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AN ALGORITMIC APPROACH FOR DESIGNATING THE HARDNESS LEVEL OF THE MOBILE GAME

M.Sc. Thesis by

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ALGORITMIC APPROACH FOR DESIGNATING THE HARDNESS LEVEL OF THE MOBILE GAME

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We have read the thesis entitled **"AN ALGORITMIC APPROACH FOR DESIGNATING THE HARDNESS LEVEL OF THE MOBILE GAME"** completed by **BURÇIN TAŞDEMIR** under supervision of **ASSIST. PROF. DR. GERÇEK BUDAK** and we certify that in our opinion it is fully adequate, in scope and in quality, as a thesis for the degree of Master of Science.

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AN ALGORITMIC APPROACH FOR DESIGNATING THE HARDNESS LEVEL OF THE MOBILE GAME

ABSTRACT

The mobile gaming industry has become a very large sector with smart phones that take their place in daily life with the developing technology and has recently become a very large market with a rapid growth trend in the gaming industry. Game developers and manufacturers who want to take their place in this market have started to offer games for smartphone and tablet users. Thus, a great competitive environment was created. Game developers need to meet the demands of users to stand firmly in this competitive environment. For the mobile gaming industry, keeping the player in the game for a long time, providing sustainable player satisfaction and thus providing companies with maximum profit are the main objectives. Although there have been many studies on these issues, there are some gaps in the literature.

The aim of this thesis is to determine hardness level of game with an algorithmic approach, considering player profiles. While doing this, the most important elements to keep in mind are keeping customer satisfaction at the highest level and providing maximum profit to the manufacturer. In the thesis, flowchart was created by determining the best game hardness level and maximum game hardness level for each player profile in line with the survey study to achieve the stated goals.

Keywords: Mobile games, algorithm, RNG, player profile, hardness level of game

MOBİL OYUNUN SERTLİK SEVİYESİNİ TASARLAMAK İÇİN ALGORİTMİK BİR YAKLAŞIM

ÖZ

Mobil oyun sektörü, gelişen teknoloji ile gündelik hayatta yerini alan akıllı telefonlarla birlikte çok büyük sektör haline gelmiş ve son zamanlarda oyun sektörü içerisinde hızlı büyüme eğilimiyle çok büyük bir pazar haline gelmiştir. Bu pazarda yerini almak isteyen oyun geliştiricileri ve üreticileri akıllı telefon ve tablet kullanıcıları için oyun sunmaya başladı. Böylelikle büyük bir rekabet ortamı oluştu. Oyun geliştiricilerin bu rekabet ortamında güçlü bir şekilde ayakta durmak için kullanıcıların taleplerini karşılaması gerekmektedir. Mobil oyun endüstrisi için oyuncuyu uzun süre oyunda tutmak, sürdürülebilir oyuncu memnuniyeti sağlamak ve bu sayede şirketlere maksimum kazanç sağlamak temel amaçlardır. Bu konular ile ilgili birçok araştırma yapılmış olsa da literatürde bazı boşluklar bulunmaktadır.

Bu tez çalışmasının amacı oyuncu profillerini dikkate alarak algoritmik bir yaklaşımla oyun sertlik seviyelerinin belirlenmesidir. Bunu yaparken akılda tutulması gereken en önemli iki unsur müşteri memnuniyetini en üst düzeyde tutmak ve üreticiye maksimum kar sağlamaktır. Tezde, belirtilen amaçlara ulaşmak için anket çalışması doğrultusunda her bir oyuncu profili için en iyi oyun sertlik seviyesi ve maksimum oyun sertlik seviyesi belirlenerek akış diyagramları oluşturulmuştur.

Anahtar Kelimeler: Mobil oyunlar, algoritma, RNG, oyuncu profili, oyun sertlik seviyesi

CONTENTS

NOMENCLATURE

Acronyms

AHP	Analytic Hierarchy Process
RNG	Random Number Generator
PRNG	Pseudo Random Number Generator
TRNG	True Random Number Generator

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CHAPTER 1

INTRODUCTION

With the widespread use of telephones in the late 80s, phone developers started a new search for improvement of accessing information. Search engines have been developed primarily to meet the search needs of people in terms of information, events, science and etc. Then, as smart phone models were developed, special operating systems were also developed for these phones. After these developments, smart phones were launched with mobile applications installed. In the 90s, besides messaging, games such as Tetris and Snake, led by Nokia, were installed to the phones. The first operating system was released in 2000s specially and uniquely for the phones. In order to meet the needs arising from the development of technology, IOS operating system in 2007 and Android operating system in 2008 entered to our lives as a technological improvement. With these developments, mobile application stores have also started to be developed by many of the smart phone producers [1].

The game concept, which is a technological and cultural act, is also a product of the mobile phone industry and continues to develop rapidly [2,3]. Mobile application developers continued to produce numerous mobile applications upon and the increasing demand. The most preferred category among mobile applications is the game and entertainment applications [4]. In recent years, the popularity of mobile games are also increased, the mobile gaming industry grew rapidly and became a strong market for these companies. The increase in smartphone and tablet use also has a significant impact on the development of the mobile gaming industry as well. Game manufacturers and developers have constantly launched new and improved games to keep up with the competitive environment. It is necessary to know the factors that affect mobile gaming preferences to stay strong in the market.

The biggest factor of the rapid growth of the mobile games is that there is no need for additional hardware other than phone or tablet. In addition to this fact game development and marketing opportunities are much easier compared to applications and console and reachable to the costumer [5].

Game makers have set up a research and development system to improve existing games or develop new games based on the existing computer games to keep up with the technology and become a part of the new sector [6]. After moving to the mobile game industry, the number of new gaming companies and the total market income has grown steadily by the years [7].

Games are an open system that has certain rules and constraints, measurable outputs, they have ability to fight, cooperate, compete, and see connections, and they are also related with the environment they are in [4].

The pleasure that the player receives from the game is an important target for the mobile game companies. If player does not get satisfaction from the game, it will be inevitable for the player to leave the game. In addition to the pleasure of the player, focusing on the difficulty level of the game will be the right move for the mobile game manufacturer. Games must have varying difficulty levels to be at the right difficulty level for each player profile or must satisfy most of the player who play that game. Game difficulties should be balanced with the interests and the skills of the players inside that concerned game [8].

In order to keep the players in the game, the game must be both fun and the players must be fully concentrated to the game. When the difficulty rate of the task given in the game changes and the players need to pay full attention and energy in the game, in order to cope with this difficulty, all their interests and skills are needed to be successful in the new situation of the game [9].

The main subject of operational research used in the development of methods is to assist the decision maker in solving complex problems to optimize and/or to improve the performance of the systems. Operational research is essentially a holistically approach. Therefore, it examines the whole, it defines the problem in the whole and develops the most effective methods to be used in solving this problem. In general, operational research specialists use mathematical, statistical and / or algorithmic models to find the best solution by defining decision variables, parameters, technical coefficients, goal (s), constraints, and definitions with a holistic approach to the problem [10,11].

Operational research is applied to companies to generate maximum profit / minimum cost in their decision problems. It is requested that the determined solution provides minimum cost or maximum profit for the company [12]. Therefore, it is very important to apply operational research for companies' decision problems. If operational research techniques are used successfully, exchange opportunities and emerging problems can also be identified at the time these are needed. In addition to this situation, accurate, economical, reliable, and flexible solutions of the problems can be obtained by the operational research techniques. This is because operational research applies advanced analytical methods to make better decisions in terms of income or productivity [13]. In a way, the biggest benefit of operational research is to determine the decision that leads to the best results of the entire organization under the changing conditions.

For mobile gaming companies to maintain their place in the industry and become sustainable, decisions must be made correctly to the identified problems. Therefore, finding the most suitable solution for the decision-making problems in this research area has become more important for the companies. It is necessary to find the best solution to the decision problems that companies will meet and consolidate their position in this competitive market.

The problem to be mentioned, in this thesis, is going to be related to the decision of the hardness level of the mobile game to give maximum pleasure from the game to a particular player or most of the players. The hardness level of the game is aimed to be changed by manipulating the random number generator (RNG) in the game code. The decision maker of this question tries to determine the level on the fairness/hardness scale to achieve the highest level of satisfaction for the player or the majority of the players. This issue is also an individual player-based issue because the different level of hardness for each player gives maximum pleasure. For this reason, it is aimed to use the data to be obtained through a questionnaire or to change the RNG level algorithmically and to observe the response of that player.

The main motivations of this thesis study are research of Budak (2020) and in the real-life mobile game companies identify their hardness level heuristically. Budak (2020) outputs the hardness level of a mobile game should be determined by a

systematical approach to achieve a great level of satisfaction on the player which will lead into a successful mobile game company [14]. Another motivation of this study there are not many studies on this topic and none of them constructs a systematical approach. The contribution of this thesis is construction of general algorithms for the decision of the hardness level of a mobile game. Two algorithms are constructed are presented in the study by considering each player and for the majority of the player profiles respectively. The main data of these algorithms, can also be stated as parameters, are obtained by face to face a questionnaire to a certain game player.

In the first part of the following sections of the thesis study, basic studies and related studies that will help finding the hardness level of the game to give the players maximum pleasure in mobile games will be examined in detail. The reasons and contributions of the research, which is going to be addressed in this thesis, is also going to be discussed.

In the third part of the study, the definition of the problem and the basic concepts related to the decision problem is going to be examined. Afterwards, the new algorithms developed for the problem is going to be presented and these new algorithms are going to be examined in detail, in terms of their steps and implementation.

In the fourth section, techniques on how the basic components of the proposed new models can be estimated, obtained and / or found and results of the questionnaire is going to be given.

CHAPTER 2

LITERATURE REVIEW AND BACKGROUND

With the increasing use of technological devices such as phones and computers, interest in mobile and online games, which are the most important entertainment tools of nowadays, is significantly increasing day by day. As a result of this situation, mobile game manufacturers or developers began to produce more video games in the recent years, and we expect this will continue to increase in the future as well. When the number of games increase in the market, many problems might occur for the game manufactories. One of these problems brought about by the rapid proliferation of games is to ignore maximizing the customer satisfaction and profit. Another problem is game design creativity challenge. Many produced games have difficulty in reaching people due to imitation of other competitors. Thus, standing in the market would become quite more difficult. Making unique games will make game manufacturers or developers, advantageous in the competitive environment in this market which is saturated from similarity.

In this section, the previous research that will guide the thesis study is going to be given and examined. Subsections of this part as follows the topics of; algorithms, player profiles, game types, RNG, decision-making problems and evaluation in the mobile games. By using an algorithm to decide these levels, it will be aimed to provide a suitable game level to the player profiles with the help of the manipulation of the random number generator, therefore, all these topics and related research should be explored.

2.1 Algorithms

The algorithm concept which is created by Abu Abdullah Mohammed bin Musa al-Kharezmi, has been defined as a path and successive process steps designed to find a solution to a problem or achieve the stated goal [15]. Algorithms are the structures that used in the design of the programming and they are required for the development of the program to be explained clearly [16].

Algorithms are not only in the planning stage of the programming and in the design phase of a software, however, they are also in all of the finite processes that people use in their own lives. All these processes are considered algorithmic. Therefore, studies on the effective training of the term of algorithm are increasing in this technology era [17].

A well-defined computation process is defined as an algorithm that takes some values or sets of values as an input and produces some values or sets of values as an output [18]. Therefore, the algorithm is a sequence of calculation steps that converts input(s) to an output(s). In addition to this, an algorithm can also be viewed as a tool for solving a well-defined calculation problem. An algorithm defines a specific calculation process to ensure a system with the input versus output relationship [18].

In short, an algorithm is defined as all of the sequential necessary logical steps to solve a problem. Since, algorithms are written in a natural language, they are quite understandable. Every step in an algorithm must be extremely decisive, clear and nothing should depend on chance factors. At the end of a certain number of steps, the algorithm must be ended. Algorithms should be general enough to address all of the possibilities of the inputs. Thus, more accurate results could be obtained for a problem with different inputs.

An algorithm is called true if it ends with the correct output for each of the input instances. A correct algorithm solves the given computational problem for that particular input set. An incorrect algorithm might not stop at all on some input instances, or it might halt with an answer other than the desired or expected one on the contrary to expectations. Incorrect algorithms can sometimes be useful, if their error rate can be controlled or there are different possible solutions, for example, simulation algorithms if possible [18].

When preparing an algorithm, it should be the shortest as possible and easiest to understand and to program it. While preparing the needed algorithm, first, the details of the problem to be solved should be examined and all possibilities should be reviewed and covered. Among the many steps the decision makers face, they must choose a simple and a clear way to solve the problem in the shortest possible steps and

time. All the steps required for the solution of the prepared algorithm should be explained in a sequential order. Algorithms must also be designed flexible and appropriate for the updates. Lastly, designed algorithms should be suitable for programming but it should not be depended on any programming language [15].

2.1.1 Algorithm Types

The algorithm is the definition of the path to be followed for finding the solution of a problem. After defining the problem exactly, it is necessary to search for the best or closes to the best solution. Generally, a problem can have more than one and fully possible solution. Algorithms try to choose the most appropriate solution among all of these possible solutions. While designing a program for a problem, it both forces the programmer and takes more time without using an algorithm. If the solutions for this problem are expressed together with the algorithms, the coding part of the program would be very simple and straight for word. The algorithms to be used while designing the program depend directly on the desired application and the problem characteristics. The programmer can use the existing algorithms to find solutions to the problems as well as developing new algorithms if the existing algorithms are insufficient.

Algorithms are divided into different types according to their approaches to problem solving, usage areas, application forms and design methods. In the following subsections, the most used and known ones are going to be presented.

2.1.1.1 *Search Algorithms*

Search Algorithms are the algorithms that are used to search in digital systems and provide access to the desired information with the help of certain keywords of the input set. The search algorithms aim to reach the required data as quick as possible in the area of where large amounts of data are stored. Searches on lists, figures and texts can be done by using the search algorithms. The most used searching algorithms are binary search algorithm, deep priority search algorithm and transverse search algorithm [19].

2.1.1.2 Sorting Algorithms

Sorting Algorithms are the algorithms that provide the distributed data to be presented in a meaningful and sequential manner according to alphabetical order or numerical quantities by taking certain criteria into the consideration. Since, the data is sequential, accessing to the information is easier and at the same time faster. Examples of the sorting algorithms include fast algorithm, bubble sorting and selective sorting [15,20].

2.1.1.3 Graph Algorithms

A graph algorithm, which is a data model that allows an event or an expression to be displayed using nodes and lines, is defined as a different assignment operation to adjacent nodes on the graph. The purpose of this algorithm is to give all nodes a separate color from their neighbors by using a minimum number of colors [15].

2.1.1.4 Cryptography Algorithms

The cryptography algorithm used for encryption that it is used to store data from unauthorized persons by keeping it connected to methods such as logical, arithmetic, and scrambling. This type of algorithm ensures that a message is securely shared regardless of the environment in which it is transmitted between different multiple points [17]. Some examples of these algorithms are Des, Md5, Rsa, Aes and 3Des.

2.1.1.5 *Genetic Algorithms*

Genetic algorithms are an artificial intelligence method that is highly functional in solving complex problems [21]. Algorithms try to find the most suitable solution for a problem in many possible solutions. The basis of the genetic algorithms is based on Darwin's Theory of Evolution [22].

2.1.1.6 Compression Algorithms

As the importance of digital communication increases, transmission and storage of digital data becomes much more important. Compression algorithms provide that the data set is encoded to take up less space on the memory storage without losing the

originality of the input. Its main purpose is to always store the maximum data in the minimum space when digital data is stored in different repositories [15,23].

