DEPARTMENT OF INFORMATICS

TECHNISCHE UNIVERSITÄT MÜNCHEN

Bachelor's Thesis in Informatics: Games Engineering

Evaluation of Different Control Techniques in a Mobile Jump and Run Game

Oguzcan Kirmemis

DEPARTMENT OF INFORMATICS

TECHNISCHE UNIVERSITÄT MÜNCHEN

Bachelor's Thesis in Informatics: Games Engineering

Evaluation of Different Control Techniques in a Mobile Jump and Run Game

Evaluierung verschiedener Steuerungstechniken in einem mobilen Spring- und Laufspiel

Author:	Oguzcan Kirmemis
Supervisor:	Prof. Dr. Gudrun Klinker
Advisor:	Fabrizio Palmas
Submission Date:	14.09.2020

I confirm that this bachelor's thesis in informatics: games engineering is my own work and I have documented all sources and material used.

Munich, 14.09.2020 Oguzcan Kirmemis

Acknowledgments

First, I would like to thank Prof. Dr. Gudrun Klinker for granting me the elaboration of this thesis.

I also would like to thank my advisor Fabrizio Palmas for his continuous support and belief in the project from the very start.

In addition, I would like to thank my friend Onat Inak for helping me with the organization of the study.

Many thanks to all participants that took part in the study and enabled this research to be possible.

Finally, my deep and sincere gratitude to my family for their continuous and unparalleled love, help and support.

Abstract

The need for quality user interfaces and controlling techniques is emerging with the mobile game market growing rapidly in the number of published games. Recent developments in mobile technology allowed games in this area to be furthermore complex. For a complex designed game to succeed in the market, it is necessary to find the optimal user interface and interaction mechanisms between the player and the game. Another problem for such a game that it is expected to be run in a system where the traditional interaction mechanisms are not available, which opens many possibilities for interface design. This Bachelor's Thesis studies the interaction methods on the example of the 'Space Wanderer', a mobile game in the jump and run genre. The game and its elements are analyzed, implemented controlling techniques and user interfaces are evaluated based on a user study.

Der Bedarf an qualitativ hochwertigen Benutzeroberflächen und Steuerungstechniken entsteht, da die Zahl der veröffentlichten Spiele auf dem mobilen Spielemarkt rasch wächst. Jüngste Entwicklungen in der mobilen Technologie haben dazu geführt, dass Spiele in diesem Bereich weiterhin komplex werden. Damit ein komplex gestaltetes Spiel auf dem Markt erfolgreich sein kann, ist es notwendig, die optimale Benutzerschnittstelle und die Interaktionsmechanismen zwischen dem Spieler und dem Spiel zu finden. Ein weiteres Problem für ein solches Spiel ist, dass es in einem System ausgeführt werden soll, in dem die Standard-Interaktionsmechanismen nicht verfügbar sind, was viele Möglichkeiten für das Schnittstellendesign eröffnet. In dieser Bachelorarbeit werden die Interaktionsmethoden am Beispiel des 'Space Wanderer', einem mobilen Spiel im Jump and Run Genre, untersucht. Das Spiel und seine Elemente werden analysiert, implementierte Steuerungstechniken und Benutzerschnittstellen werden anhand einer Benutzerstudie evaluiert.

Contents

1. Introduction

The limited interaction methods and input devices in mobile devices often do not match the requirements for intricate game designs. Therefore it is crucial to find the right input style for the chosen genre in the game design[KW11].

Space Wanderer (SW) is a mobile game in the jump and run genre, which will demonstrate the effects of the various interactions throughout this Bachelor's thesis. The topic of this Bachelor's thesis is the evaluation of the control techniques in SW and finding the most optimal solution for the game and the genre in the mobile gaming area.

One of the main disadvantages of mobile games is that traditional interaction methods(keyboard, mouse) are impossible. However, this also opens up many possibilities. Game designers can use soft buttons in the touch screen to replicate a gamepad's behavior, use touch gestures, or even sensors in the mobile platform[SAS17]. All of these methods have comparative and absolute advantages against each other. For example, touch gestures can be hard to learn than soft buttons, but they do not have to take space on the screen[SAS17]. The aim is to find which factors of control are necessary for a platform game in mobile gaming and which control technique can fulfill them.

There are several methods of evaluating the success of games. They can be orientated on an expert's thoughts or automated to compare the collected telemetry. Another way is to do a user study to understand the *play experience* of the game[Ber15]. This thesis will also test its results with a user study. The challenge here is to prepare the correct questionnaire and find useful heuristics to show the differences between the implementations.

In order to identify the problems in various control mechanisms, the game must guarantee that the mechanics and the play style of the game do not change throughout different control techniques. The interaction methods should be well balanced among each other to not provide more advantages than the others. This is also difficult because some game mechanics might not be suitable for the selected control scheme. The task is not merely copying each feature one to one. Instead, it is about finding balanced gameplay to get a meaningful result.

Furthermore, the game should run smoothly in the current mobile devices despite the limited capability compared to traditional computers. Different controlling techniques

should not introduce additional delay or performance problems to the game.

The fundamentals of success in the gaming market are also not solely technical. The market must be big enough to be able to market the game. Following the trends in the market is also a good sign to achieve success.

The last obstacle of this thesis concerns the structure and enjoyability of the game. The user must be motivated to play the game for a correct evaluation. The game has to provide a flow for the users to make them forgot about their surroundings and only focus on the game.

The rest of this thesis is structured as follows:

Chapter 2 focuses on the topic of gamification. It gives information about the concepts in the gamification area, the relationship between motivation and games, the games' structure, the requirements for high-quality games, and methods to analyze them.

Chapter 3 informs the current situation of the mobile games market. The history of the market is explained with its prospects. The methods to profit from mobile games are analyzed and compared against each other.

Chapter 4 describes the widely accepted video game genres with their key game mechanics. The advantages and disadvantages of genres are also discussed.

Chapter 5 covers the interaction methods that are used in mobile devices. The difficulties and benefits of each are explained and compared against each other.

Chapter 6 focuses on the tools used for the development of the game and the user study design with the reasoning behind it.

Chapter 7 describes the mechanics, scenes, rules, and goals of the game in detail. The control techniques in the game are introduced. It also includes analysis for gamification elements in the game and current competitors in the market.

Chapter 8 explains the development procedure of the game. The code of the game is analyzed and explained in detail.

Chapter 9 shows the results collected from the user study.

Chapter 10 explains the limitations of the thesis and gives possible follow-up research areas.

Chapter 11 contains an evaluation of the results from the user study and concludes the thesis.

2. Gamification

2.1. Concept Definition of Gamification

The term gamification is a concept of methodology rather than describing an exact process. Throughout history, the term was defined by many people. This section will cover the most important ones, outlining the similarities and differences between them and concluding a final definition.

The first time the term was used in a written recording was in a blog article by Bret Terrill in 2008. Terrill described the term in a social context as applying game mechanics to applications to increase user participation[Ter08]. A similar but also broader definition is:

> *"The process of game-thinking and game mechanics to engage users and solve problems."*[ZC11]

The term gamification is also referred as a "Participation and Reward System", which encourages required user behavior that is advantageous for the application[Goe19a]. These definitions explain gamification methods but do not tell us the target area where it is used. One of the earlier opinions was that gamification belongs to a non-game context, which does not necessarily create a new game but results in playful interactions[Det+11]. A serious game defined as a game with a focus other than entertainment[DAJ11], is not an example of gamification. Figure 2.1 shows these differences by separating them into two axes: Play/Game and Whole/Parts. In this context, play is referred to as an act of engaging in activities in an unrestricted environment, where games are a structured form of play with rules and goals. Whether the elements of game or play implemented entirely or partially decides the categorization. However, this way of thinking is also criticized because it does not bring any more value; it is merely a semantic discussion. Therefore, to avoid this discussion, a synonym to gamification, called "Human-focused Design", which focuses on maximizing human motivation in a system, was invented[Cho19a].

In this thesis, based on all the definitions above, gamification will be defined as:

> *"Gamification is the act of implementing game design elements in all types of contexts to improve user motivation and engagement."*

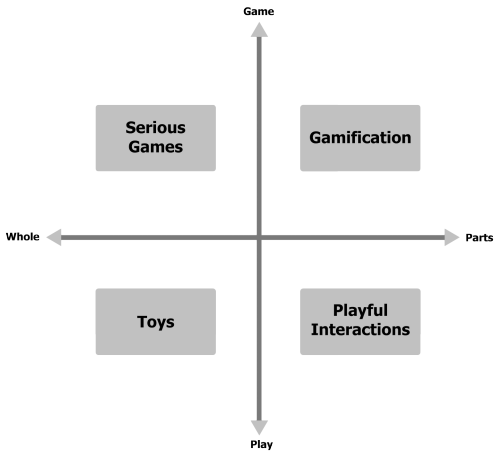


Figure 2.1.: Differences between serious games, toys, playful interactions and gamification according to Deterding[Det+11]

2.1.1. Goals of Gamification

All of the definitions above are emphasizing the methods of gamification rather than the goal of it. An increase in user engagement is not the goal of gamification; it results from a successful application. One of the gamification purposes is to create a gameful experience to enhance the user's value creation[HH12]. Other goals that can be included are [Goe19b]:

- **Learning:** Gamification can make the learning process less frustrating for the user by setting clear goals and rewarding feedback. These rewards could be points, badges, or levels (PBLs). It has been repeatedly reported that gamification in higher education is able to increase student engagement and be a source of motivation and enjoyment[SC18].
- **Marketing:** Through gamification, users can be motivated to spend more time on the application, which indirectly causes them to buy more.
- **Loyalty:** Gamification gives the users a reason to come back, for example, by giving them a status tier, so users who stick to the application get rewarded.

These goals are achieved through the feedbacks that are created by the gamified design. Creating feedback loops is a core aspect of gamification design. It prevents users from leaving, encourages, or discourages specific actions.

Positive feedback loops form reinforcing relationships. In every iteration, the impact of the feedback gets bigger. Positive feedback loops also come in a trade-off. Early decisions become more critical than late ones because they are the starting point of the loop. If the loop is uncontrolled, it can destabilize the relationship between the game and the player. The last trade-off is that they cause the game to end faster because the player gets more addicted to the game in each iteration[Goe19c].

Negative feedback loops, on the other hand, are balancing relationships. If a player gets a huge advantage, a negative feedback loop ensures that it does not occur again. This helps to stabilize the effects of positive feedback loops. Late-game is more in the focus because the advantages of the early game are reduced. They also increase the playtime of the game[Goe19c].

Both loops are used together to create a dopamine loop in the player to make the player come back. It is crucially important that the feedbacks are compatible with the player's intrinsic motivation. Otherwise, the feedbacks become dull for the player[Goe19c].

2.1.2. Types of Gamification

Depending on how gamification is implemented in a product, it can be classified as structural or content gamification[Kap13].

Structural Gamification

In this type of gamification, the contents of a target product are not altered. They are instead wrapped in a gamified structure. This type of gamification is usually applied using points, badges, achievements, and levels with leaderboards to track users' status. It gives a reason for users to learn the product's contents.

Content Gamification

Understandably, content gamification alters a target application's contents to give it a look of a game-like product. This can be applied by adding story elements into the content or implementing challenges in the content. This does not turn the content into a game. It merely gives a context for the user to enhance the user experience.

2.2. Gamification and Motivation

The term gamification is centered around motivation. For any commercial product to profit in the market, the users must be motivated to use it. When gamification

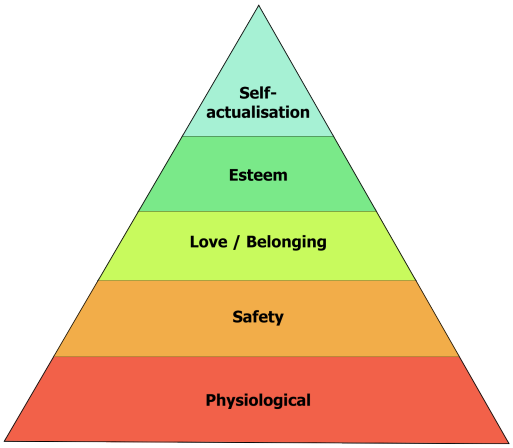


Figure 2.2.: Hiearchy of needs according to Maslow[Mas43]

is successfully applied to a product, the release of the hormone "dopamine" creates a motivation loop in which the user participates in the product over time without boredom[HM20]. Under motivation, the desire to use the product is understood. The term motivation in the context of gamification can be divided into three distinct layers[Mar18]:

- **Base:** Refers to the first two layers of *"Maslow's Hierarchy of Needs"* (figure 2.2): Safety and Physiological needs[Mas43].
- **Intrinsic:** Refers to the need for relatedness, autonomy, mastery, and purpose (RAMP).
- **Extrinsic:** Refers to the motivation that comes from the reward or the goal. In the context of gamification, this is often called PBL (Points, Badges, and Leaderboards) gamification.

Base Motivation

Gamification does not usually provide this kind of motivation[Mar18]. However, these are the essential needs of all human beings (e.g., money or security). Therefore, without covering them, it is impossible to provide intrinsic/extrinsic motivation.

Intrinsic Motivation

In intrinsic motivation, the user does the activity for internal satisfaction without focusing on the action's consequence[RD00]. In the context of this thesis, this can be described as using a product or playing a game just because of pure excitement and joy.

Extrinsic Motivation

If the user is acting due to the consequence or a reward, without necessarily enjoying the activity, it is called extrinsic motivation[Cho19b]. A good example would be the industrial social media platform: "LinkedIn"[Lin]. LinkedIn has profile progress bars, in which the users are encouraged to enter personal information to their profile to complete them[Lin19]. Extrinsic motivation cannot function well unless the base and intrinsic motivations are covered. The user can get bored and quit the product when the rewards are not enough[Mar18].

2.2.1. Self Determination Theory

While the reasons for extrinsic motivation are clear rewards, the base of intrinsic motivation is not as comprehensible as extrinsic motivation. **Self Determination Theory (SDT)** empirically explains intrinsic motivation's foundations through three primary needs of human nature: needs for competence, relatedness, and autonomy[RD17a].

- **Competence:** Competence describes the desire for mastery and being useful, given a situation. It is based on the fact that people do not enjoy wasting time. At the same time, it can also be thwarted if the challenge is too hard.
- **Relatedness:** Relatedness is about social connections. People want to be socially connected; this can be raised through attention from other people or praise for the their behaviors. As a result, this makes them feel belonged, be part of a group.
- **Autonomy:** Autonomy expresses the voluntariness of one person's actions. Self-regulation and choice without depending on others is the core aspect of autonomy. It is not necessarily about being self-reliant or independent from others. It is observed that the sources of extrinsic motivations (e.g., rewards, deadlines) reduce the need for autonomy, causing a decrease in intrinsic motivation.

To conclude, SDT demystifies the basics of intrinsic motivation and connects it with extrinsic motivation. It assumes that when any of these three basic needs are neglected, the person will lose motivation, and voluntary engagement will decrease[RD17b].

2.2.2. Player Experience of Need Satisfaction

Player Experience of Need Satisfaction (PENS) is the extended model of SDT for games, which was first formed in 2006[RRP06]. The three basic needs of SDT are mapped as an experience that the player gets from playing a game. Besides, a new type of need is introduced: immersion and presence. This concerns whether the player feels him or her as a part of the game world. Making the game more real and authentic is an essential part of game design, making immersion and presence even more important[RRP06].

PENS also defines another new variable, called: intuitive controls. It covers a quality rather than an experience in a game. The main concerns are the ease of use of the interface, how much the controls can be understood intuitively without explaining. Intuitive controls contribute to motivation as it can enhance the competence, giving more freedom and control to the player[RRP06].

2.2.3. Bartle Taxonomy of Player Types

Even though the differences and the relationship between motivation types are understood, it is not guaranteed that all players will enjoy the same motivation methods. The source of motivation may differ from person to person. Therefore, it is inevitable to categorize players to understand which elements motivate which type of players. In this thesis, *Bartle's player types* are covered[Bar96].

Bartle defines four main interests of a player in a game: interaction with the game world, action on the world, interaction with players, and action on players. Then for each interest, a player category is assigned. Except for extreme cases, every player usually has some interest in each category, with one being more dominant than others. The four types of players illustrated in figure 2.3 are:

- **Killers:** Killers are interested in acting on other players. The consent of the other player is usually not necessary. They like feeling superior to others and being dominant. An example of motivation for them is high achievements for harming other players in the game.
- **Socializers:** Socializers enjoy interacting with other players rather than acting on them. A feeling of superiority is unnecessary; they enjoy getting to know other players. The game world is only a platform to communicate with the other characters. Increasing the communication methods to other players especially motivates them.
- **Explorers:** Explorers like to find details and surprises in the game world. Scoring points or making progress in the game is not in the main focus. To motivate them,

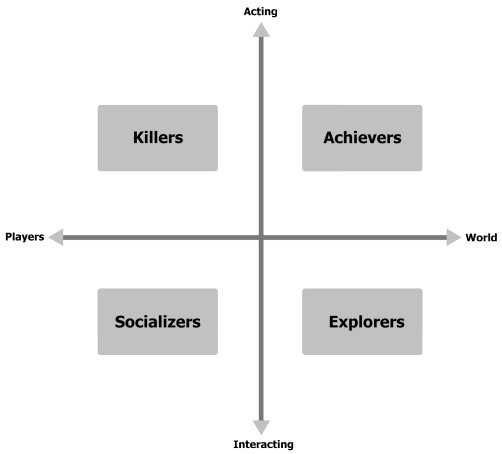


Figure 2.3.: Taxonomy of players according to Bartle[Bar96]

the game world should be maximized in size with all types of interactions.

- **Achievers:** Achievers are not interested in the players or the game world. They are interested in beating the game, scoring the maximum points. They master the game and are highly competitive. Beating a challenging puzzle in the game is a source of motivation.

2.3. Gamification and Flow

Over time the users need change. After some experience, the users need new challenges and different motivations to match their current mastery level. This concept of optimizing the user experience over time is called **flow**[Mar18]. In a flow channel, the user loses the sense of time and enjoys the product for a long time.

2.3.1. Theory of Flow by Csikszentmihalyi

Csikszentmihalyi identified three main factors that could lead to a flow state[CN02]:

- A clear set of goals is necessary to give structure and provide a direction for the user.
- Immediate feedback helps the users to adjust their behavior to match the current challenge.

- A balance between perceived challenges and the user's skill is essential. It builds up confidence in the user, which, in return, helps with user engagement.

