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An approach to improve hint systems in video games: balancing player-triggered and game-triggered hints

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Master in Computer Engineering

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TECHNOLOGY
AND ARCHITECTURE

Department of Information Science and Technology

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I dedicate this dissertation to my parents and my brother.

Acknowledgment

I would like to thank my parents and my brother for the support and words of encouragement they gave me during the development of the dissertation. I also want to thank my supervisor, Pedro Santana for helping me a lot during this year, for clarifying doubts that arose during the development of the dissertation. Finally, I want to thank the participants that took their time to participate in this experiment.

Resumo

Os videojogos incluem frequentemente sistemas de dicas para melhorar a experiência do jogador. Estes sistemas podem desencadear dicas automaticamente ou ser invocados pelo jogador, dependendo da intenção do jogador. Compreender como os diferentes métodos de entrega de dicas afetam a experiência do jogador é essencial para informar o design do jogo. No entanto, faltam estudos sistemáticos sobre o impacto das estratégias de entrega de dicas na experiência do jogador. Esta dissertação aborda esta lacuna de duas formas. Em primeiro lugar, apresenta um jogo de corrida contrarrelógio com quatro estratégias distintas de entrega de dicas: dicas aleatórias fornecidas sem a aceitação do jogador; dicas aleatórias fornecidas apenas se aceites pelo jogador; dicas relacionadas com falhas fornecidas sem exigir a aceitação do jogador; e dicas relacionadas com falhas fornecidas apenas se aceites pelo jogador. Em segundo lugar, apresenta resultados empíricos de testes do jogo com 40 participantes, mostrando diferenças na preferência dos jogadores em relação à entrega de dicas. Estas descobertas fornecem evidências empíricas sobre a relação entre a entrega de dicas e a experiência do jogador, oferecendo informações valiosas para os designers dos jogos. Além disso, espera-se que o jogo desenvolvido sirva como uma ferramenta útil para os investigadores que desejam explorar ainda mais os efeitos dos sistemas de dicas na experiência do jogador.

Palavras Chave: *Videojogos*, *Experiência do Jogador*, *Sistemas de Dicas*

Abstract

Video games often include hint systems to enhance the player experience. These systems can either trigger hints automatically or be invoked by the player, depending on the game designer intention. Understanding how different hint delivery methods affect player experience is essential for informing game design. However, there is a lack of systematic studies on the impact of hint delivery strategies on player experience. This dissertation addresses this gap in two ways. First, it introduces a time-trial racing game featuring four distinct hint delivery strategies: random hints provided without the player acceptance; random hints provided only if accepted by the player; failure-related hints provided without requiring player acceptance; and failure-related hints provided only if accepted by the player. Second, it presents empirical results from testing the game with 40 participants, showing differences in player preference regarding hint delivery. These findings provide empirical evidence on the relationship between hint delivery and player experience, offering valuable insights for game designers. Additionally, the developed game is expected to serve as a useful tool for researchers aiming to explore the effects of hint systems on player experience further.

KEYWORDS: *Video Games*, *Player Experience*, *Hint Systems*

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List of Acronyms

DSRPM: Design Science Research Process Model
IT: Information Technology
NPC: Non-Playable Character
GEQ: Game Experience Questionnaire
PENS: Player Experience of Need Satisfaction
PC: Personal Computer
UI: User Interface

CHAPTER 1

Introduction

1.1. Context

Video Games represent a modern form of entertainment, transforming traditional forms of entertainment into an interactive form that enables the player to actively impact the game world [1]. Video Games have evolved into interactive entertainment systems with a significant economic influence on society. Unlike other systems, such as educational systems, productivity software or utilitarian applications, their focus is providing entertainment and enjoyment to the player [2]. Video Games are designed for interaction, so that players can be involved with the system, which responds to their actions and choices [3]. These systems provide players with opportunities for chance, competition and role-playing, as well as the flexibility to follow structured rules or engage in open-ended, exploratory play [4].

Video Games can be played alone or with others, whether being in the same room (Co-op) or online [3]. Games can be seen has a contest to reach a goal or objective, fulfilling the players needs for freedom, social interaction and control. To win the game, players must gather information while navigating through the game world, and this render video games a precious tool for skill development and learning [5].

1.2. Motivation

In the dynamic world of video game design, hint systems play a pivotal role in shaping the players interactions and experience. These systems provide players with guidance, assistance and feedback as they are confronted with challenges presented by the game world [6]. Hints in video games can be grouped into two types: Player-triggered hints are those that are activated only via the player direct interaction. On the other hand, game-triggered hints are automatically provided by the game without the need of the player input. However, finding the ideal balance between player-triggered and game-triggered hints is a challenging task that increases the attention within the field of game design.

The design of the hint systems directly influences the players engagement and satisfaction. Specific hints that are related to the players goals can improve the game experience by minimizing cognitive load. Adaptive hint systems that are modified based on player behavior can offer necessary guidance without the player being overwhelmed with information. Sylvester [6] pointed out that in the game "Left 4 Dead", an adaptive training system for new and inexperienced players was used; specifically, in critical situations, the novice players get a message/hint to help their friend, depending on the circumstance, the hint being related to game objectives and getting resources.

This dissertation is motivated by the chance to create hint delivery strategies in video games to improve the player experience. The player-triggered and game-triggered hints have the potential to improve the player interaction with the game. When the players feel free to request guidance when needed, their sense of agency and control improves the gaming experience. In contrast, providing timely assistance without interrupting the players flow can reduce frustration, specially in a more difficulty section of a game. Attaining the right balance between these two types of hints is crucial, as it guarantees that the players receive the help that they need, while still being engaged and controlling their gameplay experience. A better understanding of this balance is vital for improving hint systems and overall player satisfaction.

1.3. Research Questions

Before introducing the research questions, it is important to explain what types of hints systems were created and analyzed in this dissertation. First, with the Random Hints system, hints appear at random intervals for a temporarily duration. The Random Hints with On-Demand option system, which is similar to the Random Hints system, adds an approval mechanic, so that players have the option to accept hints. The On-Failure Hints system displays the hints only when the player fails at a task. Finally, the On-Failure Hints with On-Demand option system, which is the same has the Random Hints with On-Demand option system, but instead of the hints appearing randomly, they emerge upon failure.

This dissertation pretends to answer the following research questions:

(1) What types of hints systems improve the player experience?
(2) What preferences do players have regarding the types of hint systems?

1.4. Objectives

The objectives for this dissertation are to compare player-triggered hints and game-triggered hints, ensuring that the hints are balanced. This dissertation also explores the effects of differing hints systems on player experience. Finally, this dissertation presents the design, development and validation of the framework to provide a reference point for future research and to provide empirical information to inform game designers on how to present hints effectively to the players.

1.5. Research Methodology

For this study, the Design Science Research Process Model (DSRPM) is the methodology used [7]. This process incorporates 5 steps: Awareness of Problem, Suggestion, Development, Evaluation and Conclusion. These steps are illustrated in Figure 1.

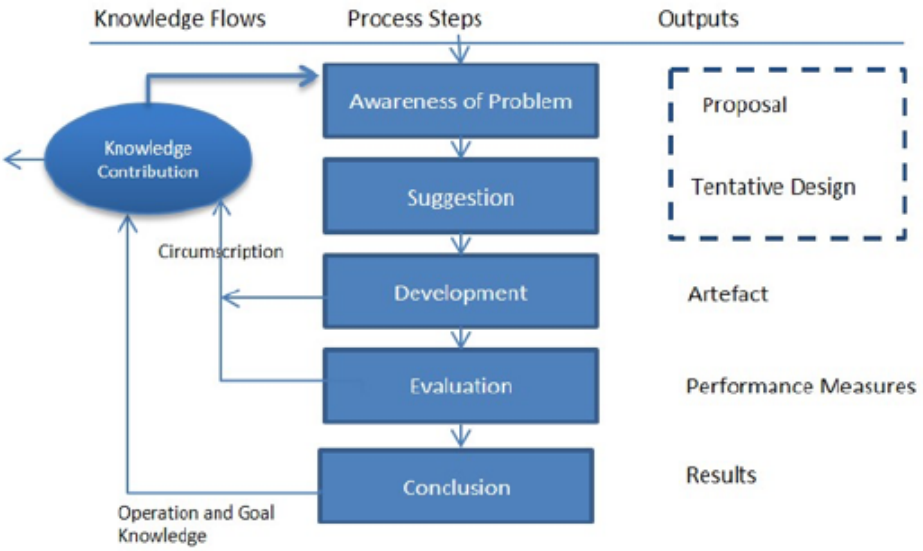

FIGURE 1.1. DSRPM (from [8])

The DSRPM is suitable to the game design and IT systems due to its interactive design and development cycles to solving problems and creating solutions. It offers an adaptive and systematic approach to problem-solving and innovation. The process model is appropriate for this study because all of its steps correspond precisely with the intended research methodology.

Awareness of Problem

Before deciding on the theme, various options related to hint systems were evaluated. Among them, the topic of comparing and balancing game-triggered and player-triggered hints in video games is the most interesting. This approach was selected due to its rarity and uncommon nature in game design. So the problem identified is determining if it is possible to develop hint systems that can integrate these two types of hints and ensuring both of them are balanced.

Suggestion

Once the problem was identified, ideas were presented regarding different types of hints and how they were going to be displayed in the game. Initial concepts were visualized through drawings, which shows each specific type of hint. These drawings are illustrated in Chapter 3 "Game Design and Development", subsection 3.1 "Storyline and Drawings".

Development

The game was developed based on the suggestion proposed in the previous step. The initial testing of this solution did not get satisfactory results, so the solution was refined, resulting in better performance. The new solution is detailed in Chapter 3 "Game Design

and Development", subsection 3.2 "Game Development", and sub-subsection 3.2.3 "Hint Systems Types".

Evaluation

The evaluation part involved testing the solution with participants through gameplay sessions and questionnaires. Feedback and responses were collected to assess the effectiveness of the solution implemented and the testers opinions on the game. The evaluation is detailed in Chapter 4 "Results Evaluation".

Conclusion

The conclusion was reached after analyzing the information collect from the questionnaires and opinions of the participants on the solution implemented, determine whether the solution was a success to the problem initially proposed. The conclusion is presented in Chapter 5 "Conclusion and Future Work".

1.6. Dissertation Structure

This dissertation is structured as follows:

(1) **Introduction**: provides an overview of the topic of the study, describing its context, problem statement, research questions, objectives, process model and the dissertation structure.

(2) **Literature Review**: offers a review of the literature, discussing relevant topics and theories that are related to the theme of this dissertation.

(3) **Game Design and Development**: describes the processes involved in the project design and development.

(4) **Evaluation**: presents an analysis of the results collected, directed on the project evaluation and the feedback from participants.

(5) **Conclusion and Future Work**: summarizes the key results from the research and proposes potential direction for the future work.

CHAPTER 2

Literature Review

2.1. Game Design

Rouse [9] defines game design as the process of determining how gameplay functions and what choices and decisions the player will make within a game. This definition states that the gameplay refers to the mechanics, rules and systems that govern the player actions within the game world. McGonigal [10] expands on this by suggesting that these systems can create powerful and socially impactful experiences. Gameplay includes a range from basic movements and controls to more complex interactions such as combat, puzzle-solving and making a range of choices and decisions that impact the narrative, character development and progression of the game.

Schell [11] views game design as the art of crafting meaningful experiences for players. This definition states that the game design goes beyond mechanics, incorporating narrative and psychological dimensions that shape the player engagement with the game. Fullerton [12], emphasizes the importance of player experience in design. Schell describes game design as a balance between art, crafting and science, where each design choice impacts the player interaction with the game. Schell introduced the concept of "lenses", which represents different ways of a designer to analyze various aspects of the game, such as challenge, player engagement, gameplay, storytelling to guarantee they are balanced.

Salen and Zimmerman [13] defined game design as the process through which designers create a game that players interact with, resulting in meaningful play. This definition refers to the techniques used to structure the game, with the objective of allowing player actions and decisions to result in engaging and enjoyable experiences. The designer role is to improve these interactions so as to become more immersive and meaningful for the player.

2.2. Cognitive Load

Iyer and Orji [14] define cognitive load as "the mental effort required or invested to achieve objectives of a task.". This definition means that involves understanding the rules, goals, and the game mechanics. It represents a mental workload necessary to process different pieces of information. When cognitive load is high, tasks feel mentally challenging, requiring greater concentration. On the other hand, a low cognitive load allows the brain to handle tasks more efficiently, leading to improved decision-making.

Iyer and Orji [14] designed five games for health applications, targeting various health issues, and propose various methods for measuring cognitive load within these games. These methods include "Cue and Highlighting", "Auditory or Visual Narrations" and

"Progressive Disclosure". Cue and Highlighting refers to visual or auditory cues to direct the player attention to essential information, aligning with the Signaling Principle defined by Mayer [15]. This technique helps to reduce the effects of cognitive load by minimizing the effort players need comprehending the game and its goals. Auditory or Visual Narrations distribute cognitive load across multiple sensory channels, in line with Mayer Multimedia Principle, which asserts that combining verbal and visual elements maximize cognitive resources [15]. Progressive Disclosure is a method that reveals information gradually, instead of overwhelming the players with too much information at once, breaking down the complex information into parts, providing the players with the necessary information at each step and reducing the cognitive load. This approach aligns with the principles discussed by Bannert [16], which highlights strategies that manage cognitive load by segmenting information and providing it in manageable pieces for better understanding and learning outcomes.

Kalyuga and Plass [17] defined cognitive load as "the demand on cognitive resources during problem solving and reasoning". This definition suggests that cognitive load refers to the mental effort required to process information, whether it involves completing tasks or making decisions. Kalyuga and Plass [17] identify two types of cognitive load in learning, "Intrinsic cognitive load" and "Extraneous cognitive load". Intrinsic cognitive load arises from the inherent complexity of a task and it is influenced by how its various components interact and is influenced by the learner level of expertise in the subject. On the other hand, the extraneous cognitive load results from the way information is designed or presented, such as overwhelming users with quick information or in complicated steps with the lack of support for users with limited knowledge.