2.1.1.7 Root Finding Algorithms

Root finding algorithms are an algorithm that runs on root operations, which are numerical operations. The greatest benefit of this algorithm in searches is that it is not limited to the searched word and has similar results. With the root finding algorithms, it is aimed to minimize the mistakes made by the user and to give wider result's area [15]. In addition to the root-finding algorithms, there are also algorithms that perform the root-finding process that examines the meaning and content of the searched words [16].

2.1.2 Heuristic Algorithms

Heuristic algorithms are algorithms that reduce the time to solve complex and time-consuming problems by giving up the search for the best solution to become more efficient in the transition time. Although these algorithms do not guarantee to find the best result, they guarantee that they will get the solution in the best time [24]. They often reach the best possible solution quickly and easily. As a result of the inadequacy of the classical methods used in optimization problems, the search for new solutions was started in 1970, and studies on heuristic methods were started [25]. Many algorithms have been developed to solve complex problems which includes real-world problems, as well.

Heuristic algorithms are divided into many classes according to the inspiration from daily life. This classification is shown in Figure 2.1.

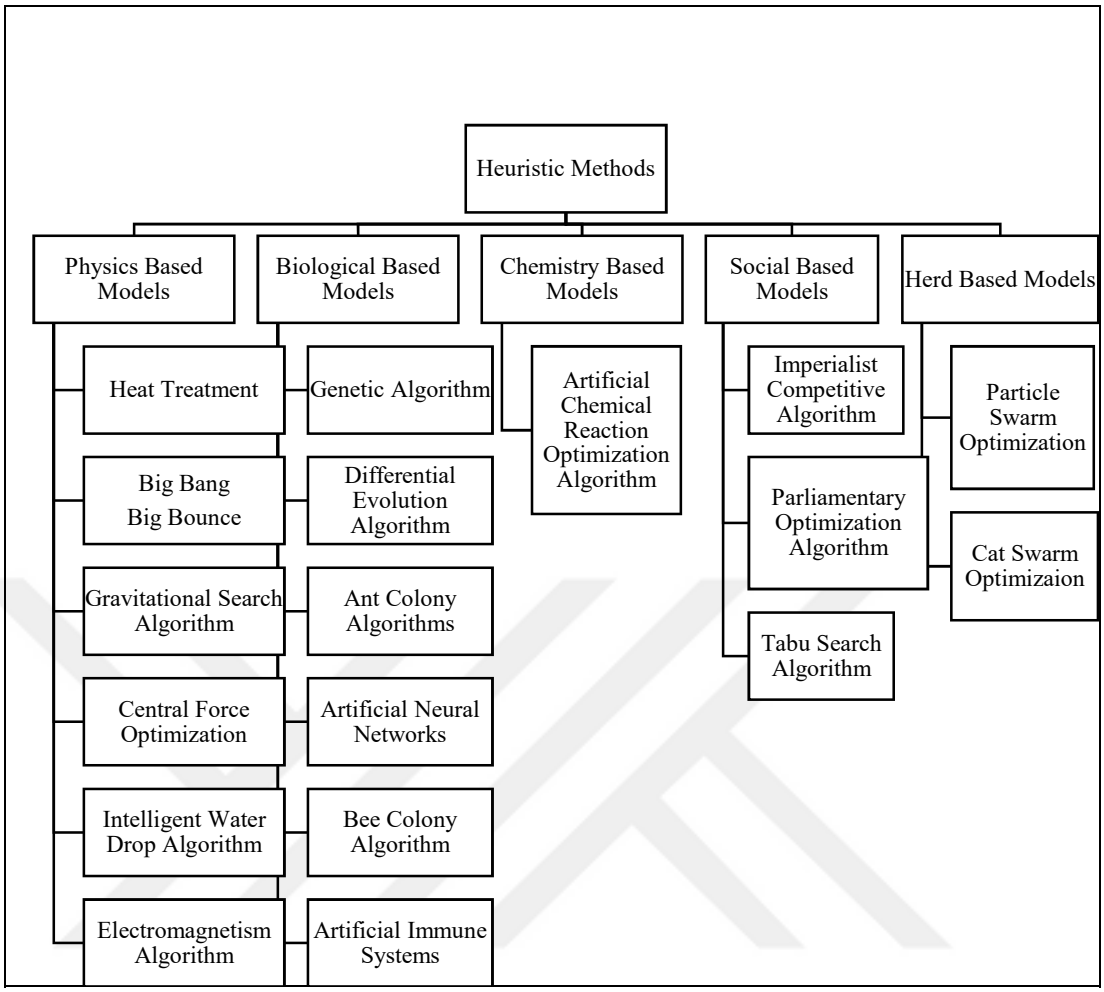

Figure 2.1 Classification of heuristic algorithms

2.2 Game Player Profile

Every day, millions of people spend most of their time with playing mobile, video or computer games. To maximize customer satisfaction and keep the player in the game for a longer time, each player has become as a goal to provide personalized content according to their personal taste and wishes. Player profiles represent motivations, emotions and mental states, goals in the game and talents of the players. Therefore, the researchers created different psychological player profiles inspired from each other according to the reasons of play, emotions, achievements, and other psychological aspects of the game players.

Salen et. al (2004) identified five different player profiles which are standard player, dedicated player, cheating player, spoil-sport player, and unsportsmanlike player [26].

Mulligan and Patrovsky (2003) made a grouping based on inter-player interactions; these include barbarians, citizens, tribesmen and general players [27]. Dena (2008) examined player profiles in three different groups [28]. These are defined as puzzle players, story players and real-world players. Pohjola (2014), on the other hand, divides the players into four different groups which are immersionist, dramatist, gamist, and simulationist type of players [29].

Bartle (2004) developed a player classification based on the behavior of the players who play "Multi-User Dungeon (MUD)" in his work. Accordingly, players are distributed to four main characters and each has different reasons for taking part in the game. The four players profiles define their style as socializers, achievers, killers and explorers. The focus of the achievers in the game is to gain status and achieve their goals. Achievers' activities in the game are to win, fight and compare themselves with other players. Explorers' focus in the game is to explore and go after the unknowable. Explorer type of players' activities in the game are to study, produce and explore. Socialists' focus on the game is to socialize and expand the environment. Socializer type of players' activities in the game are to share, comment and help. Finally, the killers' focus in the game is to win, to be in high ranks and to be in the race. Killer type of players' activities in the game are to cheat and cause harm [30]. The Figure 2.2 given below briefly summarizes Bartle player profiles [31].

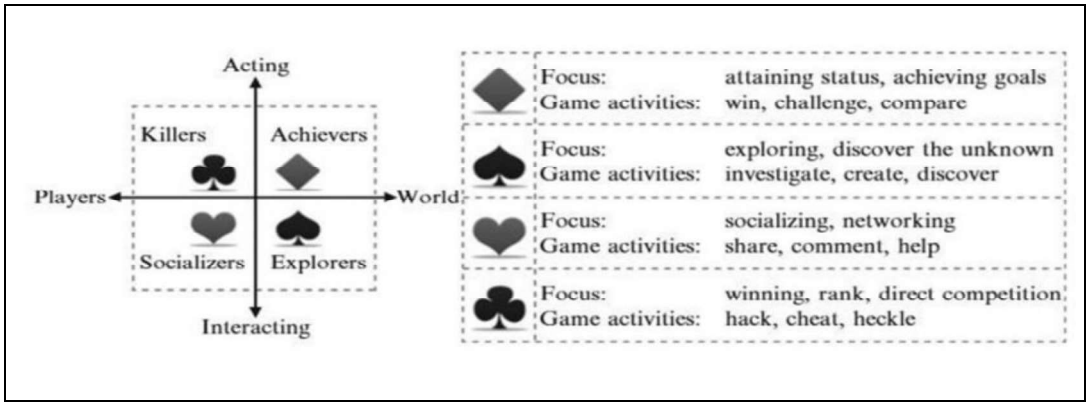

Figure 2.2 Gamer types by Bartle (adopted from Schacht and Schacht, 2012)

In his study, Yee (2006) identifies certain factors by classifying various motivation for all the criteria. As a result, it is aimed to identify elements that would motivate players

who play online games. The scale used in Yee's (2006) work is about determining online player motivations [32]. Within the framework of this scale, there are thirty-nine different expressions. As a result of working with players playing online games, factor loads were measured and evaluated, and all of these expressions creates a total of ten motivational factors for online gaming players. These factors include progress, socialization, escape, personalization, competition, association, teamwork, discovery, operation and role-playing of the player motivations. These ten motivations are examined under three sub-parts which are achievement, social, and immersion. Yee (2006) determined these factors for what motivates the players for playing online games. The Table 2.1 below shows Yee's (2006) player types and motivations.

Table 2.1 Gamer types by Nick Yee

Achievements	**Social**	**Immersion**
Advancement *Progress, Power, Accumulation, Status*	**Socializing** *Casual Chat, Helping Others, Making Friends*	**Discovery** *Exploration, Lore, Finding Hidden Things*
Mechanics *Number, Optimization, Templating, Analysis*	**Relationship** *Personal, Self-Disclosure, Find and Give Support*	**Role-Playing** *Story Line, Character History, Roles, Fantasy*
Competition *Challenging Others, Provocation, Domination*	**Teamwork** *Collaboration, Groups, Group Achievements*	**Customization** *Appearances, Accessories, Style, Color Schemes*
		Escapism *Relax, Escape from Real Life, Avoid Real-Life Problems*

2.3 Game Types

The game is defined as the entertainment that develops talent and intelligence according to the Turkish language institution's dictionary. Games have certain rules, and supply a good time [33]. The game, which is a universal concept, is defined as biological and physical activity that has always existed from the past to the present. According to Crawford (1984), games are created according to a specific system and each system has its own rules [34]. Games, according to Salen et. al (2004), has following properties [26];

• Games are a system.

• A game is a structure in which one or more players can actively play.

• Although games are a reflection of reality, their most important feature is that they are artificial.

• There is a struggle of powers in the games. Examples of struggle such as cooperation, competition, playing one-on-one with the system, and social struggle between the players can be given.

• Rules in games determine the general structure of the game.

• Games have measurable outputs.

Each game has its own rules, limits, and goals. Keeping this in mind, different types of plays are created by different researchers. Parlett (1992) divides games into formal games and informal games. In the formal games, there is a winner and there are some rules and tools to win the games [35]. Whereas in the informal games, two children roll on the floor whereas there is no significant rules, goals or purposes. According to Sutton-Smith (1997), games defined according to mental-intellectual play, solitary play, playful behavior and action, informal social play, representative play, performance-based play, celebrations and festivals, sports competitions and risky games [36].

The development of the technology brings in for both the mobile and the computer gaming industry. According to Salen et al (2004) and Whitton (2009), the types of digital games are expressed and grouped as follows [26,37]:

- Action
- Role playing game (RPG)
- Race
- Arcade
- Simulation
- Puzzle
- Adventure
- Strategy
- Sport
- Social game
- Card, dice and block games

Play Stores, the mobile game download platforms of the phone brands, categorized the game types as given below.

- Action
- Arcade
- Puzzle
- Didactic Play
- Knowledge
- Card
- Word Play
- Classic
- Casino
- Adventure
- Table
- Music
- Role Playing
- Simulation
- Sport
- Strategy
- Race

2.4 Random Number Generator (RNG)

The production of random numbers is needed for some certain reasons. To keep the encryption process confidential, random numbers are needed when modeling or simulating complex events in cryptographic algorithms or while programming games that must occur at random cases.

If the RNG system is intervened, the word “random" can no longer be mentioned. The game loses the concept of randomness, as well. These interventions or manipulations create a commitment which leads to the deterioration of randomness. RNG is an academic coding which is mostly used in algorithms and mostly in the simulation of real-life cases. By means of this tool, random number generation according to statistical distribution is tried to understand the behavior of the system. In order to understand the whole system, it is tried to be simulated by using a part of the sample space.

In games, it is used to determine what the consequences of the decisions of the players are going to produce and/or what the next stage of the game is going to look like and what will occur randomly within the game.

These embedded random numbering code libraries, which are easily added to the coding are based on which coding language the game is written, generate in terms of

time numbers very fast and are planned and implemented so as not to affect the game play speed of the players. If not, this situation would cause an unsatisfaction for the players because everyone wants to play without any disruption.

Random number generators are generally examined under two divisions which are Pseudo RNG and True RNG. One of the most convenient ways to generate random numbers in a computer environment is by using Pseudo Random Number Generator (PRNG). The main purpose of this method is to generate a series of numbers based on a particular mathematical function. With PRNG, programmers can generate array of numbers in a short time. Therefore, it is a very efficient and advantageous method. If the starting point in the array is known, a given number of arrays can be replicated later period. This method is deterministic, and determinism is useful if you need to replay the same sequence of numbers at a later stage. In addition to this, PRNGs are periodic, which means the sequence will be repeating itself at the end. PRNGs are implemented in the software with a small amount of code.

Another method of generating a random number is to generate by using a True Random Number Generator (TRNG) algorithm. Unlike pseudo random numbers that are inserted into a computer and generated by a computer program, it is an electronic part that generates real random numbers. RNGs are implemented into the hardware. TRNGs are more inefficient than PRNGs, because it takes longer time to produce random numbers.

In general, the difference between the real random number generator and the pseudo random number generator is that TRNG uses unpredictable physical means to generate numbers such as atmospheric, photopheric, cosmological noise, where PRNG uses computer-generated mathematical algorithms.

It is not very healthy to distinguish two different RNGs algorithms as good or bad. Selection should be made according to the suitability for the type of the game to be dealt with.

2.5 Decision Making Problems

Decision making process is called for the process of identifying different alternatives and choosing the most effective one among these alternatives to achieve a or many specific purposes. According to Kleindorfer (1993), decision-making is a deliberate and thoughtful choice perceived of specific needs [38]. In Evren and Ülengin's (1992) study, decision-making is defined by the decision-maker to choose the most appropriate option among all available and applicable options [39]. The main objective is to solve the problem addressed by choosing the best alternative among the available options with sorting or classifying them.

According to Olson et al. (1992), there is no single common measure to measure decision-making quality [40]. A good decision-making art is formed by systematic thinking and should be based on a logical perspective. All available resources should be used, and all possible options should be examined and compared among each other to give the perfect decision.

The first stage of the decision-making process is defining the decision problem. In this definition, the person, or people to decide (decision maker(s)), the purpose and goal of the problem, alternative forms of actions and uncertainties should be defined. Then, the model of the decision problem needs to be established. In order to solve the problem easily, the model should be formed by minimizing the uncertainties. The next steps are obtaining the solution from the model, testing the solution of the model, and finally giving the best decisions and putting these decisions into the practice [10].

The most important contribution of operational research to decision-making has been mathematical models. The elements used in mathematical models can be grouped into three main groups. These groups are objective function, decision variables and constraints. The parameters that are in control of the decision maker are defined as decision variables. The analytic representation of the effects of decision variables on the aim of the problem is called the objective function. The necessary conditions in the system are called constraints of the problem [11].

Determining the most appropriate solution, solving the model, is an important step. There are many solution techniques to solve the structured model. Analytical solution, algorithm solution, simulation solution and heuristic solution are examples for some of these techniques. The analytical solution provides the best conditional solution of the problem with Lagrange multipliers, differential and integral calculations. The algorithm solution is used to provide a solution that is closer to the optimum in each step with iteratively applied algorithms. The simulation solution is used for problems that cannot be solved analytically or by algorithms and dependent on stochastic variables. The heuristic solution is a solution method to be used if the problem is too complex to find the optimum solution in an available time range [12].

