, and some other non-game contexts. According to the analysis, we found that this theory can be capitalized in which can be considered as evaluation or criteria for excitement level. Besides, we have also analyzed the perceived enjoyment concept and gamification technique to improve the sense of entertaining including more interactive, novel, and challenging. We give the perception on the user point of view that aiming to distinct different emotions and experiences towards the games. Hence, we incorporate entertainment factors with gamification to identify the most essential factor. Therefore, we can improve entertainment factors and effectively apply in various aspects to enhancing users' engagement and experience.

- **Platform Transformation**

We reveal an overview of platform transformation aspect including perceived enjoyment and its plausible application to other domains in Chapter 2. The essential component in Chapter 5 contains three main cognitive factors; interactivity, variety and challenge. These drive the game more exciting and users getting sense of thrilling, learning, adapting, and entertaining. To clarify the proposed concept, we implemented the proposed model to our experiment by using survey and questionnaire distributed to respondents. Comparing these results with the case study and justify with our findings. These results show that users are important to determine the productive solutions for platform transformation and game development. Therefore, the concept of "user-centered study" can mark whether entertainment factors is enabling to determine the expectedness of platform transformation in near future.

Additionally, we propose above concept to other domains such as education and finance in Chapter 5 and Chapter 6. We incorporate with game refinement theory and gamification techniques to figure out a reasonable model in educational aspect, and construct a conceptual framework based on improvement factors and gamification. We found that technology can enhance contribution to both education and finance field if we systematically manage and adapt to justify the main development intention. Therefore, user-centered study on platform transformation and game development can be used for improving the entertainment impact and identify the application in various domains.

- **Game Development**

First properly finding is that game players always require changes over the time and game itself is supposed to provide enough entertainment degree and fairness. In Chapter 3, we apply game refinement theory to Snake game to find the reasonable setting. The appropriate setting show that refinement measure of the classical Snake game are in the balance between skill and chance. Consequently, while increasing speed can make entertainment impact during the game. In Chapter 4, we applies this theory to analyze the evolutionary changes in MOBA game in two different platforms. This result lead us to one of the properly finding in this thesis is to make a

game becoming more ubiquitous and accessible. As usual, MOBA is such a complex game and having long game length, but reducing of game length in mobile platform does not affect the excitement of the game in which their characteristics can improve player satisfactory and the entertainment impact. Including such entertainment factors to improve the game, it particularly improve the game excitement which we can see from game refinement measure. Furthermore, the match is quicker and more balanced in view of player due to the game update of additional systems. We can see that game refinement theory is a reliable mathematical tool to measure the excitement in order to judge the appropriate game length or score to make game being more fair to all players. From these results, we can see that game refinement theory even plays a strong role in increasing the entertainment value of games and can be used to find a reasonable setting and draw interesting conclusions for platform transformation and game development in particular.

According to the problem statement of this thesis is "how to improve the entertainment factors and identify its application to platform transformation and game development", we generally display various aspects from generation of popular game in mobile phone to achieve the evolutionary changes of platform for game entertainment until analysis gamified experience in the domain of education and finance. Developing artificial intelligence and conducting proposed experiment is to quantify the enjoyment based on game refinement theory in order to highlight the concept of entertainment factors driving the development of technology for the people. However, no matter measure value, they are able to change all the time. User-centered study only can specify the direction of games trend onto their needs. In this case, we need to propose framework or idea to predict the application and implementation of platform transformation and game development. Snake game can still be improving from single interactive game to multiplayer interactive game, MOBA games on mobile phone are now trendily available for novice player who have not much skill in MOBA games. Similarly, gaming platforms improve their performance and provide such a new experience for player every single year. Entertainment factors and experience can be improved into both innovative and creative way. This is a good reason to choose user-centered study to analyze the entertainment factors for this term.

## 7.2 Future Works

In fact, this thesis presents a basic model and more studies are needed for answering gap of research. Further work should investigate in many points as it was explained for each chapter. Mainly, we are trying to analyze the link between game and non-game context by considering education case study. In a basis, aim of this thesis is to improve entertainment perspective and to make users perceive enjoyment and exciting toward technology changes. For educational context, we intend to observe several education games and classroom including normal lecture and special activity, then analyze the component such as game elements, variants, or any factors that affect to velocity change patterns and learning rate. This overview will be continued to specify feasibility of our work. Basically, we start doing analysis the pattern of gaming technology classroom and try to accommodate the distinguish points from the regular classroom. From these data and results obtained in the scientific context of play, it is specified type of strategies enhancing the engagement, and it is compared with the speed change pattern of the regular one. In this way, we identify the common points from the student point of view and explore the direction of the internalization this cognitive knowledge and finding reflecting the research results in the science of play to the science

## Bibliography

- [1] J. Merikivi, D. Nguyen and V. K. Tuunainen. ‘Understanding Perceived Enjoyment in Mobile Game Context’. In: *2016 49th Hawaii International Conference on System Sciences (HICSS)*. Jan. 2016, pp. 3801–3810. DOI: [10.1109/HICSS.2016.473](https://doi.org/10.1109/HICSS.2016.473).
- [2] Dongseong Choi, Hoyoung Kim and Jinwoo Kim. ‘Toward the construction of fun computer games: Differences in the views of developers and players’. In: *Personal Technologies* 3.3 (Sept. 1999), pp. 92–104. ISSN: 1617-4917. DOI: [10.1007/BF01305334](https://doi.org/10.1007/BF01305334). URL: <https://doi.org/10.1007/BF01305334>.
- [3] Peter Vorderer, Tilo Hartmann and Christoph Klimmt. ‘Explaining the enjoyment of playing video games: the role of competition’. In: *ICEC*. 2003.
- [4] Pablo Lavín-Mera et al. ‘Mobile Game Development for Multiple Devices in Education’. In: *iJET* 4 (2009), pp. 19–26.
- [5] Priscilla Haring, Dimitrina Chakinska and Ute Ritterfeld. ‘Understanding Serious Gaming: A Psychological Perspective’. In: Jan. 2011, pp. 413–43. DOI: [10.4018/978-1-60960-495-0.ch020](https://doi.org/10.4018/978-1-60960-495-0.ch020).
- [6] Ivo Hilvoorde. ‘Hilvoorde, I. van (2016). Sport and play in a digital world (guest editorial). Sport, Ethics and Philosophy, DOI: 10.1080/17511321.2016.1171252’. In: *Sport Ethics and Philosophy* 10 (Jan. 2016). DOI: [10.1080/17511321.2016.1171252](https://doi.org/10.1080/17511321.2016.1171252).
- [7] Cuihua Shen Hua Wang and Ute Ritterfeld. ‘Enjoyment of Digital Games WhatMakes Them SeriouslyFun? Enjoyment: At the Heart of Digital Gaming’. In: Rabindra Ratan and Ute Ritterfeld, 2009. Chap. 3.
- [8] Giel van Lankveld. ‘Quatifying Individual Player Differences’. PhD thesis. The Dutch Research School of Information and Knowledge system, 2013.