In this dissertation, cognitive load is regulated through a hint system, contributing to game designers improving player experience. Well-implemented hints are expected to keep players engaged, enhance decision-making, and maintain a sense of accomplishment without overwhelming them with too much information at once. This practice reflects key cognitive load principles, which focus on controlling intrinsic load while reducing extraneous load.

2.3. Player Experience

Despite various discussions, there is no consensual way to define player experience. Psychological models aim to describe the components that contribute to player experience and identify the factors that influence it. Psychological models are categorized into two models, Generic models, which are designed to be used across various applications, including gaming, and Domain-specific models, which are created specifically for the gaming context [18]. Figure 2.1 displays the Player Experience Model.

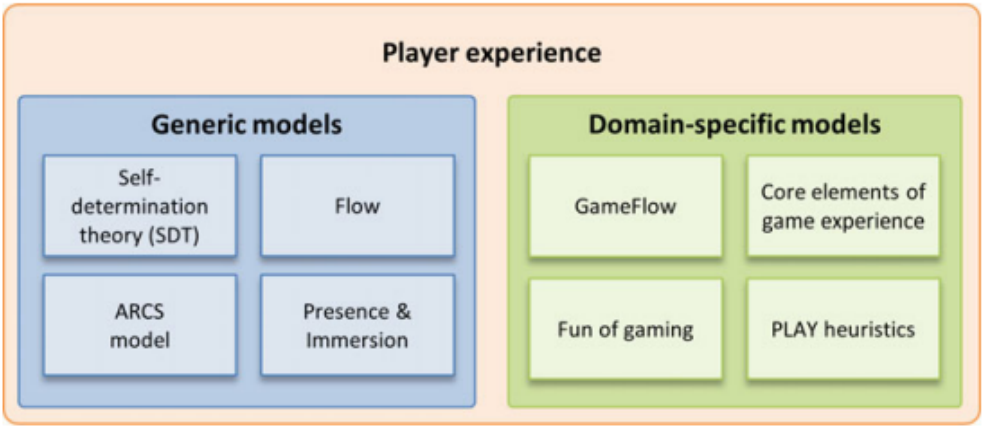

FIGURE 2.1. Player Experience Model (from [18])

Most digital games require players to engage in activities organized as a sequence of steps that involve various cognitive processes, skills and knowledge. Players typically start by identifying or defining goals, which may be partially or completely unclear, encouraging exploration. They then organize a plan to achieve these goals by problem-solving and decision-making. Following this, players take action by applying their knowledge and skills, which vary depending on the type of game. As they act, players monitor their progress and adapt their strategies as needed. After completing their actions, players evaluate the outcomes and set new goals, thus restarting the cycle. Throughout gameplay experience, players engage in inquiry, reflection, and adaption to navigate uncertainly, accept failure, and explore alternative strategies [19]. Figure 2.2 shows the steps of the game experience.

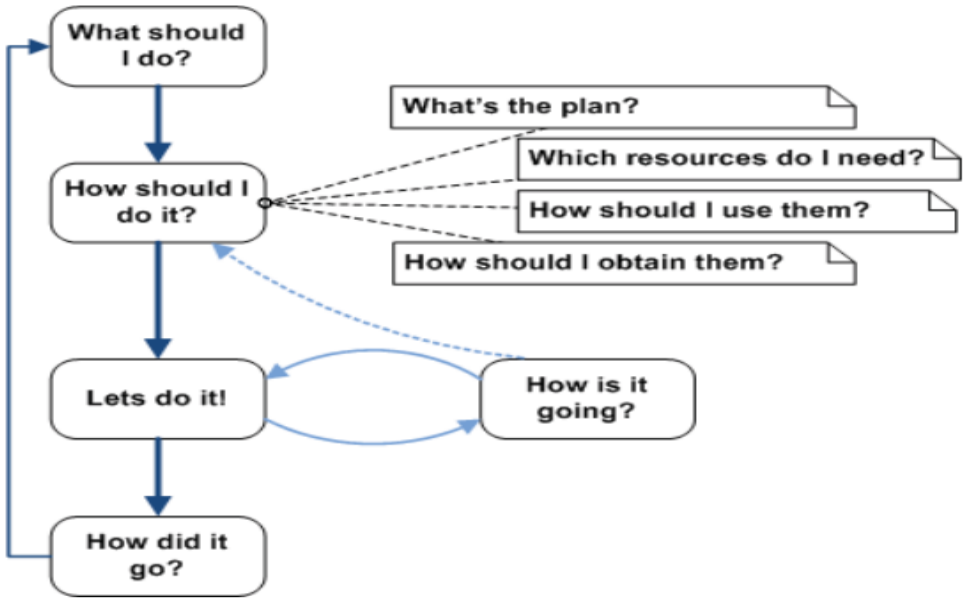

FIGURE 2.2. Steps of the game experience (from [19])

This dissertation investigates how various hint systems can improve player experience by supporting the cognitive processes by goal identification, problem-solving and strategies adaptation, resulting in facilitating the cycle of inquiry, reflection and action that players engage in during gameplay.

2.4. Flow

Schell [11] defines flow according to psychologist Mihalyi Csikszentmihalyi as "a feeling of complete and energized focus in an activity, with a high level of enjoyment and fulfillment". This definition indicates that flow occurs when a player is totally focused on a specific task or goal without distractions. Achieving this state of focus is crucial for sustaining player enjoyment and engagement. When players experience flow, they are more likely to feel satisfied, motivated, pleasured and rewarded by their interactions within the game.

To achieve flow, there must be a balance between the player interpretation of the challenge of a task and the self-assessment of their skill level related to the completion of the task. Csikszentmihalyi [20] developed a flow channel model to show this balance. If a player skill is too high compared to the difficulty of the task, they may become bored. On the other hand, if the task is too difficult for the player skill level, they may feel anxious.

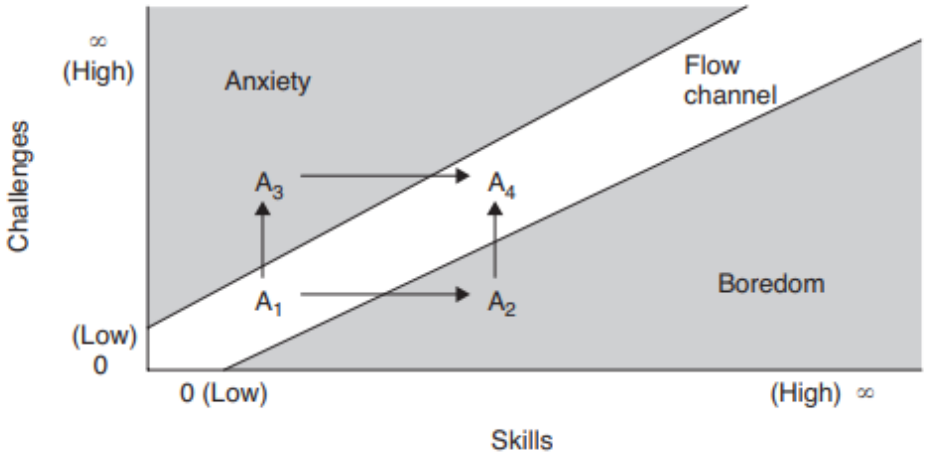

FIGURE 2.3. Flow channel model (from [11])

In Figure 2.3, the two most important dimensions of the experience, challenges and skills, are represented on the axes of the diagram. Point A represents the player. The diagram shows four different states that the player may enter and experience. At point A1, the player has no skill but can successfully complete the simple and easy tasks, finding enjoyment by doing it, and experiencing flow. At point A2, as the player keeps practicing, their skills will improve, leading to boredom with simple and easier tasks, resulting in a lack of flow. In point A3, if the player gets a more complex and difficult task without improving their skills, the players will experience anxiety, again resulting in no flow. Finally at point A4 mirrors with point A1, the player has greater skills but faces a more

challenging task, and we will be in flow. This model showcases that flow can only be achieved when challenges and skills are relatively balance.

Creating an environment that it is favorable to flow involves others factors, including game mechanics, design and player engagement, to facilitate the flow experiences.

Sweetser and Wyeth [21] also defined flow according to Csikszentmihalyi [20], as an experience that it is so deeply enjoyable and fulfilling that people are motivated to engage in activities for its own sake. Even when the task is tough or carries risks, people can find joy from the activity itself and not from focusing on external benefits.

To better study the concept of flow in video games, it is essential to develop games that fully engage the players. There are eight flow elements proposed by Jones [22] and based by Csikszentmihalyi [20] that manifest in games. These flow elements improved the immersion and enjoyment experiences for the players. Figure 2.4 illustrates the eight flow elements in video games.

Element of Flow	Manifestation in a game
1. Task that we can complete	The use of levels in games provides small sections that lead to the completion of the entire task.
2. Ability to concentrate on task	Creation of convincing worlds that draw users in. The dungeons and labyrinths in Doom II help suspend your belief systems for a time.
3. Task has clear goals	Survival, collection of points, gathering of objects and artefacts, solving the puzzle.
4. Task provides immediate feedback	Shoot people and they die. Find a clue, and you can put it in your bag.
5. Deep but effortless involvement (losing awareness of worry and frustration of everyday)	The creation of environments far removed from what we know to be real helps suspend belief systems and takes us away from the ordinary.
6. Exercising a sense of control over their actions	Mastering controls of the game, such as a mouse movement or keyboard combinations.
7. Concern for self disappears during flow, but sense of self is stronger after flow activity	Many games provide for an environment that is a simulation of life and death. One can cheat death and not really die People stay up all night to play these games. It is the creation of an integration of representation, problem, and control over systems that promotes this.
8. Sense of duration of time is altered.	Years can be played out in hours; battles can be conducted in minutes. The key point is that people stay up all night playing these games.

FIGURE 2.4. Eight Elements of Flow manifested in games (from [22])

The combination of these elements creates a profound sense of satisfaction so rewarding that people are willing to put a significant amount of effort simply to experiencing it [20] [21]. Most Flow experiences are likely to happen during activities that have clear goals, are governed by rules, and demand mental effort and the appropriate level of skill.

In the context of hint systems, flow refers to how well the hints are designed to keep players engaged without disrupting frustration or boredom. For a hint system to contribute to flow, it necessitates the right balance between assisting the player and maintaining the gameplay challenging. This dissertation will examine the most effective methods for displaying hints to improve player experience.

2.5. Hint Systems

The goal of a hint system is to support players in overcoming obstacles by providing hints or offering them the choice to receive assistance. Among the various types of hints, two common categories are player-triggered and game-triggered hints.

Player-triggered hints are hints that players can request from the game when they feel lost, stuck or need assistance. For example, players might ask a Non-Playable Character (NPC) to give them hints on how to progress in the game. The advantages of these hints is that they allows players to retain control, making it ideal for those who prefer self-directed gameplay or want to face a challenge before seeking assistance. However, there are disadvantages, as some players may not realize they can ask for help or may feel hesitant to do so, leading to a potential frustration.

Game-triggered hints are hints that the game provides automatically to the players when they encounter difficulties. For example, if a player fails to overcome a specific obstacle in a racing game, the game offer hints automatically after a certain amount of failed attempts. In an adventure game, if a player gets stuck on a specific area and can not process, the game gives automatically hints to guide them. These hints can be helpful to prevent frustration for players who may not be aware of available assistance or are too reluctant to ask for it. However, some players may find these hints intrusive or feel that they spoil the challenge by offering help too early or too frequently.

Schell [11] pointed out that in a game called "Hasbro's Nemesis Factor", it was featured a "hint" button, that players can press to receive a brief one or two worded hint. This type of hint is classified as a player-triggered hint.

Rourke et al. [23] developed a game called "Refraction", which is an educational puzzle game that requires the players to interact with a grid containing asteroids, target spaceships and laser resources. They implemented two types of hints: the first type embeds hints directly into the Refraction levels, making them part of the environment, while the second type provide hints based on the progression of the player in the game. Both of these are classified as game-triggered hints.

Wauck and Fu [24] created a puzzle game called "Three Body Puzzle", where the objective is to align two red arrows with two yellow squares simultaneously, with the player-controlled blue arrow synced to the red arrows. They implemented three types of hints: on-demand, which are player-triggered, and adaptive and automatic hints, which are classified as game-triggered hints.

This dissertation seeks to deepen our understanding of the value of these various types of hints in video games and their impact on player experience.

2.6. Demographics and Questionnaires

Each player is unique, which resulting in a unique gaming experience. To differentiate among players, it is crucial to measure their experience. One effective method for comparing the player characteristics is to segment the target group onto groups based on age and then use a questionnaire adaptable to those groups.

The two most common demographic factors to measure the player experience is by age and gender [25]. The focus will be age, as the player characteristics change significantly when they grow older. Schell [11] suggested nine different age groups when developing games:

(1) **0-3: Infant/Toddler**: Interested in toys, games are to complex and problem solving for them.
(2) **4-6: Preschooler**: Shows first signs of interest in games, they are simple games, they are often played with their parents.
(3) **7-9: Kids**: Able to think and solve problems, they become more interested in games.
(4) **10-13: Preteen or "Tween"**: Able to experience intense interests, especially, if you are a male, in games.
(5) **13-18: Teen**: Preparing for adulthood, diverge interests between genders, boys still become interested in games, unlike girls become interested in more real world issues.
(6) **18-24: Young Adult**: Playing less than children, but still consume games, with time and money.
(7) **25-35: Twenties and Thirties**: Time becomes more precise, more casual game players, some are hardcore players.
(8) **35-50: Thirties and Forties**: Busy with work and family, still casual game players, more focus on family games.
(9) **50+: Fifties and Up**: Have a lot of free time, interested in social games and new experiences.