2.6 The General Evaluation of the Chapter 2

The growing interest in mobile games with the development of technology has enabled the mobile industry to grow. For the survival of the companies in this competitive environment, mobile game manufacturers have to enter into a continuous development mentality.

The main purpose of this study is to develop a systematic method to keep up with the competitive environment for mobile game companies. While doing this, the game is to increase the satisfaction of the people for enjoying the game. The most important parameters to consider when creating a model are the in-game time and difficulty level according to player type. The main reason for the question being addressed is to maximize the satisfaction of the individual player. In games, parameters are used to determine and what the player's decisions will be or what the next stage of the game will look like. Manipulation of random number generators will be used to determine the hardness level of the game. By establishing a numerical relationship between player profiles and the hardness level of the game, maximum satisfaction is going to be sought since different levels of difficulty for each player in the game gives maximum pleasure. Therefore, the scale level to be established has a great importance for this study. The data will be obtained by observing the players' responses to the algorithmic change of RNG levels and by means of a questionnaire. It will be explained in detail in the following sections.

There has not been much work to achieve the highest possible satisfaction of the player. By using the proposed algorithms, we are going to be trying to achieve the maximum pleasure of the players which is going to bring higher profitability and higher number of players in the game. As far as we know, this is the first study that tries to accomplish this with a systematical and mathematical approach.

CHAPTER 3

METHODOLOGY

The main purpose of the thesis work is to develop a systematic model to adapt to the competitive environment of mobile games. While doing this, it is aimed to obtain customer satisfaction at the highest level. While creating the desired system, parameters such as the duration of the game according to the player profiles and the desired difficulty level of the game according to the player profile are going to be taken into consideration.

One of the main reasons for handling the addressed problem is to maximize each individual player's satisfaction. In games, parameters are used to determine what the player's decisions is going to be or what the next stage of the game is going to look like. Random number generators will be used to determine the difficulty level of the game. By establishing a numerical relationship between player profiles and the difficulty level of the game, the maximum satisfaction is going to be tried to be achieved. In the study, the survey method is going to be used as a research method. In the literature review on subjects similar to this research, appropriate strategies and methods are developed by collecting and evaluating the necessary data with the questionnaire method.

In this study, game difficulty levels are going to be determined for ten different player profiles. To do this, a two-step method is going to be used. With the first questionnaire, the player profile of the player is going to be handled in general and the player profile features is going to be determined in terms of difficulty. In the second stage, in order to determine the game difficulty level, the questionnaire results of each profile are going to be analyzed.

The survey is going to be conducted through face-to-face bilateral interview. The audience to be surveyed is generally chosen as individuals playing mobile games over the age of eighteen. The reason for this is that individuals under the age of eighteen do not have official authority to make in game purchases. At the same time, the identity

information of the volunteers participating in the survey are not going to be included. The questions in the questionnaire are all about the subject and there is no question that will leave the participants in a difficult situation. Those who do not want to participate in the survey or want to quit the survey can leave the survey by notifying the person who makes the survey. Using this survey results, an induction is not going to be made and strategies are going to be found according to the opinions of the people and their behavior in the game.

The survey consists of sixteen questions. In the first question, demographic characteristics of the respondents is going to be obtained with factual questions. Questions 2 to 15 are going to be asked to determine the behavior of respondents regarding the games. Questions 2 and 3 are asked to determine how long the players spent in the game. In Question 4, the players are asked why they preferred to play the game. In the fifth question, thoughts about time spent playing games are tried to be found out. In the 6th question, in order to determine the player profiles, analyze the characters and determine the level of game difficulty accordingly, the characters of the players have been asked. In the 7th question, a question is asked about what is felt when the game is won or lost. The aim is to analyze the player's profile towards the game when the player wins or loses. Question 8 is about which type of the games the participant plays. In Question 9, the level of addiction to mobile games is asked. In Question 10, the importance of the game hardness level is asked. In the 11th question, the desired hardness level of the game is asked. The aim is to determine the approach of player profiles to game levels and to analyze at what level he/she likes to play. Finally, in the 12th and 13th questions, it is aimed to analyze how the player is reacted if the game levels are difficult or easy.

In general, survey questions are going to help to obtain the necessary data for the algorithm to be designed in the following sections. With the answers to this question, an inference is going to be made by addressing the motivations of Yee (2006), which is going to be described in the next subsection.

The main purpose of this inference is to set a suitable level for player profiles.

3.1 Motivations of Nick Yee (2006)

In Yee's (2006) "Motivations for Play in Online Games" study, various factors were determined by classifying various motivational elements. With these factors, the motivations of the players who play online games are revealed. According to Yee's (2006) research, the scale used was generally based on determining online player motivations [32]. Within the scope of this scale, there are thirty-nine expressions in total. Expressions are designed to create certain factors. According to the responses given by the players who play online games with these expressions, certain expressions were evaluated by measuring their factor loads and thirty-nine expressions were explained in a way to create ten motivational elements from three components in total. These factors are respectively.

a) Achievement Component

I. Advancement: Players who score high on advancement motivation enjoy from achieving goals and leveling quickly. They enjoy progress and strength. Examples of these are combat prowess, social recognition, or financial/industrial superiority.

II. Mechanics: Players who score high on mechanics motivation enjoy from analyze numerical mechanics in games and understand the system of the game. Their main purpose is understanding the system in the game, is to make it easy to optimize the character that is superior in a particular area.

III. Competition: Players who score high on competition motivation enjoy from competing with other players on the battlefield. In addition, they enjoy getting an edge over other players.

b) Social Component

I. Socializing: Players who score high on socializing motivation enjoy from meeting and getting to know other players. They like to chat and gossip with other players and help others in general.

II. Relationship: Players who score high on relationship motivation enjoy from trying to establish continuous and meaningful relationships with others. They often look for close online friends when they need support and support them when others are dealing with real life crises or problems.

III. Teamwork: Players who score high on teamwork motivation enjoy from working and collaborating with the other players. Instead of being alone, they prefer grouping and getting more satisfaction from group achievements than individual achievements.

c) Immersion Component

I. Discovery: Players who score high on discovery motivation enjoy from exploring the game world and discovering in game locations, quests, or artifacts that others may not know about. They enjoy collecting information, works or trinkets that others have.

II. Role-Playing: Players who score high on role playing motivation enjoy from plunging into a story through the eyes of a character they designed. They also like to act as a way of integrating their characters into the larger on-going story of the world.

III. Customization: Players who score high on customization motivation enjoy from customizing the look of their own characters. It is very important for them that they have a unique style or apparency for their characters.

IV. Escapism: Players who score high on escapism motivation enjoy from using the environment as a place relieve from the real world of stress. These players can use the game as a way to avoid thinking about real life problems or as a way to avoid real life in general.

3.2 Determination the Hardness Level of Game

Decision problem is going to be tackled in this thesis is defining the hardness level of the game. This main purpose of this problem is to ensure that individual player's satisfactory level as maximum as possible. The hardness level of the game can be changed by manipulating the random number generator (RNG) in the game code. Figure 3.1 which is shown below describes this situation graphically:

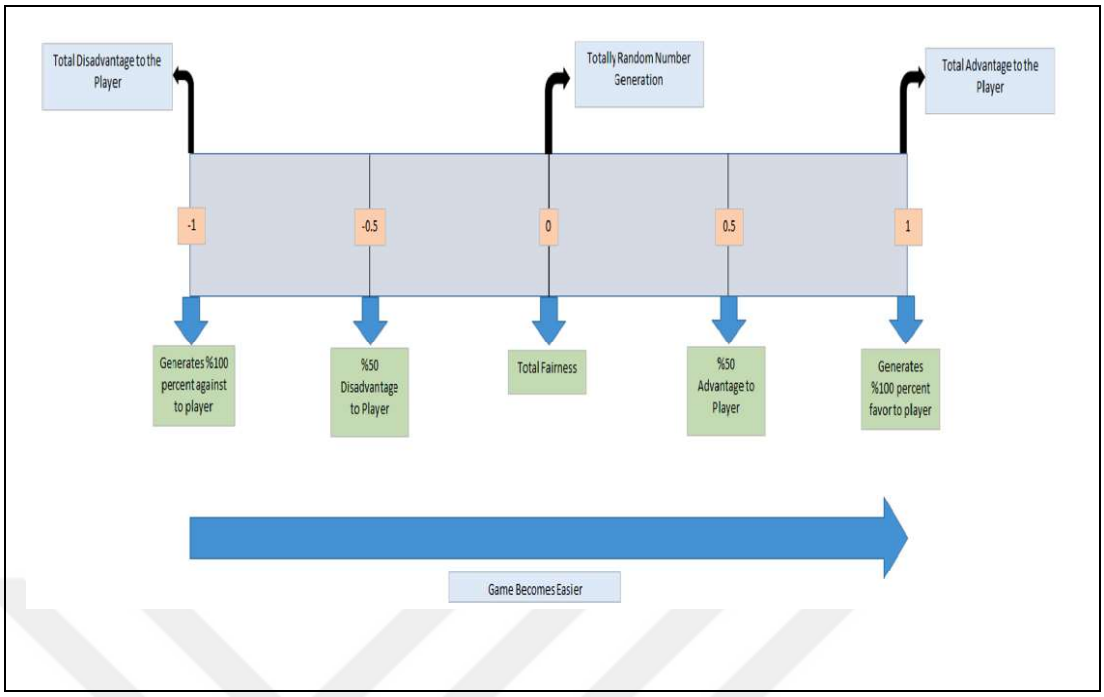

Figure 3.1 Hardness level of the game scale (adopted by Budak, 2020)

The decision maker will try to determine the level on the scale shown in Figure 3.1 for the maximum satisfaction level that the player is going to get. The decision maker is going to offer the player a level based on the player's character and his expectation from the game. This problem is based on an individual player as it will have different results for each player. Because each player has a different hardness level to get the maximum enjoy. Therefore, data from player profiles should be used and the RNG level should be changed algorithmically. Accordingly, the reaction of the player should be observed to the hardness level.

The scale indicated in Figure 3.1 shows the hardness level of the game. The fairness of the game is represented at each point shown on this scale. In this scale, which is in the range of "-1" and "+1", there is total fairness in the middle of the scale. Point "-1" generates 100% against the player, while creating 100% favor for the player.

Suppose the game is played with two players. If we match a player with another player of exactly the same level, the game will be at a completely fair point on the scale. Based on the same example, matching this player with the highest or lowest player in

the game will correspond to positive and negative edges on this scale. All points in this scale must be determined by the players in the game and the type of game.

The main purpose of the problem under consideration is to obtain maximum profit for game manufacturers and maximum playtime for players. The brief description of the algorithm to be applied for the solution of the problem is shown in Table 3.1 and Table 3.2. Table 3.1 expresses to the flow diagram in Figure 3.2, Table 3.2 expresses to the flow diagram in Figure 3.3. In the two different flowcharts indicated in Figure 3.2 and, Figure 3.3 there are two possible solutions for this problem.

Figure 3.2 and Figure 3.3 provide two flowcharts for the solution methodology to determine the hardness level of the game. The solution methodology shown in Figure 3.2 sets a hardness level for all players. Figure 3.3 finds the best hardness level for each player. Therefore, the implementation of the flow chart in Figure 3.3 is much more difficult for each cycle than Figure 3.2, but considering the solution results, the possible solution in Figure 3.3 would provide a better level of satisfaction.

Table 3.1 Pseudo code for possible solution methods for all players

STEP 1: START
STEP 2: COLLECT the player profile data from the Surveys
STEP 3: DETERMINE the best player profile for the player with the weighting method
STEP 4: CREATE database for player profile and best difficulty level
STEP 5: DECIDE the hardness level of game for the player
STEP 6: FINISH

Table 3.1 shows pseudo code for possible solution methods for all players. The first step in this pseudo code is the Start command. In the Step 2, player profiles are collected with the help of the data obtained from the survey. In Step 3, the best player profile for the player is determined according to the answers given in the questionnaire. In Step 4 is to create a database for player profiles and best game difficulty level. In

step 5, the hardness level of game will be determined for the player. Last Step 6 is the Finish command.

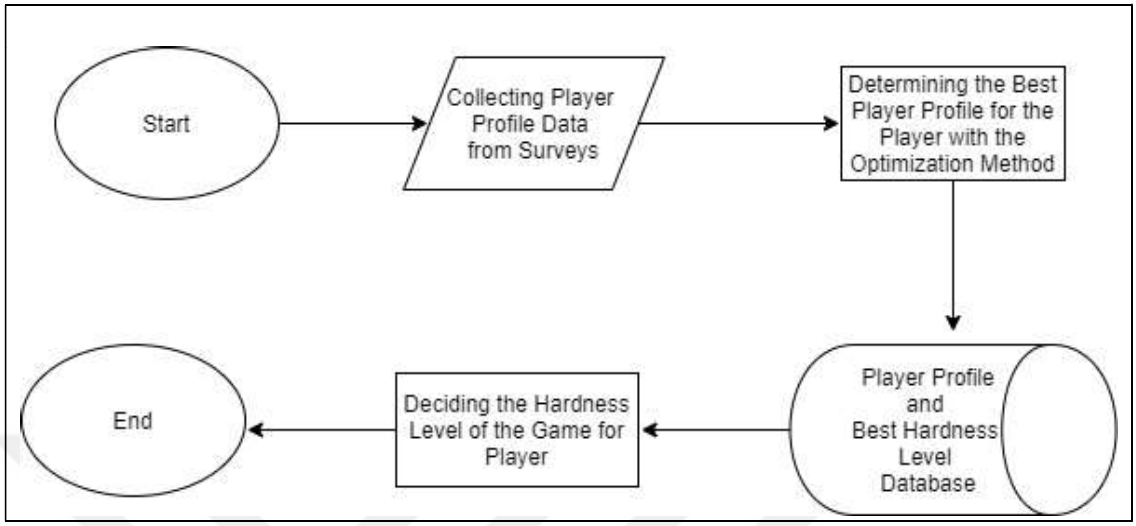

Figure 3.2 Flow charts for possible solution methods for all players (adopted by Budak, 2020)

As can be seen in Figure 3.2, data that will determine the player profiles of all players is collected in line with the surveys conducted first. Then the best player profile for the player is chosen. The results obtained are uploaded to a database. Finally, the most suitable hardness level of game is determined for the player profile.

Table 3.2 Pseudo code for possible solution methods for each player

STEP 1: START
STEP 2: SELECT the player's profile from profile data of all players
STEP 3: ASSIGNING hardness level based on player profile
STEP 4: INCREASING the fairness level
STEP 5: ASK if you are satisfied with the game level
STEP 6: IF the player is satisfied with the increase fairness level, go to Step 4, **ELSE**, go to Step 7.
STEP 7: DECREASING the fairness level. And go to Step 5.
STEP 8: FINISH

Table 3.2 shows pseudo code for possible solution methods for each player. The first step in this pseudo code is the Start command. The second step is to select the player profiles from player profile data of all players. This selection is made from the player profile data in line with the survey. In Step 3, the hardness level appropriate for the player profile will be determined. In step 4, assigning hardness level based on player profile. Next, in Step 5, players will be asked if they are satisfied with the level of play. In Step 6, if players are satisfied with the increase fairness level, they will return to Step 4 and continue to increase the fairness level. But if the players find the level difficult, in Step 7 the game will be commanded to decrease the fairness level. Later the players will be asked the same questions over again. If the player is satisfied with the decrease in the fairness level, the game level will continue to decrease, if not, the fairness level will increase again. The finish command will be given when the player wants to exit the game.