- [9] Mark Felegyhazi and Jean-Pierre Hubaux. ‘Game Theory in Wireless Networks: A Tutorial’. In: *ACM Comput. Surveys* (Jan. 2006).
- [10] Saurabh Mehta and K. S. Kwak. ‘Game Theory and Cognitive Radio Based Wireless Networks’. In: *Agent and Multi-Agent Systems: Technologies and Applications*. Ed. by Anne Håkansson et al. Berlin, Heidelberg: Springer Berlin Heidelberg, 2009, pp. 803–812. ISBN: 978-3-642-01665-3.
- [11] Pu-yan Nie et al. ‘Game Theory and Applications in Economics’. In: *Journal of Applied Mathematics* 2014 (May 2014), pp. 1–2. DOI: [10.1155/2014/936192](https://doi.org/10.1155/2014/936192).
- [12] Ross Cressman. *Evolutionary Dynamics and Extensive Form Games*. Economic Learning and Social Evolution, The MIT Press, 2003.
- [13] David Easley and Jon Kleinberg. *Networks, Crowds, and Markets: Reasoning about a Highly Connected World*. Cambridge University Press, 2010, 2010.
- [14] Daniel Friedman. ‘On economic applications of evolutionary game theory’. In: *Journal of Evolutionary Economics* 8.1 (Mar. 1998), pp. 15–43. ISSN: 1432-1386. DOI: [10.1007/s001910050054](https://doi.org/10.1007/s001910050054). URL: <https://doi.org/10.1007/s001910050054>.
- [15] Youquan Zheng and Zhenming Feng. ‘Evolutionary game and resources competition in the Internet’. In: *IEEE-Siberian Workshop of Students and Young Researches. Modern Communication Technologies SIBCOM-2001. Proceedings (Cat. No.01EX452)*. Nov. 2001, pp. 51–54. DOI: [10.1109/SIBCOM.2001.977512](https://doi.org/10.1109/SIBCOM.2001.977512).
- [16] John Nash. ‘Non-Cooperative Games’. In: *Annals of Mathematics* 54.2 (1951), pp. 286–295. ISSN: 0003486X. URL: <http://www.jstor.org/stable/1969529>.
- [17] Martin J. Osborne and Ariel Rubinstein. *A Course in Game Theory (The MIT Press) First Edition, Twelf Edition*. The MIT Press; First Edition, Twelf edition (July 12, 1994), 1994.
- [18] M. F. Amjad et al. ‘An evolutionary game theoretic framework for coexistence in Cognitive Radio Networks’. In: *2014 IEEE Global Conference on Signal and Information Processing (GlobalSIP)*. Dec. 2014, pp. 278–282. DOI: [10.1109/GlobalSIP.2014.7032122](https://doi.org/10.1109/GlobalSIP.2014.7032122).
- [19] B. Wang, K. J. R. Liu and T. C. Clancy. ‘Evolutionary cooperative spectrum sensing game: how to collaborate?’ In: *IEEE Transactions on Communications* 58.3

- (Mar. 2010), pp. 890–900. ISSN: 1558-0857. DOI: [10.1109/TCOMM.2010.03.090084](https://doi.org/10.1109/TCOMM.2010.03.090084).
- [20] Zahid Halim, Abdul Rauf Baig and Hasan Mujtaba. ‘Measuring entertainment and automatic generation of entertaining games’. In: *IJITCC* 1 (2010), pp. 92–107.
- [21] Arie Pratama Sutiono, Ayu Purwarianti and Hiroyuki Iida. ‘A Mathematical Model of Game Refinement’. In: *Intelligent Technologies for Interactive Entertainment*. Ed. by Dennis Reidsma, Insook Choi and Robin Bargar. Cham: Springer International Publishing, 2014, pp. 148–151. ISBN: 978-3-319-08189-2.
- [22] Baltasar Fernández-Manjón et al. ‘Challenges of serious games’. In: *EAI Endorsed Transactions on Game-Based Learning* 2 (Nov. 2015), p. 150611. DOI: [10.4108/eai.5-11-2015.150611](https://doi.org/10.4108/eai.5-11-2015.150611).
- [23] Long Zuo et al. ‘An Analysis of Gamification Effect of Frequent-Flyer Program’. In: *E-Learning and Games*. Ed. by Abdennour El Rhalibi et al. Cham: Springer International Publishing, 2019, pp. 53–60. ISBN: 978-3-030-23712-7.
- [24] Richard M. Ryan and Edward L. Deci. ‘Intrinsic and Extrinsic Motivations: Classic Definitions and New Directions’. In: *Contemporary Educational Psychology* 25.1 (2000), pp. 54–67. ISSN: 0361-476X. DOI: <https://doi.org/10.1006/ceps.1999.1020>. URL: <http://www.sciencedirect.com/science/article/pii/S0361476X99910202>.
- [25] I.M. Ružic and Mario Dumancic. ‘Gamification in education’. In: 48 (Dec. 2015), pp. 198–204.
- [26] Sebastian Deterding et al. ‘From Game Design Elements to Gamefulness: Defining "Gamification"’. In: *Proceedings of the 15th International Academic MindTrek Conference: Envisioning Future Media Environments*. MindTrek ’11. Tampere, Finland: ACM, 2011, pp. 9–15. ISBN: 978-1-4503-0816-8. DOI: [10.1145/2181037.2181040](https://doi.org/10.1145/2181037.2181040). URL: <http://doi.acm.org/10.1145/2181037.2181040>.
- [27] Juho Hamari and Jonna Koivisto. ‘Why do people use gamification services?’ In: *International Journal of Information Management* 35 (Aug. 2015), pp. 419–431. DOI: [10.1016/j.ijinfomgt.2015.04.006](https://doi.org/10.1016/j.ijinfomgt.2015.04.006).