Typically, younger groups undergo separations marked by experiences of mental development, while older groups are primarily defined by changes in family transitions.

One of the most commonly used questionnaires to assess player experience is the Game Experience Questionnaire (GEQ). The GEQ is a tool designed to gather feedback on player experience with video games, aiming to capture various aspects of the gaming experience. The GEQ has a modular structure, consisting of: the GEQ Core Module, the Post-Game Questionnaire (PGQ) and the Social Presence Module (SPGQ) [25].

The GEQ consists of seven components to measure the player experience [26]: Competence, Sensory and Imaginative Immersion, Flow, Tension/Annoyance, Challenge, Negative Affect and Positive Affect. Competence measures how players view their own abilities and effectiveness in the game. Sensory and Imaginative Immersion assesses how deeply players are fully engaged and captivated by the virtual environment of the game. Flow

describes the complete focus that the players experience when fully engaged in a challenge. Tension/Annoyance assesses the degree of stress or irritation that players feel when playing a game. Challenge evaluates how difficult players find the game. Negative Affect measures the negative emotions such as frustration, boredom and dissatisfaction, while Positive Affect captures the positive emotions such as satisfaction, enjoyment and excitement. Several items from the GEQ overlap with those in the Player Experience of Need Satisfaction (PENS) questionnaire [27].

PENS is often used in player design to measure player experience. It describes the manner in which experiences satisfy universal needs (competence, autonomy and relatedness) factors that contribute to the motivation and the overall well-being [27].

The PENS consists of five components [27]: Competence, Autonomy, Relatedness, Presence/Immersion, and Intuitive Controls. Competence is assessed with items that measures how skilled players feel during their gaming experience. Autonomy is gauge through items that evaluate how much freedom and control players have over their actions and decisions in the game. Relatedness is assessed through items that determines how much the players feels connected to other players in the game. Presence/Immersion, indicated by nine items, focuses on how emotionally involved players feel while being engaged in the game. Intuitive Controls is assessed with items, indicating the degree to which players can translate their decision or choices into actions within the game [27].

For this dissertation, the GEQ is the questionnaire selected to assess the overall impact of hint systems on player experience. The GEQ was chosen to capture a wide range of emotional and cognitive responses so as to better understand how players feel when interacting with different hint systems during gameplay.

2.7. Contribution

This dissertation contributes to the field of game design by studying the impact of player experience from improving hint systems in video games by prioritizing the balance between player-triggered and game-triggered hints. The primary contribution lies on the evaluation of four different types of hint delivery strategies in player experience: Random Hints, Random Hints with On-Demand approval, On-Failure Hints and On-Failure Hints with On-Demand approval.

By evaluating these systems based on their impact on player satisfaction and engagement, this dissertation aims at identifying which types of hints are most effective in enhancing the overall gaming experience.

CHAPTER 3

Game Design and Development

This chapter presents the game design and development, organized by 2 sections. Section 3.1 presents the game design, whereas Section 3.2 covers the game development.

3.1. Game Design

In this study, this section consists of a storyline and examples of drawings. The game design is going to be done in an iterative way to make sure there is a solution on what is the task of the hints in this dissertation. These sketches were created to ensure proper planning and clarity of the game and its hint systems. The storyline of the game involves a virtual character, which wants to become a time trial expert, with his muscle car (car that it is used in the game). The character wants to do the best time recorded on the track. Figure 3.1 illustrates the initial sketch of game track. The track is designed to offer an easy to medium level difficulty. The track consists of jumping sections that require speed to surpass, curves that are easier to navigate by using the car drift, bumping roads sections to increase the challenge, and a jumping area that has a big wall that contains a small gap where the character car has to go through. This jump requires both speed and precision. Figure 3.2 provides an example of a initial sketch for an on-demand hint, which only appears when the participant accepts its approval. Figure 3.3 displays a initial sketch for an random hint, where the game presents a hint at certain intervals. Finally, the Figure 3.4 demonstrates an example of a initial sketch for an on-failure hint, in which the game offers assistance on how to overcome a obstacle after failing a number of occasions. The initial sketches were changed to four types of Hint System modes, based on feedback from participants during practice sessions. These sessions were used to identify bugs and to test the Hint System, it became evident that the system was unbalanced. Resulting in changing and adjusting it.

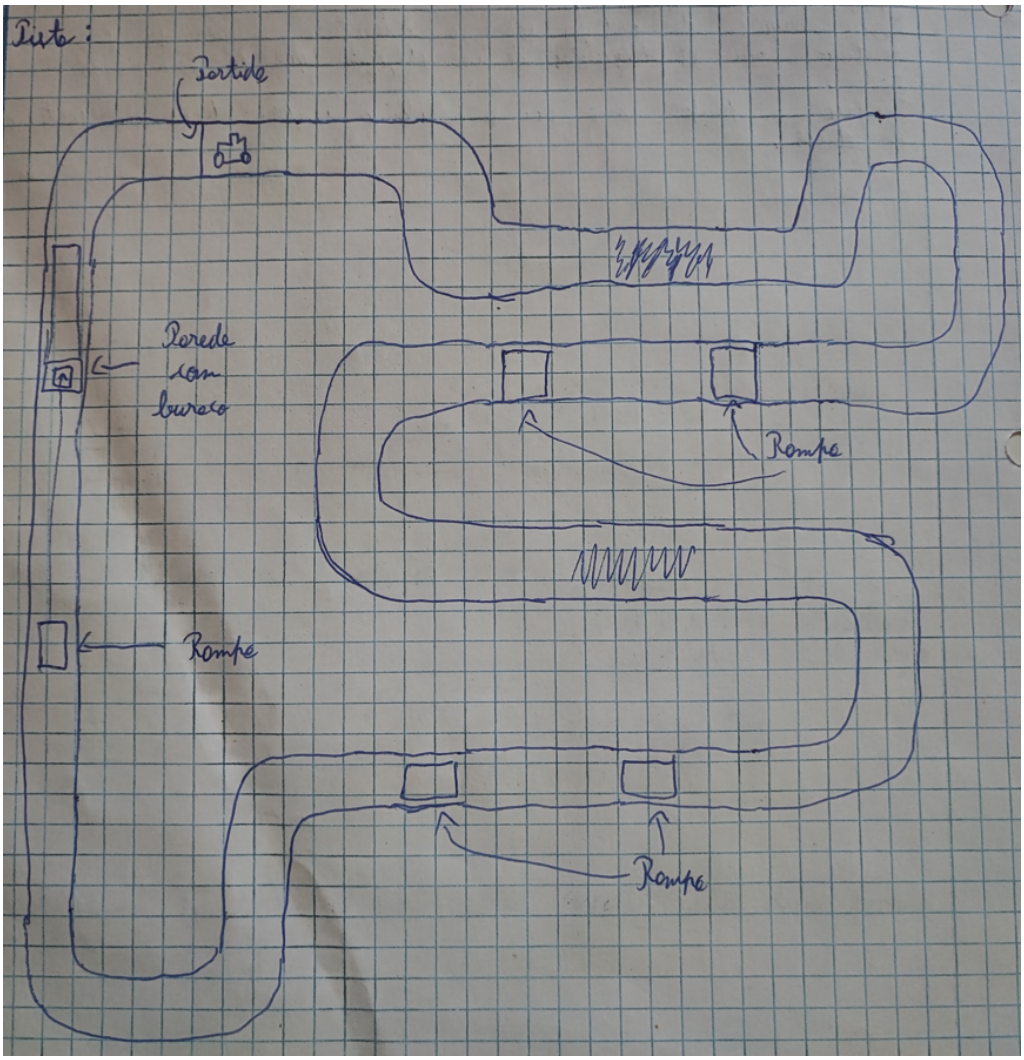

FIGURE 3.1. Game track initial sketch

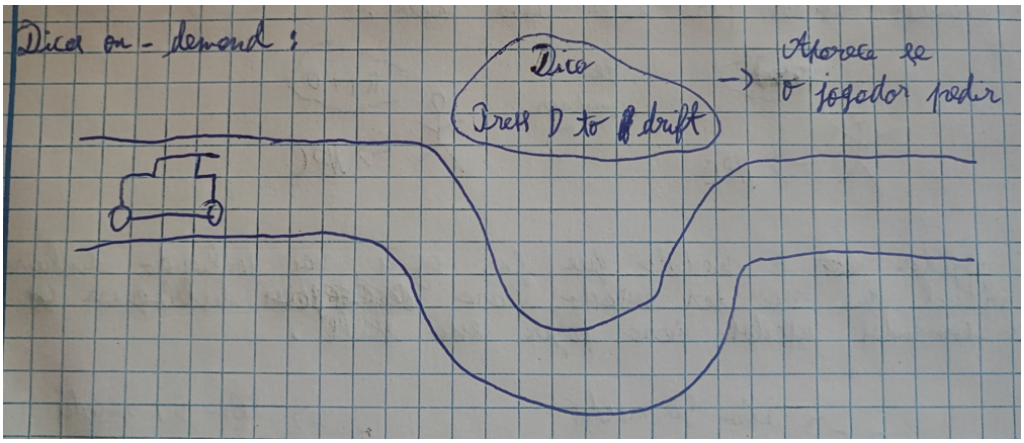

FIGURE 3.2. Hint on-demand appearance initial sketch

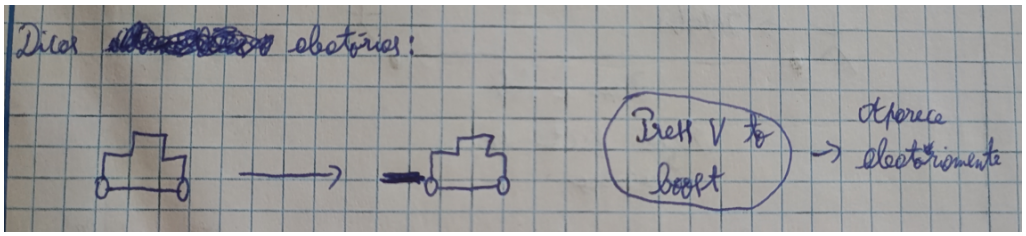

FIGURE 3.3. Random Hint appearance initial sketch

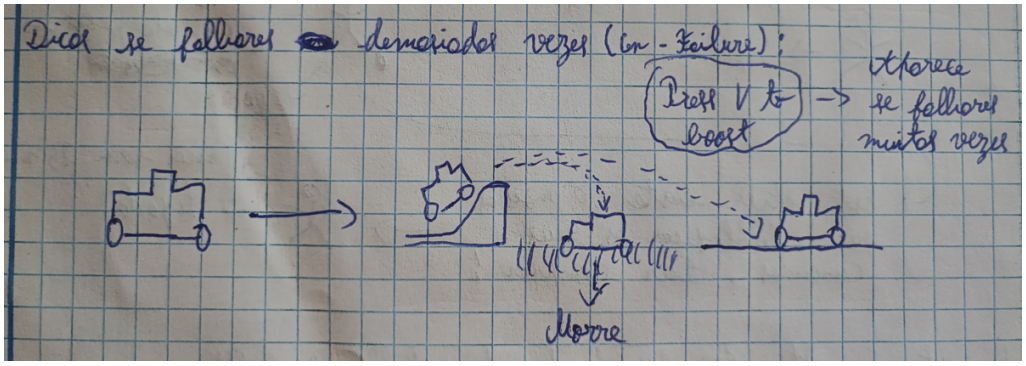

FIGURE 3.4. Hint on-failure appearance initial sketch

3.2. Game Development

The game is a third person racing time trial game, build in a 3D environment. The main objective is to overcome the gold medal time established in the track while mastering obstacles. The game was developed with the Unity game engine software [28], the implementation was programmed in C# language and designed for PC, with the game being controlled exclusively through the use of a mouse and keyboard.

3.2.1. Main Menu and Game Summary

The game is composed by three scenes: "Main Menu", "Game" and "Won". Figure 3.5 illustrates that the game begins at the "Main Menu" scene. This scene consists of the game title, a muscle car model rotating at a 360 degree angle, a space themed background, and it also includes the "PLAY", "CONTROLS" and "OBJECTIVES" buttons. Before starting the gameplay, the participants were advised to check the controls and objectives. Additionally, the participants were also informed to press the "R" key, it is necessary to give the participants a random hint system. The hint system selected is located at the bottom right corner with the text message "MODE ACTIVATED (NUMBER)", where "NUMBER" ranges from 1 to 4, meaning that each number presents a different hint system.

FIGURE 3.5. Main Menu

Upon pressing the "PLAY" button, the scene changes from "Main Menu" to "Game", where the gameplay begins. The participant controls the car that it is positioned at the starting line. The objective is to achieve the gold medal time established for the track, while overcoming and avoiding obstacles. The Hint System selected at the "Main Menu" scene offers assistance by providing hints. Successfully clearing obstacles rewards the participant with coins and nitro regeneration, these rewards varying on the obstacle difficulty. The scene changes from "Game" to "Won", only when the participant conquers the objective specified before, resulting in the game ending. Figure 3.6 illustrates the game without the User Interface (UI) elements. Figure 3.7 depicts the "Won" scene.