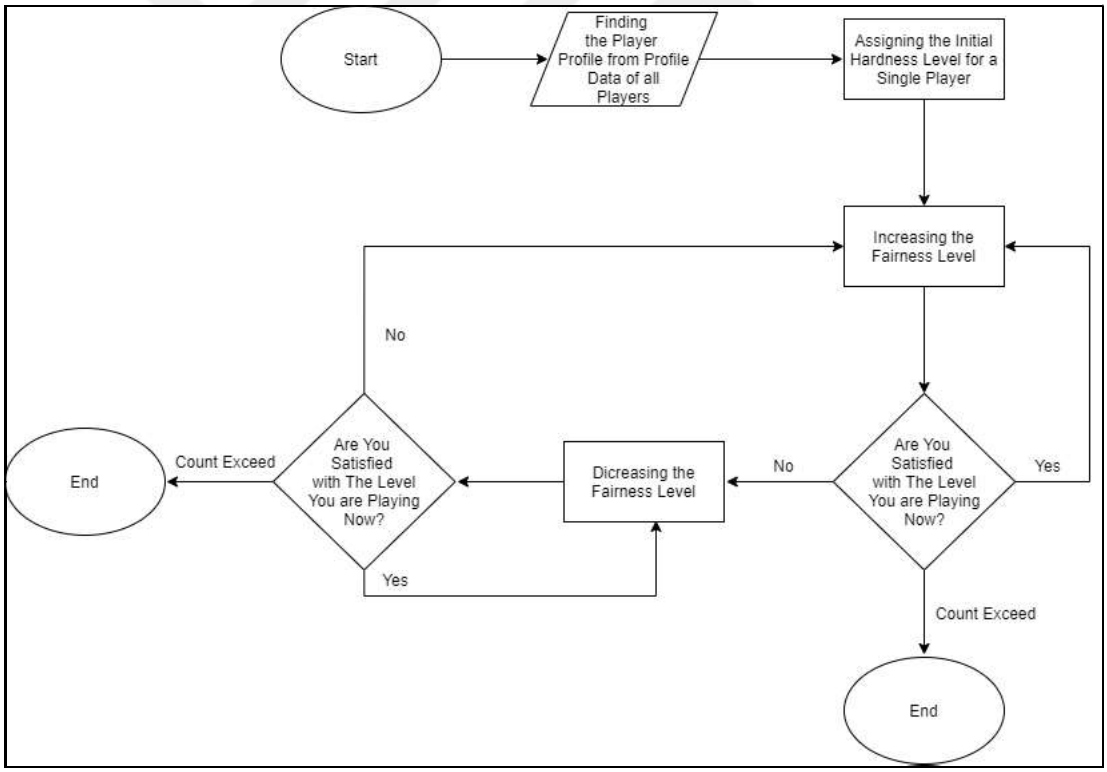

Figure 3.3 Flow charts for possible solution methods for each player (adopted by Budak, 2020)

As can be seen in the algorithm in Figure 3.3, the player profile of all players is found from the player profile data obtained from the previous algorithm. Then an initial hardness level is assigned for a single player. The determined fairness level is

increased. The player is then asked if they are satisfied with the level of play, they are currently playing. If the answer is yes, the fairness level continues to increase. But if the answer is no, the fairness level starts to be decreased. Players are asked again whether they are satisfied with the level of play they are currently playing. If the answer is yes, the fairness level continues to decrease. But if the answer is no, the fairness level starts to be increased. This cycle continues until the player leaves the game.

CHAPTER 4

DATA PROCESSING AND RESULTS

The data required for this thesis study would be done by making face-to-face questionnaires and playing games, but, since it coincided with the pandemic process, it was tried to reach a result only through the online questionnaire. In this part, questionnaire results and hardness level of the game according to these results are going to be demonstrated.

Survey questions are included in Appendix A. Descriptive statistics about the people participating in the survey are presented in detail with the diagrams below. The questionnaire applied through google survey. Thirty-four people participated in the survey and the participants were helped to conduct the survey. Participants in the survey were made to people in our immediate environment due to the pandemic. Surveys were made within the bounds of possibility to ensure consistency of data and results in this section.

38% of 34 people participating in the study are women and 62% are men. 44% of the participants are between the ages of 18-24, 53% are between the ages of 25-31 and 3% are between the ages of 32-38. These information on demographic variables are shown in Figure 4.1.

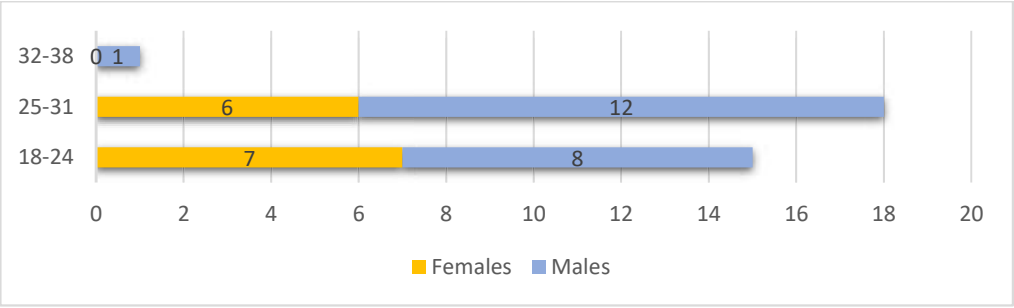

Figure 4.1 Information on demographic variables

Considering the educational status of the participants, 6% are high school graduates, 3% are junior college graduates, 56% are junior college graduates, 29% are

postgraduates, and 6% are doctorate graduates. Education status of the participants is shown in Figure 4.2.

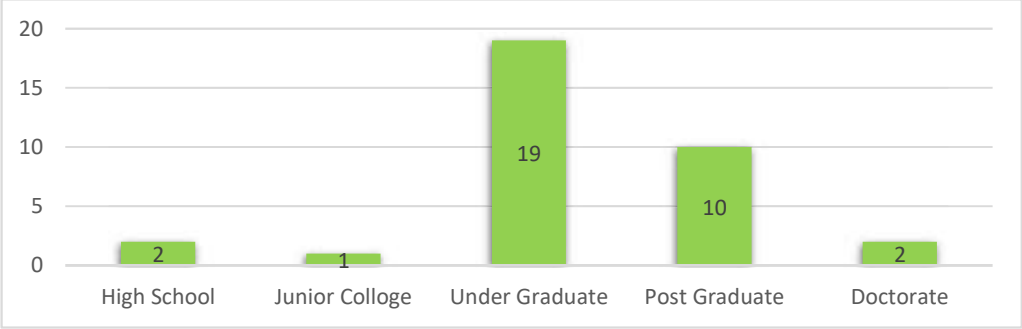

Figure 4.2 Education status

Considering the frequency of playing games, approximately 67.6% of the participants play every day, 17.6% play several days a week and 14.8% play once a week. Considering the duration of the game, 23.5% of the participants play less than 1 hour, 44.1% play 1-2 hours, 17.6% play 2-4 hours, 8.8% 5-6 hours of gameplay, and finally 5.9% of them play more than 7 hours. Frequency of playing game and duration of playing game are shown in Figure 4.3 and Figure 4.4, respectively.

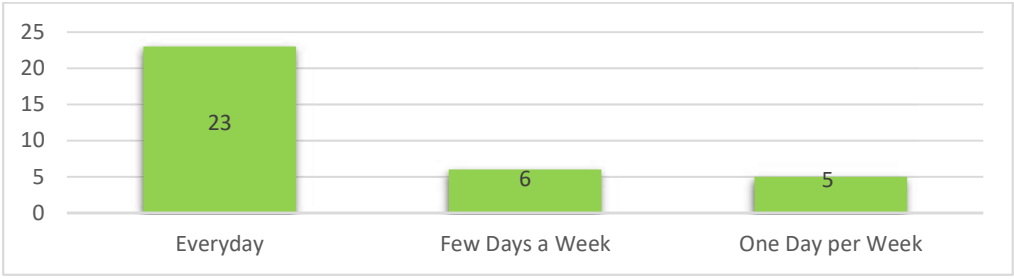

Figure 4.3 Frequency of playing game

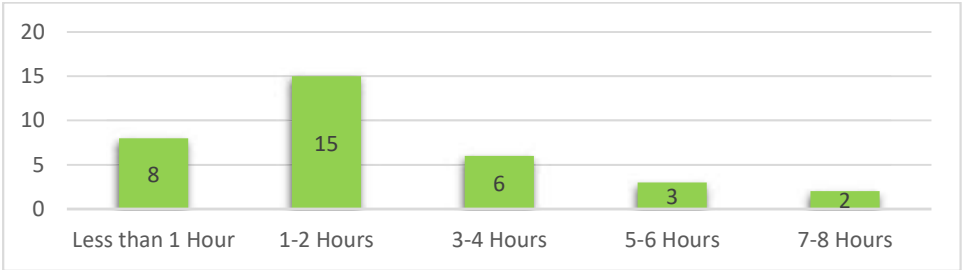

Figure 4.4 Duration of playing game

The participants were asked the reason for playing the game. As indicated in Figure 4.5, the results are 53% of the participants play games to spend time, 47% of them play games for fun. The Figure 4.5 shows reason for playing game.

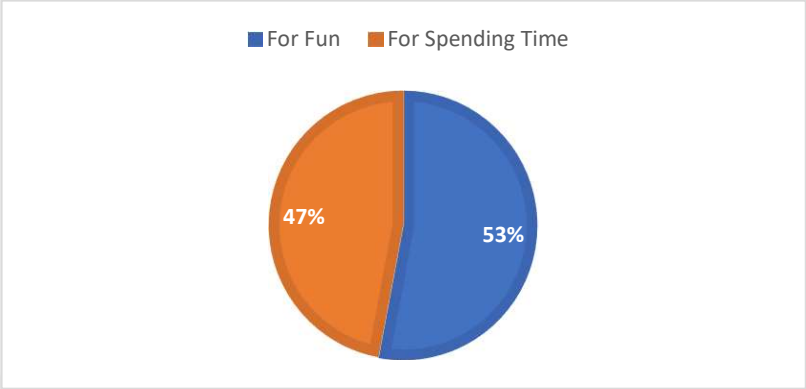

Figure 4.5 Reason of playing game

The participants were asked what they thought about the time they spent playing the game. It is as shown in Figure 4.6. 56% of respondents regard as it as a tool to assess leisure time, the time spent for 26% of the participants does not matter. 15% of the participants regard as this time as wasted time. Figure 4.6 shows thoughts about the time spent in the game.

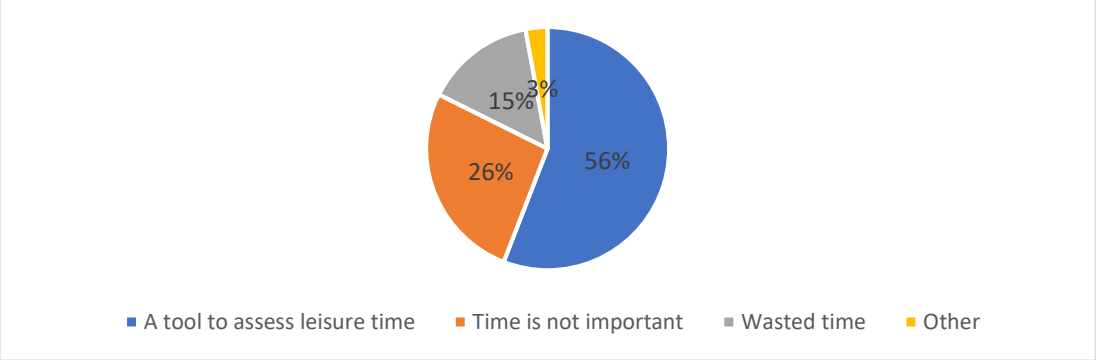

Figure 4.6 Thoughts about the spent in the game

We asked to the participants of the question. How you would feel when you win or lose the game? 47% of the participants replied, "I sorrow when I lose the game and I play again to win". 26% of the participants replied, "I play again when I win". The remaining 24% answered "I'm not sorry that I lost it, I act like nothing happened".

Apart from these answers, one participant replied, "If I lose the game, I get angry and close the game." Figure 4.7 shows a brief summary of this situation.

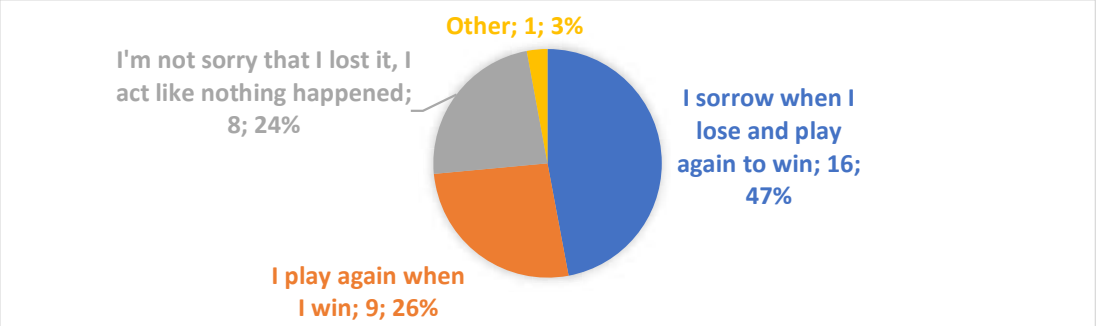

Figure 4.7 What do you feel when you win / lose the game

We asked the participants which of the three basic platforms do they prefer for playing games. 59% of the participants prefer mobile games, 29% prefer online games and the remaining 12% prefer computer games. According to these data, mobile games are preferred more today. The reason for this is thought that mobile games are more accessible than other platforms. Figure 4.8 shows the percentage of preferred platform.

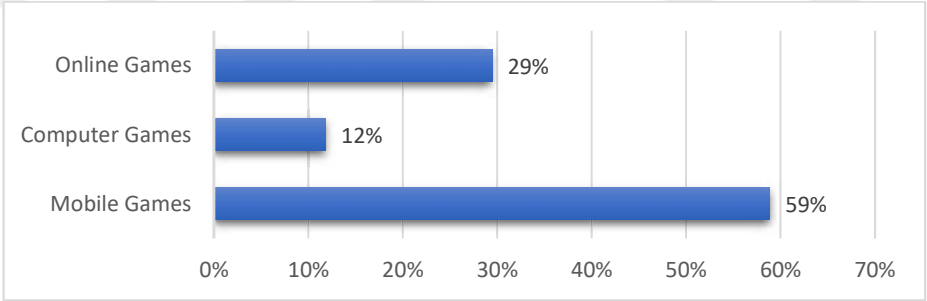

Figure 4.8 Percentage of preferred platform

The participants were asked to evaluate the level of addiction for mobile games, the most preferred platform, in the range of 1-5 scales. “1” means “very low level”, “2” means “low level”, “3” means “medium level”, “4” means “high level”, and “5” means “very high level”. As shown in Figure 4.9 the addiction level of 32% of the participants is medium level. 26% of them answered the high level. 15% responded as very high level, 15% as low level, and 12% as very low level.