- [28] Marco Furini. 'Mobile Games: What to expect in the near Future'. In: *GAMEON*. 2007.
- [29] Jinwoo Kim, Dongseong Choi and Hoyoung Kim. 'Toward the construction of fun computer games: Differences in the views of developers and players'. In: *Personal Technologies* 3 (1999), pp. 92–104.
- [30] Eui Jun Jeong and Dan J. Kim. 'Definitions, Key Characteristics, and Generations of Mobile Games'. In: 2007.
- [31] Kowit Rapeepisarn et al. 'A comparative study of digital game platforms for educational purposes'. In: 2008.
- [32] Jennifer Groff, Cathrin Howells and Sue Cranmer. *The impact of console games in the classroom: Evidence from schools in Scotland*. Jan. 2010.
- [33] Lori Takeuchi. *Level up Learning: A National Survey on Teaching with Digital Games*. Joan Ganz Cooney Center, 2014.
- [34] Amrit Tiwana. 'Evolutionary Competition in Platform Ecosystems'. In: *Information Systems Research* 26 (Apr. 2015), p. 150424094525000. DOI: [10.1287/isre.2015.0573](https://doi.org/10.1287/isre.2015.0573).
- [35] Ruonan Sun, Shirley Gregor and Byron Keating. 'Information Technology Platforms: Definition and Research Directions'. In: Dec. 2015.
- [36] Thomas E. Coleman and Arthur G. Money. 'Student-centred digital game-based learning: a conceptual framework and survey of the state of the art'. In: *Higher Education* (July 2019). ISSN: 1573-174X. DOI: [10.1007/s10734-019-00417-0](https://doi.org/10.1007/s10734-019-00417-0). URL: <https://doi.org/10.1007/s10734-019-00417-0>.
- [37] Duyen Nguyen. 'Understanding perceived enjoyment and continuance intention in mobile games'. In: 2015.
- [38] Mihaly Csikszentmihalyi. 'Finding flow: the psychology of engagement with everyday life'. In: *Choice Reviews Online* 3.35 (1997), pp. 35–1828.
- [39] Elizabeth A. Boyle et al. 'Engagement in digital entertainment games: A systematic review'. In: *Computers in Human Behavior* 28.3 (2012), pp. 771–780. ISSN: 0747-5632. DOI: <https://doi.org/10.1016/j.chb.2011.11.020>.



- URL: <http://www.sciencedirect.com/science/article/pii/S0747563211002640>.
- [40] Ritu Agarwal and Elena Karahanna. ‘Time Flies When You’re Having Fun: Cognitive Absorption and Beliefs about Information Technology Usage’. In: *MIS Quarterly* 24.4 (2000), pp. 665–694. ISSN: 02767783. URL: <http://www.jstor.org/stable/3250951>.
- [41] Monica D. Hernandez. ‘A Model of Flow Experience as Determinant of Positive Attitudes Toward Online Advergaming’. In: *Journal of Promotion Management* 17.3 (2011), pp. 315–326. DOI: [10.1080/10496491.2011.596761](https://doi.org/10.1080/10496491.2011.596761). eprint: <https://doi.org/10.1080/10496491.2011.596761>. URL: <https://doi.org/10.1080/10496491.2011.596761>.
- [42] John Sherry. ‘Flow and Media Enjoyment’. In: *Communication Theory* 14 (Nov. 2004), pp. 328–347. DOI: [10.1111/j.1468-2885.2004.tb00318.x](https://doi.org/10.1111/j.1468-2885.2004.tb00318.x).
- [43] Hiroyuki Iida. ‘What one likes, one will do well’. In: May 2018.
- [44] Shuo Xiong, Long Zuo and Hiroyuki Iida. ‘Possible Interpretations for Game Refinement Measure’. In: Aug. 2017, pp. 322–334. ISBN: 978-3-319-66714-0. DOI: [10.1007/978-3-319-66715-7\\_35](https://doi.org/10.1007/978-3-319-66715-7_35).
- [45] Hiroyuki Iida. ‘Serious Games Discover Game Refinement Measure’. In: Aug. 2017. DOI: [10.1109/ICECOS.2017.8167112](https://doi.org/10.1109/ICECOS.2017.8167112).
- [46] Shuo Xiong et al. *Using Signal Processing Model to Evaluate the Impact of Seesaw Games*. Nov. 2018.
- [47] Hiroyuki Iida et al. ‘An Application of Game-Refinement Theory to Mah Jong’. In: *Entertainment Computing – ICEC 2004*. Ed. by Matthias Rauterberg. Berlin, Heidelberg: Springer Berlin Heidelberg, 2004, pp. 333–338. ISBN: 978-3-540-28643-1.
- [48] Nathan Nossal and Hiroyuki Iida. ‘Game refinement theory and its application to score limit games’. In: *2014 IEEE Games Media Entertainment* (2014), pp. 1–3.
- [49] R. Chiewvanichakorn, N. Nossal and H. Iida. ‘Game refinement model with consideration on playing cost: A case study using crane games’. In: *2015 7th International*