FIGURE 3.6. Game without UI elements

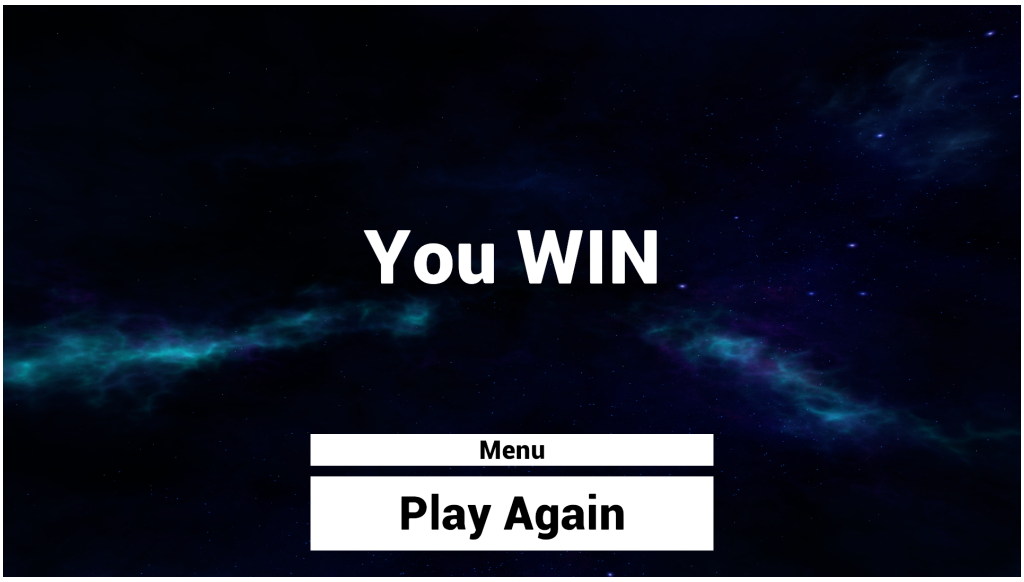

FIGURE 3.7. Won Scene

3.2.2. UI Elements and Features

The UI elements are designed to enhance the player experience in the game while also serving as specific computing purposes. Figure 3.8 displays that the top left corner, is composed by the "Current" and "Best Lap". The "Current" shows the current lap from participant for the ongoing lap, while the "Best Lap" displays the best time achieved by the participant.

The bottom left corner features a mini-map, which offers a zoomed-in view on where the participant is located in the track. The map is intentionally zoomed-in to avoid revealing the rest of the track, making it a element of discovery.

The top right corner consists of a progression bar, which features icons images representing the start, finish, the participant car, the gold, silver and bronze medals. These medals correspond to the pre-set times (times that are established) for the track. The progression bar provides an indication on how well the participant is doing compared to the track times.

Below the progressing bar there is a coin controller, represented by the coin icon and its numerical number. The participant earns coins by overcoming obstacles in the track. Failing and hitting obstacles will decrease the number of coins. The more coins collected, the less difficulty the participant is experiencing.

The bottom right corner includes the car turbo and its speedometer. The turbo element consists of turbo/nitro icon and a slider, which indicates the remaining amount of nitro available for the car. The turbo regenerates over time, and by overcoming obstacles it regenerates faster. The speedometer displays a speedometer icon with a orange arrow and a numerical text. The arrow moves dependent of the car speed, while the text showing the exact speed.

All UI elements except mini-map are composed by a black background to improve visibility, as some texts were difficult to read due to the text bright color and some background bright colors. The UI elements stay always visible through the game except for the "Best Lap" element, which only appears when the participant completes the first lap.

FIGURE 3.8. Game with UI elements

An additional UI element appears in the screen when the participant car enters a zone that it is outside of the track and mainly in contact with the surrounding hills. Figure 3.9 illustrates that this UI element is composed by a black background with a white text "You're out of the track. Respawning in 2". The number signifies the countdown in seconds until the car returns to the track. The countdown begins at 3 seconds and continues until it reaches 0. This feature was designed so that the participant could not see other areas of the track and also they could not skip parts of the race.

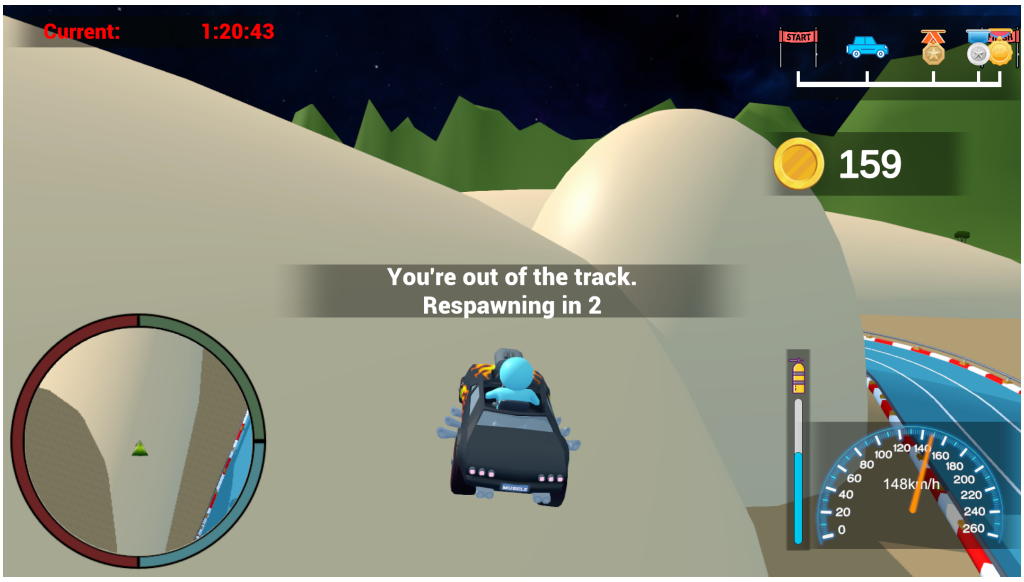

FIGURE 3.9. Respawn UI element when car is outside of the track

Another additional UI element appears in the screen when the participant car achieves the bronze and silver times. Figure 3.10 shows the UI element staying active for 2.5 seconds, with the message "You beat the Bronze and Silver Times, you get 1500 coins.". This indicates that the participant has surpassed both the bronze and silver times of the track and a got rewarded by a correspondent amount of coins. A similar UI element is triggered when the participant car acquires only the bronze time, with the message "You beat the Bronze Time, you get 500 coins.". The coins rewards varying depending on the time achieved, better time means more coins earned.

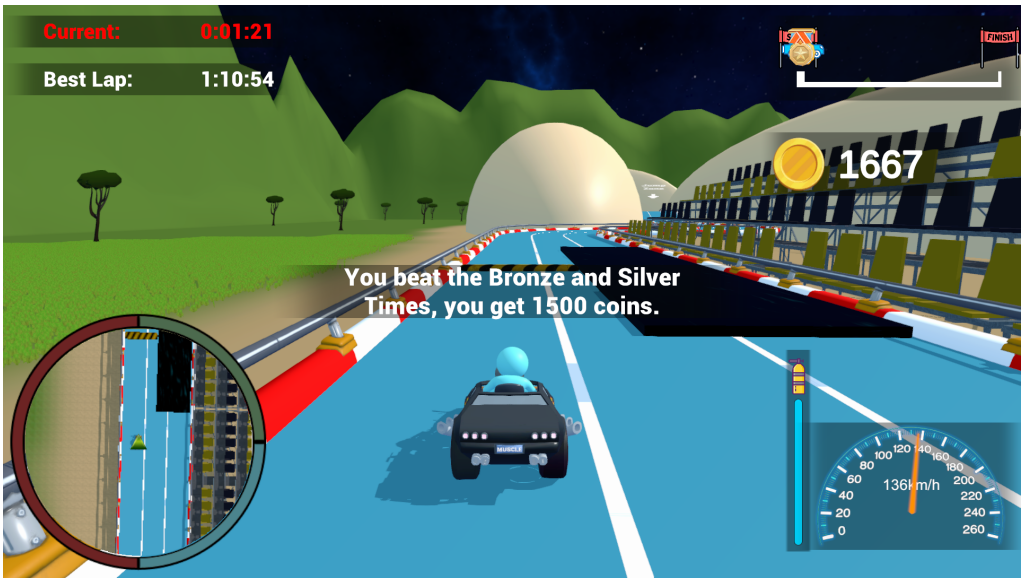

FIGURE 3.10. UI element when car beats time trials times

Finally, there is the last two UI elements that appear on the screen when the participant car obtains the best lap time of the track. The Figure 3.11 displays that the UI elements are composed by two messages. The first message is similar to the one presented

in Figure 3.10. After the best time is acquired, stays active for 2.5 seconds. The message displays "You beat All of the Times, you get 25000 coins.". This means that the participant has conquered all of the times that the track has and got a huge amount of coins. The second message appears one second later after the best time was bested, that displays "You beated the Gold Medal!". This indicates that the participant obtained the gold time and the game will end in victory.

FIGURE 3.11. UI element when car beats the best lap time

3.2.3. Hint Systems Types

Some changes were made to the Hint System from the initial design ideas in the Section 3.1 "Game Design", which originally included three types of hints: On-Demand, Random and On-Failure. These were expanded to four types of Hint System modes, based on feedback from participants during practice sessions.

Mode 1 (Random Hints)

Hints are presented randomly temporarily and remain on the screen for a brief period of time. This system provides that the hints show temporarily and are entirely random. The hints may be helpful for that situation or could be irrelevant. The system is based on luck, making that the hints become unpredictable. The Figure 3.12 shows an example on how random hints are being displayed.

FIGURE 3.12. Random Hint displayed

Mode 2 (Random Hints with On-Demand Option)

It is similar to the Random Hints mode, but it includes an On-Demand approval option. Every 15 seconds, an On-Demand option appears asking the participant if would like to receive the hint. If the participant accepts, the hint is displayed in the screen. If the participant declines, the game continues without displaying the hint. The Random Hints with On-Demand approval provides random hints, but additionally grants the participant the deciding power to accept or refuse them. Figures 3.13 and 3.14 illustrate the On-Demand approval being displayed and the Random Hint being displayed after the approval was granted, respectively.

FIGURE 3.13. On-Demand permission displayed after time has passed

FIGURE 3.14. Random Hint displayed after permission granted

Mode 3 (Hints On-Failure)

The hints are not time-based and are only triggered by the participant second failure on obstacles, collisions and lap time, ensuring that the participant has the opportunity to attempt the challenge on their own and correct their mistakes after the first failure. The hints offered are specific to the type of failure. Figures 3.15 and 3.16 shows the car failing the jump and the On-Failure Hint being displayed after the failure, respectively.

FIGURE 3.15. Car failing the jump

FIGURE 3.16. On-Failure Hint displayed after failure

Mode 4 (Hints On-Failure with On-Demand Option)

It is similar to the On-Failure mode, but it includes the addition of the On-Demand button option same with the Random Hints with On-Demand option mode. This system offers hints that are more specific to the type of failure, with the help of providing the choice to accept or refuse hints. Figures 3.17 and 3.18 show the On-Demand option and the hint displayed, respectively.

In terms of user interface, the On-Demand Option is positioned in center of the screen on a purple panel and a text with a message saying "Press H to get a Hint!". This ensure that the participant is aware of the availability of a hint. If the participant presses the "H" key, the hint will be shown; if not, the panel will disappear after 5 seconds. Figure 3.17 displays the On-Demand approval. The hints are presented in the top center corner of the screen on a purple panel. The display includes the hint text, a slider that indicates how long the hint will be displayed (5 seconds), a slow motion icon, and a message saying "Press X to Skip". The skip option allows the participant to dismiss the hint early if he already read or no longer needs it. The slow motion icon indicates that the game slow down until the hint is being displayed, allowing the participant to have enough time to read the hint without loss of flow in the gameplay. The slow motion feature was chosen over pausing the game to avoid breaking the game momentum and minimize the participant loss of focus. Figure 3.18 displays the multiple UI elements that are used for showing the hint.

FIGURE 3.17. On-Demand permission displayed after car hit the speed bump

FIGURE 3.18. On-Failure Hint after permission granted

The implementation of these hint systems are intended to help participants improve their performance in the track by gaining different types of skills. These skills, such as evading oil on the track, jumping speed bumps more smoother, drift through curves to avoid hitting or crashing into the wall. Participants also learn how to strategically use nitro during jumps, manage nitro usage to avoid its depletion, and how to combine the nitro with the car speed for a more controlled landing and avoiding risking of overshooting. These systems guide participants to master in-game mechanics and to overcome the most difficulty track challenges more efficiently.

3.2.4. Environment

The game environment was designed in a 3D dimensional space with the main goal of creating a more immersive and realistic experience. In Figure 3.19 is shown that the game happens in outer space, featuring the sky filled with stars and a portion of the track surrounded by hills, with sizable mountains in the background. The terrain around the track consists of an off-road pavement. Figure 3.20 illustrates an additional terrain that was added to contain grass and trees between the off-track area and the mountains, creating a forest-vibe atmosphere, resulting in a more natural environment. Figure 3.21 displays the seats in multiple sections of the track, to replicate the real-world racing environments. These environment details contribute a more engaging and dynamic game experience.