For user engagement to continue, these conditions must be met over time. As the user's skill increases, if the tasks' difficulty does not increase accordingly, the user gets bored, and the flow state is disrupted. Likewise, if the challenges become more complicated than the user's perceived skills, the user feels anxious and cannot stay in the flow channel. In figure 2.4, this concept is represented. In games, the way players stay in the flow channel zone resembles a "zig-zag", increasing the challenges proportionally to the player's skills at quantified timesteps. Each step introduces a cycle between the phases: grinding, leveling, mastering, and testing[Mar15].

- **Grinding:** Challenges that do not require a lot of skill and time, players use them to gain experience and increase their skills.
- **Levelling:** In the leveling phase, the challenges become harder to keep up with the player's skill.
- **Mastering:** Mastering is the point where the challenges of the game match the skills of the player.
- **Testing:** Testing is the point where the user's current skills are not enough for the challenges.

Cycles in the "zig-zag" path do not necessarily have to include all phases. There are three different types of cycles when it comes to games[Mar15]:

- **Grinding:** Users start with the grinding phase. As users gain experience, they start to get bored and level-up. Hence they go into the leveling phase. Then the challenges catch up with the skills of the player where the master phase comes in. After the mastering phase, challenges become much more demanding, so the user goes back into the grinding phase.
- **Challenging:** The challenging cycle includes all four phases. Instead of the mastering phase to the grinding phase, users are welcomed with a more formidable challenge then users' skills and expected to beat them. This phase can cause frustration if the player is unable to beat the challenge.
- **Mastering:** The mastering cycle does not have a grinding phase. The user goes into the leveling phase after the testing phase, and challenges start to become harder right away.

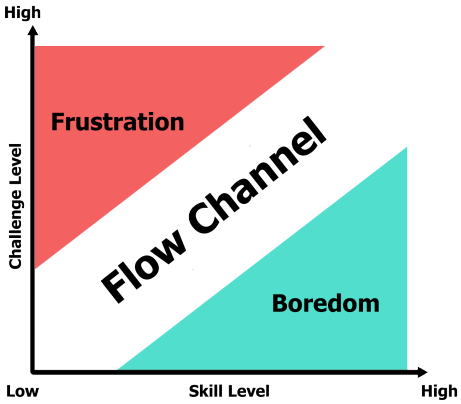


Figure 2.4.: Flow channel diagram according to Csikszentmihalyi[CN02]

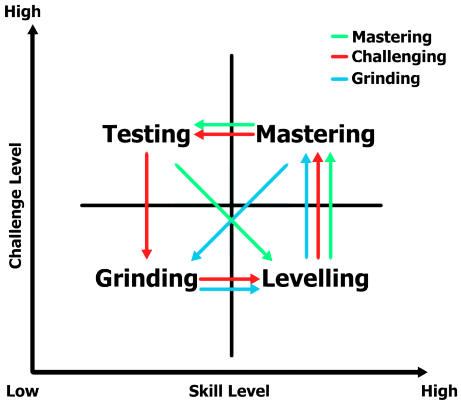


Figure 2.5.: Cycles and phases in flow according to Marczewski[Mar15]

Figure 2.5 illustrates the three cycles and the transitions between the phases in the cycles.

It is logical to think that there is a connection between flow and games, since games try to keep the player occupied with the game for a long time by creating a flow channel. However, this relationship might not apply to gamification in non-game contexts. The main purpose of gamification in these contexts is to increase user engagement, not to create a flow channel for the users. While the challenges when applying gamification should be balanced as always, users might not feel themselves disconnected from the reality, since they are just using a product which is not necessarilly a thrilling experience on its own. So, flow is not the real goal or the key for gamification, it is the result of a

well-designed system[Mar19].

2.4. Gamification Techniques

Standard gamification techniques that are used in today's market are explained below[Goe19d]:

- **Engagement curves:** These show the participation of the user in the program. Making this information public for the user can increase the participation if the user thinks that he/she is doing poorly.
- **Achievements:** Achievements set milestones in the product that the user has to meet in order to succeed. Milestones can define a path for the user to get recognized by the system. They are one of the primary sources of extrinsic motivation.
- **Anticipation:** Creating the feeling of getting close to a final reward supports the extrinsic motivation and prevents the user from quitting the product.
- **Character:** Characters with an appropriate story and background can lead to a connection between the user and the character. After the connection, users will continue to participate simply because of empathy.
- **Subculture:** Here, the idea is to create a social circle using unique vocabulary and other cultural aspects to make the user feel belonged. It supports intrinsic motivation and can be compared to doing an activity for the sake of the family.
- **Goals:** A set of goals with increasing difficulty supports the flow channel and keeps the user engaged.
- **Rewards:** These are similar to achievements, but they are different in quantity. Rewards occur more and are used for little achievements. They are also beneficial later in the product, where achievement is like a reached status.
- **Rules:** A set of precise rules limits the actions that the user can take. It makes the user experience puzzling and intrigues the user.
- **Stats:** Statistical information about the user's play helps to keep track of the user's progress.
- **Quests:** Quests are missions in the game. They can be used to make the user act in a desired way. They are also often combined with rewards, so the user has the motivation to complete them.

- **Role Playing:** Assigning roles to the users creates a social network where users depend on each other. For the success of the individual, all the roles must participate in the program.
- **Real World:** Integrating the product with the real world using mobile contexts or augmented reality binds real life with the product, so it becomes a vital aspect of the user.

2.5. Octalysis Framework for Applying Gamification

After the term gamification is defined, a method called *"Octalysis Framework"* is presented below to analyze and apply gamification methods to products[Cho19c].

The framework consists of 8 parts, where each part covers specific gamification techniques. For each part, a point between 0 and 10 is assigned according to the number of used techniques in that section. The scores of each part are squared and added together to reach a final score. It is reported that usually, games with some success in the market score more than 350 points, where successfully gamified products score between 150 and 350[Cho19d].

The framework also makes some distinguishments between sections. Some sections are referred to as "Black Hat Gamification", in which the product addicts the user to itself, and "White Hat Gamification", in which the user feels fulfilled and satisfied when they are using the product. While the black hat gamification makes the user come back in the early stage, the white hat gamification is more motivating in the late stage[Cho19e].

The sections are also grouped as "Right/Left Brain Gamification". These groupings are closely related to extrinsic and intrinsic motivation. Right brain gamification techniques focus on intrinsic motivation, and left brain gamification techniques support extrinsic motivation[Cho19b]. An example representation of the framework can be found at Figure 2.6.

2.6. Game

Games are a structured form of play that provides an environment for problem-solving and encourage creative thought processes. In other words, they are systems "in which players engage in an abstract challenge, defined by rules, interactivity and feedback that result in a quantifiable outcome often eliciting an emotional reaction"[KC13]. Games are usually played for fun and entertainment (intrinsic motivation) or rewards (extrinsic motivation)[Goe19e]. They are also efficient tools for learning purposes[KC13].

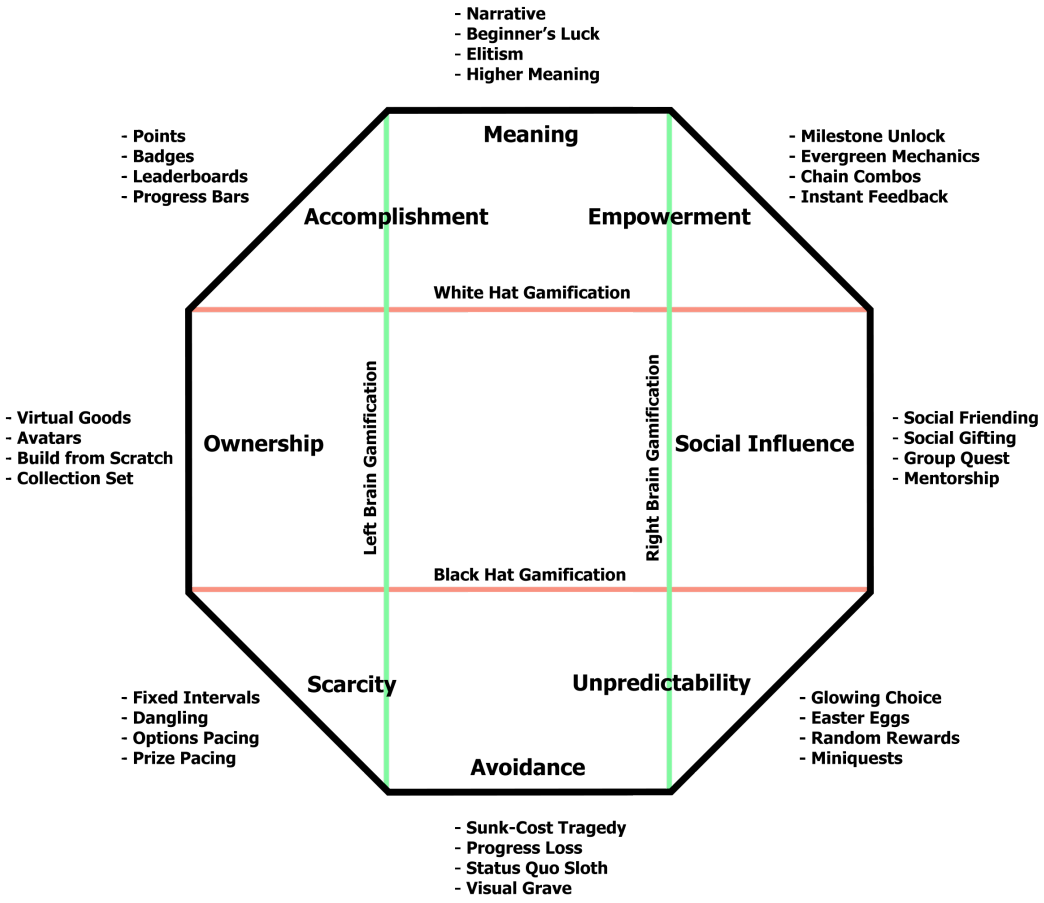


Figure 2.6.: Octalysis Framework according to Chou[Cho19f], the upper/lower part of the octagon covers white/black hat gamification, while the left/right part represents left/right brain gamification.

Typically, games provide players a ***goal*** or a list of ***challenges*** and a ***game environment*** with strict ***rules***. Players interact with the environment or other players to complete the given tasks. Alongside the challenges, games also present precise ***feedback mechanisms*** and usually have a ***quantifiable outcome***, which causes an emotional reaction in the player[BK17].

Goal

Goals give a structure to the play and define a win condition for the player. In contrast to a game, the play does not necessarily have a goal (e.g., a child playing with a toy).

Challenges

Challenges can be against a player or the game environment. It can be combined with a goal or used solo. Like a goal, challenges also structure the play.

Game Environment

The game space in which the play takes place can be virtual or real. It has specific rules for consistent interaction and provides an area to accomplish the game goal or challenges.

Rules

These are the constraints in the game that the user cannot break. They regulate the game environment and balance the game. Depending on the usage, the player can feel overwhelmed or bored if the rules are not balanced.

Feedback Mechanism

Immediate feedbacks are a critical aspect of a game. It allows the player to give instant reactions to succeed. For example, these can be progress bars or score points in a game. In general, there are four types of feedback[Kap14]:

- **Conformational:** Conformational feedbacks inform the players how well they are doing in the game. The measurement can be binary(wrong or correct) or an arbitrary value(scoring).
- **Corrective:** Corrective feedback attempts to guide the user into the correct solution in the game. Pointing towards the end goal in a level is an excellent example of corrective feedback.

- **Explanatory:** Explanatory feedback has the same purpose as corrective feedback, but it also explains why what players are doing is wrong or correct.
- **Diagnostic:** Diagnostic feedback is built around the mistakes the players make during gameplay. Typical mistakes are anticipated, and accordingly, feedback is given for each anticipated mistake.

Quantifiable Outcome

An exact result that the user reaches after succeeding or failing. In general, the play also does not have a quantifiable outcome. Instead, people get bored with the activity and stop.

Emotional Reaction

After each action, there is a consequence in the game environment that the player reacts. It can be positive or negative and includes all emotions.

Balance

In addition to all these elements, all games feature a hidden element called balance. Balance can be defined in many ways; in general, it matches the player's skills with the game's challenges, explained in chapter 2.3.1. Three common ways to adjust balance are[Kap15]:

- **Equal chances:** Players start with the same resources on the same conditions to prevent unfair starting situations in the game.
- **Randomness:** The game creates opportunities for players that are behind to reach the same level of leading players. Randomness opens a margin for errors, so the player does not lose the game with a single mistake.
- **Key elements:** Elements in the game that have a direct impact on the gameplay must be listed and balanced individually.

2.7. Game Design

Games are based on models, which define various elements of the game. This process of modeling a game using aesthetics and designs is called game design. It is the process between the start and the final product. It is often an iterative process, meaning that the design can adapt to feedback[Goe19a].

2.7.1. Game Designer

A game designer is a person who models the game. The game designer's goal is not to create a game, but instead, create an experience in the player through the game's playing. The type of experience that the designer wants guides the designer to find the right model[SS19a].

2.7.2. Game Design Values

Designers do not determine how the game is played. They only determine the constraints. Therefore, the exact play experience of the individual is unpredictable. Nevertheless, some values can guide the designer to achieve the desired experience[MS16a].

- **Aesthetic:** Aesthetic focuses on the form and the "look" of the game.
- **Social:** Social change and improving the society is the center of attention.
- **Environmental:** Protection of the environment and its sustainability are the keywords of environmental values.
- **Traditional:** Traditional values include the history and the traditions of a region. As an example, this can be used to find a historical setting that suits the player experience.
- **Gender-based:** It focuses on the gender-equality.

2.7.3. Iterative Game Design

Evaluation of design is hard to do before it is fully finished and tested. Iterative development fixes this problem using four development cycles[MS16b]: **Conceptualization, Prototyping, Testing, and Evaluation**[MS16b].

- **Conceptualization:** Finding an idea for a game and its play experience.
- **Prototyping:** Building a rapid product where the core elements of the game are presentable.
- **Playtest:** Getting the experiences of the player after playing with the prototype.
- **Evaluation:** Reviewing the experiences and comparing the results with the desires at the start. If the game is still not complete, a new cycle begins using the evaluation results to improve the design.

2.8. Game Elements

Games consist of many layers and elements. Together they form the play. Four main elements, which most of the games have, comes to the attention.[SS19b]:

2.8.1. Mechanics

Mechanics create the main difference between linear entertainment(books, films) and games. They describe the actions and the consequences of them in the game. Mechanics should be passing with other game elements to be meaningful for the player.

2.8.2. Story

The story is the events in a game. There is no formal rule for the story to be. It can come in any format. Nevertheless, the story can give meaning to game mechanics. It should also fit the aesthetics of the game; otherwise, it can lead to contradicting experience and disrupt the flow.

The storytelling in a game is participative and interactive[Dah19]. Players participate in the game world to discover the pieces of the story. In some games, players can also dynamically change the storytelling throughout their choices in the game. This part of the storytelling is what makes the games stronger than movies and other products with a linear static storyline[Dah19].

2.8.3. Aesthetics

Aesthetics describe the "look" of the game. It is the most visible game element to the player. Therefore it has a significant impact on the player. When it is not blended well with other game elements, aesthetics stands odd for the player and creates an undesired experience.

2.8.4. Technology

Technology includes all of the materials that make the game possible. While not directly visible to the player, this element has an apparent impact on the other game elements. A game mechanic that cannot be adequately developed due to lack of technology can make the game dull.

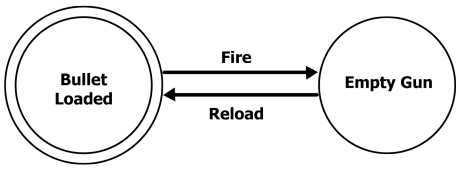


Figure 2.7.: State diagram of a gun that can only carry one bullet at a time, the initial state is marked by a double circle.

2.9. Game Mechanics

Games are abstract models of reality; all types of interactions between the game and the player and the constraints and goals are part of game mechanics[Moo16]. For a game to be appealing, the mechanics of the game must be well balanced. Here, core mechanics that appear almost on all games will be discussed. [SS19c]:

2.9.1. Space

Space defines the areas that exist in the game and link between them. The term here does not refer to aesthetics. It is purely a mathematical construction. It can be continuous (free world games) or discrete (level based games). Space is closely related to rules and the constraints in the game environment.

2.9.2. Time

Unlike real life, where time is continuous and always moves forward, it can be wholly manipulated in a game-time. Players can pause or even use the ability to rewind to change its course. Like space, time can also be continuous (real-time strategy games) or discrete (turn-based games).

2.9.3. Objects

Every game space has a set of objects that creates interactions between the player and the game. Objects can have attributes, which determine the behavior of the object. An example would be a gun in a shooter game. The ammunition or the fire rate of the gun would be its attributes. An attribute can be static (color, sound) or dynamic. A dynamic attribute consists of valid states and triggers between the states. In figure 2.7, a simple state diagram of a gun for the ammunition attribute in a shooter game is shown.

2.9.4. Actions

Actions define what the player can do in a environment. They are the verbs, player must take a valid sequence of them to reach the win condition. Actions can be inspected in two different groups: basic actions and strategic actions. Basic actions tells us the valid options that player can choose given a situation. In a traditional platforming game, these actions can look like this: move left, move right, jump. Strategic actions are side effects of the combination of basic actions. They represent the path to win condition. In a platforming game jumping to avoid a pit can be considered as a strategic action.

2.9.5. Rules

The rules of the game determine the win and lose the conditions of the game. In this sense, it is the fundamental mechanic of a game. They also balance the actions by giving them constraints (e.g., not being able to jump in mid-air). In real life games, the rules are enforced by players or a referee. In a video game, however, the system's rules are enforced, and therefore they are entirely absolute. Games can also have modes. A mode is essentially a set of rules. Modes have the benefit of presenting the same game environment under different rules, which can increase the playtime.

2.9.6. Skill

Skill is the only mechanic that is based on the player. Every game expects specific skills from the player to win. These skills can be physical (endurance, stamina, reaction time), mental (memory, observation, puzzle-solving), or social (reading an opponent's mind). Other mechanics of the game define together the expected skills from the player. Skills are also progressing; a game can teach the player a particular skill, from scratch to advanced level.

2.9.7. Chance

Chance is the uncertainty between other game mechanics. It is an essential aspect of good quality games and has a direct impact on gamification[Cho19g]. Chance causes unpredictability in the game, which in return creates surprises for the player. These surprises can have positive or negative effects on the player. Chance must be used with precaution. If it is unbalanced, it can frustrate the player (e.g., low winning chance in a lottery).