- Conference on Knowledge and Smart Technology (KST)*. Jan. 2015, pp. 87–92. DOI: [10.1109/KST.2015.7051458](https://doi.org/10.1109/KST.2015.7051458).
- [50] Shuo Xiong et al. ‘E-learning Rhythm Design: Case Study Using Fighting Games’. In: *Edutainment*. 2018.
- [51] C. Panumate, S. Xiong and H. Iida. ‘An Approach to Quantifying Pokemon’s Entertainment Impact with Focus on Battle’. In: *2015 3rd International Conference on Applied Computing and Information Technology/2nd International Conference on Computational Science and Intelligence*. July 2015, pp. 60–66. DOI: [10.1109/ACIT-CSEI.2015.19](https://doi.org/10.1109/ACIT-CSEI.2015.19).
- [52] H. Iida. ‘Serious games discover game refinement measure’. In: *2017 International Conference on Electrical Engineering and Computer Science (ICECOS)*. Aug. 2017, pp. 1–6. DOI: [10.1109/ICECOS.2017.8167112](https://doi.org/10.1109/ICECOS.2017.8167112).
- [53] Duy Huynh, Long Zuo and Hiroyuki Iida. ‘Analyzing Gamification of "Duolingo" with Focus on Its Course Structure’. In: *GALA*. 2016.
- [54] Duy Huynh, Long Zuo and Hiroyuki Iida. ‘An Assessment of Game Elements in Language-Learning Platform Duolingo’. In: Aug. 2018. DOI: [10.1109/ICCOINS.2018.8510568](https://doi.org/10.1109/ICCOINS.2018.8510568).
- [55] Duy Huynh and Hiroyuki Iida. ‘An Analysis of Winning Streak’s Effects in Language Course of "Duolingo"’. In: *Asia-Pacific Journal of Information Technology and Multimedia Jurnal Teknologi Maklumat dan Multimedia Asia-Pasifik* 6 (Dec. 2017), pp. 23–29.
- [56] S. Adepu and R. F. Adler. ‘A comparison of performance and preference on mobile devices vs. desktop computers’. In: *2016 IEEE 7th Annual Ubiquitous Computing, Electronics Mobile Communication Conference (UEMCON)*. Oct. 2016, pp. 1–7. DOI: [10.1109/UEMCON.2016.7777808](https://doi.org/10.1109/UEMCON.2016.7777808).
- [57] Christopher A. Sanchez and Russell J. Branaghan. ‘Turning to learn: Screen orientation and reasoning with small devices’. In: *Computers in Human Behavior* 27.2 (2011). Web 2.0 in Travel and Tourism: Empowering and Changing the Role of Travelers, pp. 793–797. ISSN: 0747-5632. DOI: <https://doi.org/10.1016/j.chb>.

- 2010.11.004. URL: <http://www.sciencedirect.com/science/article/pii/S0747563210003468>.
- [58] Patti Bao et al. 'Smart Phone Use by Non-mobile Business Users'. In: *Proceedings of the 13th International Conference on Human Computer Interaction with Mobile Devices and Services*. MobileHCI '11. Stockholm, Sweden: ACM, 2011, pp. 445–454. ISBN: 978-1-4503-0541-9. DOI: [10.1145/2037373.2037440](https://doi.org/10.1145/2037373.2037440). URL: <http://doi.acm.org/10.1145/2037373.2037440>.
- [59] Mick P. Couper and Gregg J. Peterson. 'Why Do Web Surveys Take Longer on Smartphones?' In: *Social Science Computer Review* 35.3 (2017), pp. 357–377. DOI: [10.1177/0894439316629932](https://doi.org/10.1177/0894439316629932). eprint: <https://doi.org/10.1177/0894439316629932>. URL: <https://doi.org/10.1177/0894439316629932>.
- [60] Byron Reeves et al. 'The Effects of Screen Size and Message Content on Attention and Arousal'. In: *Media Psychology* 1.1 (1999), pp. 49–67. DOI: [10.1207/s1532785xmep0101\\_4](https://doi.org/10.1207/s1532785xmep0101_4).
- [61] Dimitrios Raptis et al. 'Does Size Matter?: Investigating the Impact of Mobile Phone Screen Size on Users' Perceived Usability, Effectiveness and Efficiency.' In: *Proceedings of the 15th International Conference on Human-computer Interaction with Mobile Devices and Services*. MobileHCI '13. Munich, Germany: ACM, 2013, pp. 127–136. ISBN: 978-1-4503-2273-7. DOI: [10.1145/2493190.2493204](https://doi.org/10.1145/2493190.2493204). URL: <http://doi.acm.org/10.1145/2493190.2493204>.
- [62] Laura Haak Marcial and Bradley M. Hemminger. 'Scrolling and pagination for within document searching: The impact of screen size and interaction style'. In: *ASIST*. 2011.
- [63] Amy K. Karlson et al. 'Mobile Taskflow in Context: A Screenshot Study of Smartphone Usage'. In: *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems*. CHI '10. Atlanta, Georgia, USA: ACM, 2010, pp. 2009–2018. ISBN: 978-1-60558-929-9. DOI: [10.1145/1753326.1753631](https://doi.org/10.1145/1753326.1753631). URL: <http://doi.acm.org/10.1145/1753326.1753631>.
- [64] Amy K. Karlson et al. 'Working Overtime: Patterns of Smartphone and PC Usage in the Day of an Information Worker'. In: *Pervasive Computing*. Ed. by Hideyuki