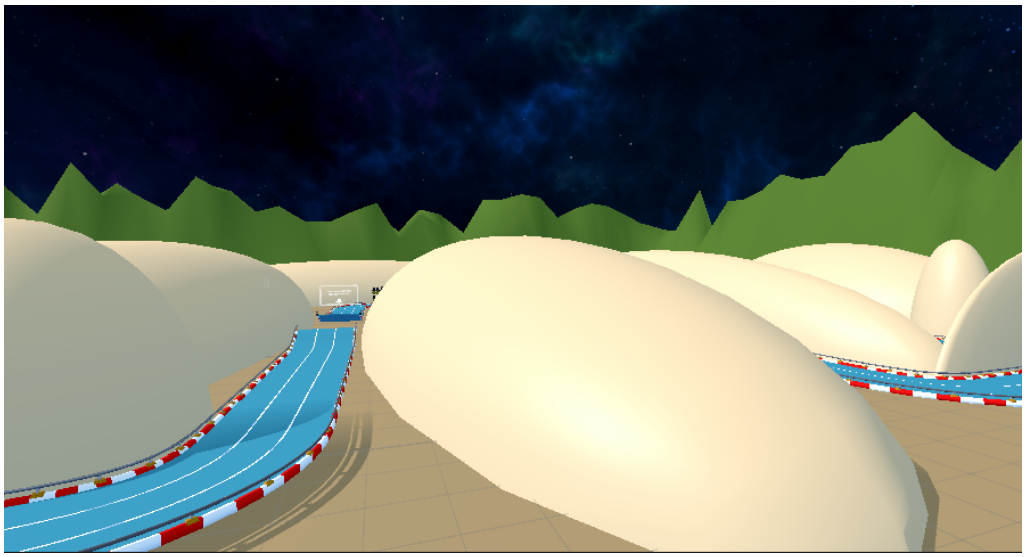

FIGURE 3.19. Environment View

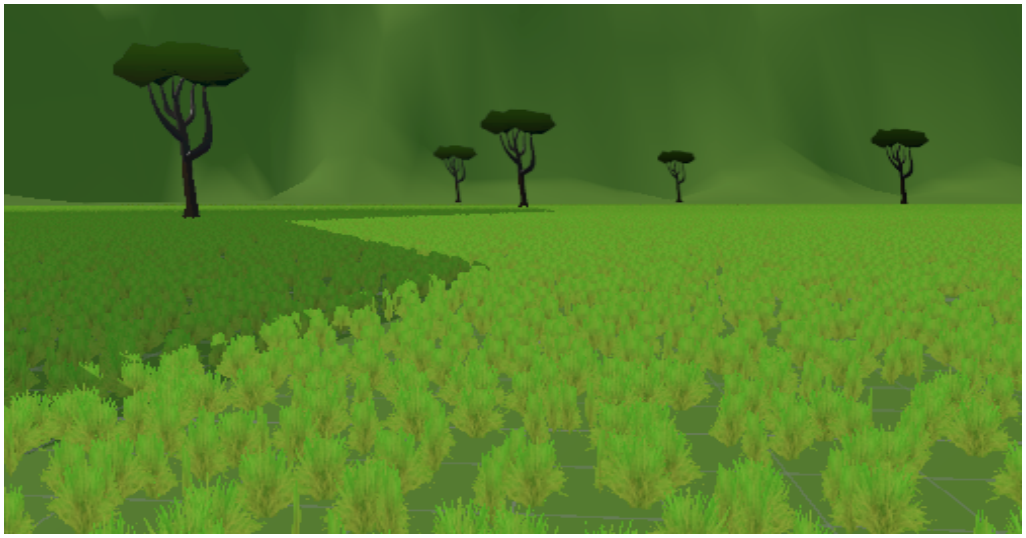

FIGURE 3.20. Grass and Trees

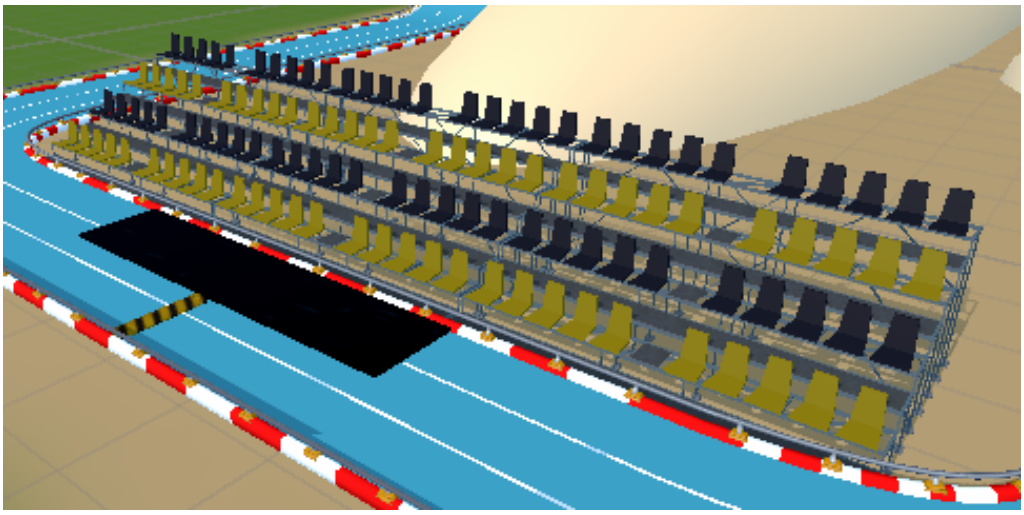

FIGURE 3.21. Seats

3.2.5. Track and Obstacles

The track design experienced several modifications from the initial concept refereed in the Section 3.1 "Game Design". The bumps roads where replaced with jumps, and the final jump, that consisted of a wall that has a space in the middle was substituted with two separate jumps. These changes require a higher dependence on the hint systems.

The track was intentionally designed to offer an easy to medium level of difficulty, featuring various obstacles that the participants need to overcome. In total, there are 28 obstacles, comprising of five distinct types. Figure 3.22 shows a top-down view of the entire track. Figure 3.23 displays the speed bump serving as an obstacle that momentarily slows the participant down. Figure 3.24 illustrates the oil patch, whose objective is to reduce the car speed as long as it remains in the patch. Figure 3.25 shows the curve road, which was designed to challenge participants to change direction, either left or right, rather than driving straight. At times, simply turning is insufficient and the participants must drift effectively to make sharper turns.

To introduce greater challenge, Figure 3.26 displays the U-turn road, which offers an even greater challenge. There, the participants must master drifting techniques to navigate the tighter curve. Figure 3.27 illustrates the jump obstacle, which tests the participants ability to control the car speed and its landing precision. Jumps vary in difficulty, from those that can be cleared just by normal speed to those that demand the usage of nitro boost. The most challenging jumps require the combination of the car speed and its nitro to land more accurate on the track platform. Figure 3.28 shows that each jump has a label marked as "JUMP ZONE" and a downward-pointing arrow, located at the start of each jump. This prevents confusion, as jumps might be mistaken for ravines when viewed from a distance.

The inclusion of all of the types of obstacles is essential in maintaining track excitement and difficulty, preventing from being to easy and boring. Without them, it would make the track lack challenge, and the Hint Systems would become less helpful. The obstacles also

ensure that the participant keeps focused on the game (Flow) while being continuously challenged. This combination of Flow and Challenge is crucial for time trial racing games, encouraging participants to overcome obstacles and to conquer the established difficult times.