3. Games Market

3.1. History of Mobile Game Market

The first occurrence of a mobile game on a mobile phone is dated back to 1994[Pho14]. However, the idea of handheld devices to play games goes back to 1976[DW04]. It can be argued that the first commercial success of the mobile games market belongs to GameBoy by Nintendo[Vgc20a]. While the first generation devices only came with one game or a limited selection of games, GameBoy provided a big library of games with great flexibility and low costs, thus created a new market[Ars19].

The first mobile phone with a pre-installed game was introduced in 1994, called Hagenuk MT-2000. It featured a ported version of the popular game of that time, Tetris[Pho14]. However, the first popular mobile phone game was Snake, introduced by Nokia in 1997. The reason behind the popularity was the simplicity and suitability for all age groups[Pub20].

Until 2008, mobile phones only come with pre-installed games without any gaming market. In 2007, after the company Apple launched the smartphone iPhone and a year after the store application App Store, mobile game developers were able to market and monetize their games[Pub20]. Quickly after, Android Market, currently named Play Store, was announced by Google to provide a similar market for applications[And17].

One of the first successful mobile market games that set a bar was Angry Birds in the 2010s. In 2012, this was followed by Candy Crush, which is one of the industry's highest-grossing games[Pub20]. With developments in Augmented Reality (AR), a new area for mobile games was born, which was successfully implemented in Pokemon GO with high profit[Pub20].

3.2. Prospects of Mobile Game Market

Even though mobile games are dated back to the 1980s, the current market was born in 2008s with the development of application stores. Even though the market is still very young, it has been developing and growing very fast and has become an essential factor in the world economy[Kom19].

The market for mobile games is growing over time, with the number of published

games increasing each year[Poc20]. The number of downloaded games worldwide in 2019 was more than 200 billion, with an increase of 6.25% compared to 2018[Tak20]. Furthermore, it is expected that in 2020 the mobile game industry reaches the barrier of 100 billion U.S. dollars revenue, with an increase of roughly 16.25% in comparison of 2019 with $86 billion[Tak20]. A similar trend also follows in the markets of smartphones. From 2016 to 2020, the markets in Google Play Store and App Store combined grow by 27% [Cha20], generating a revenue of 19.3 billion U.S. dollars altogether. The number of mobile game players worldwide is also expected to increase, reaching 1.8 billion until 2025 from 1.5 billion in 2020 with more than 20%. The trend is also the same in Germany, with an increase of 22% in the revenue between 2018-2019, reaching €1.84 billion[Gam20].

Another critical aspect of the mobile game industry is that it leads the video games market for a long period. Data from Newzoo shows that mobile game revenues in 2020 will account for 48% of the global market, surpassing the PC market(23%) and console market(28%)[New20].

With this information, it is clear that the mobile game industry will continue to proliferate over time. It also reveals that the mobile game market is the most critical market among other video game markets.

3.3. Platforms of Mobile Game Marketing

Mobile games are mainly played in two types of devices: mobile consoles and smartphones. Mobile consoles like Nintendo Switch are currently popular, and the sales of the device are continually increasing, reaching 50 million marks at the start of 2020[Vgc20b].

According to Mobile Statistics Report by Radicati, smartphones are also in demand. The number of activated smartphones is increasing each year, approximately 1 billion[Rad19]. The number of users using these smartphones has exceeded 3.2 billion and is expected to reach 3.8 billion at the end of 2021[New19].

The application markets of smartphones where the mobile games are published are mainly led by Play Store from Android by Google and App Store from iOS by Apple. As of 2020, Android has the lead by having almost three-quarters of the total market share, with App Store having 25%. Together they have more than 99% of the total market share[Sta20a]. It should be noted that Android devices include all smartphones from all companies that use this operating system. iOS is only used by Apple. Therefore, 25% market share is an enormous success rather than a failure.

Many other application markets are also growing, like Samsung Galaxy Store[Sam] or Huawei AppGallery[Hua]. As of 2020, the biggest of them is Amazon Appstore,

containing half a million apps, which is approximately five times smaller than Google Play[App20]. Despite being currently small, it is vital to publish a game in all possible markets because, in these small markets, there is a better chance of getting recognized due to the overall small number of published applications. They are growing faster than App Store and Google Play, and it is estimated that 1.7 billion users will use these stores by the end of 2023[Unie]. There are also distribution portals, which allow publishing games through one portal to all markets. Unity Distribution Portal allows publishing games in more than over ten stores except for Google Play and App Stores, reaching a total audience of approximately 1 billion users.[Unie].

3.4. Revenues in Mobile Game Industry

In order to profit from mobile games, there are a couple of business models that are used. In this section, the main ways of profiting will be examined.

3.4.1. Advertising Model

Developers can use advertisement platforms like Admix[Adm] to place in-game ads to gain profit. In this model, the advertisement platform and the developer depends on each other. Platforms need games with a significant user base to get paid for the advertisement, which then can be placed into the game, so the game can also profit. If the revenue of the platform is low, it has the risk of getting canceled[JWG19]. Data from 2019 shows that it is the least popular and profitable model, among others[Fyb19]. However, the implementation is relatively easy and straightforward.

3.4.2. Freemium Model

Freemiumship is based on two keywords: free and premium. In this model, the game has a free but limited version which the players can upgrade to premium. The game can also sell various in-game items to enhance the player experience through microtransactions. While the free version of the game benefits market expansion, the premium version increases the revenue[GKM18]. The most crucial problem of the freemium model is balancing. If the game's premium version is aggressively advertised, it feels pushed, and the player might give up on the game. On the contrary, if the free version is not limiting, there will be no need to buy the premium version[HON18]. It is the second popular chosen business model of application developers[Fyb19].

3.4.3. Subscription Model

The subscription business model refers to the user paying a regular fee to access a product. It is based on the idea that the user will keep paying as long as the product has value. A vital aspect of this business model is keeping the price dynamic and matching its quality[Pro20]. It is the most profitable business model for mobile applications[Fyb19].

3.4.4. Hybrid Model

Most of the time, two or more business models are combined. For example, Candy Crush[Can], one of the most successful games of the mobile market mentioned earlier, uses a combined version of advertisement and freemium models. Since the aggressively used hard monetization methods discourage the player, soft monetization methods like advertisements can fill the gap[HON18].

3.5. Market Analysis of Mobile Gaming Market

In 2020, according to a study in the United States of America, smartphones are by far the most popular choice for video games[Ent20]. As mentioned before, Android phones have the biggest market share in the smartphone industry[Chapter 3.3].

As of 2020, puzzle, casual, and arcade games are the most popular in the Android environment, having more than 50% market reach[Sha19]. The traces of these three genres' dominance can also be observed at the games with most market revenues. Out of five of the ten games with the most revenues belong to them[Pri19b]. With the most revenue, the game Candy Crush, with a revenue of more than 67 million U.S. dollars, is a casual and puzzle game[Pri19b]. Also, it is considered one of the first successes of the mobile market[Chapter 3.1]. A similar trend can be seen if the new games are sorted according to most downloads [Sta20b]. However, there is noticeable increase in the popularity of action games. Call of Duty: Mobile[Cal], which is currently the second most downloaded game overall in Android Market and App Store with over 188 million downloads[Sta20b], also PUBG: Mobile[PUB], which is the ninth leading game by revenues, show action games are also successful in the market[Pri19b]. Brain and puzzle, sports, cards, and casino games are the least profitable genres. Together, they only sum up to 3% of the total market share[Pri19b].

A notable thing about the success of PUBG: Mobile that is worth mentioning is that roughly 80% of its income comes from App Store and the rest 20% from Play Store[Sen20]. PUBG: Mobile is a freemium game and its income comes from the in-app purchases[PUB]. It has surpassed the milestone of $3.5 billion in total revenue and

generated $500 million in just over two months. It also has been downloaded more than 750 million worldwide. However, the game's player base comes primarily from Play Store (65.3%), and only 34.7% of the players are from App Store[Sen20]. This is a fascinating fact because App Store generated more revenue, despite having fewer players than Play Store.

4. Game Genre

In order to describe and market games easier, a method of taxonomy is needed. In this section, the concept of genres in games will be examined, and the major genres will be explained.

Like movies, the genre is used to classify the content of the work in other entertainment areas. In a game, however, the genre is independent of the environment setting or the content. It describes the challenges and gameplay that is presented to the player.[Ada14a]. Game genres also have a role in the perceived learning of the player. Different genres provide different pieces of training for the user.[Jun20]. Today, it is often difficult to assign a single genre to a game. The growth of the complexity in games allowed developers to package multiple gameplays into a single game[Ada14a]. It is also possible to divide a genre into its subgenres to better describe the game (e.g., arena shooter or tactical shooter games). The developers make the distinctions between them, so the subgenres' definitions can be subjective and change[Ada14a]. Therefore, only the major genres and their core properties will be included in this thesis.

This categorization approach using the gameplay elements of the games is also criticized because they are no longer clear. Subgenres only partially solve this problem, but the categorization process can be quite complicated when a game contains elements from many genres.[Doh+18]. Instead of using categorization through gameplay, games can be classified using a various categories, presented in table 4.1:

Another reason why game genres may fail is instability due to growth. The nature of game genres is not strict and formal. As previously discussed, developers can define their genres when they believe that their game does not fit into the current ones. The newly introduced genre can confuse the users because a customer may not know the new genre that is solely defined for one game. Therefore instead of specification, it is suggested that the developer should choose the common categories when it is possible[CLC17].

The last criticism about the game genres is the restriction they bring. The well-established game genres, like shooter or platformer, can lead to misconceptions if used in an unconventional way, where it is not evident if the game belongs to the specified genre. It can be stated that they are not agile, allowing change[AC14].

At this point, it is essential to understand that the concept of game genres are loosely defined. There might be huge or little differences between them. Some attributes of

Aesthetics	Control Actions	Psychological Effects	Perceptual, Attentional & Cognitive Benefits	Game User Reactions
The purposes of the play: fantasy, narrative, discovery, etc.	Control aspects of the game: frequency of interaction, degree of error tolerance and control movement type.	Psychological behaviors that are caused by the game attributes: motivation, skill-based learning and cognitive process & knowledge.	Improvements of the user skills: visual acuity, contrast sensitivity, useful field of view, mental rotation.	Metrics of user reactions experienced during game play: usability, enjoyment, social connectivity, etc.

Table 4.1.: Five methods of game classification proposed in the paper *"Recategorization of Video Game Genres"*[Doh+18]

a genre can reappear in another. It is up to the community and the developer to find the right specification. A good example would be the similarities between simulation and strategy games. The actions involved in simulation games are mostly strategic. Sometimes the only thing that differs in a simulation game is the fact that the game is centered around the process rather than the crucial decisions that the player took to win[App06].

4.1. Shooter Games

Shooter games refer to an interaction between the player and the targets. Usually, the challenge in these games is simple: avoiding threats while shooting the targets. They test the physical skills of the player, like reflexes, aiming, fast thinking. These games can be further categorized in terms of camera dimension (2D/3D), camera position (first-person or third-person), the setting of the environment (arena, tactical). The core mechanics of a shooter game are[Ada14a]:

- **Shooting Device:** The player possesses a gun or a weapon that can be shoot at the targets. The weapon can have restrictive properties, like the magazine size, damage, range, accuracy, fire rate, or recoil. These properties are used to balance the weapon to provide challenging gameplay.

- **Targets:** Targets can be stationary objects, artificial intelligence, or real players (multiplayer shooter games). Through shooting them, players can get points or finish a level. The target can also own a shooting device for counter-measures. Other attributes of them can be their health, armor, or weapon.
- **Avatar:** In most of the shooter games, the player is represented as an avatar in the game world. The avatar has to avoid incoming threats while shooting the targets. The avatar can move or also be stationary. The avatar also shares the same attributes as the targets.

4.2. Action and Arcade Games

Action games, like shooter games, offer physical challenges for the player. They include little puzzles, races, or conflict challenges that must be solved in a little time. Therefore, the puzzles cannot be complicated, and hence it differs from puzzle or strategy games. Arcade games are also action games that are, most of the time, unwinnable and get harder through progression. Historically, they were entertainment machines that can be used by inserting a coin[Ada14a]. Action games contain two prominent subgenres, which are going to be explained because they are well-established. Some of the core mechanics are[Ada14d]:

- **Progression:** Progression can be made through levels, or it can be endless, meaning that the game is unwinnable.
- **Checkpoints:** Checkpoints are the states that are saved during gameplay. After losing, the player resumes the game without losing too much progression. Action games are fast. Therefore there is usually no room for errors. Therefore it is essential to keep track of the player.
- **Challenges:** These are the obstacles, hazards, or dangers that are encountered during gameplay. They can be stationary or dynamic.
- **Player actions:** The action games are fast-paced. The user has to move and maneuver fast enough to progress.
- **Powerups:** Players can encounter with powerups as a reward for progression. This opens up new possibilities for the player to progress.
- **Lives:** The amount of trials in a run is significantly limited in arcade games to make the game unwinnable.

- **Time Limit:** Action games do not have tricky puzzles. Therefore to make them more challenging, a time limit can be added.

4.2.1. Jump and Run (Platform Games)

Platformers focus on jumping and running. There is often a destination, which the player should reach while avoiding obstacles and dangers. They also use unrealistic physics to allow the players to take action using their reflexes. The player can have boosters and use elements closely related to jumping like wall jumping, double jumping, and wall running[Ada14d].

4.2.2. Fighting Games

Fighting games do not have most of the elements in a platformer game. They do not contain puzzles or exploration. They simulate hand-to-hand combat. The player can attack or take defensive actions to block the attacks from the opponent. The player can have an energy bar to limit the number of actions that the player can take over time. They can also implement "combo" moves, powerful attacks that can only be orchestrated by the player using the right combination of inputs in the right moment[Ada14d].

4.3. Strategy Games

Strategy games are about long term decisions to make the player the experience being a manager of an extensive system, like an army or a country. The game may not provide instant action and feedback, but this is not the game's goal. Success in the long term is the purpose[Sel17]. They are mainly divided into two subcategories: real-time strategy and turn-based strategy. In real-time strategy, quick decisions are necessary, while turn-based strategy eliminates this factor, thus providing an unlimited amount of time to reach the goal. They both usually share the view of god's eye, managing the system from above.[App06]. The most important aspects of strategy games are[Ada14c]:

- **Combat attributes:** Strategy games about wars assign a set of attributes to the units that are managed by the player. These describe the advantages and disadvantages of different units that are against each other. These can be health, range, morale, accuracy, or other values not listed here.
- **Manaeuver attributes:** These attributes describe the movement capabilities of the units. The maximum and minimum speed, turn rate, or unit size are good examples of maneuver attributes.

- **Special capabilities:** Units can also possess unique abilities to increase their strategic usage. Possible capabilities are stealth, builder, leadership.
- **Upgrades and Research:** Strategy games allow ways of improving the units for better combat. These upgrades are usually structured as a tree, allowing the player to choose different paths that suit their style best.

4.4. Role-Playing Games

In role-playing games, the player controls an individual that has a specific role. The player can explore the world as any of the possible roles. Character and skill growth are the main elements of a role-playing game[Sel17]. Role-playing games give a "sense of growing from an ordinary person into a superhero with amazing powers"[Ada14a]. Some of the typical mechanics of role-playing games are[Ada14f]:

- **Character attributes:** Character attributes describe the qualities and abilities of the character. As the game progresses, some are subject to change (power, health), representing the character's growth. Others are chosen at the start of the game and cannot be changed after (sex, race)[Ada14f]. Compared to a strategy game, a character has many more attributes than a unit in a strategy game because it is focused solely on a single individual[Sel17].
- **Status attributes, experience:** Experience shows the linear progress in the game. It can be earned through completing quests, defeating enemies. It also has a close connection to character attributes. The character levels up at a specific amount of experiences to allow the player to upgrade a character attribute.
- **Skills:** Skills allow the characters to do things that are typically not possible in the game world. Different roles in the game specialize in a different set of skills.
- **Character design:** Typically, role-playing games allow players to design their avatars. These are mainly cosmetic attributes (sex, race, hair) but can also be character attributes.

4.5. Sports Games

Sports games simulate real-world sports activities. These are often major sports like basketball, football. They use action, feedback, cognition interactivity to simulate the sport as correctly as possible[Sel17]. Although the sports games are a simulation of

the real world, it is a mistake to consider them realistic. A couple of the mechanics of sports games are[Ada14b]:

- **Athlete ratings:** Ratings of athletes determine what the physics engine simulates in individual positions in the game. Speed, agility, endurance are common attributes of athletes in sports games.
- **Automatic match simulation:** To generate results for the matches that the player does not participate in, a way to simulate them is needed. This can be accomplished using a loaded random number generator, where the better teams have a higher probability of winning.
- **Injuries:** Serious sports games also simulate athlete injuries for a more realistic presentation. These happen in extreme positions like collisions with a speed above a threshold.

4.6. Simulation Games

Simulation games are based on real-world activities like sports games. The player experiences creating and running a business system, like building a city or a farm[Sel17]. All games can be considered as a simulation, but the simulation games specifically refer to real-world activities[App06]. Simulation games often operate under economic constraints, where a set of materials are traded to get services. The player has to expand the system without going bankrupt. The essential mechanics of simulation games are[Ada14e]:

- **Resources:** Money and human resources are considered as primary resources in a simulation game. There can also be other resources, for example, wood for buildings. There are methods to produce these resources and services in all simulation games.
- **Drains and Maintenance:** Drains are a method to keep the number of resources balanced. Buildings or roads can get old and need maintenance to keep them operational. These are ways of continuous outcome, so the player cannot reach unlimited resources.
- **Disasters:** Some simulation games also include disasters, a way of instant balancing rather than a continuous drain. Disasters also need immediate action, or the simulation can fail.

4.7. Adventure Games

Adventure games contain many fast action/feedback loops. However, they contribute to an overall story, which is at the center of the game[Sel17]. Players witness the dramatic growth of their avatar in the story. Unlike role-playing games, a numeric growth (character attributes, experience) is not present. Their core mechanics are[Ada14a]:

- **Point and click interfaces:** This is an indirect mechanism that is used in many adventure games. The player points towards a location and clicks an action. If the action is possible, the avatar does it. Otherwise, the game gives immediate feedback that says it is impossible. It has the effect of making the avatar a separate person rather than a controlled character.
- **Menu-driven actions:** This defines the possibilities in a situation in the game that the player can select. Chosen actions or not chosen ones may impact the story's progress, allowing the player to decide the rest of the course.
- **Inventory:** Adventure games present many puzzles that can only be solved by items that were picked before. This requires an inventory system, where the player can review the items that are possessed. It can also feature crafting, which allows combining two or more items in the inventory.