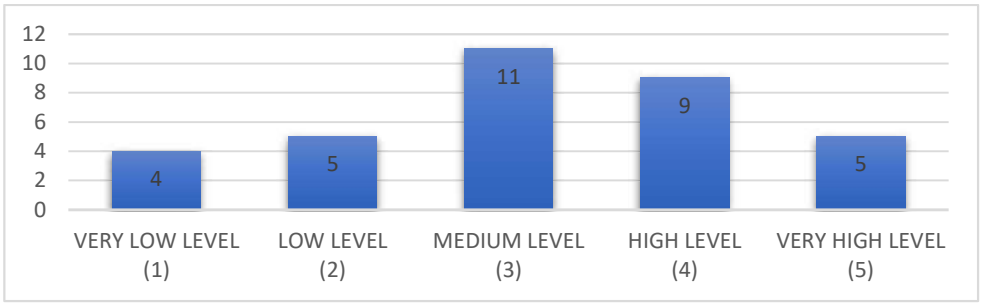

Figure 4.9 Addiction level of mobile game

The participants were asked to evaluate the importance of level of game for mobile games, the most preferred platform, in the range of 1-5 scales. “1” means “very low level”, “2” means “low level”, “3” means “medium level”, “4” means “high level”, and “5” means “very high level”. As shown in Figure 4.10 the level of game importance of 32% of the participants is high level. 24% of them answered the very high level. 18% responded as medium level, 18% as low level, and 6% as very low level.

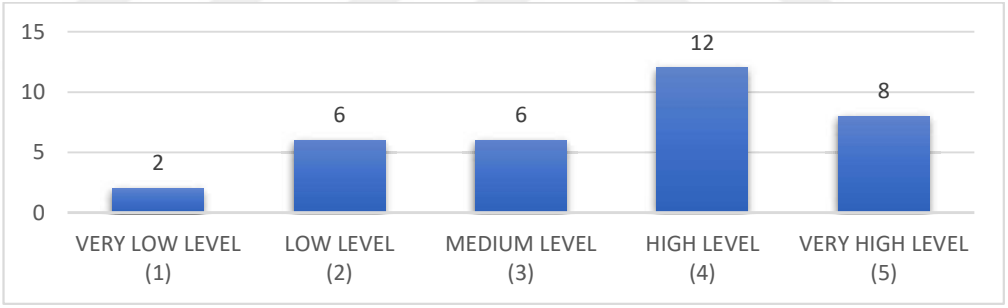

Figure 4.10 Game level importance

The participants were asked how the levels of playing should be. It was asked to choose one of the five different options. These options are it is very easy, easy, medium, hard and very hard. As shown in Figure 4.11 below, 50% of participants want the game level to be hard. 38% preferred the middle level. 6% preferred a very hard level and the remaining 6% preferred an easy level. Very easy level is not preferred by anyone.

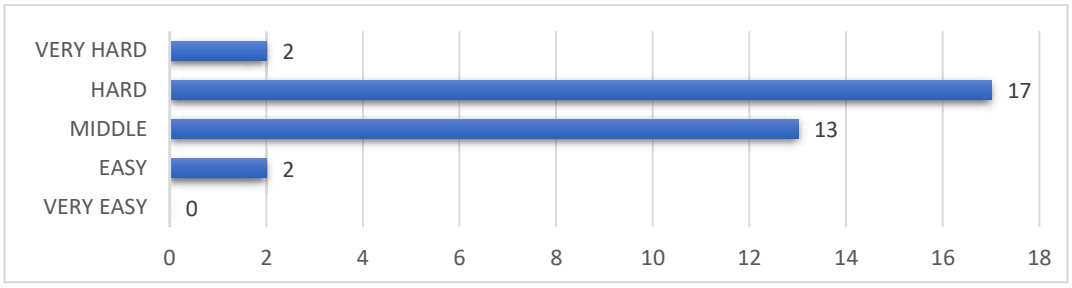

Figure 4.11 Game level

We asked the participants about the reactions to the easy game. As shown in Figure 4.12 below, 53% of the participants answered, "I want the game level to be harder". 26% said they would leave the game. 18% answered "I play the game just to spend time", while only one person said he would enjoy the easy level game more.

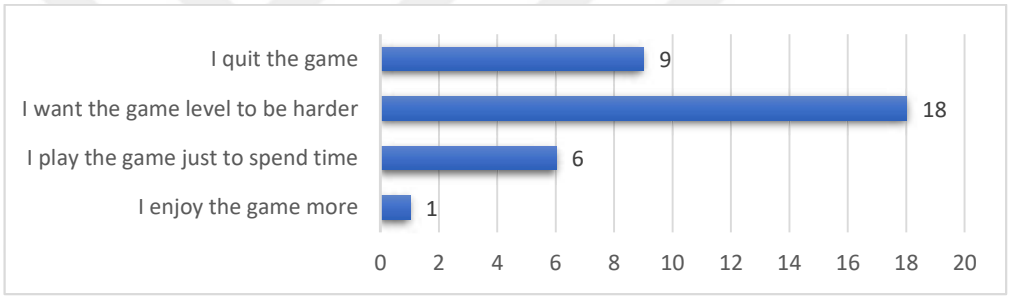

Figure 4.12 Reactions for easy game

We asked the participants about the reactions to the hard game. As shown in Figure 4.13 below, 62% of the participants answered, "I enjoy the game more". 18% answered "I play the game just to spend time" and %15 answered, “I want the game level to be easier”. 6% said they would leave the game.

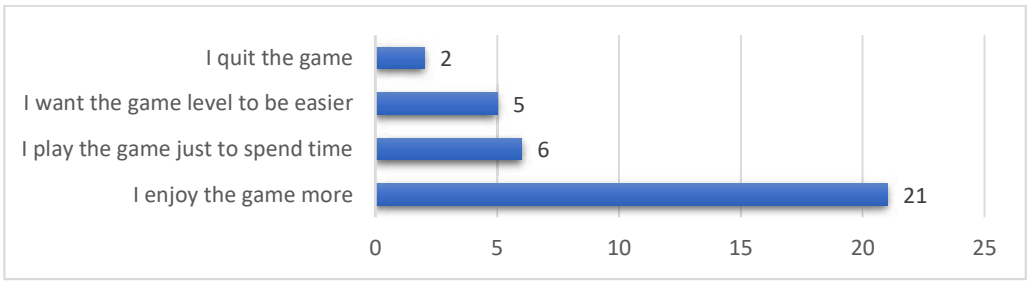

Figure 4.13 Reactions for harder game

Based on the results in Figure 4.11, Figure 4.12, and Figure 4.13, we can make an inference about hardness level of game. When we look at the percentages, most of the participants prefer difficult levels. When they come across an easy game level, they either want the game level to get harder or they leave the game. The important point here is how the player profile reacts to the game. Based on the questionnaire, we will try to find the answer in line with the algorithms mentioned in the methodology.

4.1 Hardness Level of Player Profiles

The answers to the questions in the questionnaire were examined in the literature and the game level to be determined for each player profile was arranged on a 5-point Likert scale. This scale is arranged according to the game level preferred by the participants in the questionnaire, and it is as "Very Easy = 1; Easy = 2, Medium = 3; Hard = 4; Very Hard = 5", respectively. The arithmetic means of the numerical values corresponding to the responses of 34 people participating in the questionnaire was taken. The results are shown in Table 4.1.

Table 4.1 Arithmetic means of the numerical values of each player profile

Player Profile	Value
Advancement	3,45
Mechanics	3,57
Competition	3,63
Socializing	3,36
Relationship	3,50
Teamwork	3,53
Discovery	3,42
Role-Playing	3,44
Customization	3,50
Escapism	3,45

According to the results, hardness level of game values was determined for player profiles. These results have been obtained by evaluating all the characters of the people. The order of the game hardness level values of the player characters from big to small is as follows.

Competition > Mechanics > Teamwork > Relationship ≥ Customization > Advancement ≥ Escapism > Role-Playing > Discovery > Socializing

In a study questionnaire, a paired comparison was performed on 34 people using the AHP method. According to AHP results from a study in which 34 people participated.

- The number of people whose first character is Advancement is 13.
- The number of people whose first character is Competition is 6.
- The number of people whose first character is Escapism is 5.
- The number of people whose first character is Teamwork is 3.
- The number of people whose first character is Mechanics is 2.
- The number of people whose first character is Socializing is 2.
- The number of people whose first character is Relationship is 1.
- The number of people whose first character is Role-Playing is 1.
- The number of people whose first character is Customization is 1.
- No one has appeared whose first character is Discovery.

According to these results, % 38 of the participants has Advancement player character. %18 of the participants has Competition and % 15 have Escapism player characters. 9 percent of the participants have Teamwork. % 6 of the participants has Mechanics and the other % 6 have Socializing player characters. Relationship, Role-Playing, and Customization share the remaining %3.

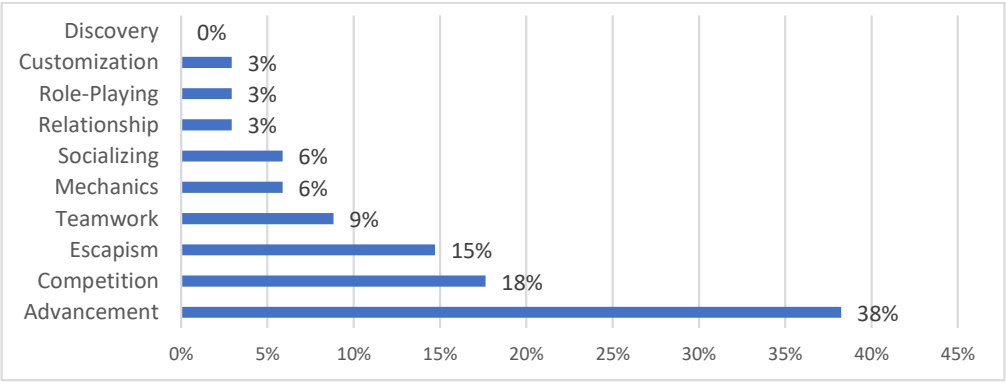

Figure 4.14 Players main character percentages

The game difficulty levels calculated in line with the first main player profile determined for each person with the AHP method are given in Table 4.2. The game difficulty levels of the first characters for each player profile were obtained by calculating the arithmetic average of the preferred game levels (Very Easy = 1; Easy = 2, Medium = 3; Hard = 4; Very Hard = 5).

Table 4.2 Arithmetic means of the numerical values of main character for each player

Player Profile	Value
Advancement	3,69
Mechanics	3,50
Competition	3,50
Socializing	4,00
Relationship	4,00
Teamwork	3,67
Discovery	N/A
Role-Playing	3,00
Customization	4,00
Escapism	3,00

According to the results, hardness level of game values was determined for player profiles. These results have been obtained by evaluating main characters of the people. The order of the game hardness level values of the player characters from big to small is as follows.

Relationship ≥ Socializing ≥ Customization > Advancement > Teamwork > Mechanics ≥ Competition > Role-Playing ≥ Escapism

While Figure 4.15 gives us the game hardness levels of all players regardless of their character ranking, Figure 4.16 shows the game hardness level of the main characters of the players. Although there is a difference in ranking between the two cases, when we look at their arithmetic mean, no big differences are observed. In both cases, the difficulty levels are collected in the range of 3-4. Determining game hardness levels according to the main characters from the AHP results of the players is more difficult as it will require an algorithm that requires more cycles than the initial calculation. However, when sufficient data is provided, it will provide much more accurate and much more satisfactory levels.

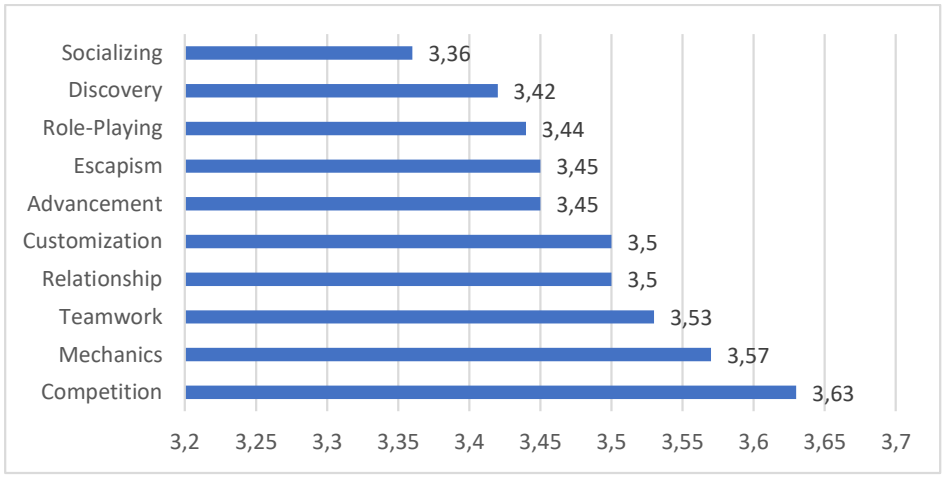

Figure 4.15 Hardness level of game each player

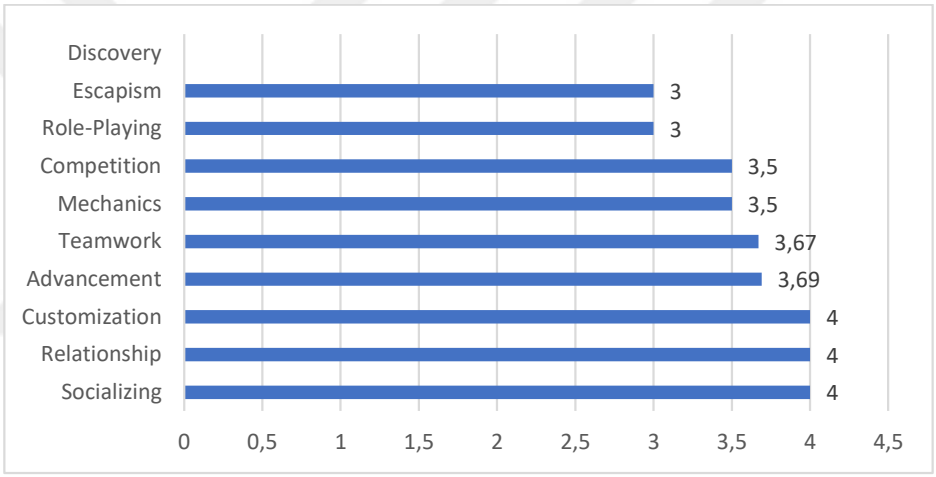

Figure 4.16 Hardness level of game of main character for each player

In the survey, players were asked about their reactions to game difficulty levels. We tried to determine the approach of the characters towards the level of play by grouping the answers according to the player profiles.

In a group of 22 people with competitive player motivation, the reactions when the game is easy, as stated in the column chart like Figure 4.17, eighteen of them want the game to be more difficult, while one person wants the game to be easy. Since the other three people play games just to pass the time, it doesn't matter whether the game is difficult or easy. Hardness level of game is 3.63 for competition as stated previously. The people in this player profile give more enjoy playing the game at an average

difficulty level of 3.63. Since players with a competition motivation like to beat and dominate, offering them difficult levels of play will increase their stay in the game.