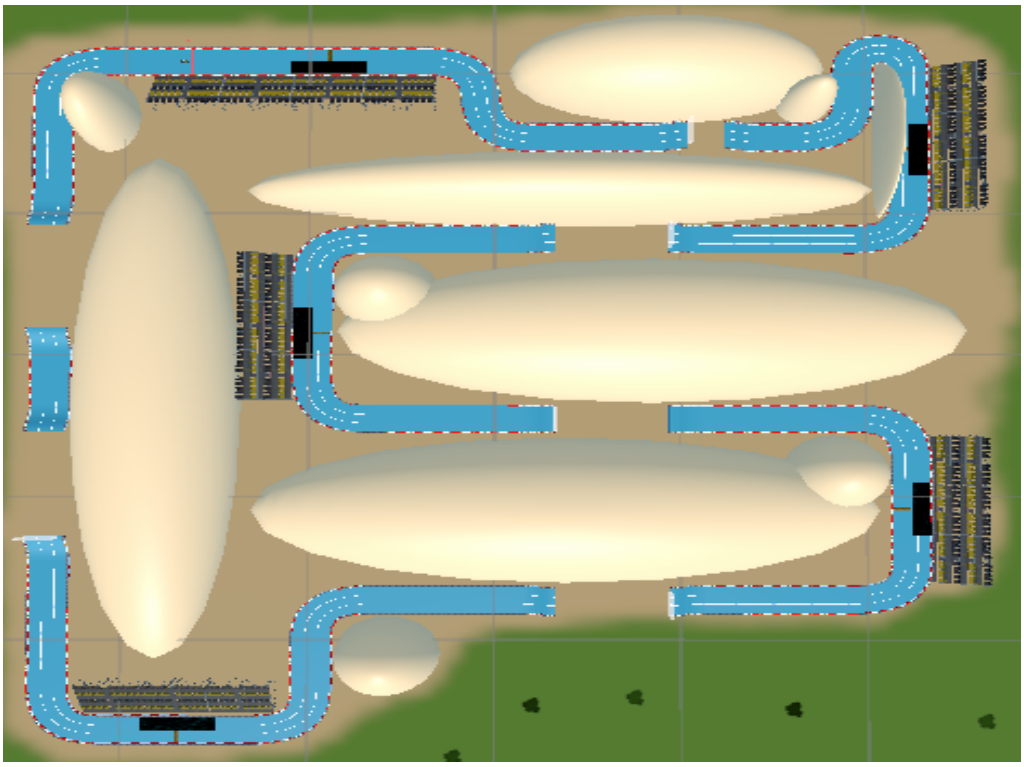

FIGURE 3.22. Track viewed from above with obstacles and environment objects

FIGURE 3.23. Speed Bump obstacle

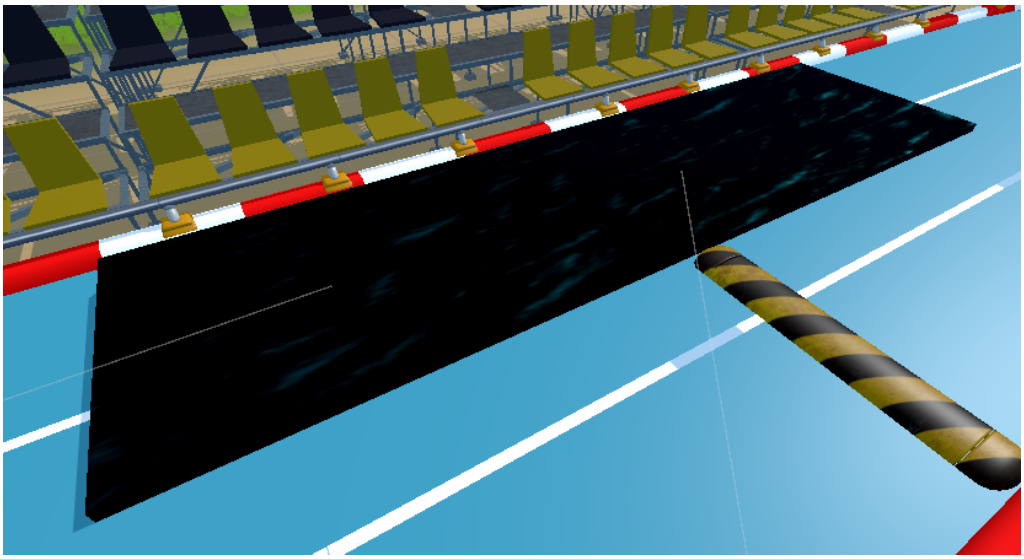

FIGURE 3.24. Oil obstacle

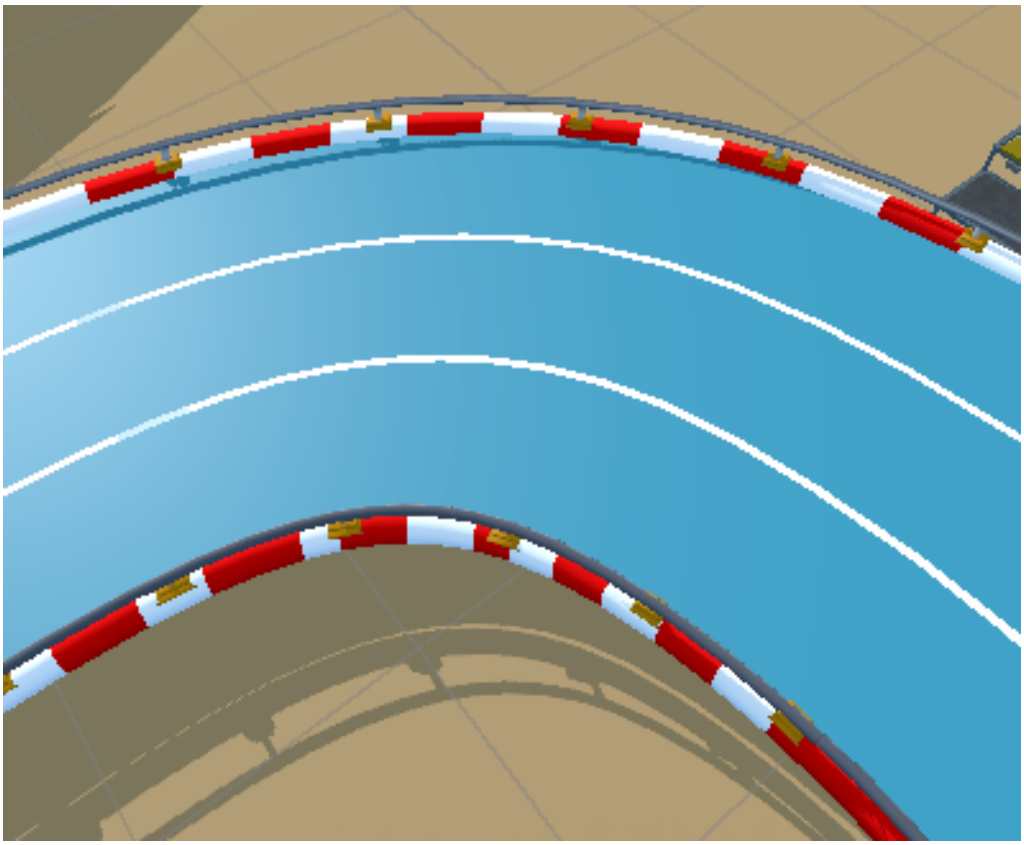

FIGURE 3.25. Curve Road Obstacle

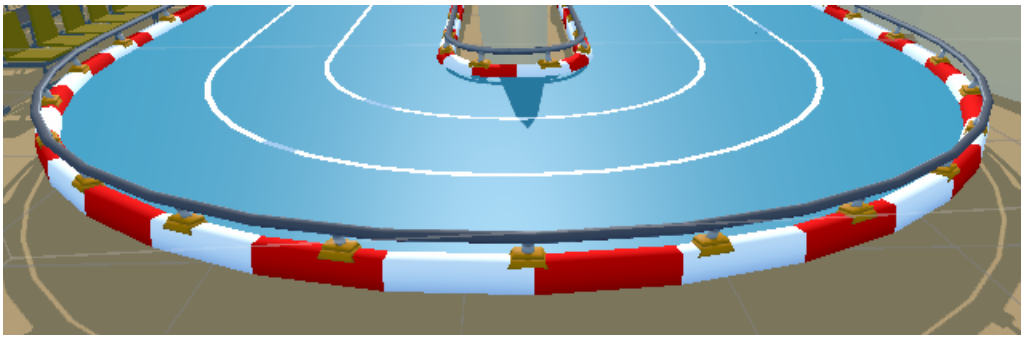

FIGURE 3.26. U-Turn road obstacle

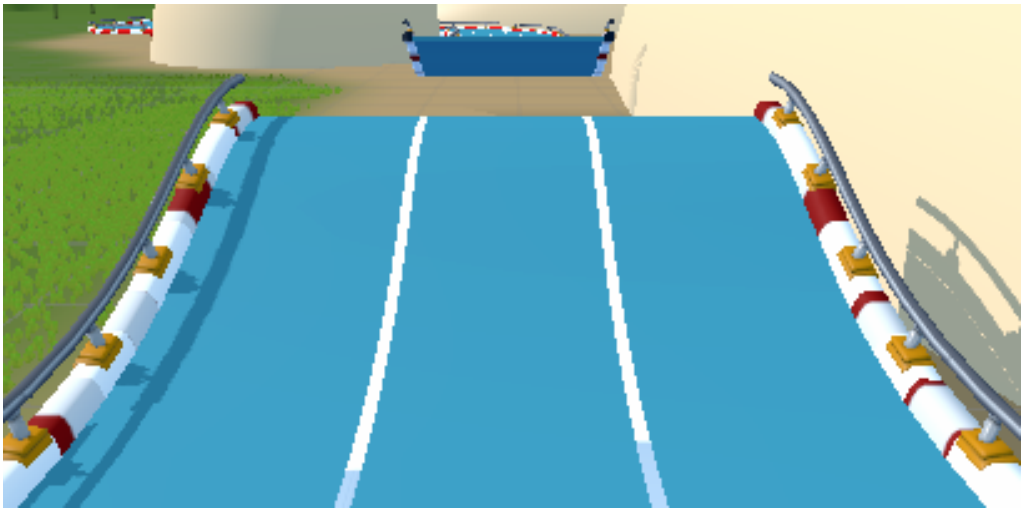

FIGURE 3.27. Jump obstacle

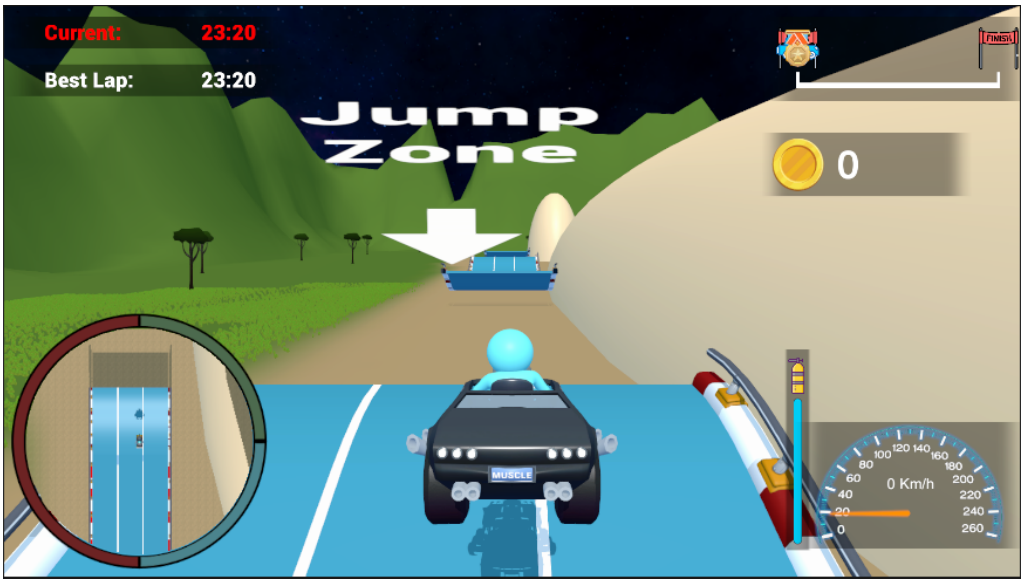

FIGURE 3.28. Jump zone text

3.2.6. Implementation of the Hint System

This section presents the key pseudo-code of the Hint Systems implementation. Figure 3.29 presents the function to add hints to a list of strings, preparing them for use during gameplay.

```
Function Start:
        Add "Avoid oil in the track by all costs." to the list of hints
        Add "To pass a speed bump, jump it by pressing Space." to the list of hints
        Add "Avoid hitting a curve wall by pressing and holding Z." to the list of hints
        Add "To pass a jump, use turbo by pressing and holding V." to the list of hints
        Add "Don't use nitro on a curve. Do a drift by pressing and holding Z." to the list of hints
        Add "Don't waste all of your nitro, save it for the jumps." to the list of hints
        Add "Avoid hitting the walls by all costs." to the list of hints
        Add "Use your nitro, to go faster." to the list of hints
        Add "Press R, if you are stuck." to the list of hints
End function
```

FIGURE 3.29. Pseudo-code of all the hints from the game

Figure 3.30 exhibits the function responsible for the random hints. First it checks if any hint is being displayed in the UI; if one is currently active; no other hints will show until the previous one has stopped appearing; if no hint is shown, then a random hint will be displayed for 5 seconds, and also slows down the time to 70% of its normal speed, ensuring that the participant has enough time to read the hint.

```
Function GetRandomHintMandatoryOnDemand:
        If a hint is not currently displayed:
                Display a random hint for 5 seconds
                Slow down game time to 70% of the original game time
        End if
End function
```

FIGURE 3.30. Pseudo-code of the random hints function

Figure 3.31 presents the function that is specific for when the car fails a jump with insufficient nitro. This function is similar to the random hints function, but instead of displaying a random hint, it provides a hint related to the car failing the jump due to low nitro. Additionally, individual functions were created for each hint that is included in the list of strings, ensuring that the participants receive guidance based on their specific failures.

```
Function HintOnFailureMandatoryOnDemandBoostWaste:
        If a hint is not currently displayed:
                Display the hint "Don't waste all of your nitro, save it for the jumps." for 5 seconds
                Slow down game time to 70% of the original game time
        End if
End function
```

FIGURE 3.31. Pseudo-code for On-Failure Hint function for failing the jump with low or no nitro

The approach to invoke hints is by using Unity Events. Unity Events provide an efficient method to control triggers from various game objects. Figure 3.32 depicts two Unity Events that correspond to the random hints function and on-failure hint function of the participant not achieving any medal when they finish a lap, respectively. The relationship between the events and the hints, is that the developer creates a Unity Event. After this, the Unity Event appears in the Inspector and the developer can add the functions related to hints into the event. Then the developer can invoke the event whenever they feel is right.

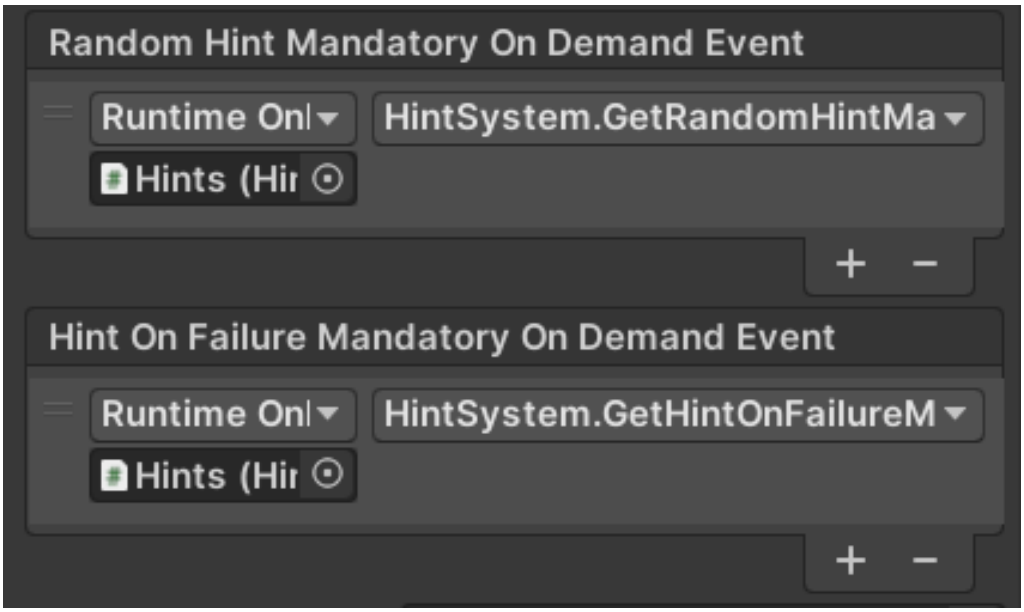

FIGURE 3.32. Unity Events that correspond to the random hints function and the on-failure hint function related to the participant not achieveing any medal when they finish a lap

Figure 3.33 presents the pseudo-code of the On-failure hint modes. Initially, if the current lap time is higher than the bronze time established, the function verifies which of the modes "On-Failure Hints" and "On-Failure Hints with On-Demand approval" is active. After that, it checks if it is the second occurrence of the participant failure in that situation; if it is, then in case of "On-Failure Hints", participants are provided with a On-Failure Hint related to that specific failure. In case of "On-Failure Hints with On-Demand approval", a secondary panel is activated. This panel includes the On-Demand approval,

allowing the participants to confirm their desire to accept the On-Failure hint. After this, the hint sound is played and the number of failure occurrences of that situation resets. It is not the second occurrence of the participant failure, the number of failure occurrences increases to one.

```
If the current lap time is greater than the bronze time estabilished for the track:

        If the mode selected is On-Failure Hints:
                If the variable "the player failed to beat the bronze time" is 2:
                        Invoke the On-Failure hint event related to that situation
                        Play the hint sound
                        Reset the variable "the player failed to beat the bronze time" to 0
                Else:
                        Increment the variable "the player failed to beat the bronze time" to 1

        If the mode selected is On-Failure Hints with On-Demand approval:
                If the variable "the player failed to beat the bronze time" is 2:
                        Activate the On-Demand approval panel
                        Invoke the On-Failure hint event related to that situation
                        Play the hint sound
                        Reset the variable "the player failed to beat the bronze time" to 0
                Else:
                        Increment the variable "the player failed to beat the bronze time" to 1
```

FIGURE 3.33. Pseudo-code for Mode 3 and Mode 4 implementation of the bronze lap time lap vs the current lap time

Figure 3.34, presents the pseudo-code of the random hint modes. The process begins by verifying the difference between the total time and the last hint time displayed exceeds or is equal to 15 seconds. If the condition is met, then the function verifies which of the modes "Random Hints" or "Random Hints with On-Demand approval" is active. If "Random Hints" is active, participants are provided with a random hint. In the case of "Random Hints with the On-Demand approval", a secondary panel is activated. This panel includes the On-Demand approval, allowing the participants to have the choice to approve the random hint. After this, the hint sound is played and the last hint time is equal to the total time, this ensures that their difference will always be between zero and fifteen seconds. The pseudo-code for the on-failure hints systems for the other situations follows a similar way to the previously ones already presented.

```
If the difference between the total time and the time that the last hint was displayed is >= to 15 seconds:

        If the mode selected is Random Hints:
                Invoke the Random hint event
                Play the hint sound
                Set the time of the last hint displayed = the total time

        If the mode selected is Random Hints with On-Demand approval:
                Activate the On-Demand approval panel
                Invoke the Random hint event
                Play the hint sound
                Set the time of the last hint displayed = the total time
```

FIGURE 3.34. Pseudo-code for Mode 1 and Mode 2 implementation for random hints

Figure 3.35 illustrates the class diagram for the Hint System implementation. The arrow are all dependencies, indicating that one class depends on another, meaning it relies on the class methods and properties. The arrow is represented with a dashed arrow from the calling script to the called script. The HintSystem script is where the functions for the Random Hints and On-Failure Hints are created, it also controls the activating of the On-Demand approval panel. The OnDemandPanelController script controls the activating of hint panel when the On-Demand approval panel is activated. The GameManager script controls the modes. The ArcadeKart script controls the car, in terms of hints, is associated with the jumping hints. The TimeDisplay controls race time, in terms of hints, is associated with the random hints and hints when the participants do not achieve any medal time. The CurveScript, BarrierCollision and SpeedBumpScript scripts controls the collision between its object and the car, and hints appear dependent on that situation. Finally, the OilScript script controls when the car enters its trigger area, and hints appear related to the oil object.