4.8. Puzzle Games

Puzzle game depends on strong puzzle-solving skills. They can have a story, but not necessarily. To progress, the player has to make logical deductions and understand the puzzles in the game. This requires pattern recognition, trial, and error. They do not have any specifically related mechanics. The mechanics are only developed to solve the puzzle, so the type of puzzle determines the game mechanics[Ada14a].

4.9. Casual Games

Casual games are dependent on action/feedback loops, where there are no fast-paced challenges. They are easy to learn and have short sessions of playtime. Casual games are designed for people that do not see themselves as "gamers". Bright and clear graphics are essential features of a casual game[Sel17]. Casual games are the most popular genre in the mobile market[Chapter 3]. Casual games usually do not have many mechanics to keep the game simple. Some popular are[Mob19]:

- **Tap/Timing:** This mechanic is based on the player tapping or giving input at a specific time to progress. A score can be given depending on the precision of the tap.
- **Rising/Falling:** This mechanic provides a journey for the player, where the accuracy is not at the center. The game continually progresses without any interruptions. The level develops itself and introduces obstacles that the player has to avoid.
- **Stacking Mechanics:** Stacking is an improved version of Tap/Timing. Previous taps have an impact on the progress of the user. Tolerance of error is usually more significant than in Tap/Timing, but it decreases over progress.

5. Mobile Devices and Interaction Methods

Comparing the control techniques in a mobile game requires the knowledge of the mobile device's available interaction methods. In this chapter, the main methods of interactions, their benefits and limitations will be covered.

5.1. Mobility

Mobility describes the devices that are "designed to be transported by their human owner"[Pos09]. There are different types of mobile devices presented in table 5.1.

Since mobile game consoles and smartphones are handheld devices, interaction methods of them will be in the focus.

5.2. Interaction Techniques

5.2.1. Touch Interface

Handheld mobile devices like smartphones or mobile gaming consoles come with a touchscreen. Touchscreens allow two-dimensional inputs from a finger. However, this type of input is not precise due to the nature of the human body. Another common issue is that blind spots on the screen cannot be reached by the fingers when using the

Accompanied	**Handheld**	**Portable**	**Wearable**	**Implanted or embedded**
Devices that is carried on clothes or fashion accessories	Devices that can be operated one handed or hands free without being seated	Devices that is operated by two hands while seated	Accessory devices that usually operate autonomously	Micro devices that is implanted in human body, used mostly for medical applications

Table 5.1.: Categories of mobile devices according to Poslad[Pos09]

Tap	Double Tap	Swipe & Slide	Tap and Hold	Zoom	Rotate
Touching and removing a point in the screen, used in buttons	Tapping twice rapidly to trigger a specific action	Touching and moving the finger on the screen	Tapping and waiting without removing the finger to trigger an action	Touching with two fingers and moving them towards/against each other	Touching with two fingers and rotating one of them

Table 5.2.: Six universally accepted gestures according to Lacey[Lac18]

device. Other than that, they are relatively cheap and perfectly capable of handling direct interactions just by touching to the screen. The technology behind is mature and accepted as a standard method of interaction in today's world[SAS17]. Buttons in touch screens are referred to as soft keys, which are based on software. Soft keys alone may lack feedback and be less sensitive, unlike hard keys. In order to increase feedback, vibration and sound outputs can be used. For sensitivity purposes, buttons should be big enough to tolerate human errors[Kim+16]. Another critical design limitation is the edges of the screen where the user holds the device. Therefore, the edges of the screen should not be used as a part of the user interface[MC10]. The development of multi-touch screens allowed usage of gestures, specific finger movements that can be detected and acted upon. Gestures allow shortcuts to ease the use of a mobile application. However, they must also be known by the user, so it is critical not to use uncommon gestures in a user interface[Lac18]. Otherwise, the user has to repeat the gesture, and the usability of the application is damaged[Buc+10]. Some of the gestures that are accepted universally are listed in table 45.2.

5.2.2. Position Sensors and Accelerometers

Mobile devices usually contain sensors for the orientation of the device (gyroscope) and accelerometers to analyze the device's movement. An application listening on these sensors can act upon specific gestures. A common area of usage is automatic screen alignment upon rotating the device. The sensor's values only depend on the device's handling by the user, so they are environment independent. A drawback of this method is that it cannot replace some interaction methods like tapping. They can also be triggered falsely or against the will of the user[SAS17]. While in touch interfaces user's finger can block the screen's view and decrease playability, sensors

Real world metaphors	**Mimic normal use**	**Natural consistent mapping**	**Need for feedback**
Meaningful connection between physical action and its effect on the application	Connecting normal usage movements with gestures	Movement and its reverse movement trigger opposite effects	Fast and constantly given feedbacks to approve user's gesture

Table 5.3.: Four principles to consider when defining gestures according to Ruiz[RLL11]

and accelerometers allow controlling without any blocking[BWM12]. There are four essential concepts for a successful interface based upon gestures with sensors and accelerometers shown in table 5 5.3[SAS17].

5.2.3. Camera-based Techniques

The cameras in mobile devices can be used to capture a user's gestures. There are two approaches for interaction with cameras: device motion detection and user motion detection. In device motion detection, the device's orientation is detected by analyzing the camera feed without using the sensors. In order to accomplish that, the device deduces which parts of the feed is altered. In user motion detection, a camera opposing the user tracks the user for gestures. Even though camera-based methods are usable in all devices with cameras, the main problem in all camera-based methods is robustness and low success rate. They also most likely need calibration at the start to function correctly[SAS17].

6. Methods and Study Design

6.1. Methods

6.1.1. Game Engine

In order to implement a game for the purposes of this thesis, the game engine Unity3D version 2019.3 will be used[Unif]. Unity3D is an engine for 2D/3D game development that supports builds for Android, iOS, Nintendo Switch, Windows, Mac OS, GNU/Linux, Android, Playstation, and Xbox. Its advantage is providing a rapid development environment for high-quality games. It is a platform that natively supports the object-oriented programming language C#, standard 2D/3D file formats, and audio file formats. Unity3D also provides various debugging and testing features, like previewing the game in development. The engine is free of use for students in educational institutes[Unif].

6.1.2. Editor

For programming parts in Unity, the editor Microsoft Visual Studio 2019, will be used. Visual Studio is a code editor for C# that is also integrated with Unity. The editor provides automatic code completion and a linter to fix syntactic mistakes quickly[Mic].

6.1.3. Version Control

Git is a distributed version control software that helps the developers keep track of the project's changes. It can restore previous states of the project for quick debugging or show changes between the states[Gita]. It is also integrated within Unity and provides a fail-safe development environment. The repository of the game is hosted as a private repository at Github[Gitb].

6.1.4. Game Testing

Testing of the game will be done in three stages:

1. **Unity Preview Mode:** In preview mode, the visuals of the game can be tested alongside with some functionality. However, the interaction methods unique to the mobile platform like touch screens cannot be tested.

2. **Android Emulator:** Android Emulator from Android Studio by Google has the capability of emulating a smartphone in a PC. This allows quick testing of capabilities that are unique to mobile devices. Nonetheless, it still is not an ultimate way of testing because it cannot create the real experience of mobile device interaction methods (e.g., emulating touches through mouse buttons)[And].

3. **Smartphone:** The last step of the testing is a smartphone. The testing device for this thesis is HTC Desire 12+[HTC]. Its main features are:
   - Octa-Core 1.8GHz Processor
   - 720x1440 Pixel Display
   - Multi-Touch support
   - Android 8.0 Operating System
   - Accelerometer and Gyroscope Sensors

6.2. Study Design

In the study, three different control techniques for the same game will be evaluated according to the user experience. These control techniques will be later explained in Chapter 7.

6.2.1. User Experience

User experience is defined as "user's perceptions and responses that result from the use and/or anticipated use of a system, product or service" according to the ISO standards[ISO19]. User experience can be investigated in four main dimensions, which are listed in table 6.1.

6.2.2. Study Setting

This study's independent variables are the chosen control scheme in the game and the user's testing device. The study's outcome is the user experience, measured by two questionnaires: System Usability Scale (SUS) and Player Experience Inventory (PXI). A group of 25 people will evaluate the game using two questionnaires after playtesting the game with each control technique. The study will be done in an online environment

Aesthetics	Emotion/Affect	Stimulation	Identification
The visual experience that gained from sensory perceptions	The emotional experience, feeling of competence	The needs that the product can support	The identification of the user through the product

Table 6.1.: Four main dimensions of user experience for products by Bernhaupt[Ber15]

using teleconferencing applications, and the two questionnaires will be hosted online. Each participant will be guided to questionnaires after playtesting a control scheme in the game. The game will be tested at the participant's device. Minimum requirements for a testing device are defined to keep the impact of selected devices on the user experience minimal. The minimum requirements are similar to the features of the game testing device[Chapter 6.1.4]. These requirements are:

- Multi-touch support for at least 2 fingers
- Android version 8 and above
- Display resolution of 720x1440 and above

6.2.3. System Usability Scale

SUS is a quick method for measuring usability. It includes ten items to evaluate usability. The participant rates each item on a scale of zero to four from strongly disagree to agree strongly. Each item's points are multiplied by 2.5 and added together to assemble a final score from 0-100. Generally, scores below 68 are considered as below average and not very usable. Since SUS focuses solely on usability, each control scheme's usability can be compared to find the best technique among them[Bro96].

6.2.4. Player Experience Inventory

PXI is a user-oriented measurement method for player experience at functional and psychological levels. It has five categories for each level, where each category has three statements that identify with the category. These categories are ease of control, progress feedback, audiovisual appeal, goals and rules, challenge, mastery, curiosity, immersion, autonomy, and meaning. Each statement is rated on a seven-point Likert scale, from strongly agree to disagree strongly. The mean of the three statements then gives the score of the category. PXI is chosen for this study because it has a distinct and exact

category for control (ease of control) and other psychological categories for the user experience controlled by it. So, the correlation between each control method and the user experience will be observable[Abe+20].

7. Game Description

7.1. Game Concept

Space Wanderer is a 2D mobile game of the jump and run genre. However, unlike traditional platform games, the player is not in the avatar's control. Instead, the player manipulates the space and objects to guide the avatar to its destination. This unconventional idea of control opens up many possibilities for new control techniques and game mechanics.

7.1.1. Target Platforms

Space Wanderer is developed for Android. However, it is possible to port the game to other mobile consoles, as long as the console meets the minimum requirements[Chapter 6.1.4], mainly a touch screen with multi-touch support. Practically, this means the game can be ported to Nintendo Switch and iOS.

7.1.2. Game Features

In Space Wanderer player is in the control of a sphere-shaped avatar. The game consists of levels that the player has to beat. The game progresses as the player beats a level and unlocks the next one. With each level, the game gets more challenging. The game features a timer and a three-star rating system for every level, depending on the completion time. Levels consist of platforms that can be rotated or scaled, other avatars that can apply gravitational force to the player, and a destination point.

7.1.3. Game Mechanics

Rotation

Rotation is used to rotate the platforms in the game. This mechanic's only limitation is that all platforms have to be rotated at the same time, so the player cannot rotate a platform individually. Rotation can be combined with gravitational forces to guide the avatar to a particular path. Figure 7.1 demonstrates this mechanic.

(a) Rest state (b) Rotated platform

Figure 7.1.: Rotation mechanic in Space Wanderer, white ball represents the player avatar.

(a) Rest state (b) Down-scaled platform

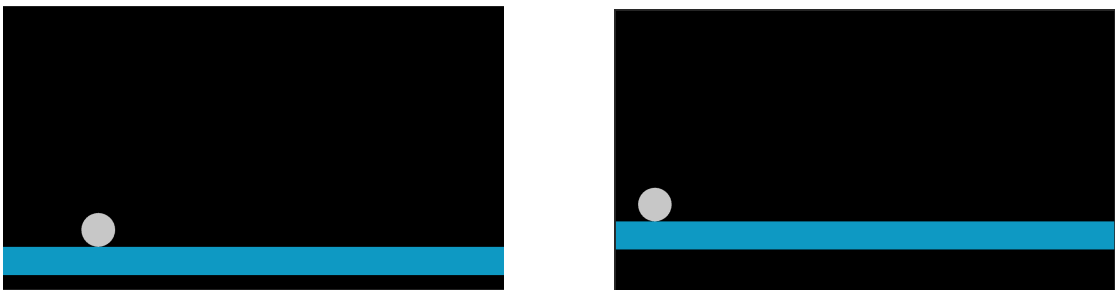
Figure 7.2.: Scale mechanic in Space Wanderer, white sphere represents the player avatar.

Scaling

The player can up or downscale the platforms in the game with two limitations:

1. Every platform has its boundary minimum and maximum scales.
2. All platforms are scaled simultaneously. Individual scaling is not allowed.

Scale can be used to connect two platforms. Since there is no jump mechanic in the game, it is a vital mechanic that can accomplish the same effect as the jump mechanic. Furthermore, it can also be used to disconnect two platforms to open a path for the avatar. An example of scaling is seen in figure 7.2.



(a) Rest state (b) Moved camera with swipe

Figure 7.3.: Swipe mechanic in Space Wanderer, white sphere represents the player avatar.

(a) Starting position (b) Player falling due to main gravity

Figure 7.4.: Main gravitation mechanic in Space Wanderer, white sphere represents the player avatar.

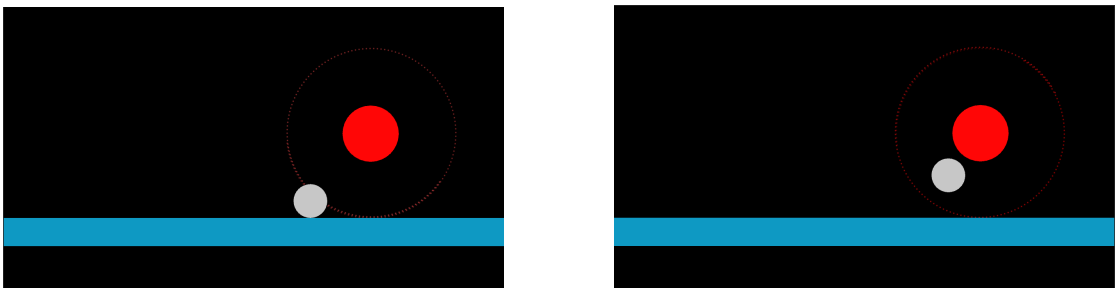
Swipe

Swipe enables camera movement and allows bigger levels, which can be seen in figure 7.3. Players can use it to explore the level. It also has a critical role in the game goals, which will be covered later.

Gravitational Force

In Space Wanderer, gravitational forces are the primary source for the movement of the player. There are two types of gravitational force in the game:

- **Main Gravity:** Main gravity always applies towards downwards of the space. Rotation can create a negative slope, so the player starts to move due to the main gravitational force. Figure 7.4 features an example of the main gravitational force.



(a) Starting position (b) Enemy pulling the player with gravity

Figure 7.5.: Enemy gravitation mechanic in Space Wanderer, white ball represents the player avatar, red ball represents the enemy avatar. Red circle around the red sphere indicates the area of the gravitational force applied by the enemy avatar.

- **Enemy Gravity:** This is the gravity applied by the enemy avatars, which is shown in figure 7.5. Enemy avatars are not affected by the rotation or scaling. However, they can also be used for the movement of the player, like preventing falling downwards. Every enemy avatar has an area that affects the player. The closer the player gets, the stronger the force becomes.

7.1.4. Goals and Rules

The goal of the game is similar to other platform games. The player must reach the destination point in the level. There are only two rules that the player has to obey:

1. If the player collides with an enemy avatar, the player loses.
2. The player avatar must always stay in the sight of the camera. In other words, the players must at all times be able to see where their avatar is. To accomplish this, players can adjust the camera with the swipe mechanic according to their needs.

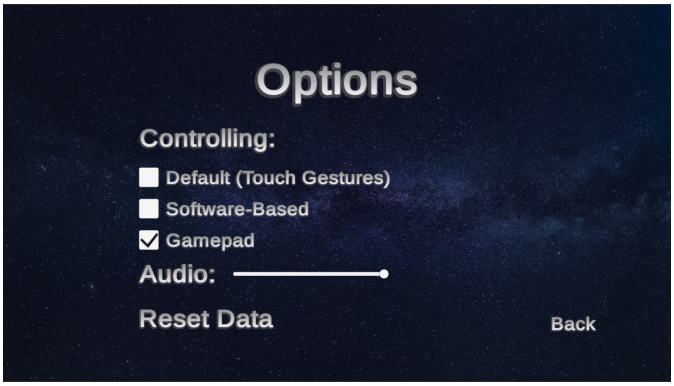
7.2. Game Scenes

The game consists of two scenes: the main menu and a level scene.

7.2.1. Menu Scene

The menu scene provides the basic user interface for the transition between levels and settings. It is also the starting scene of the game. It consists of the game title followed

(a) Intro



(b) Settings

(c) Level selection

Figure 7.6.: Main menu scene in Space Wanderer

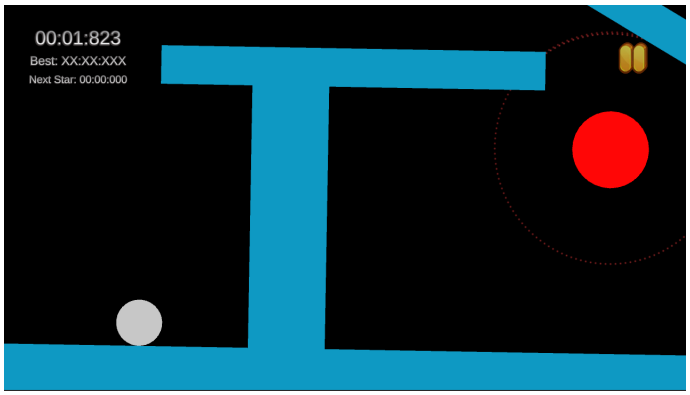


Figure 7.7.: A level scene in Space Wanderer using gesture-based control scheme

by two buttons for settings and level selection. In settings, players are able to choose the control scheme, adjust the sound level, and reset the game. In level selection, the levels are shown with their current status: the number of stars the player has for each level and whether it is unlocked. The player can then touch to unlocked levels to play that level. All buttons in the menu scene are highlighted upon touch to provide feedback. Figure 7.6 presents the menu scene.

7.2.2. Level Scene

The level scene is the play area of the game. It has a timer on the top left corner, indicating how much time has passed since its beginning. It also tells how many stars have been earned so far and the next time limit to beat for the next star. The scene also has a pause button on the top right corner. Depending on the control scheme, the scene can also have an interface for the corresponding control scheme. An example of a level scene is seen in figure 7.7.