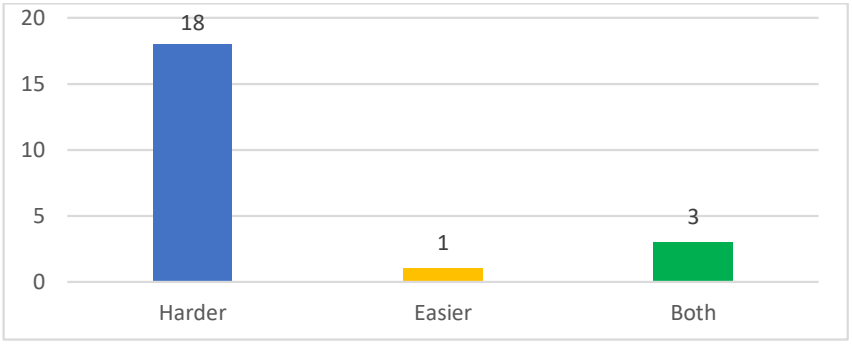

Figure 4.17 Competitions' reactions to easy game

In a group of seven people with mechanics player motivation, the reactions when the game is easy, as stated in the column chart like Figure 4.18, five of them want the game to be more difficult, while one person wants the game to be easy. Since the other one person play games just to pass the time, it doesn't matter whether the game is difficult or easy. Hardness level of game is 3.57 for mechanics as stated previously. The people in this player profile give more enjoy playing the game at an average difficulty level of 3.57. Since getting a high score in mechanics motivation, analyzing the numerical mechanics in the games and understanding the game system are important criteria, keeping the game at difficult levels makes it easier to keep the player in the game in the most optimum way.

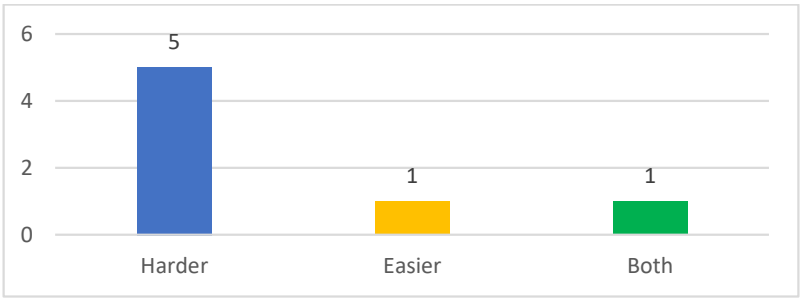

Figure 4.18 Mechanics' reactions to easy game

In a group of fifteen people with teamwork player motivation, the reactions when the game is easy, as stated in the column chart like Figure 4.19, eleven of them want the

game to be more difficult, while no one person wants the game to be easy. Since the other four people play games just to pass the time, it doesn't matter whether the game is difficult or easy. Hardness level of game is 3.53 for teamwork as stated previously. The people in this player profile give more enjoy playing the game at an average difficulty level of 3.53. Since players with teamwork motivation both enjoy high scores and enjoy collaborating with others, keeping them on the level of difficulty they want will keep them in the game. They always want the game to be difficult according to the results. They don't prefer easy game.

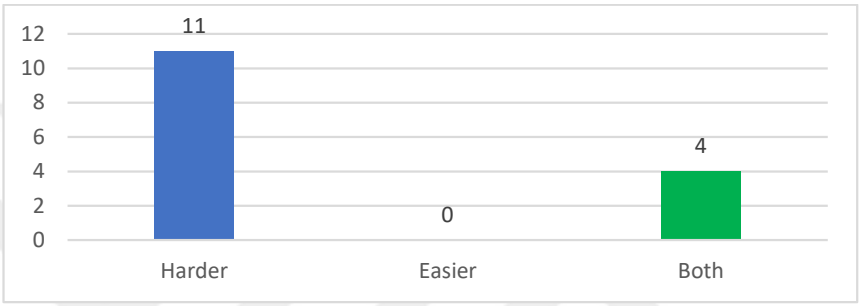

Figure 4.19 Teamwork' reactions to easy game

In a group of two people with relationship player motivation, the reactions when the game is easy, as stated in the column chart like Figure 4.20, one of them want the game to be more difficult, while no one person wants the game to be easy. Since the other one person play games just to pass the time, it doesn't matter whether the game is difficult or easy. Hardness level of game is 3.50 for relationship as stated previously. Players who have this motivation like to communicate with other players and expect their support in the game. So, keeping them at an average difficulty level of 3.50 will allow them to enjoy the game more.

Figure 4.20 Relationship' reactions to easy game

In a group of four people with customization player motivation, the reactions when the game is easy, as stated in the column chart like Figure 4.21, all of them want the game to be more difficult. Hardness level of game is 3.50 for customization as stated previously. In the customization motivation, players like to win games, get high scores, and have a different style and appearance with scores. According to the result, the game difficulty level of 3.50 is an ideal level for them.

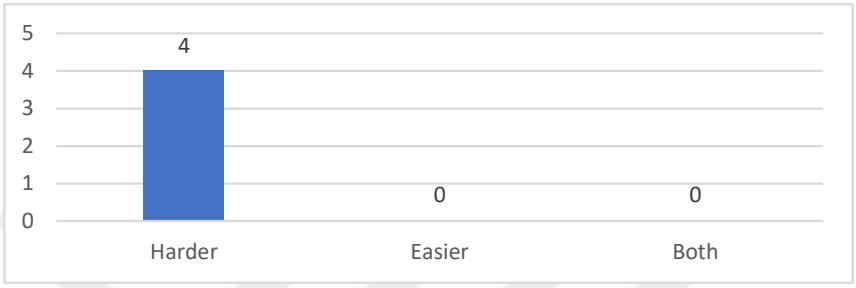

Figure 4.21 Customization' reactions to easy game

In a group of twenty people with advancement player motivation, the reactions when the game is easy, as stated in the column chart like Figure 4.22, seventeen of them want the game to be more difficult, while one person wants the game to be easy. Since the other three people play games just to pass the time, it doesn't matter whether the game is difficult or easy. Hardness level of game is 3.45 for advancement as stated previously. In the motivation to progress, the players prefer to win games, reach goals and level up easily. They like to achieve these at difficult levels. Often the easy levels are not fun for them. Rather, levels between medium and hard keep players motivated to progress.

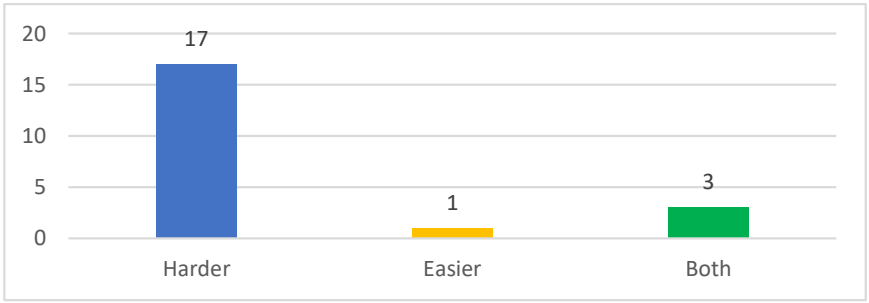

Figure 4.22 Advancement' reactions to easy game

In a group of eleven people with escapism player motivation, the reactions when the game is easy, as stated in the column chart like Figure 4.23, seven of them want the game to be more difficult, while one person wants the game to be easy. Since the other three people play games just to pass the time, it doesn't matter whether the game is difficult or easy. Hardness level of game is 3.45 for escapism as stated previously. In the motivation of escapism, players play games to get away from stress in the real world rather than win games. According to the results, they mostly prefer the game level to be difficult. The medium to hard level is ideal for players with this motivation.

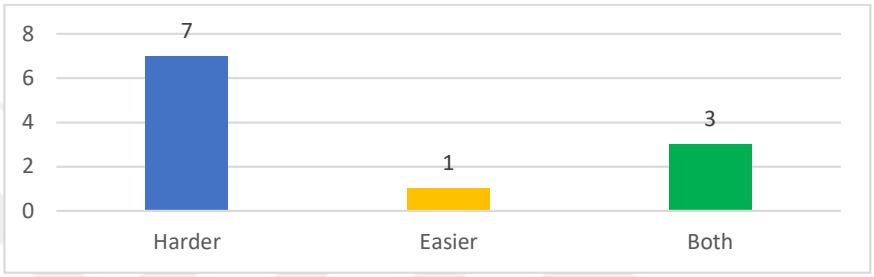

Figure 4.23 Escapism' reactions to easy game

In a group of nine people with role-playing player motivation, the reactions when the game is easy, as stated in the column chart like Figure 4.24, six of them want the game to be more difficult, while one person wants the game to be easy. Since the other two people play games just to pass the time, it doesn't matter whether the game is difficult or easy. Hardness level of game is 3.44 for role-playing as stated previously. In the role-playing motivation, the actors like to play the character they have created and to construct a story through it. They also make this character live in the real world. In line with the results, they like to cope with the difficulties they encounter in the game just like in real life. The medium to hard level is ideal for players with this motivation.

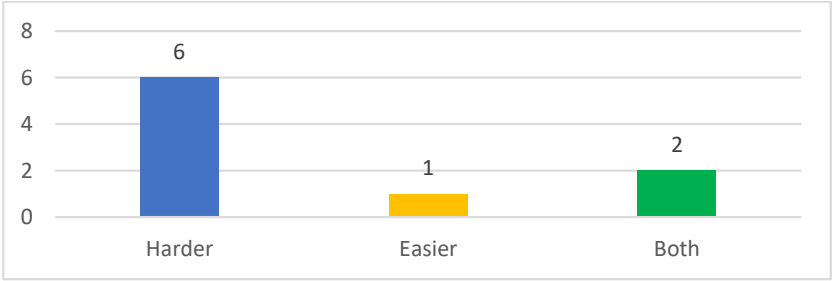

Figure 4.24 Role-playing' reactions to easy game

In a group of five people with discovery player motivation, the reactions when the game is easy, as stated in the column chart like Figure 4.25, three of them want the game to be more difficult, while no one person wants the game to be easy. Since the other two people play games just to pass the time, it doesn't matter whether the game is difficult or easy. Hardness level of game is 3.42 for discovery as stated previously. In the discovery motivation, the players have features such as exploring new places, seeing unseen places, and completing given missions. They do not give up even in the difficult levels that they will encounter. In line with the results of the answers given in the questionnaire, they mostly prefer the game to be difficult. Medium and hard levels will allow players with this motivation to spend more time in the game.

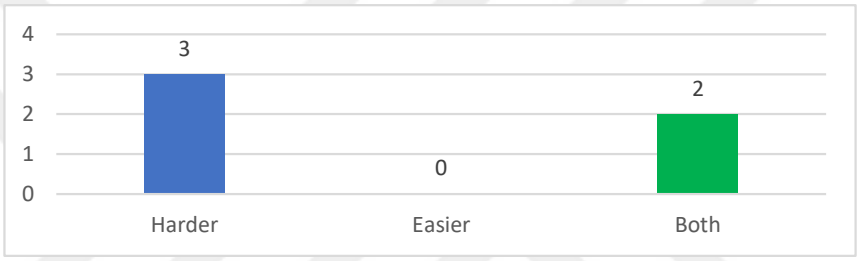

Figure 4.25 Discovery' reactions to easy game

In a group of nine people with socializing player motivation, the reactions when the game is easy, as stated in the column chart like Figure 4.26, five of them want the game to be more difficult, while one person wants the game to be easy. Since the other three people play games just to pass the time, it doesn't matter whether the game is difficult or easy. Hardness level of game is 3.36 for socializing as stated previously. In socializing motivation, players prefer to be in contact with other players. For this reason, any level between medium and hard will be enough to keep them in the game.

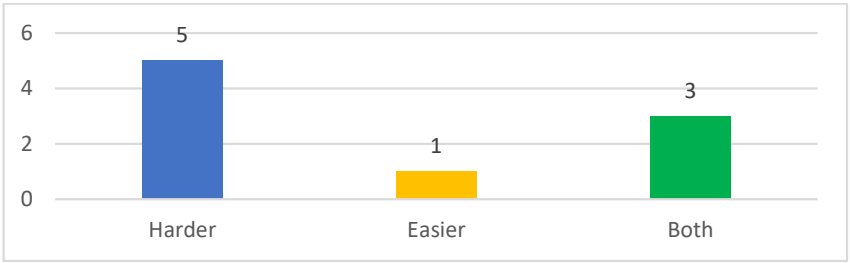

Figure 4.26 Socializing' reactions to easy game

4.2 Algorithm for Each Player Profile

According to the survey results, the best hardness level of the player profiles was determined in the previous section. The maximum hardness level must be added to the algorithm in order to take an determine with how hard the game maker should make the game for each character. For this, the maximum difficulty level was calculated according to the reactions of the players participating in the survey to the game difficulty levels. The maximum hardness level was calculated according to the best hardness levels in Table 4.1.

Since sufficient data cannot be collected due to the pandemic, more data is needed. However, we tried to obtain an algorithm for each profile with the data obtained. According to the responses of 34 people participating in the questionnaire, a symbolic algorithm was obtained because sufficient data could not be provided for player profiles with less than four people, but in future studies, the missing data should be re-searched, and flowchart should be rearranged.

In the following subheadings, a separate algorithm has been created for each player profile.

4.2.1 Algorithm for Competition

In the algorithm shown in Figure 4.27, the necessary steps for the players with a competition motivation to enjoy the game and to adjust the duration of the game in the most optimum way are shown.

In accordance with the results of the survey, using the past information of the players, among the players with competition motivation, 82% of the participants with this profile want the game to be more difficult, while 5% want the game to be easier. Calculation of the maximum hardness level for the competition profile with a best hardness level of 3.63 is described below.

Firstly, the best hardness level is subtracted from level 5, which is considered the most difficult level.

5-3.63=1.37

Secondly, since 82% of the players want the game to be more difficult, we make the game harder by 82%.

*1.37*0.82=1.1234*

3.63+1.1234=4.7534

Thirdly, since 5% of players want the game to be easier, we make the game easier by 5%.

*1.37*0.05=0.0685*

Finally, using the results we obtained, we get the maximum hardness level.

4.7534-0.0685=4.6849≈4.68

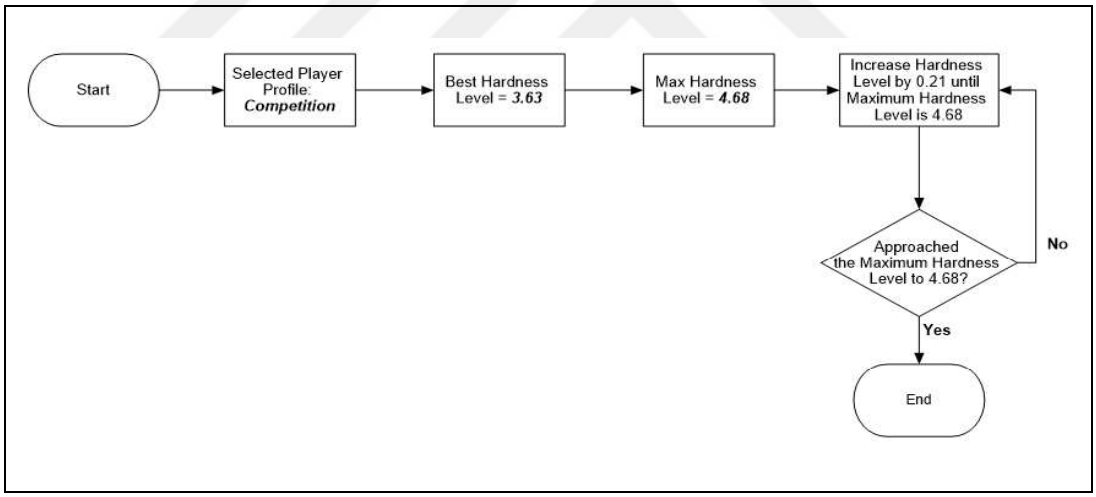

Figure 4.27 Algorithm for competition

In the algorithm above, the competition profile from the database is selected. Then the best hardness level and maximum hardness level processes are processed. In the next process, the hardness level is started to be increased in 5 steps, that is, 0.21 for the competition profile. This process continues until the maximum hardness level is reached. When the game level reaches the maximum hardness level, the process of increasing the game difficulty level ends.