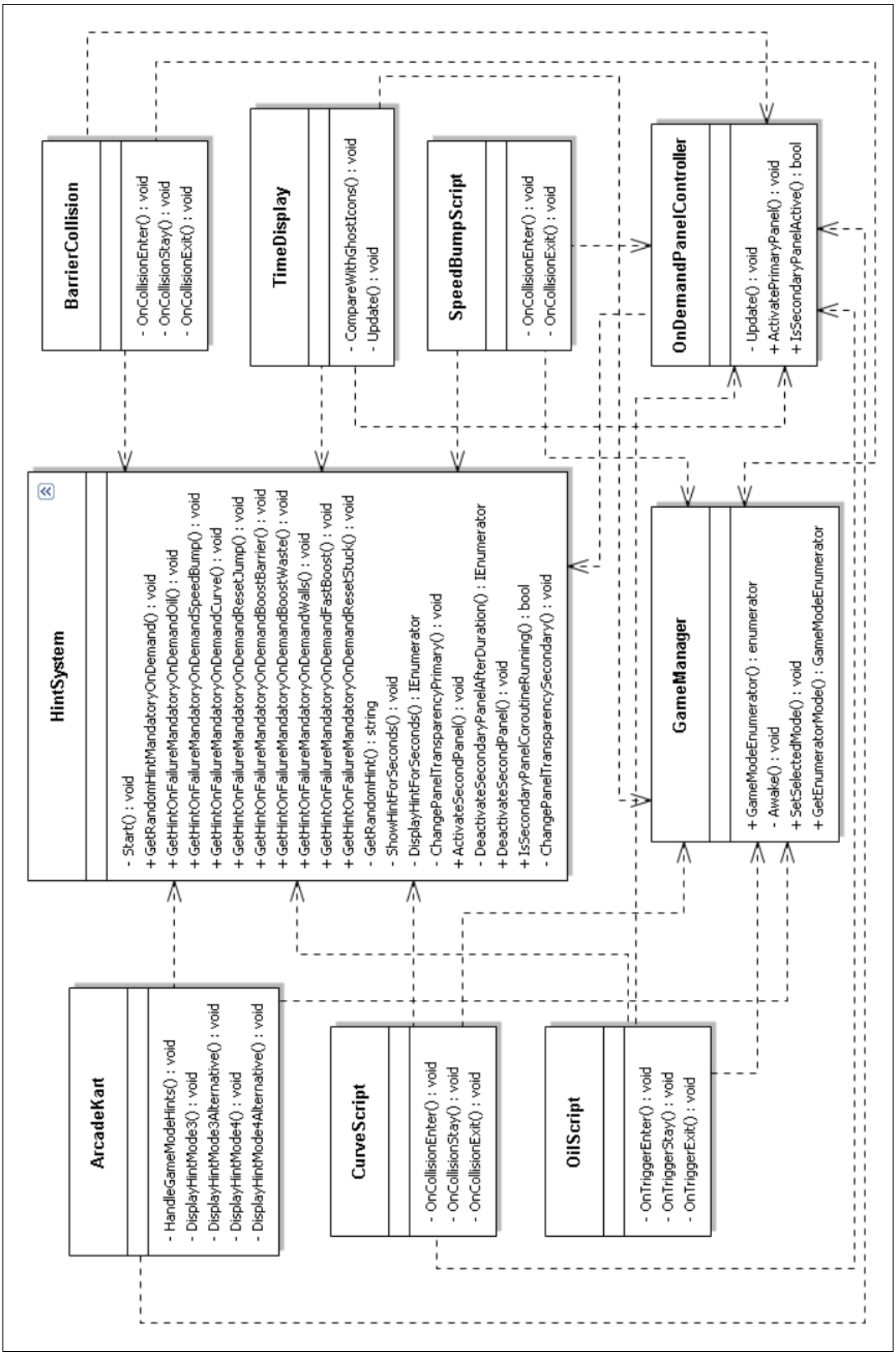

FIGURE 3.35. Class Diagram for Hint System Implementation

CHAPTER 4

Evaluation

This chapter presents the evaluation of the game and its hint systems, organized by five sections. Section 4.1 describes the experimental procedure, Section 4.2 presents the Game Experience Questionnaire (GEQ) answered by the participants, Section 4.3 details the demographic information of the participants gathered after the game, Section 4.4 summarizes user feedback obtained during the debriefing. Finally, Section 4.5 offers a discussion regarding the obtained results.

4.1. Experimental Procedure

The procedure was done in-person at ISCTE, specifically in the study room due to its low-noise environment. This would minimize distractions, allowing participants to engage the game effectively. In terms of equipment, the experiment was done in the developer PC, so that the procedure would not take longer. The procedure was organized in various steps:

(1) **Participant Agreement**: Participants are asked if they had approximately 30 minutes.
(2) **Explanation**: After the participants agreement, participants were provided with an explanation covering the following:
   - Dissertation Title;
   - Explaining the concepts of Game-Triggered and Player-Triggered hints and how they function in games;
   - The objectives of the study.
(3) **Briefing after starting the application**: After the application was started, there was a briefing to the participants about the instructions of the Main Menu, including checking controls and objectives of the game and after that pressing "R" key to select a random Hint System.
(4) **Start of the game**: Participants play the game with the help of the Hint System selected.
(5) **First GEQ Question**: After completing the mode selected, participants answer the first GEQ question, because we wanted to collect information from the participants based on how they felt while playing the game and compare those results between modes
(6) **Play Remaining Modes**: Participants go back to the game, to play the remaining modes.

(7) **Answer remaining GEQ Questions**: After playing all modes, participants finish the remaining GEQ questions.
(8) **Post-Game Demographic Survey**: Participants complete the Post-Game Demographic Survey questions.
(9) **Feedback**: After filling the last questionnaire, participants shared their feedback on their overall experience.

4.2. Questionnaires

The Game Experience Questionnaire (GEQ) evaluates the player experience after playing a game. The structure for the GEQ presented to the participants includes the GEQ Core Module Questions [26], which assesses the game experience; a hint preference question that asks players about their preference between Random Hints and On-Failure Hints; and On-Demand approval question to determine if they want the On-Demand option in the game.

GEQ Core Module is composed by seven components: Competence, Sensory and Imaginative Immersion, Flow, Tension/Annoyance, Challenge, Negative Affect and Positive Affect. Each of these components is measured by a set of items. The overall value of each component is calculated by the average of these items [26]. Participants responded to each item with a 5-point Likert scale ranging from "Not at all" to "Extremely".

The Post-Game Demographic Survey, which includes information from the participants such as gender, age, experience in video games in general, experience in racing games, experience with video games that provide hints, average number of hours played per week and the hexad scale.

This study involved 40 participants, with 23 classifying as "Male" and 17 as "Female". The age of the participants was ranged between 18 to 29 years old, resulting in a mean age of 21.85 $\pm$2.76.

4.3. Questionnaires Results

Table 4.1, illustrates the mean and standard deviation of each modes with the seven components from the GEQ Core Module. In terms of Competence, mode 2 has the highest mean score with 1.46, with a high standard deviation of 1.00. For Sensory and Imaginative Immersion, mode 1 has the highest mean score with 2.32, with a relatively low standard deviation of 0.49. Flow is highest in mode 3, with a mean score of 3.12, with a moderate standard deviation of 0.65. In terms of Tension/Annoyance, mode 1 has the highest mean score with 1.27, with a high standard deviation of 1.09. For Challenge, modes 1 and 2 have the highest mean score with 2.16. but mode 2 standard deviation (0.59) is lower than mode 1 (0.78). Negative Affect is highest in mode 1, with a mean score of 0.55, with a moderate standard deviation of 0.59. Finally, the Positive Affect is highest in mode 4, with a mean score of 3.14, with a low standard deviation of 0.35.

	Mode 1	Mode 2	Mode 3	Mode 4
Competence	1.18 ±1.00	1.46 ±1.00	1.00 ±0.81	1.24 ±0.76
Sensory and Imaginative Immersion	2.32 ±0.49	2.08 ±0.50	1.93 ±0.78	2.18 ±0.45
Flow	2.80 ±0.69	2.68 ±0.81	3.12 ±0.65	2.48 ±0.94
Tension/Annoyance	1.27 ±1.09	0.67 ±0.92	1.13 ±0.82	0.87 ±0.63
Challenge	2.16 ±0.78	2.16 ±0.59	1.82 ±0.62	1.58 ±0.46
Negative Affect	0.55 ±0.59	0.38 ±0.44	0.48 ±0.51	0.45 ±0.35
Positive Affect	2.74 ±0.63	3.00 ±0.85	2.80 ±0.49	3.14 ±0.35

TABLE 4.1. GEQ Core Module results of mean and standard deviation between the mode selected and the seven components

Upon completion of the GEQ first question (GEQ Core Module), participants proceeded to play the remaining modes of the game. After playing all of the modes, participants were given an explanation on what each mode does in the game before they could answer the following questions. Table 4.2 displays the number of participants that choose between Random Hints and On-Failure Hints. 36 out of 40 participants picked On-Failure Hints has their hint preference, and only 4 picked Random Hints. Once the participants selected their preferred option, they were asked to explain their choice. Table 4.3 illustrates the explanations given for the participants who picked On-Failure Hints, the common answers are related to the participants trying to play the game alone before asking for a hint, On-Failure Hints are precise, straight forward and essential compared to the Random Hints that makes the participants cause distraction and losing there focus on the game. The Table 4.4 displays the explanations from the participants who picked Random Hints, the common answers are say that Random Hints are a good way to quickly gain experience in the game, related to the participants that do not control the controls well, also it increases performance and progress in the game. Following this, the table 4.5 show that the participants answered a question related to their approval to the On-Demand feature. 16 out the 40 participants picked that they want the On-Demand approval feature. However, the other 24 participants picked that they did not want the approval. Table 4.6 illustrates the common answers from the participants if they want the On-Demand approval feature in the game, they said that they want to play the game on their own and when they are have difficulties then they ask for a hint, resulting in the participant having the power to decide when they want the hint. Table 4.7 displays the common answer from the participants if they did not want the On-Demand approval feature, the common answer is that the participants by looking to find the "H" key on the keyboard, it will cause distraction or loss of focus due to being a fast paced game.

Options	Number of participants
I prefer that hints appear in the game only when I fail to progress	36
I prefer that hints appear in the game even when I don't fail to progress	4

TABLE 4.2. Distribution of answers to the hint preference between Random Hints and On-Failure Hints

Option	Common Answers
I prefer that hints appear in the game only when I fail to progress	Try doing things in the game and explore them by myself before asking for a hint
	Random Hints cause distraction and lost of focus on the game
	On-Failure Hints are precise, straight forward and essential compared to the Random Hints and help the player more

TABLE 4.3. Common Answers from "I prefer that hints appear in the game only when I fail to progress" in Table 4.2

Option	Common Answers
I prefer that hints appear in the game even when I don't fail to progress	Increases performance and progress in the game, making the game more motivating
	Random Hints are a good way to quickly gain experience in the game, especially for those who cannot control the controls well

TABLE 4.4. Common Answers from "I prefer that hints appear in the game even when I don't fail to progress" in Table 4.2

Options	Number of participants
I want the game to ask for my approval before showing each hint	16
I do not want the game to ask for my approval before showing each hint	24

TABLE 4.5. Distribution of answers from the participants preference on having On-Demand approval for hints in the game

Option	Common Answers
I want the game to ask for my approval before showing each hint	Try to play the game by myself and when i have difficulties i ask for a hint
	I have the Power of decision when i want the hint

TABLE 4.6. Common Answers from "I want the game to ask for my approval before showing each hint" in Table 4.5

Option	Common Answer
I do not want the game to ask for my approval before showing each hint	When looking for and clicking on the "H" key, it causes distraction or loss of focus on the game, as it is a fast paced game it doesn't make much sense to have to click on the "H" key

TABLE 4.7. Common Answers from "I do not want the game to ask for my approval before showing each hint" in Table 4.6

To further investigate the results presented in Tables 4.1, 4.2, and 4.3, the open-source software Jamovi [29] was used for data analysis. The Table 4.8 displays the findings using One-Way ANOVA (Non-Parametric), employing the Kruskal-Wallis test. This approach was used to explore the relationship between the modes and the seven components of the GEQ Core Module, with the objective of identifying any significant variables, with a significant level set at $p < 0.05$. The X^2 is called the chi-square. Challenge has the highest value, it means that there is a greater difference between the medians of the modes, resulting in the probability of having a statistical significant difference (low p value). The df results as degrees of freedom, it means the number of independent variables that can vary in the analysis, the df value is 3 for everyone, is calculated by the formula "K-1", where K is the number of modes being compared, since there is four modes, the result is the following: "4-1 = 3". The p value is the probability that determines if a variable is statistically significant. The Challenge has the lowest value, it makes sense since his chi-square is the highest. All of the p values are higher than 0.05, resulting in none of the variable being statistical significant. Tables 4.9 and 4.10 show the results of the data analysis using Proportion Test (2 outcomes), utilizing the Binomial test. This method is used to evaluate the hypothesis level in accordance with the binomial distribution. In terms of Table 4.9, 36 out of 40 participants picked "I prefer that hints appear in the game only when I fail to progress", resulting in a proportion of 0.9 (90%). The other 4 participants picked "I prefer that hints appear in the game even when I don't fail to progress", resulting in a proportion of 0.1 (10%). The p values of both is < 0.001, indicating that the difference in proportion is statistically significant. In terms of Table 4.10, 16 out of 40 participants picked "I want the game to ask for my approval before showing each hint", resulting in a proportion of 0.4 (40%). The remaining 24 participants picked "I do not want the game to ask for my approval before showing each hint", resulting in proportion of 0.6 (60%). The p values of both is 0.268, indicating that the difference in proportion is not statistically significant.