- Tokuda et al. Berlin, Heidelberg: Springer Berlin Heidelberg, 2009, pp. 398–405. ISBN: 978-3-642-01516-8.
- [65] Hannu Korhonen and Elina M. I. Koivisto. ‘Playability Heuristics for Mobile Games’. In: *Proceedings of the 8th Conference on Human-computer Interaction with Mobile Devices and Services*. MobileHCI ’06. Helsinki, Finland: ACM, 2006, pp. 9–16. ISBN: 1-59593-390-5. DOI: [10.1145/1152215.1152218](https://doi.org/10.1145/1152215.1152218). URL: <http://doi.acm.org/10.1145/1152215.1152218>.
- [66] Viswanath Venkatesh and Fred D. Davis. ‘A Model of the Antecedents of Perceived Ease of Use: Development and Test\*’. In: 1996.
- [67] Mohammad Chuttur. ‘Overview of the Technology Acceptance Model: Origins, Developments and Future Directions’. In: *Sprouts: Working Papers on Information Systems* 9 (Jan. 2009).
- [68] Sangjae Lee and Chun-fu Quan. ‘Factors affecting Chinese Ubiquitous Game Service usage intention’. In: *International Journal of Mobile Communications* 11 (Mar. 2013), pp. 194–212. DOI: [10.1504/IJMC.2013.052641](https://doi.org/10.1504/IJMC.2013.052641).
- [69] Herbjørn Nysveen, Per E. Pedersen and Helge Thorbjørnsen. ‘Intentions to use mobile services: Antecedents and cross-service comparisons’. In: *Journal of the Academy of Marketing Science* 33.3 (June 2005), p. 330. ISSN: 1552-7824. DOI: [10.1177/0092070305276149](https://doi.org/10.1177/0092070305276149). URL: <https://doi.org/10.1177/0092070305276149>.
- [70] Yong Liu and Hongxiu Li. ‘Exploring the impact of use context on mobile hedonic services adoption: An empirical study on mobile gaming in China’. In: *Computers in Human Behavior* 27.2 (2011). Web 2.0 in Travel and Tourism: Empowering and Changing the Role of Travelers, pp. 890–898. ISSN: 0747-5632. DOI: <https://doi.org/10.1016/j.chb.2010.11.014>. URL: <http://www.sciencedirect.com/science/article/pii/S0747563210003596>.
- [71] Shintaro Okazaki, Radoslav Škapa and Ildefonso Grande. ‘Global Youth and Mobile Games: Applying the Extended Technology Acceptance Model in the U.S.A., Japan, Spain, and the Czech Republic’. In: *Advances in International Marketing* 18 (May 2007), pp. 253–270. DOI: [10.1016/S1474-7979\(06\)18011-4](https://doi.org/10.1016/S1474-7979(06)18011-4).

- [72] Ting-Peng Liang and Yi-Hsuan Yeh. 'Effect of Use Contexts on the Continuous Use of Mobile Services: The Case of Mobile Games'. In: *Personal Ubiquitous Comput.* 15.2 (Feb. 2011), pp. 187–196. ISSN: 1617-4909. DOI: [10.1007/s00779-010-0300-1](https://doi.org/10.1007/s00779-010-0300-1). URL: <http://dx.doi.org/10.1007/s00779-010-0300-1>.
- [73] Tao Zhou. 'Understanding the Effect of Flow on User Adoption of Mobile Games'. In: *Personal Ubiquitous Comput.* 17.4 (Apr. 2013), pp. 741–748. ISSN: 1617-4909. DOI: [10.1007/s00779-012-0613-3](https://doi.org/10.1007/s00779-012-0613-3). URL: <http://dx.doi.org/10.1007/s00779-012-0613-3>.
- [74] Dong-Hee Shin and Youn-Joo Shin. 'Why Do People Play Social Network Games?' In: *Comput. Hum. Behav.* 27.2 (Mar. 2011), pp. 852–861. ISSN: 0747-5632. DOI: [10.1016/j.chb.2010.11.010](https://doi.org/10.1016/j.chb.2010.11.010). URL: <http://dx.doi.org/10.1016/j.chb.2010.11.010>.
- [75] Minna Pura and Gregory Brush. 'Comparing the Perceived Value of Information and Entertainment Mobile Services'. In: *Psychology and Marketing* 25 (Aug. 2008), pp. 732–755. DOI: [10.1002/mar.20236](https://doi.org/10.1002/mar.20236).
- [76] Xiaowen Fang and Fan Zhao. 'Personality and Enjoyment of Computer Game Play'. In: *Comput. Ind.* 61.4 (May 2010), pp. 342–349. ISSN: 0166-3615. DOI: [10.1016/j.compind.2009.12.005](https://doi.org/10.1016/j.compind.2009.12.005). URL: <http://dx.doi.org/10.1016/j.compind.2009.12.005>.
- [77] David Furió et al. 'Evaluation of learning outcomes using an educational iPhone game vs. traditional game'. In: *Computers Education* 64 (2013), pp. 1–23.
- [78] Eric Klopfer et al. *Using the Technology of Today, in the Classroom Today: The Instructional Power of Digital Gaming and Social Networking and How Teachers Can Leverage It*. Jan. 2009.
- [79] Xiangyu Wang. 'Augmented Reality: A new way of augmented learning'. In: *eLearn* 2012 (Oct. 2012). DOI: [10.1145/2380716.2380717](https://doi.org/10.1145/2380716.2380717).
- [80] Vincentas Lamanauskas et al. 'Evaluating the Educational Value and Usability of an Augmented Reality Platform for School Environments: Some Preliminary Results'. In: 2007.

- [81] Ricardo Rosas et al. 'Beyond Nintendo: design and assessment of educational video games for first and second grade students'. In: *Computers Education* 40 (2003), pp. 71–94.
- [82] Kowit Rapeepisarn et al. 'Educational use of handheld game consoles – PSP and NDS in Thai colleges'. In: 2008.
- [83] Kowit Rapeepisarn et al. 'Creating effective educational computer games for undergraduate classroom learning: a conceptual model'. In: 2008.
- [84] Wilawan Inchamnan, Peta Wyeth and Daniel M. Johnson. 'Design for Creative Activity: A Framework for Analyzing the Creative Potential of Computer Games'. In: *ICEC*. 2014.
- [85] Alexander Bartel and Georg Hagel. 'Engaging students with a mobile game-based learning system in university education'. In: *2014 IEEE Global Engineering Education Conference (EDUCON)* (2014), pp. 957–960.
- [86] Gerhard Schwabe and Christoph Göth. 'Mobile learning with a mobile game: design and motivational effects'. In: *J. Comp. Assisted Learning* 21 (2005), pp. 204–216.
- [87] Pellegrini A. Smith PK. *Learning Through Play*. In: Tremblay RE, Boivin M, Peters RDeV, eds. Smith PK, topic ed. *Encyclopedia on Early Childhood Development* [online], 2013.
- [88] Jared R. Chapman and Peter J. Rich. 'Does educational gamification improve students' motivation? If so, which game elements work best?' In: *Journal of Education for Business* 93.7 (2018), pp. 315–322. DOI: [10.1080/08832323.2018.1490687](https://doi.org/10.1080/08832323.2018.1490687). eprint: <https://doi.org/10.1080/08832323.2018.1490687>. URL: <https://doi.org/10.1080/08832323.2018.1490687>.
- [89] R. Raja and P. Nagasubramani. 'Impact of modern technology in education'. In: *Journal of Applied and Advanced Research* 3 (May 2018), p. 33. DOI: [10.21839/jaar.2018.v3iS1.165](https://doi.org/10.21839/jaar.2018.v3iS1.165).
- [90] Samuel Zirawaga, Adeleye Olusanya and Tinovimbanashe Maduku. 'Gaming in Education: Using Games as a Support Tool to Teach History'. In: (Jan. 2017).