4.2.2 Algorithm for Mechanics

In the algorithm shown in Figure 4.28, the necessary steps for the players with a mechanics motivation to enjoy the game and to adjust the duration of the game in the most optimum way are shown.

In accordance with the results of the survey, using the past information of the players, among the players with mechanics motivation, 71% of the participants with this profile want the game to be more difficult, while 14% want the game to be easier. Calculation of the maximum hardness level for the mechanics profile with a best hardness level of 3.57 is described below.

Firstly, the best hardness level is subtracted from level 5, which is considered the most difficult level.

5-3.57=1.43

Secondly, since 71% of the players want the game to be more difficult, we make the game harder by 71%.

*1.43*0.71=1.0153*

3.57+1.0153=4.5853

Thirdly, since 14% of players want the game to be easier, we make the game easier by 14%.

*1.43*0.14=0.2002*

Finally, using the results we obtained, we get the maximum hardness level.

4.5853-0.2002=4.3851≈4.38

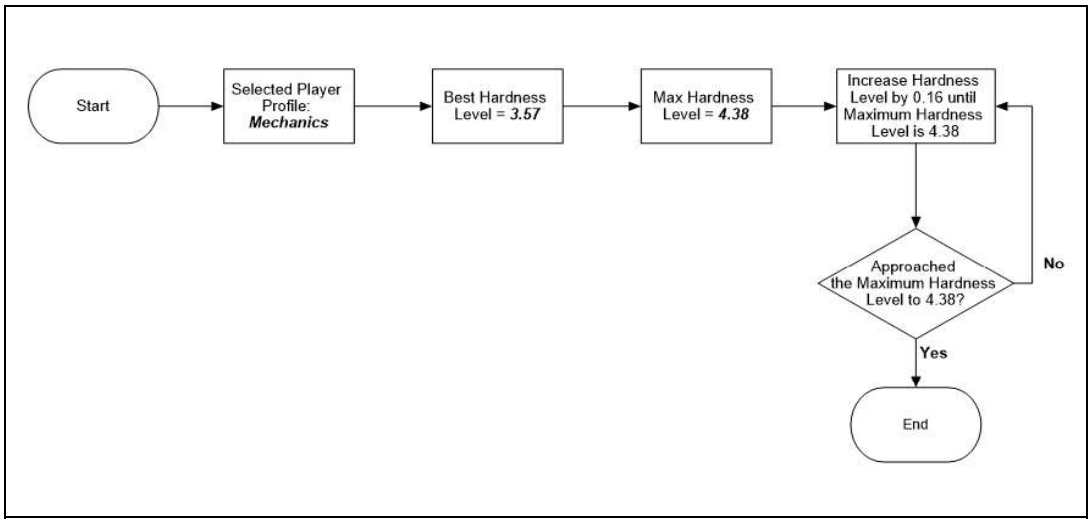

Figure 4.28 Algorithm for mechanics

In the algorithm above, the mechanics profile from the database is selected. Then the best hardness level and maximum hardness level processes are processed. In the next process, the hardness level is started to be increased in 5 steps, that is, 0.16 for the mechanics motivation. This process continues until the maximum hardness level is reached. When the game level reaches the maximum hardness level, the process of increasing the game difficulty level ends.

4.2.3 Algorithm for Teamwork

In the algorithm shown in Figure 4.29, the necessary steps for the players with a teamwork motivation to enjoy the game and to adjust the duration of the game in the most optimum way are shown.

In accordance with the results of the survey, using the past information of the players, among the players with teamwork motivation, 73% of the participants with this profile want the game to be more difficult, while no one want the game to be easier. Calculation of the maximum hardness level for the teamwork profile with a best hardness level of 3.53 is described below.

Firstly, the best hardness level is subtracted from level 5, which is considered the most difficult level.

5-3.53=1.47

Secondly, since 73% of the players want the game to be more difficult, we make the game harder by 73%.

*1.47*0.73=1.0731*

3.53+1.0731=4.6031≈4.60

Since no one wants the game to be easier, the maximum hardness level is 4.60.

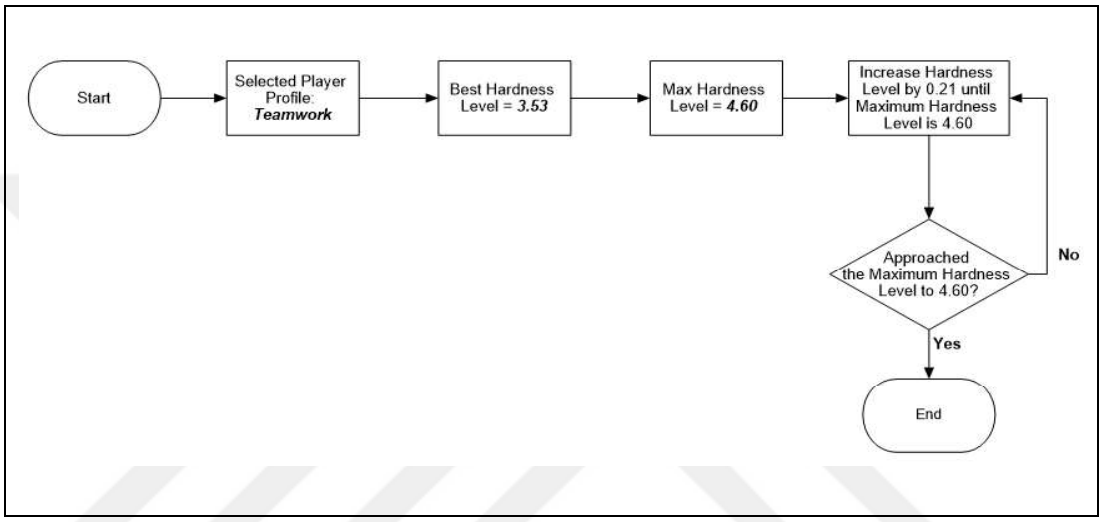

Figure 4.29 Algorithm for teamwork

In the algorithm above, the teamwork profile from the database is selected. Then the best hardness level and maximum hardness level processes are processed. In the next process, the hardness level is started to be increased in 5 steps, that is, 0.21 for the teamwork motivation. This process continues until the maximum hardness level is reached. When the game level reaches the maximum hardness level, the process of increasing the game difficulty level ends.

4.2.4 Algorithm for Relationship

In the algorithm shown in Figure 4.30, the necessary steps for the players with a relationship motivation to enjoy the game and to adjust the duration of the game in the most optimum way are shown.

In accordance with the results of the survey, using the past information of the players, among the players with relationship motivation, 50% of the participants with this profile want the game to be more difficult, while no one want the game to be easier. Calculation of the maximum hardness level for the relationship profile with a best hardness level of 3.53 is described below.

Firstly, the best hardness level is subtracted from level 5, which is considered the most difficult level.

5-3.50=1.50

Secondly, since 50% of the players want the game to be more difficult, we make the game harder by 50%.

*1.50*0.50=0.75*

3.50+0.75=4.25

Since no one wants the game to be easier, the maximum hardness level is 4.25.

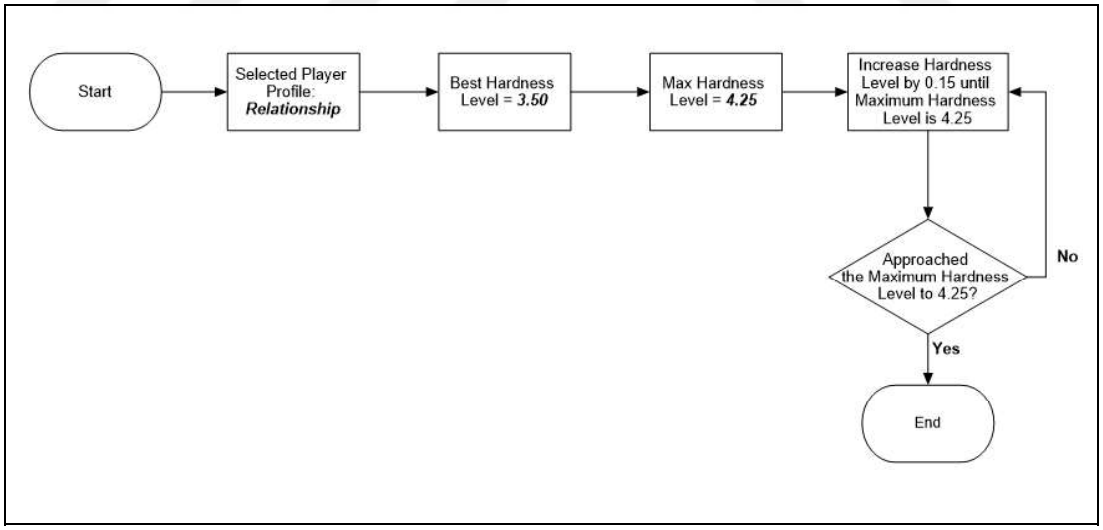

Figure 4.30 Algorithm for relationship

In the algorithm above, the relationship profile from the database is selected. Then the best hardness level and maximum hardness level processes are processed. In the next process, the hardness level is started to be increased in 5 steps, that is, 0.15 for the

relationship motivation. This process continues until the maximum hardness level is reached. When the game level reaches the maximum hardness level, the process of increasing the game difficulty level ends.

4.2.5 Algorithm for Customization

In the algorithm shown in Figure 4.31, the necessary steps for the players with a customization motivation to enjoy the game and to adjust the duration of the game in the most optimum way are shown.

In accordance with the results of the survey, using the past information of the players, among the players with relationship motivation, 100% of the participants with this profile want the game to be more difficult, while no one want the game to be easier. Calculation of the maximum hardness level for the customization profile with a best hardness level of 3.46 is described below.

Firstly, the best hardness level is subtracted from level 5, which is considered the most difficult level.

5-3.46=1.54

Secondly, since 100% of the players want the game to be more difficult, we make the game harder by 100%.

*1.54*1=1.54*

3.46+1.54=5.00

Since no one wants the game to be easier, the maximum hardness level is 5.00.

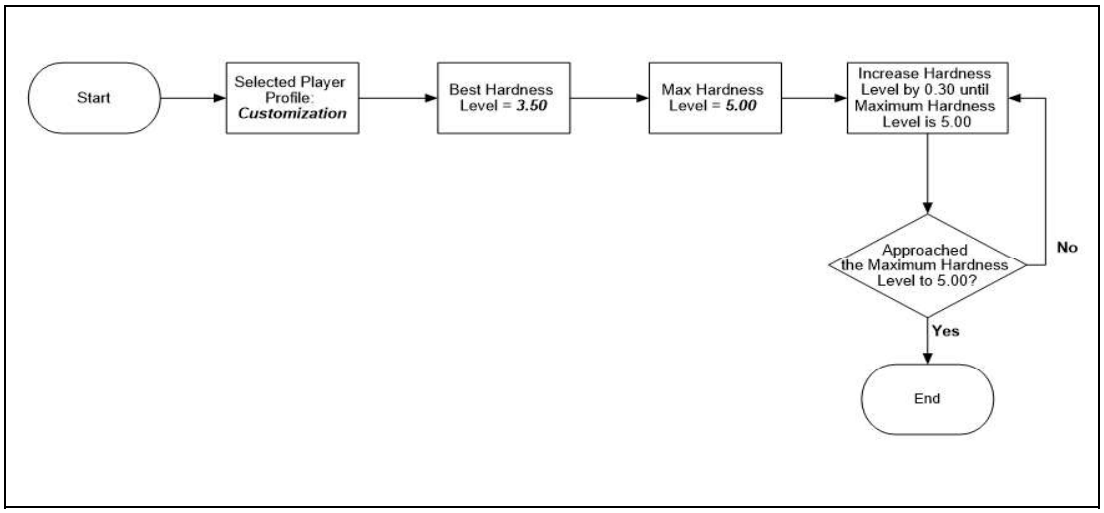

Figure 4.31 Algorithm for customization

In the algorithm above, the customization profile from the database is selected. Then the best hardness level and maximum hardness level processes are processed. In the next process, the hardness level is started to be increased in 5 steps, that is, 0.30 for the customization motivation. This process continues until the maximum hardness level is reached. When the game level reaches the maximum hardness level, the process of increasing the game difficulty level ends.

4.2.6 Algorithm for Advancement

In the algorithm shown in Figure 4.32, the necessary steps for the players with a advancement motivation to enjoy the game and to adjust the duration of the game in the most optimum way are shown.

In accordance with the results of the survey, using the past information of the players, among the players with advancement motivation, 81% of the participants with this profile want the game to be more difficult, while 5% want the game to be easier. Calculation of the maximum hardness level for the advancement profile with a best hardness level of 3.45 is described below.

Firstly, the best hardness level is subtracted from level 5, which is considered the most difficult level.

5-3.45=1.55

Secondly, since 81% of the players want the game to be more difficult, we make the game harder by 81%.

*1.55*0.81=1.2555*

3.54+1.2555=4.7055

Thirdly, since 5% of players want the game to be easier, we make the game easier by 5%.

*1.55*0.05=0.0775*

Finally, using the results we obtained, we get the maximum hardness level.

4.7055-0.0775=4.6228≈4.62

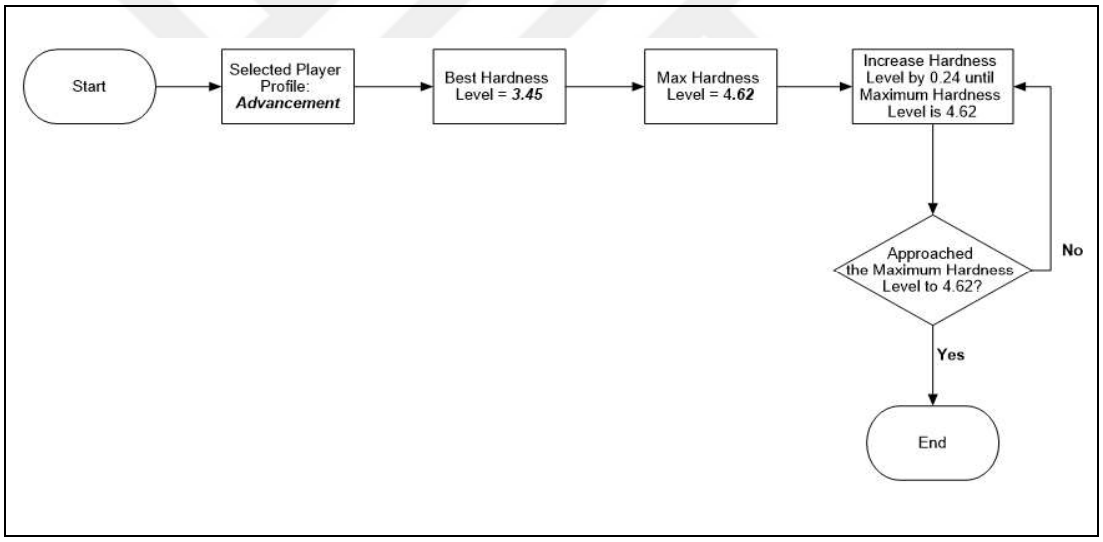

Figure 4.32 Algorithm for advancement

In the algorithm above, the advancement profile from the database is selected. Then the best hardness level and maximum hardness level processes are processed. In the next process, the hardness level is started to be increased in 5 steps, that is, 0.24 for the advancement motivation. This process continues until the maximum hardness level is reached. When the game level reaches the maximum hardness level, the process of increasing the game difficulty level ends.