7.3. Control Schemes

There are three control schemes implemented in the game to evaluate. All of the control schemes are based on the touch screen. Camera-based interaction is not used due to its complexity and inaccuracy[Chapter 5]. Orientation and accelerometer sensors are not used because there are no apparent real-world metaphors for scaling[Chapter 5]. For orientation, the player could rotate the device in real life. However, the game allows for unlimited rotation in any direction. This was considered impractical because players have to switch hands after a 180° rotation in either direction. Therefore it was not

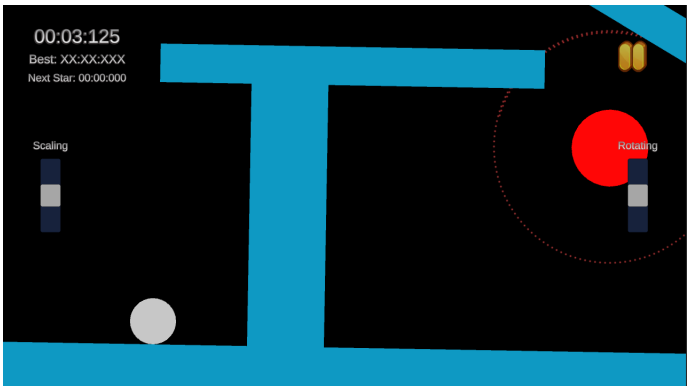


Figure 7.8.: A level scene in Space Wanderer using software-based control scheme, slider for scaling is on the middle left of the screen and slider for rotation is located on the middle right of the screen.

implemented.

7.3.1. Gesture-based Control Scheme

In the gesture-based control scheme, the player uses touch gestures to control the game. For the rotation mechanic, the player can use the rotate gesture[Chapter 5]. Zoom gesture[Chapter 5] is used to control the scaling mechanic. Zooming in scales the platforms up and consistently, zooming out scales them down. Finally, players can use the swipe gesture[Chapter 6.1.4] in any place on the touch screen to move the camera. Since all of the controlling is gesture-based, an additional user interface in the level scene is unnecessary. An example of a level with the gesture-based control scheme is seen in figure 7.7.

7.3.2. Software-based Control Scheme

In the software-based control scheme, the level scene additionally has two sliders for rotation and scaling. Sliders can be scrolled up or down to control each mechanic, respectively. Sliders also bring a new limitation in the game. In the gesture-based control, the speed of the scaling and rotation depends on the speed of the player's hand. However, sliders have a maximum and a minimum value. Therefore, the speed of both mechanics is theoretically limited. Camera movement is done through a swipe gesture, the same way as in a gesture-based control scheme. The software-based control scheme is demonstrated in figure 7.8.

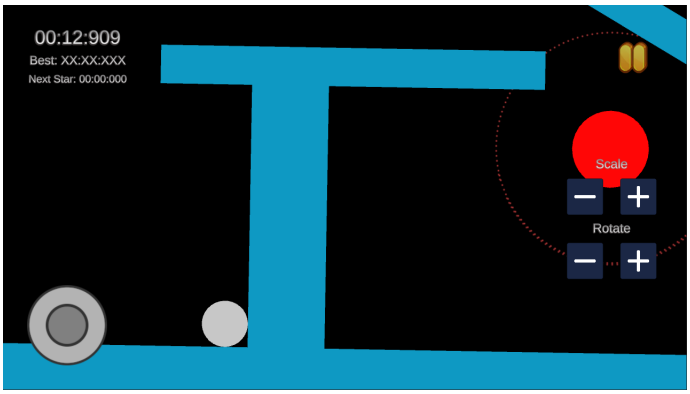


Figure 7.9.: A level scene in Space Wanderer using software-based control scheme, button pairs for scaling and rotation are located on the middle right and the analog stick is on the lower left corner of the screen.

7.3.3. Virtual Gamepad Control Scheme

The virtual gamepad control scheme consists of a virtual analog stick and two-button pairs. Button pairs are used for rotation and scaling mechanics. Button pairs have plus and minus buttons for scaling up and down or for rotating in opposite directions. This has a further limitation. The speed of the scaling and rotation has to be constant because buttons represent binary states. The analog stick is used for the camera movement. Figure 7.9 shows the gamepad control scheme.

7.4. Octalysis Gamification Analysis

In order to get an idea of how well the game is gamified, the game will be analyzed according to the Octalysis Framework introduced in chapter 2. The assignment of points for each core drive is subjective and can change for other people. However, it is still a useful analysis in the sense that what the game has for its users.

- **Epic Meaning and Calling:** Currently, Space Wanderer does not have a narrative side, so zero points are assigned.
- **Development and Accomplishment:** Space Wanderer gives players star ratings depending on how quickly they can beat a level. A level in the game only unlock after beating the previous level, so there is also a clear progress in the game. Therefore, ten points will be given for this core drive.

- **Empowerment of Creativity and Feedback:** Space Wanderer has unique mechanics compared to the classic mechanics of the jump and run genre[Chapter 4]. The game also gives instant feedback for using each mechanic. Levels often have more than one solution, which increases the replayability. Ten points are given for this core drive.
- **Ownership and Possession:** There is no ownership relationship in Space Wanderer. Zero points are given.
- **Social Influence and Relatedness:** Space Wanderer is a single-player game with no social features. Therefore, the game has zero points for this core drive.
- **Scarcity and Impatience:** Players have to beat other levels to unlock further levels. Otherwise, they cannot progress. Another scarcity is the time factor. Although players have unlimited time to complete a level, spending too much time on a level is discouraged because of the rating system. The game gets six points for this core drive.
- **Curiosity and Unpredictability:** The challenges in each level get more challenging and complex as the game progresses. This allows creating new tactics to beat levels and creates a significant surprise element in the game. Therefore, the game gets ten points for this core drive.
- **Loss and Avoidance:** Failing at a level does not cause much loss for the player other than the time and progress. For this reason, the game gets only three points in this section.

The squared summation of all the points results in a score of 345 points, which is close to 350, meaning that Space Wanderer is approximately at the same level as the other games that are successful in the market[Chapter 2]. The game has slightly more white hat gamification elements, so users likely give up playing the game in the early stage rather than the late stage. It is also reasonably balanced in the right and left brain gamification, providing balanced elements for extrinsic and intrinsic motivation.

7.5. Competitor Analysis

Space Wanderer is mainly designed as a jump and run game. However, it contains many elements from casual and puzzle games' genres. Every level in Space Wanderer has a playtime not more than a minute, and only four mechanics. The uniqueness of the mechanics allows the creation of puzzling levels. As shown before, puzzle and casual games are the most successful games in the mobile market[Chapter 3]. At the

same time, it differs from other games in the same genre with its unique mechanics. A similar game, where space is controlled instead of the player, is Helix Jump[Hel]. In 2019, it was the eighth-most downloaded game in Google Play with more than 15 million downloads[Pri19a]. Altogether, this indicates that Space Wanderer has the potential to become successful in the market.

8. Development

8.1. Game Core

Game core provides a basic set of functionality for the gameplay. These are the core elements of Space Wanderer:

- The player wins if the player avatar collides with the destination object.
- The player loses if the player avatar collides with an enemy object.
- The player loses if the player avatar is not seen in the camera view.
- The main gravitational force only affects the player and always points towards downwards.
- Enemy objects apply gravitational force to the player.
- In-level timer with rating information

Unity scenes consist of entities that are called game objects[Unic]. In order to implement the core, the game has separate game objects for the player, camera, platforms, enemies, and the final destination. Additionally, the game also has three separate game objects for management purposes invisible to the player. These are objects for game management, level data management, and options data management. The scripts are placed inside the game objects to define the behavior of the object. The general structure of the objects in the game can be seen in figure 8.1. The purposes of each object will be explained here.

Player

The player object is the only object in the game that is affected by physics. Unity provides a *rigid body* component to implement fundamental physics in game objects[Unid]. This allows to automatic application of global gravity if it is defined.

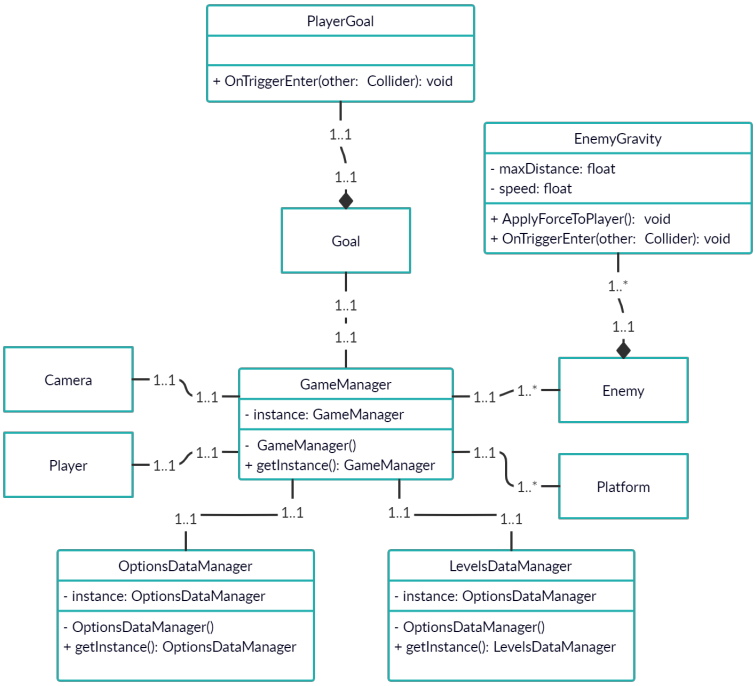


Figure 8.1.: Simplified UML class diagram that shows the general structure of the game. Some classes, methods, and interactions are omitted for the sake of simplicity.

Camera

The camera object is used to capture views of the game space to display it to the player[Unia]. Additionally, the camera object has three crucial roles in the gameplay:

- Adjust gravity direction according to the camera orientation
- Implement the rotation mechanic
- Implement the swipe mechanic

A simplified diagram of the camera classes can be seen in figure 8.2. In every frame, Camera Gravity updates the direction of the gravity using the cameras up vector[Unia]. The two interfaces, Camera Movement Strategy and Camera Rotation Strategy implement the rotation and swipe mechanics. Details will be covered later. Instead of rotating the platforms in the level, the game only rotates the camera and resets the gravity direction accordingly. Otherwise, the overhead of rotation increases linearly with each object and causes performance loss.

Platform

Platform objects are the core of the game. Together they form the level and its obstacles. Platforms can be manipulated with the scaling mechanic. A simplified diagram of the platform classes is located in figure 8.3. Scale Strategy implements the scaling mechanic and checks the platform's boundary conditions for minimum and maximum scales. Other details will be explained later.

Enemy

Enemy objects have two purposes. They apply gravitational force to the player if the player is in their range, and if they collide with the player, the player loses the game. In figure 8.1, it can be seen that the EnemyGravity class provides both of the functionalities. With the help of Unity's *event-driven architecture*[Unib], the game manager is notified upon collision with the player. Additionally, in every frame, it checks whether the player is in range and applies an inversely proportional force with the distance between the player and the enemy.

Goal

The goal object is the destination point in the game. If the player reaches it, then the player wins the level. Player Goal class in figure 8.1 implements this functionality using the collision events of Unity[Unib].

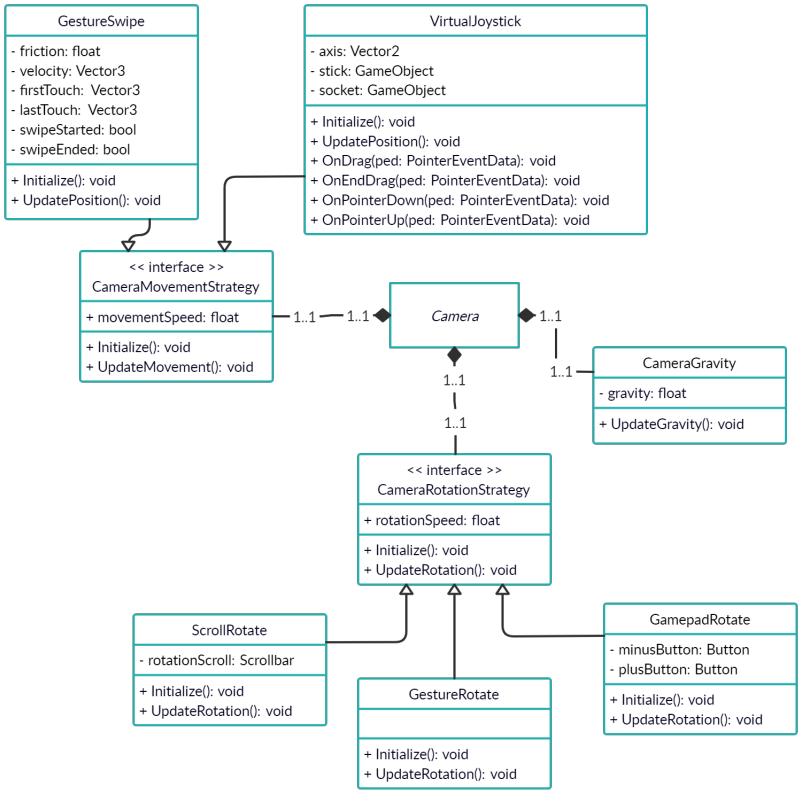


Figure 8.2.: Simplified UML class diagram for the camera object, interactions with other classes constructors, and methods are omitted for the sake of simplicity.

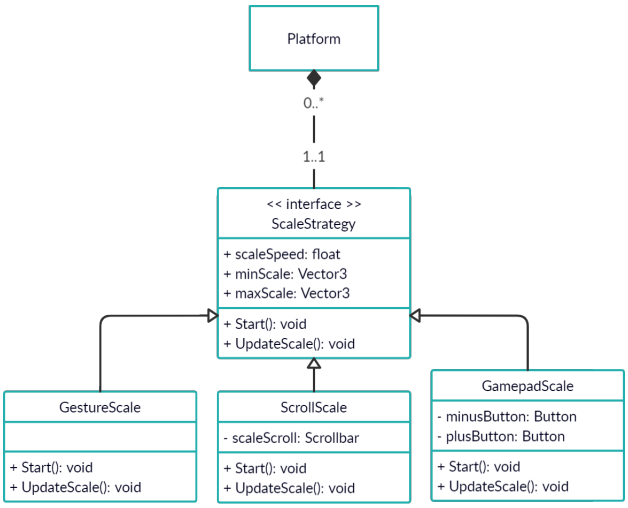


Figure 8.3.: Simplified UML class diagram for the platform object, interactions with other classes, constructors, and methods are omitted for the sake of simplicity.

Game Manager

The game manager is responsible for providing a general library to be used by other objects and managing them. By design, it implements the singleton pattern to allow global access and make sure there is only a single instance present[DC17b]. It handles the timer and also checks whether the player is in the camera frustum using an *axis-aligned boundary box* intersection. At the start of a level, it initializes the player's selected control scheme with the options data manager's help. After finishing a level, it notifies the level data manager, so the new time and rating can be saved.

Levels Data Manager

The levels data manager is also a singleton object. It provides access to level data for all levels. These are the completion time, time limits for stars, and whether the level is unlocked. It serializes the level data and saves it into a file in the system for persistent storage.

Options Data Manager

The options data manager is responsible for storing and loading of settings data of the player. This includes the control scheme that is going to be used and the sound level of the game. For persistency, the data is serialized and is saved into a file in the system.

8.2. Controls

There are three controllable mechanics in the game. The game only knows which control scheme to initialize at runtime. In order to cope with this problem, the strategy design pattern is used. The strategy pattern allows the selection of an algorithm at runtime by defining an abstract interface[DC17a]. Therefore, the interfaces Camera Movement Strategy, Camera Rotation Strategy, and Scale Strategy are introduced in figures 8.2 and 8.3. At the start of a level, the game loads the selected control scheme for each interface and calls the strategies' initialization methods. After the initialization, the update methods of the selected strategies are called in every frame.

8.2.1. Gesture-based Controls

Gesture-based controls use Gesture Swipe[Figure 8.2], Gesture Rotate[Figure 8.2], and Gesture Scale[Figure 8.3] classes to implement swipe, rotation, and scale mechanics.

Swipe

In gesture-based swipe, The first touch and the last touch of the swipe is stored. The difference between the touches and the time until then determines the speed and the direction of the movement. For more natural feedback, swipe is used as a force rather than direct velocity on the camera. The velocity and the position of the camera are then calculated using a two-step *explicit euler integration*.

Rotation

For rotation, the vector between the two touches is calculated. Then, the angle between the vectors in consecutive frames is measured. The time between the two frames and the angle's size determines the rotation's direction and speed.

Scale

Similar to the rotation, the vector between the two touches is gathered. The difference between the sizes of the vectors of two consecutive frames is used to calculate the direction and the size of the scaling.

8.2.2. Software-based Controls

Gesture Swipe[Figure 8.2], Scroll Rotate[Figure 8.2], and Scroll Scale[Figure 8.3] classes implement the software-based control scheme. The swipe mechanic is the same as in

gesture-based control. Unity provides user interface objects for sliders, which are used for rotation and scaling. In both mechanics, the slider's value is loaded and subtracted from the slider's middle value. The sign and the size of the difference determine the speed and the direction of the change. After the touch of a slider is released, the slider is reset to its middle value.

8.2.3. Virtual Gamepad Controls

Virtual gamepad consists of Virtual Joystick[Figure 8.2], Gamepad Rotate[Figure 8.2], and Gamepad Scale[Figure 8.3] classes.

8.2.4. Virtual Joystick

The virtual joystick is used for camera movement. It implements pointer events of Unity[Unib] to determine whether the joystick has been touched or moved. The relative difference of the stick's position between two consecutive frames is used to calculate the camera movement's direction and speed. The position of the stick is reset after the touch ends.

8.2.5. Rotation and Scaling

In both mechanics, there are two buttons for direction. The speed of the rotation and scale is kept constant. The script finds which button is being touched and acts accordingly.

8.3. User Interface

Unity provides default objects to implement user interfaces for buttons, scroll menus, and scrollbars and generates events when the users interact with them. All user interface objects are kept as children of a single user interface controller object, which handles the transitions between in-game menus. The implementation of the UI is trivial and not part of this thesis. Therefore it is not explained extensively.

8.4. Level Design

The game only uses spheres and boxes with simple materials for coloring that are defined in Unity. The first level is designed as a test area where the user can test the controls. The second level is the real level that is designed as a challenge for the user.