- [91] Christian Arzate Cruz and Jorge Adolfo Ramírez Uresti. ‘Player-centered game AI from a flow perspective: Towards a better understanding of past trends and future directions’. In: *Entertainment Computing* 20 (2017), pp. 11–24.
- [92] Diana Oblinger. ‘The Next Generation of Educational Engagement’. In: *Journal of Interactive Media in Education* 8 (May 2004), pp. 1–. DOI: [10.5334/2004-8-oblinger](https://doi.org/10.5334/2004-8-oblinger).
- [93] Ismo Alakärppä et al. ‘Using Nature Elements in Mobile AR for Education with Children’. In: *Proceedings of the 19th International Conference on Human-Computer Interaction with Mobile Devices and Services*. MobileHCI ’17. Vienna, Austria: ACM, 2017, 41:1–41:13. ISBN: 978-1-4503-5075-4. DOI: [10.1145/3098279.3098547](https://doi.org/10.1145/3098279.3098547). URL: <http://doi.acm.org/10.1145/3098279.3098547>.
- [94] Jennifer Redd and Denise Schmidt-Crawford. *The Potential of Building High School Students’ Vocabulary Using an iPod Touch and Gaming App*. 2011. URL: <http://hdl.handle.net/20.500.12424/28797>.
- [95] *Snake (video game genre)*. URL: [https://en.wikipedia.org/wiki/Snake\\_\(video\\_game\\_genre\)](https://en.wikipedia.org/wiki/Snake_(video_game_genre)).
- [96] *Snake (video game)*. URL: [https://gamia-archive.gamepedia.com/Snake\\_\(video\\_game\)](https://gamia-archive.gamepedia.com/Snake_(video_game)).
- [97] Tobin Ehlis. ‘Application of Genetic Programming to the “Snake Game”’. In: *Game-dev.Net* 175 (2000). URL: <http://www.gamedev.net/articles/programming/artificial-intelligence/application-of-genetic-programming-to-the-snake-r1175/>.
- [98] Microsoft Devices Team. *The evolution of Snake*. Nov. 2010. URL: <https://blogs.windows.com/devices/2010/11/25/the-evolution-of-snake/>.
- [99] HMD Global. *Iconic Snake game is back and available on Messenger*. Feb. 2017. URL: <https://www.hmdglobal.com/press/2017-02-27-snake/>.
- [100] Jia-Fong Yeh et al. ‘Snake game AI: Movement rating functions and evolutionary algorithm-based optimization’. In: *2016 Conference on Technologies and Applications of Artificial Intelligence (TAAI)* (2016), pp. 256–261.

- [101] Wikipedia: *Wikipedia Arena of Valor (AOV)*. Dec. 2016. URL: <https://en.wikipedia.org/wiki/Arena-of-Valor>.
- [102] V.Butalov. *Arena of Valor: mobile version of League of Legends*. Feb. 2017. URL: <https://medium.com/vadimbutalov/arena-of-valor-mobile-version-of-league-of-legends-9db53224b594>.
- [103] Long Zuo, Shuo Xiong and Hiroyuki Iida. 'An Analysis of DOTA2 Using Game Refinement Measure'. In: *ICEC*. 2017.
- [104] Gabe Zichermann and Christopher Cunningham. *Gamification by Design: Implementing Game Mechanics in Web and Mobile Apps*. 1st. O'Reilly Media, Inc., 2011. ISBN: 1449397670, 9781449397678.
- [105] Alha Kati et al. 'Free-to-Play Games: Professionals's Perspectives'. In: *DiGRA Nordic &#3914: Proceedings of the 2014 International DiGRA Nordic Conference*. DiGRA, 2014. ISBN: ISSN 2342-9666. URL: [http://www.digra.org/wp-content/uploads/digital-library/nordicdigra2014\\_submission\\_8.pdf](http://www.digra.org/wp-content/uploads/digital-library/nordicdigra2014_submission_8.pdf).
- [106] TUULI IRINA PÖLLÄNEN. 'The influence of cognitive skills and team cohesion on player performance in Multiplayer Online Battle Arena'. In: 2014.
- [107] *Arena of Valor (Guide)*. Jan. 2017. URL: <https://samurai-gamers.com/arena-of-valor/>.
- [108] Sagguneswaraan Thavamuni, Hadzariah Ismail and Hiroyuki Iida. 'An Analysis of Gamification on Dota 2's Business Model'. In: *Computational Science and Engineering*. Vol. 892. Applied Mechanics and Materials. Trans Tech Publications Ltd, July 2019, pp. 55–63. DOI: [10.4028/www.scientific.net/AMM.892.55](https://doi.org/10.4028/www.scientific.net/AMM.892.55).
- [109] *The Arena of Valor encyclopedia*. Jan. 2017. URL: [https://liquipedia.net/arenaofvalor/Main\\_Page](https://liquipedia.net/arenaofvalor/Main_Page).
- [110] R. Cowley. *Tencent revenues grow to 8.56 billion dollars as mobile games sales beat PC for the first time*. Jan. 2018. URL: <http://www.pocketgamer.biz/asia/news/67000/tencent-financials>.
- [111] Jamie Pinchot, Karen L. Paullet and Daniel R. Rota. 'How Mobile Technology is Changing Our Culture'. In: 2010.