4.2.7 Algorithm for Escapism

In the algorithm shown in Figure 4.33, the necessary steps for the players with an escapism motivation to enjoy the game and to adjust the duration of the game in the most optimum way are shown.

In accordance with the results of the survey, using the past information of the players, among the players with escapism motivation, 64% of the participants with this profile want the game to be more difficult, while 9% want the game to be easier. Calculation of the maximum hardness level for the escapism profile with a best hardness level of 3.45 is described below.

Firstly, the best hardness level is subtracted from level 5, which is considered the most difficult level.

5-3.45=1.55

Secondly, since 64% of the players want the game to be more difficult, we make the game harder by 64%.

*1.55*0.64=0.992*

3.45+0.992=4.442

Thirdly, since 9% of players want the game to be easier, we make the game easier by 9%.

*1.55*0.09=0.1395*

Finally, using the results we obtained, we get the maximum hardness level.

4.442-0.1395=4.3025≈4.30

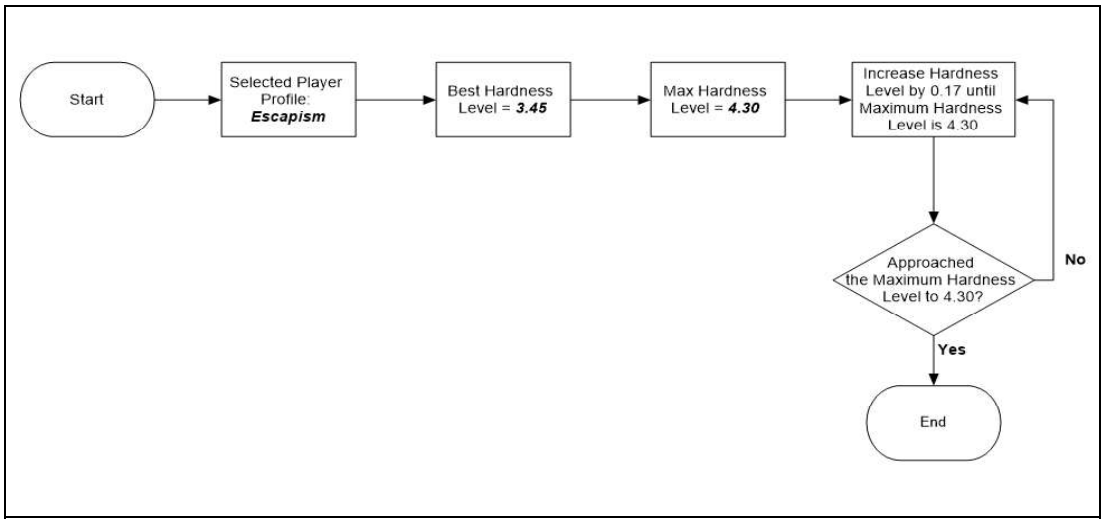

Figure 4.33 Algorithm for escapism

In the algorithm above, the escapism profile from the database is selected. Then the best hardness level and maximum hardness level processes are processed. In the next process, the hardness level is started to be increased in 5 steps, that is, 0.17 for the escapism motivation. This process continues until the maximum hardness level is reached. When the game level reaches the maximum hardness level, the process of increasing the game difficulty level ends.

4.2.8 Algorithm for Role-Playing

In the algorithm shown in Figure 4.34, the necessary steps for the players with a role-playing motivation to enjoy the game and to adjust the duration of the game in the most optimum way are shown.

In accordance with the results of the survey, using the past information of the players, among the players with role-playing motivation, 64% of the participants with this profile want the game to be more difficult, while 11% want the game to be easier. Calculation of the maximum hardness level for the role-playing profile with a best hardness level of 3.44 is described below.

Firstly, the best hardness level is subtracted from level 5, which is considered the most difficult level.

5-3.44=1.56

Secondly, since 67% of the players want the game to be more difficult, we make the game harder by 67%.

*1.56*0.67=1.045*

3.44+1.045=4.4852

Thirdly, since 11% of players want the game to be easier, we make the game easier by 11%.

*1.56*0.11=0.1716*

Finally, using the results we obtained, we get the maximum hardness level.

4.4852-0.1716=4.3136≈4.31

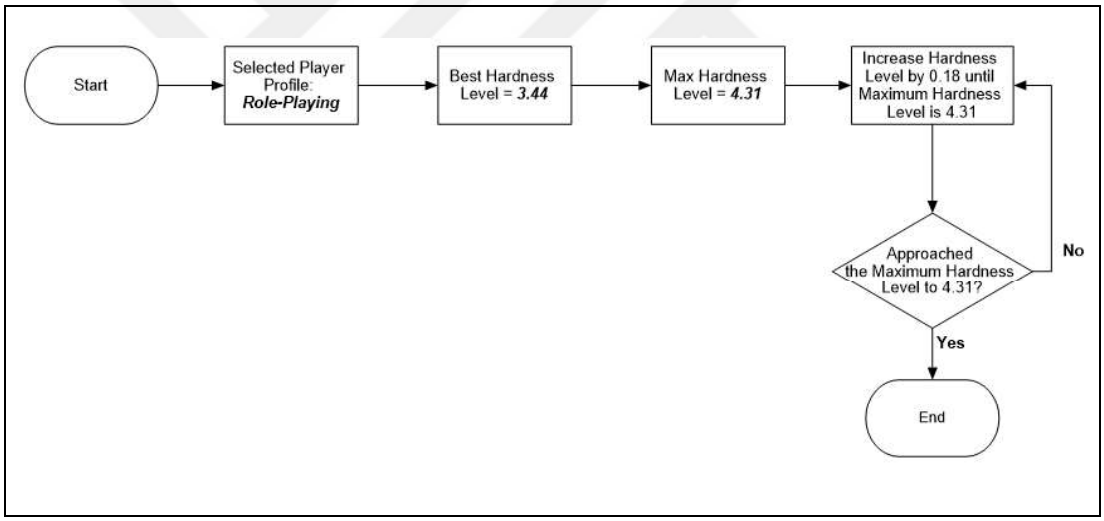

Figure 4.34 Algorithm for role-playing

In the algorithm above, the role-playing profile from the database is selected. Then the best hardness level and maximum hardness level processes are processed. In the next process, the hardness level is started to be increased in 5 steps, that is, 0.18 for the role-playing motivation. This process continues until the maximum hardness level is reached. When the game level reaches the maximum hardness level, the process of increasing the game difficulty level ends.

4.2.9 Algorithm for Discovery

In the algorithm shown in Figure 4.35, the necessary steps for the players with a discovery motivation to enjoy the game and to adjust the duration of the game in the most optimum way are shown.

In accordance with the results of the survey, using the past information of the players, among the players with relationship motivation, 60% of the participants with this profile want the game to be more difficult, while no one want the game to be easier. Calculation of the maximum hardness level for the discovery profile with a best hardness level of 3.42 is described below.

Firstly, the best hardness level is subtracted from level 5, which is considered the most difficult level.

5-3.42=1.58

Secondly, since 100% of the players want the game to be more difficult, we make the game harder by 100%.

*1.58*0.60=0.948*

3.42+0.948=4.368≈4.36

Since no one wants the game to be easier, the maximum hardness level is 4.36.

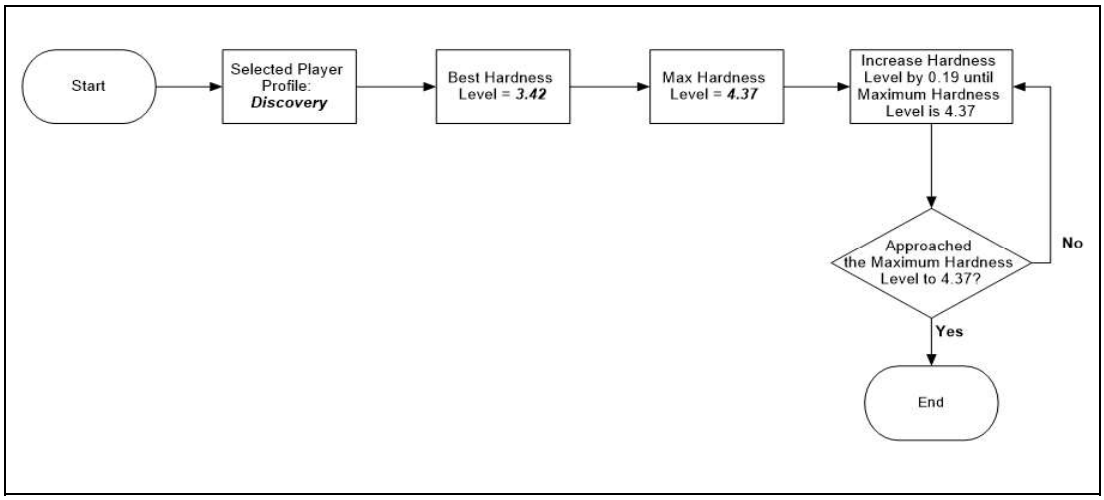

Figure 4.35 Algorithm for discovery

In the algorithm above, the discovery profile from the database is selected. Then the best hardness level and maximum hardness level processes are processed. In the next process, the hardness level is started to be increased in 5 steps, that is, 0.19 for the discovery motivation. This process continues until the maximum hardness level is reached. When the game level reaches the maximum hardness level, the process of increasing the game difficulty level ends.

4.2.10 Algorithm for Socializing

In the algorithm shown in Figure 4.36, the necessary steps for the players with a socializing motivation to enjoy the game and to adjust the duration of the game in the most optimum way are shown.

In accordance with the results of the survey, using the past information of the players, among the players with socializing motivation, 56% of the participants with this profile want the game to be more difficult, while 11% want the game to be easier. Calculation of the maximum hardness level for the role-playing profile with a best hardness level of 3.36 is described below.

Firstly, the best hardness level is subtracted from level 5, which is considered the most difficult level.

5-3.36=1.64

Secondly, since 56% of the players want the game to be more difficult, we make the game harder by 56%.

*1.64*0.56=0.9184*

3.36+0,9184=4.2784

Thirdly, since 11% of players want the game to be easier, we make the game easier by 11%.

*1.64*0.11=0.1804*

Finally, using the results we obtained, we get the maximum hardness level.

4.2784-0.1804=4.098≈4.10

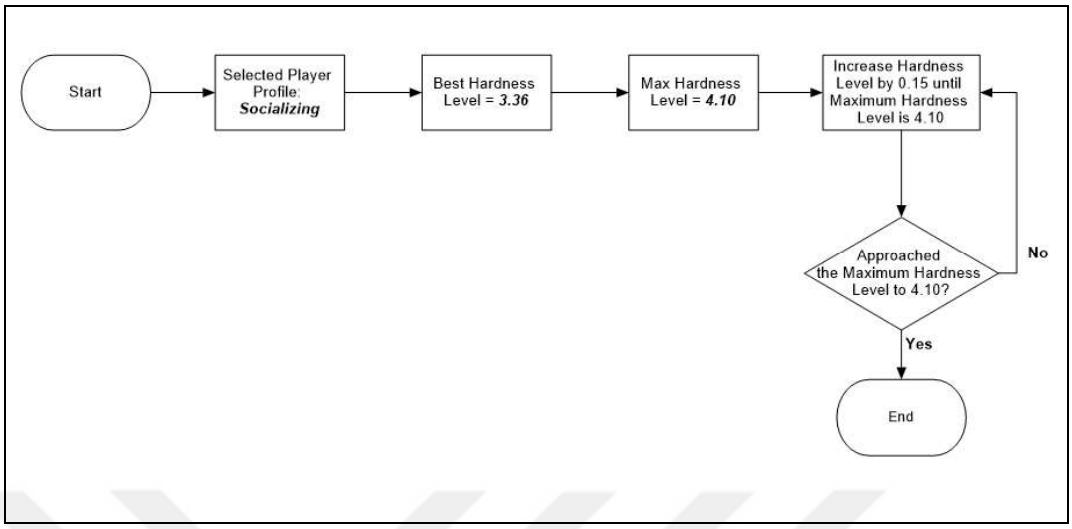

Figure 4.36 Algorithm for socializing

In the algorithm above, the socializing profile from the database is selected. Then the best hardness level and maximum hardness level processes are processed. In the next process, the hardness level is started to be increased in 5 steps, that is, 0.15 for the socializing motivation. This process continues until the maximum hardness level is reached. When the game level reaches the maximum hardness level, the process of increasing the game difficulty level ends.

The algorithms prepared for each player profile are shown together in the Appendix B.

CHAPTER 5

CONCLUSION AND DISCUSSION

The rapid growth of interest in mobile games has made the mobile gaming industry a major market. This situation created a great competitive environment. In order for game producers to remain strong in this competitive environment, they must respond to the demands of the players and be in continuous development. The problem we deal with in our study is to find game hardness levels according to player profiles and to create an algorithm. For this, factors such as keeping the player in the game longer and providing maximum satisfaction are taken into consideration. However, it is quite difficult to determine a hardness level for each profile and to ensure that the determined game hardness levels apply to each game. More data are required for this.

The aim of the thesis study was to adjust the hardness level of game for algorithm to give a certain player the maximum pleasure from the game, by calculating the best hardness level of game accordance with the past data of the players who participated in the survey. In the qualitative dimension of the study, 34 people were surveyed and their attitudes towards hardness levels of game were determined in accordance with the answers given to the questionnaire. It is purposed to maintain player satisfaction and thus maximize profit by keeping the player in the game. Its main parameters are considered as the effects of player profiles and game hardness levels on the player. Constraints depending on the game type and change in player profile-demand relationship are issues to be considered. Based on these criteria, it is aimed to achieve the most accurate game hardness level.

When the study is considered as a whole, an algorithm has been created to adjust the game difficulty level for player profiles. While doing this, the most important elements to keep in mind are keeping customer satisfaction at the highest level and providing maximum profit to the manufacturer. For this, it is necessary to determine at which stage of the game how the justice adjustment should be made. RNG is an academic coding used mostly in algorithms and mostly in simulation. Thanks to this tool, it is tried to understand the behavior of the random number generation system according to

the statistical distribution. In order to understand the whole system, it is tried to be simulated by using a part of the sample. It is used in games to determine what the consequences of the players' decisions will lead to and / or what the next stage of the game will look like, and in situations that will occur randomly within the game. These embedded random numbering code libraries, which are easily added to the coding bases on which the game is written, are planned, and implemented in a way that generates very fast numbers and does not affect the game play speed of the players. For these reasons, it has been made fairness adjustment with RNG.

Participants were asked what player profiles they had and which game level they preferred. Then, if the game was easy or the game was difficult, their reactions to the game were observed in line with the answers given. While creating algorithm, the game is started at the best hardness level according to the player profiles, increasing until it reaches the maximum game hardness level. The loop ends when the maximum game difficulty level is reached.

Due to the pandemic, no experiments could be done on computer applications and players in this study. For this reason, the study is somewhat lacking.

There has been no previous study on this subject. However, it is very important for game producers who want to take their place in the gaming industry, and they need academic support. In line with the data obtained, we designed an algorithm for each player profile, but deeper research is needed. The parameters and restrictions discussed vary with different game types and the profiles of the players playing the respective game. The algorithm we designed is open to development, taking into account many side factors.

In future studies, mathematical modeling can be developed by creating more comprehensive parameters and constraints. An algorithm can then be developed that can be embedded in the game, with more comprehensive results. In doing so, player profile, game type and company policies should be examined in more depth.

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