9. Game Evaluation

9.1. Participants

The study participants consisted of 25 university students, with a male majority (84%). The majority (80%) of the participants were aged between 20-24, three of them between 25-29, and only two between 15-19. The participants had come from various gaming backgrounds. Only two participants reported that they do not play video games regularly. 40% of the participants stated that they play video games for less than 5 hours a week. 24% of them play video games 5 to 10 hours a week. While 20% said that they play 10 to 15 hours a week, the remaining two participants reported that they play more than 20 hours a week. The most common platform to play video games was PC (92%), followed by mobile (42%) and console (12%). The majority (80%) of the participants preferred the PC for playing video games, followed by 12% for mobile and 8% for the console. The most liked video game genres were Action (56%), Strategy (48%) and Platform (36%), while the least were Sports (16%), Adventure (20%), and Role-Playing (20%).

9.2. Gesture-based Control Scheme Evaluation

System Usability Scale (SUS) Evaluation

When the participants were asked whether they want to use this control system again, they gave a mixed response. While the majority (58%) of the participants wanted to use the system again, 6 participants (24%) did not want, with rest being undecided. The majority (56%) found the system not complicated, while 32% stated otherwise. The control scheme was found overall hard to use (40%). The common criticism here was that the scale gesture and rotation gesture getting mixed during gameplay. However, the majority (72%) did not require assistance from a technical person. Out of 25 participants, 20 of them thought the control mechanism was well integrated. The system was also found relatively consistent (84%). On the contrary, 15 participants responded that the system could not be quickly learned. Almost half of the participants found the system cumbersome, while 8 participants disagreed. The control scheme also got mixed responses for feeling confident. Four of the participants primarily found the swipe

Statement	Mean(μ)	Median	Mode	Deviation(σ)	Min	Max
I think that I would like to use this system frequently.	2.48	3	3	1.3578	0	4
I found the system unnecessarily complex.	1.6	1	1	1.3229	0	4
I thought the system was easy to use.	2.04	2	1	1.4283	0	4
I think that I would need the support of a technical person to be able to use this system.	0.84	0	0	1.3128	0	4
I found the various functions in this system were well integrated.	3.36	4	4	0.8103	2	4
I thought there was too much inconsistency in this system.	0.84	1	0	1.106	0	4
I would imagine that most people would learn to use this system very quickly.	2.4	3	3	1.2583	0	4
I found the system very cumbersome to use.	1.68	1	0	1.547	0	4
I felt very confident using the system.	2.16	2	1	1.3748	0	4
I needed to learn a lot of things before I could get going with this system.	1.16	1	0	1.3128	0	4
Mean(μ) Total Score: 65.8						

Table 9.1.: System Usability Scale (SUS) Results of Gesture-based Control Scheme, N=25, possible values for each question are between 0 and 4

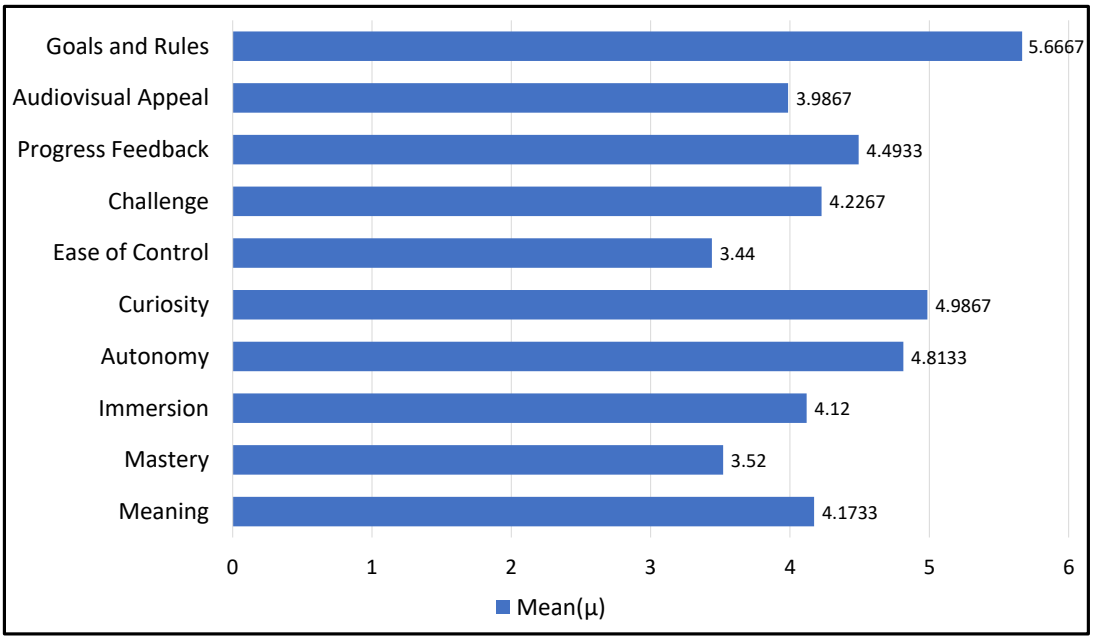


Figure 9.1.: Player Experience Inventory (PXI) Mean Values of Gesture-based Control Scheme, N=25, values are scaled between 0 and 6

gesture too sensitive for camera movement. The majority (64%) of the participants did not need any prerequisites to play the game. The gesture-based control scheme's SUS evaluation got overall 65.8 points, below 2.2 points of the average SUS score[Chapter 6]. It is the highest-rated control scheme among other implemented schemes. The results of all questions can be seen in table 9.1.

Player Experience Inventory (PXI) Evaluation

With the gesture-based control scheme, the game was found mildly meaningful ($\mu = 4.1733$). In this category, the highest positive rated statement was "The game was valuable to me." with 76%. The mastery category got almost a neutral response, with an average value of 3.52. The game felt more or less immersive ($\mu = 4.12$). Participants agreed that the game offered choices to players, with an autonomy score of 4.8133. They were also curious to find out how the game continued ($\mu = 4.9867$). However, the game got mixed responses in the ease of the control category. The actions to control the game were clear (80%), but on the contrary, almost half of the participants (40%) found the controls not so easy to use. The majority of the players (72%) also said that the game was at the right difficulty for them. The progress feedback category got an average value of 4.4933. The game was found more or less visually appealing. One participant stated that the minimalistic design suited the game concept. The highest-rated category was goals and rules. 80% of the players said that the goals and rules of the game were clear to them. The mean values of each category can be inspected in figure 9.1.

9.3. Software-based Control Scheme Evaluation

System Usability Scale (SUS) Evaluation

The software-based control scheme got mixed responses for frequent usage with a negative tendency ($mode = 1$). Eleven participants did not want to use this control scheme not frequently. The player reacted overall neutral towards the complexity of the controls ($\mu = 1.92$ and $median = 2$). The controls were evaluated as slightly easy to control ($\mu = 2.2$). The majority (64%) of the participants did not require assistance from a technical person. The system was found well integrated ($\mu = 2.8$) with the highest deviation ($\sigma = 1.5811$) in this part. The controls felt mostly very consistent ($mode = 0$). Most of the participants agreed that they could learn the controls quickly. The players responded to the statements, "I found the system very cumbersome to use." and "I felt very confident using the system." almost neutral ($\mu = 2.28$). The main criticism here was that the players could not scale and rotate with the sliders simultaneously. Fourteen participants disagreed that they required many prerequisites to play the game.

Statement	Mean(μ)	Median	Mode	Deviation(σ)	Min	Max
I think that I would like to use this system frequently.	2	2	1	1.4434	0	4
I found the system unnecessarily complex.	1.92	2	0	1.579	0	4
I thought the system was easy to use.	2.2	2	1	1.291	0	4
I think that I would need the support of a technical person to be able to use this system.	1.2	0	0	1.5811	0	4
I found the various functions in this system were well integrated.	2.8	4	4	1.5546	0	4
I thought there was too much inconsistency in this system.	1.12	1	0	1.3638	0	4
I would imagine that most people would learn to use this system very quickly.	2.6	3	4	1.2247	0	4
I found the system very cumbersome to use.	2.28	3	3	1.4583	0	4
I felt very confident using the system.	2.28	2	2	1.3392	0	4
I needed to learn a lot of things before I could get going with this system.	1.48	1	0	1.5578	0	4
Mean(μ) Total Score: 59.7						

Table 9.2.: System Usability Scale (SUS) Results of Software-based Control Scheme, N=25, possible values for each question are between 0 and 4

The SUS evaluation of the software-based control scheme got overall 59.7 points, below 8.3 points of the average SUS score[Chapter 6]. Its score is the minimum among other control schemes. The results of the SUS evaluation of the software-based control scheme can be found in table 9.1.

Player Experience Inventory (PXI) Evaluation

The game felt more or less meaningful for the majority of the participants(76%). The sense of mastery was rated an average value of 3.76. The statement that got the worst rating in this category was, "I felt I was good at playing this game." with 28%. Players also agreed that the game felt slightly immersive . Twenty participants rated autonomy above neutral, with 11 strongly agree that the game offered choices about gameplay. The curiosity section's statements were rated similar, with 17 participants agreeing or strongly agreeing that they felt curious about the game's continuation. Ease of control got an average value of 4.44. The game was more or less challenging ($\mu = 4.16$), and the players responded that they got clear feedback for their signs of progress ($\mu = 4.8667$). The game was more or less audiovisual appealing ($\mu = 4.2267$). Twenty participants strongly agreed that the goals and rules of the game were clear to them. The results for the mean values of the categories are demonstrated in figure 9.2.

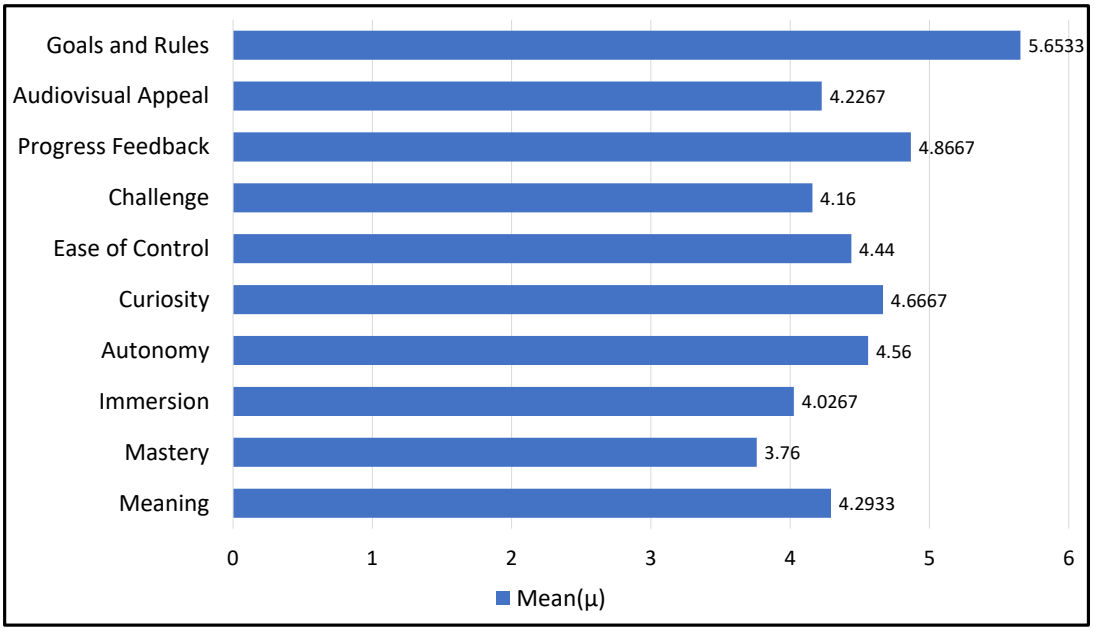


Figure 9.2.: Player Experience Inventory (PXI) Mean Values of Software-based Control Scheme, N=25, values are scaled between 0 and 6

9.4. Virtual Gamepad Control Scheme Evaluation

System Usability Scale (SUS) Evaluation

The virtual gamepad scheme performed worst at the statement, "I think that I would like to use this system frequently.". It got a neutral response with a negative tendency ($\mu = 1.92$ and $mode = 1$). The participants also mostly stayed neutral for the system's complexity with a high deviation ($\sigma = 1.5524$). Twelve of the participants found the scheme hard to use. The majority (76%) of the players stated that they do not require technical assistance to use the controls. The system was considered well integrated with an average value of 2.88 and the lowest standard deviation of 1.2689. 68% of the participants agreed that the controls were consistent. Most of the participants ($mode = 4$) said that people would learn this scheme quickly. However, the rest of the participants either disagreed or stayed neutral, so the statement "I would imagine that most people would learn to use this system very quickly." scored only 2.48. A similar result can be seen for the cumbersomeness of the system. Only 48% of the participants felt confident while playing the game. Fourteen participants disagreed that they needed some prerequisites to play the game. Overall, the virtual gamepad control scheme got

Statement	Mean(μ)	Median	Mode	Deviation(σ)	Min	Max
I think that I would like to use this system frequently.	1.92	1	1	1.579	0	4
I found the system unnecessarily complex.	2.08	2	0	1.5524	0	4
I thought the system was easy to use.	1.96	2	1	1.4572	0	4
I think that I would need the support of a technical person to be able to use this system.	0.88	0	0	1.3329	0	4
I found the various functions in this system were well integrated.	2.88	3	4	1.2689	0	4
I thought there was too much inconsistency in this system.	1.16	1	0	1.4341	0	4
I would imagine that most people would learn to use this system very quickly.	2.48	2	4	1.4922	0	4
I found the system very cumbersome to use.	2.32	3	4	1.5737	0	4
I felt very confident using the system.	2.36	2	1	1.2543	0	4
I needed to learn a lot of things before I could get going with this system.	1.32	1	0	1.4059	0	4
Mean(μ) Total Score: 61.7						

Table 9.3.: System Usability Scale (SUS) Results of Virtual Gamepad Control Scheme, N=25, possible values for each question are between 0 and 4

a mean score of 61.7, which is the second-highest-rated control scheme. The results of the evaluation are represented in table 9.3.

Player Experience Inventory (PXI) Evaluation

Similar to the other two control schemes, the participants felt that the game was mildly meaningful ($\mu = 4.08$). The mastery category scored an average of 3.8667 with balanced responses to the statement, "I felt I was good at playing this game."(5 participants for each positive response, 4 for neutral and 4 for more or less disagree). The game felt generally immersive ($\mu = 4.24$) and autonomous ($\mu = 4.4533$). Twenty participants were eager to find out how the game progressed. The ease of the control section got a mean rating of 4.4133. The statement that scored worst in that category was "I thought the game was easy to control." with 36% negative response. The game was found more or less challenging ($\mu = 4.1067$) and audiovisually appealing ($\mu = 4.2267$). Twenty participants stated that the game gives clear feedback for progress and all participants agreed that the game's goals and rules were easily grasped. Figure 9.3 shows the mean values of each category.

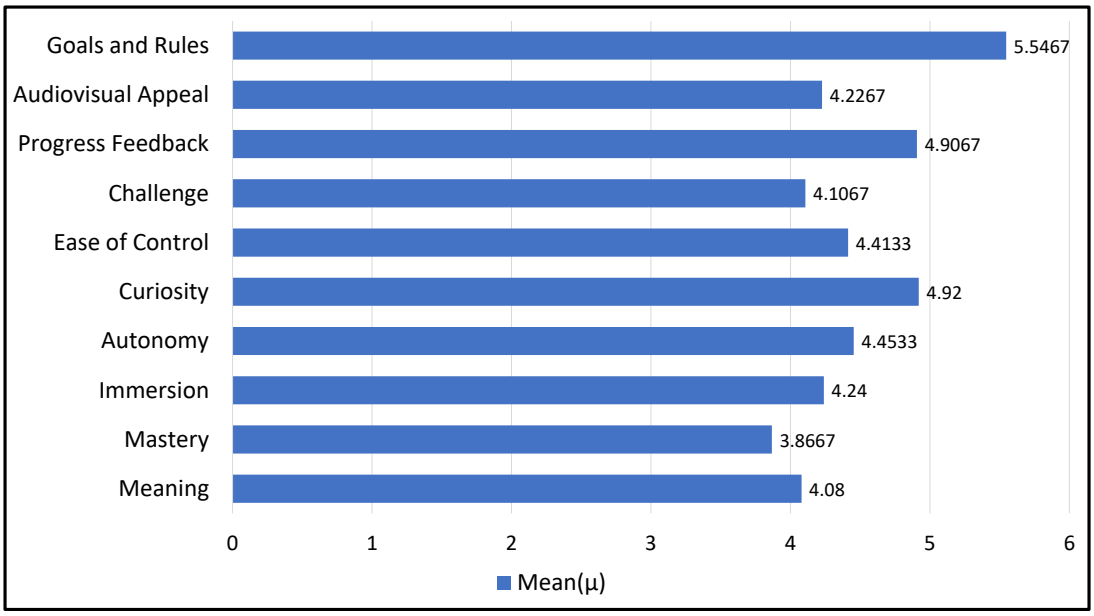


Figure 9.3.: Player Experience Inventory (PXI) Mean Values of Virtual Gamepad Control Scheme, N=25, values are scaled between 0 and 6

10. Future Works

Even though the control schemes are evaluated, further evaluation using different participant groups is necessary. In this thesis, participants were mostly university students and aged between 20-24, so to see if there is any correlation between age/status and preferred controls, the game is to be evaluated with other participant groups. During the game evaluation, many participants suggested that there should be sensitivity control for each control scheme. In order to make the comparison independent from the sensitivity of each control, a sensitivity option is to be added to the options menu. After that, the game is to be re-evaluated. Like sensor-based methods, some interaction methods were omitted during implementation because it was thought that they were not suitable for the game. However, this might not be the case for possible combinations of interaction methods(e.g., combining sensor-based methods with the touch screen). Other control schemes are to be implemented and evaluated accordingly. In this thesis, the System Usability Scale and Player Experience Inventory were used to evaluate the game. There are also other questionnaires that measure a system's usability, which should be considered for more detailed results.