- [112] M. Munezero et al. ‘Are They Different? Affect, Feeling, Emotion, Sentiment, and Opinion Detection in Text’. In: *IEEE Transactions on Affective Computing* 5.2 (Apr. 2014), pp. 101–111. ISSN: 2371-9850. DOI: [10.1109/TAFPC.2014.2317187](https://doi.org/10.1109/TAFPC.2014.2317187).
- [113] Giel Van Lankveld, Sonny Schreurs and Pieter Spronck. ‘Psychologically verified player modelling’. In: *In 10th International Conference on Intelligent Games and Simulation GAME-ON 2009* (ed. Linda Breitlauch. Pp. 12–19.
- [114] *Nintendo video game consoles*. Jan. 2020. URL: <https://en.wikipedia.org/wiki/Nintendo-video-game-consoles>.
- [115] Gaming Statista Richter. *The Most Important Gaming Platforms in 2019 from Game Developers Conference*. Jan. 2019. URL: <https://www.statista.com/chart/4527/game-developers-platform-preferences/>.
- [116] Mario Martínez-Zarzuela et al. ‘Educational Tourism through a Virtual Reality Platform’. In: *VARE*. 2013.
- [117] Chantzi Athanasia Eleftheria et al. ‘An innovative augmented reality educational platform using Gamification to enhance lifelong learning and cultural education’. In: *IISA 2013* (2013), pp. 1–5.
- [118] Patrick Roth et al. ‘From Dots to Shapes: an auditory haptic game platform for teaching geometry to blind pupils’. In: 2000.
- [119] Victor Samuel Zirawaga, Adeleye Idowu Olusanya and Tinovimbanashe Maduku. ‘Gaming in Education: Using Games as a Support Tool to Teach History’. In: 2017.
- [120] Eric Klopfer et al. *Using the Technology of Today, in the Classroom Today: The Instructional Power of Digital Gaming and Social Networking and How Teachers Can Leverage It*. Jan. 2009.
- [121] *The Nintendo Labo Teacher Guide*. Sept. 2018. URL: <https://labo.nintendo.com/classroom/assets/labo-teacher-guide.pdf>.
- [122] Harri Ketamo et al. ‘Integrating Games into the Classroom: Towards New Teachership’. In: 2013.
- [123] Huseyin Bicen and Senay Kocakoyun. ‘Perceptions of Students for Gamification Approach: Kahoot as a Case Study’. In: 2018.

- [124] Carolyn M. Plump and Julia LaRosa. ‘Using Kahoot! in the Classroom to Create Engagement and Active Learning: A Game-Based Technology Solution for eLearning Novices’. In: *Management Teaching Review* 2.2 (2017), pp. 151–158. DOI: [10.1177/2379298116689783](https://doi.org/10.1177/2379298116689783). eprint: <https://doi.org/10.1177/2379298116689783>. URL: <https://doi.org/10.1177/2379298116689783>.
- [125] Hiroyuki Iida. *Fairness, Judges and Thrill in Games*. Mar. 2008.
- [126] Nadja Zaric. ‘Personalization of gamification in (programming) e-learning environments’. In: Jan. 2019.
- [127] Punyawee Anunpattana, Mohd Nor Akmal Khalid and Hiroyuki Iida. ‘User-centered Entertainment Factors for Platform Transformation and Game Development’. In: EAI, INCITEST2019, Oct. 2019. DOI: [10.4108/eai.18-7-2019.2287794](https://doi.org/10.4108/eai.18-7-2019.2287794).
- [128] Liliia deCos. *Opportunity for banks to utilize gamification as a tool to promote financial education to children*. 10th European Conference on Games Based Learning: ECGBL 2016, 2016.
- [129] Annamaria Lusardi and Olivia Mitchell. ‘The Economic Importance of Financial Literacy: Theory and Evidence’. In: *Journal of Economic Literature* 52 (Apr. 2013). DOI: [10.2139/ssrn.2243635](https://doi.org/10.2139/ssrn.2243635).
- [130] Kanittha Tambunlertchai. *Financial Inclusion, Financial Regulation, and Financial Education in Thailand*. ADBI Working Papers 537. Asian Development Bank Institute, Sept. 2015. URL: <https://ideas.repec.org/p/ris/adbiwp/0537.html>.
- [131] Adele Atkinson and Flore-Anne Messy. ‘Measuring Financial Literacy’. In: 15 (2012). DOI: <https://doi.org/https://doi.org/10.1787/5k9csfs90fr4-en>. URL: <https://www.oecd-ilibrary.org/content/paper/5k9csfs90fr4-en>.
- [132] James Chen. *What Is an Investment?* June 2019. URL: <https://www.investopedia.com/terms/i/investment.asp>.
- [133] Chennai. *FUNDSINDIA.COM LAUNCHES GAMIFICATION IN MUTUAL FUND INVESTING*. Nov. 2016. URL: <https://pages.fundsindia.com/pages/>

- media / fundsindia - com - launches - gamification - in - mutual - fund - investing /.
- [134] Pulkit Jain. *Mutual Funds Overview*. Nov. 2018. URL: <https://www.finbucket.com/mutual-funds/mutual-funds-overview/>.
- [135] Luis Rodrigues, Carlos Costa and Abílio Oliveira. 'The adoption of gamification in e-banking'. In: July 2013, pp. 47–55. DOI: [10.1145/2503859.2503867](https://doi.org/10.1145/2503859.2503867).
- [136] Dennis L. Kappen and Rita Orji. 'Gamified and Persuasive Systems As Behavior Change Agents for Health and Wellness'. In: *XRDS* 24.1 (Sept. 2017), pp. 52–55. ISSN: 1528-4972. DOI: [10.1145/3123750](https://doi.org/10.1145/3123750). URL: <http://doi.acm.org/10.1145/3123750>.
- [137] Rita Orji. 'Why Are Persuasive Strategies Effective? Exploring the Strengths and Weaknesses of Socially-Oriented Persuasive Strategies'. In: *PERSUASIVE*. 2017.
- [138] Cristina Muntean. 'Raising engagement in e-learning through gamification'. In: *Proc. 6th International Conference on Virtual Learning ICVL* (Jan. 2011).
- [139] R Garriss, Robert H. Ahlers and James E. Driskell. 'Games, Motivation, and Learning: A Research and Practice Model'. In: 2002.
- [140] Ganit Richter, Daphne R. Raban and Sheizaf Rafaeli. 'Studying Gamification: The Effect of Rewards and Incentives on Motivation'. In: *Gamification in Education and Business*. Ed. by Torsten Reiners and Lincoln C. Wood. Cham: Springer International Publishing, 2015, pp. 21–46. ISBN: 978-3-319-10208-5. DOI: [10.1007/978-3-319-10208-5\\_2](https://doi.org/10.1007/978-3-319-10208-5_2). URL: [https://doi.org/10.1007/978-3-319-10208-5\\_2](https://doi.org/10.1007/978-3-319-10208-5_2).
- [141] Fatma Kayan Fadlelmula. 'Educational motivation and students' achievement goal orientations'. In: *Procedia - Social and Behavioral Sciences* 2.2 (2010). Innovation and Creativity in Education, pp. 859–863. ISSN: 1877-0428. DOI: <https://doi.org/10.1016/j.sbspro.2010.03.116>. URL: <http://www.sciencedirect.com/science/article/pii/S1877042810001564>.
- [142] Donald A. Norman and Stephen W. Draper. *User Centered System Design; New Perspectives on Human-Computer Interaction*. Hillsdale, NJ, USA: L. Erlbaum Associates Inc., 1986. ISBN: 0898597811.