11. Conclusion

Overall, the highest-rated control scheme, according to the SUS, is the gesture-based control scheme, followed by the virtual gamepad control scheme and software-based control scheme. One reason for this outcome can be the complexity of each control scheme. Almost any smartphone user nowadays uses zoom and rotation gestures, and on the plus side, both gestures have a clear connection between the real world and the game[Chapter 7]. The other two control schemes need extra UI elements that can block the player's view and make the game unnecessarily complex. Another big difference is in the integration of the controls. The virtual gamepad scheme is used in many first or third-person shooter games, in which the gamepad directly controls the character. In this case, the gamepad controls the environment, which might create an unusual feeling in the user. On the other hand, the software-based control scheme is a unique way of controlling that is only created for Space Wanderer. It is suspected that the innovation and the unfamiliarity of the control made the users think that it is not suited for their taste. The other two controls also felt cumbersome compared to gesture-based controls. The critical factor here is the speed. In the gesture-based control, the player can adjust the speed of movement with the gesture's speed. However, this is partially possible or even not possible in other control mechanisms. The software-based method is, however, evaluated as the method that can be most quickly learned. The possible explanation there is in the simplicity of the software-based controls. Sliders are represented in the game as scrollbars with a clear definition of what they do. Swipe gesture is also more faster and provides more freedom than a gamepad stick for camera movement. The gesture-based control scheme fails here because the players have to learn to control scale and rotation simultaneously. In the software-based control scheme, simultaneous rotation and scaling is not allowed, which reduces the complexity that the gesture-based control scheme has. SUS scores for each control scheme were below average[Chapter 6]. It is suspected that the hard difficulty of the second demo level caused this outcome. It took too long for some participants to figure out the second level, and they might have blamed the controls for it.

In PXI evaluation, goals and rules, audiovisual appeal, progress feedback, challenge, curiosity, autonomy, immersion, and meaning sections got similar results. These categories mainly do not depend on the control of the game, so this result was expected. This leaves the categories ease of control and mastery, which both should directly

depend on the chosen control scheme. In the ease of control category, gesture-based controls got the worst rating, followed by virtual gamepad and then software-based controls. The problematic statement here was that the gesture-based control scheme was not easy to use because it allowed simultaneous rotation and scaling. Players also cannot execute gestures well in situations where precision is crucial. At first glance, this might seem contradictory to the results of SUS. However, this not the case. From SUS, it is already known that the gesture-based system is hard to learn quickly. However, the integration of this system in the game is better than other controls. Also, other controls were experienced as cumbersome when compared to the gesture-based controls. These two reasons combined overweighted the fact that the gesture-based controls are harder to learn, so it reached a higher rating. Mastery rating also shows a similar trend like the ease of control category, where the gesture-based system again got the lowest rating. This might imply a correlation between the time required to learn a control system and the sense of mastery that the player gets.

In this work, the controls in the mobile jump and run game Space Wanderer has been evaluated. First, the core mechanics of the game has been developed. Thereafter, three different control schemes, gesture-based, software-based, and virtual gamepad have been integrated into the game and tested using System Usability Scale (SUS) and Player Experience Inventory (PXI) questionnaires. It has been found that gesture-based control scheme is the most usable control scheme for the players. However, it needed the most time to learn and it reduced the sense of mastery player got from the game. The virtual gamepad control scheme was selected as the second most usable scheme, followed by the software-based control scheme. When deciding between controls in a mobile jump and run game, it has been learned that the trade-off between the sense of mastery of the player/required time to learn the system and the general usability of the system has to be considered.

A. Personal Information and Games in General Questionnaire

The following questionnaire was used at the start of the user study to gather personal information and participant's relationship to games in general.

Personal Data and Games in General Questionnaire

1. Name

2. E-mail

3. Model of the smartphone (For debugging purposes)

4. Gender

Mark only one oval.

- ◯ Female
- ◯ Male
- ◯ Prefer not to say
- ◯ Other

5. Age

Mark only one oval.

- ◯ < 15
- ◯ 15-19
- ◯ 20-24
- ◯ 25-29
- ◯ 30-34
- ◯ 35-39
- ◯ 40-44
- ◯ 45-49
- ◯ 50-54
- ◯ 55-60
- ◯ 61-65
- ◯ > 65

6. What's your current (main) status?

Mark only one oval.

- ◯ Student
- ◯ Employee
- ◯ Unemployed

7. How often do you play video games?

Mark only one oval.

- ◯ Not at all
- ◯ < 5 hours a week
- ◯ 5-10 hours a week
- ◯ 11-15 hours a week
- ◯ 16-20 hours a week
- ◯ > 20 hours a week

8. On which platforms do you generally play video games?
Multiple options possible

Tick all that apply.

- [ ] Mobile
- [ ] Console
- [ ] PC
- [ ] Other: _____

9. Which platform is the one you like most to play video games on?

Mark only one oval.

- ◯ Mobile
- ◯ Console
- ◯ PC
- ◯ Other: _____

10. What kind of video game genres do you like?
Multiple options possible

Tick all that apply.

- [ ] Casual Games (e.g. Candy Crush, Angry Birds)
- [ ] Platform Games(e.g. Mario, Sonic)
- [ ] Strategy (e.g. Age of Empires, Civilization)
- [ ] Simulation (e.g. The Sims, SimCity)
- [ ] Role-Playing (e.g. Final Fantasy, World of Warcraft)
- [ ] Action-Adventure (e.g. Legend of Zelda, Metroid)
- [ ] Adventure (text & point'n'click games, e.g. Monkey Island)
- [ ] Action (e.g. Counter Strike)
- [ ] Sports (e.g. FIFA)

B. System Usability Scale Questionnaire

The following questionnaire was used to evaluate System Usability Scale[Bro96]. Participants were asked to complete one for each control scheme.

System Usability Scale Questionnaire

1. I think that I would like to use this system frequently.

Mark only one oval.

	0	1	2	3	4	
Strongly disagree	◯	◯	◯	◯	◯	Strongly agree

2. I found the system unnecessarily complex.

Mark only one oval.

	0	1	2	3	4	
Strongly disagree	◯	◯	◯	◯	◯	Strongly agree

3. I thought the system was easy to use.

Mark only one oval.

	0	1	2	3	4	
Strongly disagree	◯	◯	◯	◯	◯	Strongly agree

4. I think that I would need the support of a technical person to be able to use this system.

Mark only one oval.

	0	1	2	3	4	
Strongly disagree	◯	◯	◯	◯	◯	Strongly agree

5. I found the various functions in this system were well integrated.

Mark only one oval.

	0	1	2	3	4	
Strongly disagree	◯	◯	◯	◯	◯	Strongly agree

6. I thought there was too much inconsistency in this system.

Mark only one oval.

	0	1	2	3	4	
Strongly disagree	◯	◯	◯	◯	◯	Strongly agree

7. I would imagine that most people would learn to use this system very quickly.

Mark only one oval.

	0	1	2	3	4	
Strongly disagree	◯	◯	◯	◯	◯	Strongly agree

8. I found the system very cumbersome to use.

Mark only one oval.

	0	1	2	3	4	
Strongly disagree	◯	◯	◯	◯	◯	Strongly agree

9. I felt very confident using the system.

Mark only one oval.

	0	1	2	3	4	
Strongly disagree	◯	◯	◯	◯	◯	Strongly agree

10. I needed to learn a lot of things before I could get going with this system.

Mark only one oval.

	0	1	2	3	4	
Strongly disagree	◯	◯	◯	◯	◯	Strongly agree

11. Other notes

C. Player Experience Inventory Questionnaire

The following questionnaire was used to evaluate Player Experience Inventory[Abe+20]. Participants were asked to complete one for each control scheme.

Player Experience Inventory Questionnaire

MEANING

1. Playing the game was meaningful to me.

Mark only one oval.

	0	1	2	3	4	5	6	
Strongly disagree	◯	◯	◯	◯	◯	◯	◯	Strongly agree

2. The game felt relevant to me.

Mark only one oval.

	0	1	2	3	4	5	6	
Strongly disagree	◯	◯	◯	◯	◯	◯	◯	Strongly agree

3. Playing this game was valuable to me.

Mark only one oval.

	0	1	2	3	4	5	6	
Strongly disagree	◯	◯	◯	◯	◯	◯	◯	Strongly agree

MASTERY

4. I felt capable while playing the game.

Mark only one oval.

	0	1	2	3	4	5	6	
Strongly disagree	◯	◯	◯	◯	◯	◯	◯	Strongly agree

5. I felt I was good at playing this game.

Mark only one oval.

	0	1	2	3	4	5	6	
Strongly disagree	◯	◯	◯	◯	◯	◯	◯	Strongly agree

6. I felt a sense of mastery playing this game.

Mark only one oval.

	0	1	2	3	4	5	6	
Strongly disagree	◯	◯	◯	◯	◯	◯	◯	Strongly agree

IMMERSION

7. I was no longer aware of my surroundings while I was playing.

Mark only one oval.

	0	1	2	3	4	5	6	
Strongly disagree	◯	◯	◯	◯	◯	◯	◯	Strongly agree

8. I was immersed in the game.

Mark only one oval.

	0	1	2	3	4	5	6	
Strongly disagree	◯	◯	◯	◯	◯	◯	◯	Strongly agree

9. I was fully focused on the game.

Mark only one oval.

	0	1	2	3	4	5	6	
Strongly disagree	◯	◯	◯	◯	◯	◯	◯	Strongly agree

AUTONOMY

10. I felt a sense of freedom about how I wanted to play this game.

Mark only one oval.

	0	1	2	3	4	5	6	
Strongly disagree	◯	◯	◯	◯	◯	◯	◯	Strongly agree

11. I felt free to play the game in my own way.

Mark only one oval.

	0	1	2	3	4	5	6	
Strongly disagree	◯	◯	◯	◯	◯	◯	◯	Strongly agree

12. I felt like I had choices regarding how I wanted to play this game.

Mark only one oval.

	0	1	2	3	4	5	6	
Strongly disagree	◯	◯	◯	◯	◯	◯	◯	Strongly agree

CURIOSITY

13. I felt eager to discover how the game continued.

Mark only one oval.

	0	1	2	3	4	5	6	
Strongly disagree	◯	◯	◯	◯	◯	◯	◯	Strongly agree

14. I wanted to explore how the game evolved.

Mark only one oval.

	0	1	2	3	4	5	6	
Strongly disagree	◯	◯	◯	◯	◯	◯	◯	Strongly agree

15. I wanted to find out how the game progressed.

Mark only one oval.

	0	1	2	3	4	5	6	
Strongly disagree	◯	◯	◯	◯	◯	◯	◯	Strongly agree

EASE OF CONTROL

16. I though the game was easy to control.

Mark only one oval.

	0	1	2	3	4	5	6	
Strongly disagree	◯	◯	◯	◯	◯	◯	◯	Strongly agree

17. The actions to control the game were clear to me.

Mark only one oval.

	0	1	2	3	4	5	6	
Strongly disagree	◯	◯	◯	◯	◯	◯	◯	Strongly agree

18. It was easy to know how to perform actions in this game.

Mark only one oval.

	0	1	2	3	4	5	6	
Strongly disagree	◯	◯	◯	◯	◯	◯	◯	Strongly agree

CHALLENGE

19. The game was challenging but not too challenging.

Mark only one oval.

	0	1	2	3	4	5	6	
Strongly disagree	◯	◯	◯	◯	◯	◯	◯	Strongly agree

20. The game was not too easy and not too hard to play.

Mark only one oval.

	0	1	2	3	4	5	6	
Strongly disagree	◯	◯	◯	◯	◯	◯	◯	Strongly agree

21. The challenges in the game were at the right level of difficulty for me.

Mark only one oval.

	0	1	2	3	4	5	6	
Strongly disagree	◯	◯	◯	◯	◯	◯	◯	Strongly agree

PROGRESS FEEDBACK

22. The game gave clear feedback on my progress towards the goals.

Mark only one oval.

	0	1	2	3	4	5	6	
Strongly disagree	◯	◯	◯	◯	◯	◯	◯	Strongly agree

23. I could easily assess how I was performing in the game.

Mark only one oval.

	0	1	2	3	4	5	6	
Strongly disagree	◯	◯	◯	◯	◯	◯	◯	Strongly agree

24. The game informed me of my progress in the game.

Mark only one oval.

	0	1	2	3	4	5	6	
Strongly disagree	◯	◯	◯	◯	◯	◯	◯	Strongly agree

AUDIOVISUAL APPEAL

25. I enjoyed the way the game was styled.

Mark only one oval.

	0	1	2	3	4	5	6	
Strongly disagree	◯	◯	◯	◯	◯	◯	◯	Strongly agree

26. I liked the look and the feel of the game.

Mark only one oval.

	0	1	2	3	4	5	6	
Strongly disagree	◯	◯	◯	◯	◯	◯	◯	Strongly agree

27. I appreciated the aesthetics of the game.

Mark only one oval.

	0	1	2	3	4	5	6	
Strongly disagree	◯	◯	◯	◯	◯	◯	◯	Strongly agree

GOALS AND RULES

28. The goals of the game were clear to me.

Mark only one oval.

	0	1	2	3	4	5	6	
Strongly disagree	◯	◯	◯	◯	◯	◯	◯	Strongly agree

29. I grasped the overall goal of the game.

Mark only one oval.

	0	1	2	3	4	5	6	
Strongly disagree	◯	◯	◯	◯	◯	◯	◯	Strongly agree

30. I understood the objectives of the game.

Mark only one oval.

	0	1	2	3	4	5	6	
Strongly disagree	◯	◯	◯	◯	◯	◯	◯	Strongly agree

31. Other notes

List of Figures

List of Tables

Bibliography

[Abe+20] V. V. Abeele, K. Spiel, L. Nacke, D. Johnson, and K. Gerling. "Development and validation of the player experience inventory: A scale to measure player experiences at the level of functional and psychosocial consequences." In: *International Journal of Human-Computer Studies* 135 (2020), p. 102370. ISSN: 1071-5819. DOI: https://doi.org/10.1016/j.ijhcs.2019.102370.

[AC14] A. Anthropy and N. Clark. *A Game Design Vocabulary: Exploring the Foundational Principles Behind Good Game Design*. Game Design Series. Addison-Wesley, 2014. Chap. 1. ISBN: 9780321886927.

[Ada14a] E. Adams. *Fundamentals of Game Design*. Always learning Pearson. New Riders, 2014. Chap. 3. ISBN: 9780321929679.

[Ada14b] E. Adams. *Fundamentals of Sports Game Design*. Pearson Education, 2014. ISBN: 9780133812183.

[Ada14c] E. Adams. *Fundamentals of Strategy Game Design*. Pearson Education, 2014. ISBN: 9780133812107.

[Ada14d] E. Adams. *Fundamentals of Action and Arcade Game Design*. New Riders, 2014. ISBN: 9780133811308.

[Ada14e] E. Adams. *Fundamentals of Construction and Simulation Game Design*. New Riders, 2014. ISBN: 9780133812626.

[Ada14f] E. Adams. *Fundamentals of Role-playing Game Design*. New Riders, 2014. ISBN: 9780133811926.

[Adm] *Admix*. https://admixplay.com/.

[And] *Android Emulator*. https://developer.android.com/studio/run/emulator.

[And17] Android Authority. *From Android Market to Google Play: a brief history of the Play Store*. https://www.androidauthority.com/android-market-google-play-history-754989, last accessed on 18.08.2020. Mar. 2017.

[App06] T. H. Apperley. "Genre and game studies: Toward a critical approach to video game genres." In: *Simulation & Gaming* 37.1 (2006), pp. 6–23. DOI: 10.1177/1046878105282278.

[App20] Appfigures & VentureBeat. *Number of apps available in leading app stores as of 1st quarter 2020*. https://www.statista.com/statistics/276623/number-of-apps-available-in-leading-app-stores/, last accessed on 27.08.2020. May 2020.

[Ars19] Arstechnica. *Happy 30th B-Day, Game Boy: Here are six reasons why you're #1*. https://arstechnica.com/gaming/2019/04/game-boy-20th-anniversary/, last accessed on 20.08.2020. Apr. 2019.

[Bar96] R. Bartle. "Hearts, clubs, diamonds, spades: Players who suit MUDs." In: *Journal of MUD Research* (June 1996).

[Ber15] R. Bernhaupt. "User Experience Evaluation Methods in the Games Development Life Cycle." In: *Game User Experience Evaluation*. Ed. by R. Bernhaupt. Cham: Springer International Publishing, 2015, pp. 1–8. ISBN: 978-3-319-15985-0. DOI: 10.1007/978-3-319-15985-0_1.

[BK17] S. Boller and K. Kapp. *Play to Learn: Everything You Need to Know About Designing Effective Learning Games*. American Society for Training & Development, 2017. Chap. 1. ISBN: 9781562867720.

[Bro96] J. Brooke. "SUS - A quick and dirty usability scale." In: *Usability evaluation in industry*. London: Taylor and Francis, 1996, pp. 189–194. ISBN: 9780748404605.

[Buc+10] S. Buchinger, F. De Simone, E. Hotop, H. Hlavacs, and T. Ebrahimi. "Gesture and Touch Controlled Video Player Interface for Mobile Devices." In: *MM'10: Proceedings of the International Conference on Multimedia*. New York: ACM Press, Oct. 2010, pp. 699–702. DOI: 10.1145/1873951.1874055.

[BWM12] D. Böhrs, D. Wenig, and R. Malaka. "Mobile Gaming with Indirect Sensor Control." In: *Entertainment Computing - ICEC 2012*. Ed. by M. Herrlich, R. Malaka, and M. Masuch. Berlin, Heidelberg: Springer Berlin Heidelberg, 2012, pp. 441–444. ISBN: 978-3-642-33542-6.

[Cal] *Call of Duty: Mobile*. https://play.google.com/store/apps/details?id=com.activision.callofduty.shooter.

[Can] *Candy Crush*. https://king.com/tr/game/candycrush.

[Cha20] C. Chapple. *Mobile Gaming Revenue Surged 27% Year-Over-Year to $19.3 Billion in Q2 2020 Amid COVID-19*. https://sensortower.com/blog/mobile-games-covid-19-impact, last accessed on 19.08.2020. July 2020.

[Cho19a] Y.-k. Chou. *Actionable Gamification*. 1st. O'Reilly Media, Inc., 2019. Chap. 4. ISBN: 9781839211706.

[Cho19b] Y.-k. Chou. *Actionable Gamification*. 1st. O'Reilly Media, Inc., 2019. Chap. 13. ISBN: 9781839211706.

[Cho19c] Y.-k. Chou. *Actionable Gamification*. 1st. O'Reilly Media, Inc., 2019. ISBN: 9781839211706.

[Cho19d] Y.-k. Chou. *Actionable Gamification*. 1st. O'Reilly Media, Inc., 2019. Chap. 16. ISBN: 9781839211706.

[Cho19e] Y.-k. Chou. *Actionable Gamification*. 1st. O'Reilly Media, Inc., 2019. Chap. 14. ISBN: 9781839211706.

[Cho19f] Y.-k. Chou. *Actionable Gamification*. 1st. O'Reilly Media, Inc., 2019. Chap. 3. ISBN: 9781839211706.

[Cho19g] Y.-k. Chou. *Actionable Gamification*. 1st. O'Reilly Media, Inc., 2019. Chap. 10. ISBN: 9781839211706.

[CLC17] R. I. Clarke, J. H. Lee, and N. Clark. "Why Video Game Genres Fail: A Classificatory Analysis." In: *Games and Culture* 12.5 (2017), pp. 445–465. DOI: 10.1177/1555412015591900.

[CN02] M. Csikszentmihalyi and J. Nakamura. "The Concept of Flow." In: *Flow and the Foundations of Positive Psychology: The Collected Works of Mihaly Csikszentmihalyi*. Jan. 2002, pp. 89–92. ISBN: 9780195135336. DOI: 10.1007/978-94-017-9088-8_16.

[Dah19] A. Dahlström. *Storytelling in Design: Defining, Designing, and Selling Multidevice Products*. O'Reilly Media, 2019. Chap. 3. ISBN: 9781491959374.

[DAJ11] D. Djaouti, J. Alvarez, and J.-P. Jessel. "Classifying Serious Games: the G/P/S model." In: *Handbook of Research on Improving Learning and Motivation through Educational Games: Multidisciplinary Approaches* (Jan. 2011). DOI: 10.4018/978-1-60960-495-0.ch006.

[DC17a] J. Doran and M. Casanova. "The Strategy pattern explained." In: *Game Development Patterns and Best Practices*. Packt Publishing, 2017. ISBN: 9781787126961.

[DC17b] J. Doran and M. Casanova. "What is a Singleton?" In: *Game Development Patterns and Best Practices*. Packt Publishing, 2017. ISBN: 9781787126961.

[Det+11] S. Deterding, R. Khaled, L. Nacke, and D. Dixon. "Gamification: Toward a definition." In: *CHI 2011 Gamification Workshop Proceedings*. Jan. 2011, pp. 12–15.

[Doh+18] S. M. Doherty, J. R. Keebler, S. S. Davidson, E. M. Palmer, and C. M. Frederick. "Recategorization of Video Game Genres." In: *Proceedings of the Human Factors and Ergonomics Society Annual Meeting* 62.1 (2018), pp. 2099–2103. DOI: 10.1177/1541931218621473.

[DW04] R. DeMaria and J. Wilson. *High Score!: The Illustrated History of Electronic Games*. Computer Games Series. McGraw-Hill/Osborne, 2004. ISBN: 9780072231724.

[Ent20] Entertainment Software Association. *Essential Facts About the Computer and Video Game Industry 2020*. https://www.theesa.com/wp-content/uploads/2020/07/2020-ESA_Essential_facts_070820_Final_lowres.pdf/, last accessed on 22.08.2020. July 2020.

[Fyb19] Fyber. *2019 State of In-App Advertising and Monetization*. https://blog.fyber.com/2019-state-of-in-app-advertising-and-monetization, last accessed on 17.08.2020. Sept. 2019.

[Gam20] Gamesmarkt. *Deutscher Mobile-Markt liegt bei 1,8 Milliarden Euro*. https://www.mediabiz.de/games/news/x/452346?NL=gmd&uid=m80748&ausg=20200722&lpos=Main_1, last accessed on 19.08.2020. July 2020.

[Gita] *Git*. https://git-scm.com/book/en/v2/Getting-Started-About-Version-Control.

[Gitb] *Github*. https://github.com/.

[GKM18] X. Gu, P. K. Kannan, and L. Ma. "Selling the Premium in Freemium." In: *Journal of Marketing* 82 (Oct. 2018), p. 002224291880717. DOI: 10.1177/0022242918807170.

[Goe19a] O. Goethe. *Gamification Mindset*. 1st. Springer International Publishing, 2019. Chap. 2, p. 15. ISBN: 9783030110789.

[Goe19b] O. Goethe. *Gamification Mindset*. 1st. Springer International Publishing, 2019. Chap. 2, pp. 21–22. ISBN: 9783030110789.

[Goe19c] O. Goethe. *Gamification Mindset*. 1st. Springer International Publishing, 2019. Chap. 9, pp. 95–97. ISBN: 9783030110789.

[Goe19d] O. Goethe. *Gamification Mindset*. 1st. Springer International Publishing, 2019. Chap. 2, pp. 20–21. ISBN: 9783030110789.

[Goe19e] O. Goethe. *Gamification Mindset*. 1st. Springer International Publishing, 2019. Chap. 2, p. 14. ISBN: 9783030110789.

[Hel] *Helix Jump*. https://play.google.com/store/apps/details?id=com.h8games.helixjump.

[HH12] K. Huotari and J. Hamari. "Defining Gamification: A Service Marketing Perspective." In: *Proceeding of the 16th International Academic MindTrek Conference*. MindTrek '12. Tampere, Finland: Association for Computing Machinery, 2012, pp. 17–22. ISBN: 9781450316378. DOI: 10.1145/2393132.2393137.

[HM20] M. Helmefalk and L. Marcusson. *Utilizing Gamification in Servicescapes for Improved Consumer Engagement*. IGI Global, 2020. Chap. 2, p. 27. ISBN: 9781799819707. DOI: 10.4018/978-1-7998-1970-7.

[HON18] J. T. Harviainen, J. Ojasalo, and S. Nanda Kumar. "Customer preferences in mobile game pricing: a service design based case study." In: *Electronic Markets* 28.2 (May 2018), pp. 191–203. ISSN: 1422-8890. DOI: 10.1007/s12525-018-0285-6.

[HTC] *HTC Desire 12+*. https://www.htc.com/de/smartphones/htc-desire-12-desire-12-plus/.

[Hua] *Huawei AppGallery*. https://consumer.huawei.com/en/mobileservices/appgallery/.

[ISO19] ISO 9241-210:2019(en). *Ergonomics of human-system interaction — Part 210: Human-centred design for interactive systems*. Standard. Geneva, CH: International Organization for Standardization, Mar. 2019.

[Jun20] C. Jung. "The role of game genres and gamers' communication networks in perceived learning." In: *Palgrave Communications* 6 (Dec. 2020). DOI: 10.1057/s41599-020-0439-y.

[JWG19] Y. Ji, R. Wang, and Q. Gou. "Monetization on Mobile Platforms: Balancing in-App Advertising and User Base Growth." In: *Production and Operations Management* 28 (May 2019). DOI: 10.1111/poms.13035.

[Kap13] K. Kapp. *Two Types of Gamification*. http://karlkapp.com/two-types-of-gamification/, last accessed on 11.09.2020. Mar. 2013.

[Kap14] K. Kapp. *Game Element: Feedback*. http://karlkapp.com/game-element-feedback/, last accessed on 11.09.2020. Aug. 2014.

[Kap15] K. Kapp. *Game Element: Balance*. http://karlkapp.com/game-element-balance/, last accessed on 11.09.2020. Aug. 2015.

[KC13] K. Kapp and J. Coné. *What Every Chief Learning Officer Needs to Know about Games and Gamification for Learning*. http://karlkapp.com/wp-content/uploads/2013/01/clo_gamification.pdf, last accessed on 11.09.2020. Jan. 2013.

[Kim+16] C. Kimberly, T. Y. Lim, C. W. Khong, and C. Y. Wong. "Usability and Player Experience of Input Device for Mobile Gaming." In: *International Journal of Mobile Human Computer Interaction* 8 (July 2016), pp. 52–69. DOI: 10.4018/IJMHCI.2016070104.

[Kom19] Kommandotech. *Mobile Killed the PC Star: Mobile Gaming Statistics for 2020*. https://kommandotech.com/statistics/mobile-gaming-statistics/, last accessed on 20.08.2020. Dec. 2019.

[KW11] C. Kimberly and C. Y. Wong. "Mobile input devices for gaming experience." In: *Proceedings - 2011 International Conference on User Science and Engineering, i-USEr 2011* (Nov. 2011). DOI: 10.1109/iUSEr.2011.6150542.

[Lac18] M. Lacey. *Usability Matters: Practical UX for Developers and other Accidental Designers*. Manning Publications, 2018. Chap. 5. ISBN: 9781617293 931.

[Lin] *LinkedIn*. www.linkedin.com.

[Lin19] T. Lindemann. www.thomas-lindemann.com/en/gamification-en/how-linkedin-uses-gamification-to-boost-engagement/, last accessed on 25.07.2020. Jan. 2019.

[Mar15] A. Marczewski. *Grinding to Mastery and Flow*. https://www.gamified.uk/2015/11/17/grinding-to-mastery-and-flow/, last accessed on 11.09.2020. Nov. 2015.

[Mar18] A. Marczewski. "The Science of Gamification." In: *Even Ninja Monkeys Like to Play: Unicorn Edition*. Independently Published, 2018. ISBN: 9781724017109.

[Mar19] A. Marczewski. *Stop Using Flow as an Objective in Gamification*. https://www.gamified.uk/2019/06/27/stop-using-flow-as-an-objective-in-gamification/, last accessed on 11.09.2020. June 2019.

[Mas43] A. H. Maslow. "A theory of human motivation." In: *Psychological Review* (1943).

[MC10] L. McKnight and B. Cassidy. "Children's Interaction with Mobile Touch-Screen Devices: Experiences and Guidelines for Design." English. In: *International Journal of Mobile Human Computer Interaction* 2 (Apr. 2010). Report. ISSN: 1942390X.

[Mic] *Microsoft Visual Studio*. https://visualstudio.microsoft.com/.

[Mob19] Mobile Free To Play. *Top 10 Game Mechanics for Hyper Casual Games*. https://mobilefreetoplay.com/top-10-game-mechanics-for-hyper-casual-games/, last accessed on 23.08.2020. Jan. 2019.

[Moo16] M. Moore. *Basics of Game Design*. CRC Press, 2016. Chap. 2. ISBN: 9781439867761.

[MS16a] C. Macklin and J. Sharp. *Games, Design and Play: A detailed approach to iterative game design*. Game Design. Pearson Education, 2016. Chap. 6. ISBN: 9780134392226.

[MS16b] C. Macklin and J. Sharp. *Games, Design and Play: A detailed approach to iterative game design*. Game Design. Pearson Education, 2016. Chap. 5. ISBN: 9780134392226.

[New19] Newzoo. *Newzoo's Global Mobile Market Report: Insights into the World's 3.2 Billion Smartphone Users, the Devices They Use & the Mobile Games They Play*. https://newzoo.com/insights/articles/newzoos-global-mobile-market-report-insights-into-the-worlds-3-2-billion-smartphone-users-the-devices-they-use-the-mobile-games-they-play/, last accessed on 18.08.2020. Sept. 2019.

[New20] Newzoo. *The World's 2.7 Billion Gamers Will Spend $159.3 Billion on Games in 2020; The Market Will Surpass $200 Billion by 2023*. https://newzoo.com/insights/articles/newzoo-games-market-numbers-revenues-and-audience-2020-2023/, last accessed on 18.08.2020. May 2020.

[Pho14] Phone Arena. *This was the world's first cell phone with a game loaded on it*. https://www.phonearena.com/news/This-was-the-worlds-first-cell-phone-with-a-game-loaded-on-it_id62920, last accessed on 18.08.2020. Oct. 2014.

[Poc20] PocketGamer. https://www.pocketgamer.biz/metrics/app-store/submissions/, last accessed on 20.08.2020. Aug. 2020.

[Pos09] S. Poslad. *Ubiquitous Computing: Smart Devices, Environments and Interactions*. Wiley, 2009. Chap. 1, p. 29. ISBN: 9780470779453.

[Pri19a] PrioriData. *Leading mobile gaming app titles in the Google Play Store worldwide as of January 2019, by number of downloads*. https://www.statista.com/statistics/688372/leading-mobile-games-google-play-worldwide-downloads/, last accessed on 30.08.2020. Jan. 2019.

[Pri19b] PrioriData. *Leading mobile gaming app titles in the Google Play Store worldwide as of January 2019, by revenue (in million U.S. dollars)*. https://www.statista.com/statistics/690150/leading-mobile-games-google-play-world-revenue/, last accessed on 20.08.2020. Jan. 2019.

[Pro20] ProfitWell. *Guide to Subscription Business Models for 2019*. https://www.priceintelligently.com/blog/subscription-business-model, last accessed on 17.08.2020. May 2020.

[PUB] *PUBG: Mobile*. https://www.pubgmobile.com/.

[Pub20] Pubnative. *From Tetris to Candy Crush: The History of Mobile Gaming*. https://pubnative.net/blog/from-tetris-to-candy-crush-the-history-of-mobile-gaming, last accessed on 19.08.2020. Apr. 2020.

[Rad19] Radicati. *Mobile Statistics Report, 2019-2023*. https://www.radicati.com/wp/wp-content/uploads/2019/01/Mobile_Statistics_Report,_2019-2023_Executive_Summary.pdf, last accessed on 19.08.2020. Jan. 2019.

[RD00] R. Ryan and E. Deci. "Self-Determination Theory and the Facilitation of Intrinsic Motivation, Social Development, and Well-Being." In: *The American psychologist* 55 (Feb. 2000), pp. 68–78. DOI: 10.1037/0003-066X.55.1.68.

[RD17a] R. M. Ryan and E. L. Deci. *Self-Determination Theory : Basic Psychological Needs in Motivation, Development, and Wellness.* The Guilford Press, 2017. Chap. 1, pp. 10–11. ISBN: 9781462528769.

[RD17b] R. M. Ryan and E. L. Deci. *Self-Determination Theory : Basic Psychological Needs in Motivation, Development, and Wellness.* The Guilford Press, 2017. Chap. 4, p. 86. ISBN: 9781462528769.

[RLL11] J. Ruiz, Y. Li, and E. Lank. "User-defined motion gestures for mobile interaction." In: *Conference on Human Factors in Computing Systems - Proceedings* (May 2011), pp. 197–206. DOI: 10.1145/1978942.1978971.

[RRP06] R. M. Ryan, C. S. Rigby, and A. Przybylski. "The Motivational Pull of Video Games: A Self-Determination Theory Approach." In: *Motivation and Emotion* 30.4 (Dec. 2006), pp. 344–360. ISSN: 1573-6644. DOI: 10.1007/s11031-006-9051-8.

[Sam] *Samsung Galaxy Store*. https://www.samsung.com/levant/apps/galaxy-store/.

[SAS17] T. Shittu, L. Abdullah, and P. Sulaiman. "A Review on Interaction Techniques on Mobile Phones." In: *International Journal of Information Systems and Engineering* 5 (Nov. 2017), pp. 72–79. DOI: 10.24924/ijise/2017.04/v5.iss2/72.79.

[SC18] S. Subhash and E. A. Cudney. "Gamified learning in higher education: A systematic review of the literature." In: *Computers in Human Behavior* 87 (2018), pp. 192–206. ISSN: 0747-5632. DOI: https://doi.org/10.1016/j.chb.2018.05.028.

[Sel17] M. Sellers. *Advanced Game Design: A Systems Approach*. Addison-Wesley game design and development series. Addison-Wesley, 2017. Chap. 6. ISBN: 9780134668185.

[Sen20] SensorTower. *PUBG Mobile Generates $500 Million in Just Over Two Months as it Races Past $3.5 Billion Lifetime Revenue*. https://sensortower.com/blog/pubg-mobile-three-point-five-billion-revenue/, last accessed on 11.09.2020. Sept. 2020.

[Sha19] Shared2you. *Market reach of the most popular Android gaming app genres worldwide in 3rd quarter 2019*. https://www.statista.com/statistics/515399/global-reach-popular-android-game-genres/, last accessed on 20.08.2020. Oct. 2019.

[SS19a] J. Schell and a. O. M. C. Safari. *The Art of Game Design, 3rd Edition*. A K Peters/CRC Press, 2019. Chap. 2.

[SS19b] J. Schell and a. O. M. C. Safari. *The Art of Game Design, 3rd Edition*. A K Peters/CRC Press, 2019. Chap. 5.

[SS19c] J. Schell and a. O. M. C. Safari. *The Art of Game Design, 3rd Edition*. A K Peters/CRC Press, 2019. Chap. 12.

[Sta20a] Statcounter. *Mobile Operating System Market Share Worldwide*. https://gs.statcounter.com/os-market-share/mobile/worldwide/#monthly-201901-201912, last accessed on 17.08.2020. Aug. 2020.

[Sta20b] Statista. *Most popular new mobile games worldwide in 2019, by number of downloads (in millions)*. https://www.statista.com/statistics/1111116/new-mobile-game-downloads/, last accessed on 20.08.2020. May 2020.

[Tak20] D. Takahashi. *App Annie: Mobile game spending will top $100 billion in 2020*. https://venturebeat.com/2020/01/15/app-annie-mobile-game-spending-is-expected-to-top-100-billion-in-2020/, last accessed on 19.08.2020. Jan. 2020.

[Ter08] B. Terrill. *My Coverage of Lobby of the Social Gaming Summit*. www.bretterrill.com/2008/06/my-coverage-of-lobby-of-social-gaming.html, last accessed on 24.07.2020. June 2008.

[Unia] Unity Technologies. *Cameras Overview*. https://docs.unity3d.com/Manual/CamerasOverview.html, last accessed on 27.08.2020.

[Unib] Unity Technologies. *Event Functions*. https://docs.unity3d.com/Manual/EventFunctions.html, last accessed on 27.08.2020.

[Unic] Unity Technologies. *Important Classes - GameObject*. https://docs.unity3d.com/Manual/class-GameObject.html, last accessed on 27.08.2020.

[Unid] Unity Technologies. *Rigidbody*. `https://docs.unity3d.com/Manual/class-Rigidbody.html`, last accessed on 27.08.2020.

[Unie] Unity Technologies. *Unity Distribution Platform*. `https://unity.com/unity-distribution-portal`, last accessed on 27.08.2020.

[Unif] Unity Technologies. *Unity Platform*. `https://unity.com/products/unity-platform`, last accessed on 27.08.2020.

[Vgc20a] Vgchartz. *Platform Totals*. `https://www.vgchartz.com/analysis/platform_totals/`, last accessed on 20.08.2020. Aug. 2020.

[Vgc20b] Vgchartz. *Switch vs PS4 vs Xbox One Global Lifetime Sales - July 2020 - Sales*. `https://www.vgchartz.com/article/444801/switch-vs-ps4-vs-xbox-one-global-lifetime-sales-july-2020/`, last accessed on 19.08.2020. Aug. 2020.

[ZC11] G. Zichermann and C. Cunningham. *Gamification by Design: Implementing Game Mechanics in Web and Mobile Apps*. 1st. O'Reilly Media, Inc., 2011. Chap. Introduction, p. xiv. ISBN: 1449397670.