- [143] Wilawan Inchamnan. 'Gamification design process for the aging society in Thailand'. In: *Humanities Social Sciences Reviews* 7 (Mar. 2019), pp. 47–54. DOI: [10.18510/hssr.2019.716](https://doi.org/10.18510/hssr.2019.716).
- [144] Therese McGinnis et al. 'Enhancing E-Learning Engagement Using Design Patterns from Computer Games'. In: *First International Conference on Advances in Computer-Human Interaction* (2008), pp. 124–130.
- [145] Vanessa Wanick and Hong Bui. 'Gamification in Management: a systematic review and research directions'. In: *International Journal of Serious Games* 6.2 (June 2019), pp. 57–74. DOI: [10.17083/ijsg.v6i2.282](https://doi.org/10.17083/ijsg.v6i2.282). URL: <https://journal.seriousgamesociety.org/index.php/IJSG/article/view/282>.
- [146] Punyawee Anunpattana et al. 'Analysis of REALM OF VALOR and its Business Model on PC and Mobile Platform Comparison'. In: 7 (Jan. 2019), pp. 1–11.
- [147] Jenni Majuri, Jonna Koivisto and Juho Hamari. 'Gamification of Education and Learning: A Review of Empirical Literature.' In: May 2018.
- [148] Juho Hamari, Jonna Koivisto and Tuomas Pakkanen. 'Do Persuasive Technologies Persuade? - A Review of Empirical Studies'. In: vol. 8462. May 2014, pp. 118–136. ISBN: [http://dx.doi.org/10.1007/978-3-319-07127-5\\_11](http://dx.doi.org/10.1007/978-3-319-07127-5_11). DOI: [10.1007/978-3-319-07127-5\\_11](https://doi.org/10.1007/978-3-319-07127-5_11).
- [149] Juho Hamari, Lauri Keronen and Kati Alha. 'Why Do People Play Games? A Review of Studies on Adoption and Use'. In: vol. 2015. Jan. 2015. DOI: [10.1109/HICSS.2015.428](https://doi.org/10.1109/HICSS.2015.428).
- [150] Ooi Wei Xin et al. 'Gamification Effect of Loyalty Program and Its Assessment Using Game Refinement Measure: Case Study on Starbucks'. In: *Computational Science and Technology*. Ed. by Rayner Alfred et al. Singapore: Springer Singapore, 2018, pp. 161–171. ISBN: 978-981-10-8276-4.
- [151] Camilla Dahlstrøm. *Impacts of gamification on intrinsic motivation*. Vol. 1-11. -, 2012.
- [152] Long Zuo, Shuo Xiong and Hiroyuki Iida. 'An Analysis of Hotel Loyalty Program with focus on Tiers and Points System'. In: Nov. 2017. DOI: [10.1109/ICSAI.2017.8248345](https://doi.org/10.1109/ICSAI.2017.8248345).

- [153] Lobna Hassan, Antonio Dias and Juho Hamari. ‘How motivational feedback increases user’s benefits and continued use: A study on gamification, quantified-self and social networking’. In: *International Journal of Information Management* 46 (2019), pp. 151–162. ISSN: 0268-4012. DOI: <https://doi.org/10.1016/j.ijinfomgt.2018.12.004>. URL: <http://www.sciencedirect.com/science/article/pii/S0268401218306844>.
- [154] Luís Filipe Rodrigues, Abílio Oliveira and Helena Rodrigues. ‘Main gamification concepts: A systematic mapping study’. In: *Heliyon* 5.7 (2019), e01993. ISSN: 2405-8440. DOI: <https://doi.org/10.1016/j.heliyon.2019.e01993>. URL: <http://www.sciencedirect.com/science/article/pii/S240584401935618X>.
- [155] Harshal Charhate. ‘Studying the implications of applying gamification technique on knowledge management in projects’. In: (July 2016), Volume 7 Issue 2, 198–208. DOI: <http://dx.doi.org/10.21172/1.72.533>.

## 1 Appendix A

Here is the general questionnaire that distributed for 350 respondents as shown in Table .1. This questionnaire was analyzed among three improvement factor and used Likert-scale from 1 (absolutely not important) to 5 (absolutely important) score.

TABLE .1: The general questionnaire for improvement factors evaluation

No.	Questions
1	How much rating of " Interactivity " to fun games are more important ?
2	How much rating of " Interactivity " to home console games are more important ?
3	How much rating of " Interactivity " to smartphone games are more important ?
4	How much rating of " Interactivity " to hybrid console games are more important ?
5	How much rating of " Interactivity " to VR games are more important ?
6	How much rating of " Variety " to fun games are more important ?
7	How much rating of " Variety " to home console games are more important ?
8	How much rating of " Variety " to smartphone games are more important ?
9	How much rating of " Variety " to hybrid console games are more important ?
10	How much rating of " Variety " to VR games are more important ?
11	How much rating of " Challenge " to fun games are more important ?
12	How much rating of " Challenge " to home console games are more important ?
13	How much rating of " Challenge " to smartphone games are more important ?
14	How much rating of " Challenge " to hybrid console games are more important ?
15	How much rating of " Challenge " to VR games are more important ?