	X^2	df	p
Competence	1.470	3	0.689
Sensory and Imaginative Immersion	1.307	3	0.727
Flow	2.873	3	0.412
Tension/Annoyance	3.704	3	0.295
Challenge	6.038	3	0.110
Negative effect	0.848	3	0.838
Positive effect	3.585	3	0.310

TABLE 4.8. Data Analysis using One-Way ANOVA (Non-Parametric) between the first mode selected and all of the other 7 components of the GEQ Core Module

Options	Count	Total	Proportion	p
I prefer that hints appear in the game only when i fail to progress	36	40	0.900	< 0.001
I prefer that hints appear in the game even when i don't fail to progress	4	40	0.100	< 0.001

TABLE 4.9. Data Analysis using Proportion Test (2 outcomes) for the 2º question of the GEQ

Options	Count	Total	Proportion	p
I want the game to ask for my approval before showing each hint	16	40	0.400	0.268
I do not want the game to ask for my approval before showing each hint	24	40	0.600	0.268

TABLE 4.10. Data Analysis using Proportion Test (2 outcomes) for the 3º question of the GEQ

Table 4.11 displays that the results reveal that participants experience in racing games is relatively low compared to their overall experience with video games and those providing hints, the option "Few" is the most frequent. On the contrary, the overall experience in video games is leaning towards the "Fair" category, with a wider range of responses. In terms of the experience in playing video games that provide hints, the option "Moderate" is the most frequent. It is also essential to get the average number of hours the participants play video games per week. The findings show that almost one-third of participants do not play video games, while the majority play between 1 hour to 10 hours. The information is shown in Figure 4.1.

	None	Few	Moderate	Fair	A lot
Please classify your experience in playing video games	7	8	8	9	8
Please classify your experience in playing racing games	8	16	8	4	4
Please classify your experience in playing video games that provide hints	4	10	14	9	3

TABLE 4.11. Players Experience results

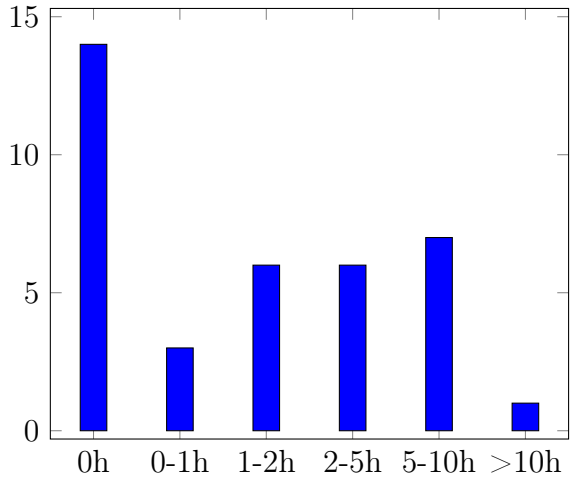

FIGURE 4.1. How many hours per week do the participants play, on average

The Hexad Scale is a tool used for personalized gamification in user experience design to identify the participant hexad type based on their answers [30]. The Hexad Scale consists of six hexad types: Philanthropist, Achiever, Socializer, Player, Free Spirit and Disruptor. The Philanthropist is a player that is happy to help others and cares about their well-being. The Socializer is a player that feels comfortable being part of a team and enjoys doing group activities. The Achiever is a player that likes a challenge by mastering it and puts everything to complete it. The Player is a person that conquers rewards, it builds his motivating and puts effort if the reward is good enough. The Free Spirit is a player that likes to do thing by himself, he follows his own path and likes to be independent. Finally the Disruptor is a player that does not care about the rules and behaves in a way that a normal person does not. The original Hexad Scale consists of a 24-item questionnaire, but it was reduced to a 12-item questionnaire in this study to improve the assessment process and the effectiveness of the answers [30].

Each hexad type is measured by two questions, with responses captured on a 7-point Likert scale from "strongly disagree" to "strongly agree" [31]. The scores for each hexad type range between 0 to 6, and the sum of both questions determines the power of that hexad type for each participant. The hexad type with the highest score, corresponds to the participant type. There are some cases that multiple hexad types share the highest score, meaning that the participant is assigned more than one hexad type. The Figures 4.2, 4.3 and 4.4, presents the hexad scale results, in terms of total occurrences, mean and standard deviation.

The results from Figure 4.2 indicate that the hexad type that the participants most identify as, was the "Achiever" with 21 participants. Following closely, both the "Philanthropist" and the "Socializer" are tied with 18 participants each. The "Free Spirit" type was identified with 14 participants, while the "Player" category includes 12 participants. No participants identified as a "Disruptor".

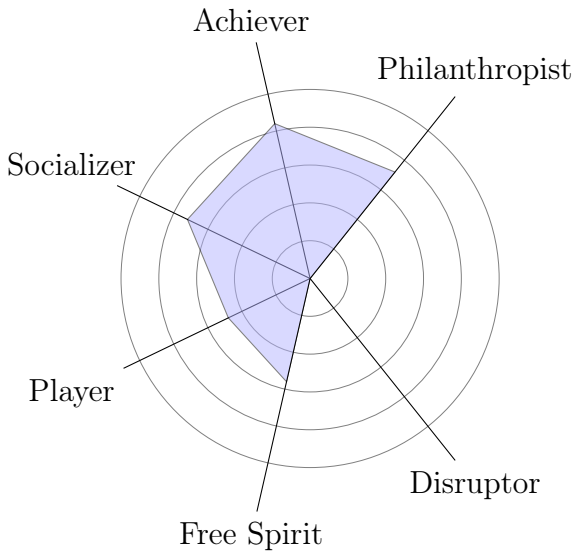

FIGURE 4.2. Total occurrences of Hexad Scale

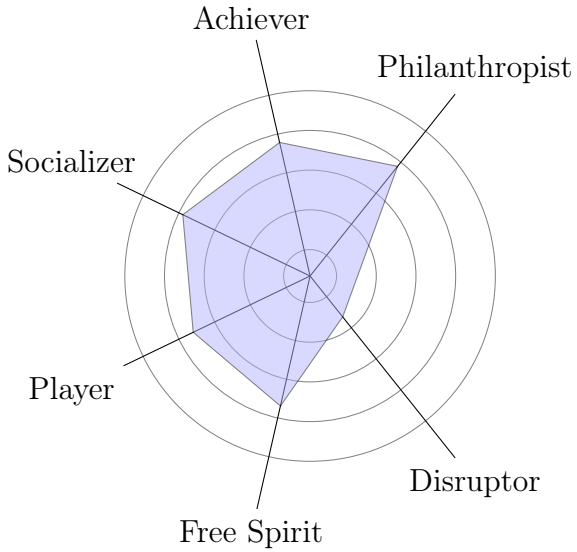

FIGURE 4.3. Mean of Hexad Scale

In Figure 4.3, the "Achiever" type was the most identified among participants, through its mean score (5.175) is lower compared to the "Philanthropist" (5.3) and "Socializer" (5.3375) types, respectively. Following by, the "Free Spirit" with 5.0375. while the "Player" category with a mean score of 4.9. Although no participant identified as "Disruptor", it got 1.975, meaning that their were participants that got Disruptor behavior but they were not identified as.

In Figure 4.4, the "Player" is the type with the higher standard deviation of 0.61, suggesting a wider range of the participants answers. Following by, "Disruptor" with 0.53, although its mean score was low, there was a wider range of answers. Next, is the "Free Spirit" with 0.46. After that, is the "Achiever" with 0.41. Following by, the "Socializer" with 0.39. Lastly, we got the "Philanthropist" with 0.33.

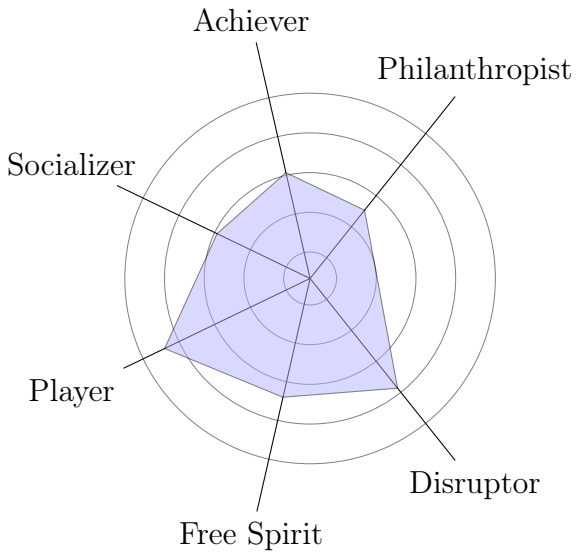

FIGURE 4.4. Standard Deviation of Hexad Scale

4.4. Debriefing User Feedback

After the completion of the experience, participants were engaged in a discussion to provide feedback on their overall thoughts and what areas could be improved.

Regarding the visual aspects of the game, most of the participants expressed positive feedback, praising the color scheme, high-quality of the environment (Hills, Mountain, Grass, etc), the level of detail on objects such as car nitro and its shadow and the user interface (UI) elements that were display on the screen (Timers, Mini-Map, Coins, Speedometer, nitro capacity and Track Progress). However, some participants pointed out some areas of improvement, they suggest that the UI elements should be moved a bit closer to the center of the screen. They also mentioned that some UI elements were unnoticed due to the focus required to the game itself and the hints. One participant noted that the mini-map was to zoomed in, making it difficult to see the rest of the track and referenced "Gran Turismo" as an example where the track was always visible. This design option is explained in Chapter 3 "Game Design and Development".

Feedback on the gameplay itself was generally positive, with participants noticing a smooth experience free of frames dropped or lag, praising all of the sounds effects (soundtrack, car sound when moving, drift sound, etc). However, some participants indicated areas of improvement. They mentioned that the car gained speed when drifting, and rarely drifts in the wrong direction. A few participants noted that the combination of the last two jumps was too challenging, making it difficulty to complete a lap.

Regarding the controls, some participants suggested the inclusion of an alternative movement controls, such as using the W/S/A/D keys (W for forward, S for backwards, A for left and D for right), as some of them were more familiar to this setup in other video games or were left handed. Participants also pointed out that, with the exception of the pause button, the remaining controls could be placed closer together to allow easier access with one hand.

Finally in terms of the hints systems, the participants also gave a positive feedback, such as favoring hints that require the use of a specific button, such as "To pass a jump, use turbo by pressing and holding V.". However, hints that did not involve button inputs were less liked, as participants found them too obvious or already known. One exception was the hint "Don't waste all of your nitro, save it for the jumps.", which helped the participants understand that there is a nitro capacity for the car. They also suggested that it should be added additional hints, such as "For gaining nitro and coins, do tricks and surpass obstacles.". This similar message was presented in the objectives section in the Main Menu, but participants though it would be better if it was displayed as a hint instead.

We can conclude that the feedback received from the participants was positive, with specific praise for the visual aspects, gameplay, controls and hint systems. Participants also provided feedback on areas of the game that could be improved. Addressing these areas in future work, specially hint systems, could further improve the impact on player experience.

4.5. Discussion

Based on the results presented, it shows that there is a statistical significance ($p < 0.05$) to the hint preference between Random Hints and On-Failure Hints. The On-Failure Hints having a proportion of 0.9 (90%). This demonstrates that there is enough evidence to conclude that there is a preference between Random Hints and On-Failure Hints. However, the relationships between the modes and the seven components of the GEQ Core Module, the p values are all > 0.05. This means that none of those relationships are significant, concluding that there may be a preference between the modes, but there is insufficient evidence to understand the factors/components that contribute to that preference. For the proportion test between having the On-Demand approval for hints and not having the On-Demand approval for hints is not statistical significant ($p < 0.05$), with the proportion of the participant that have picked having On-Demand approval of 0.4 (40%) and of not having the On-Demand approval of 0.6 (60%), meaning that the relationship is not statistical significant.

In several results, there is notable lack of evidence to conclude that the player experience was affected by the distinct hint systems modes of the game. This could likely be due to the sample size being relatively small in the study. With a limited number of participants the capacity of the data is reduced, resulting in being more difficult to detect various changes or relationships between the hint systems modes. A larger sample size, would make the data analysis stronger, and improve the ability to understand how hint systems modes and its features would influence player experiences and preferences.

CHAPTER 5

Conclusion and Future Work

This chapter presents the conclusions from analyses of results, responses to the research questions from this dissertation, limitations from this study and suggested improvements for future work.

5.1. Conclusion

This dissertation presents a time trial racing game developed in Unity, with the implementation of four different hint modes designed to study the impact of Game-Triggered and Player-Triggered hints on player experience. The study aimed at answering the following research questions: "What types of hints improve the player experience?" and "What preferences do players have regarding the types of hint systems?".

An experience was realized with 40 participants to study the impact of hint systems on player experience. The Game Experience Questionnaire (GEQ) was used to compare the hint system modes. Participants answered questions from the GEQ Core Module, hint preference between Random Hints and On-Failure Hints and the use of On-Demand approval for the hints.

Additionally, a Post-Game Demographic Survey was used to collect the participant demographic data. This survey assessed participants experience in playing video games, playing racing games and games that provide hints. It also gathered information on participants' average weekly playing time and included a hexad scale to determine the type of player they would be in a game.

The results from the GEQ Core Module showed that, across the seven components measured, there was insufficient information to indicate a clear preference from one hint system over another. The responses to the hint preference question confirm a significant preference, with almost all participants favoring On-Failure Hints. For the On-Demand approval question, the choices were evenly equal, resulting in no statistically significant preference.

Based on the demographic data, there were considerable variability in participants experience in playing video games, but the option "Fair" was slightly the most frequent. Experience in racing games was typically "Few", and experience in games that provide hints was rated "Average". This suggests that results could differ if participants were more experienced with other game genre that incorporates hint systems.

For the research question "What types of hint systems improve the player experience?", the results from the hint preference between Random Hints and On-Failure Hints show that participants favor On-Failure Hints in a statistically significant amount. However,

the results did not show any statistically significant preference between requiring or not requiring player approval before displaying the hint. Furthermore, the results show no statistically significant influence of hint modes and the seven components from the GEQ Core Module to affect player experience.

For the research question "What preferences do players have regarding the types of hint systems?", the results from the hint preference between Random Hints and On-Failure Hints show that participants have a preference for On-Failure Hints over Random Hints. However, the results did not show any hint preference between requiring or not requiring player approval before displaying the hint. Furthermore, the results did not show any hint preference from hint modes and the seven components from the GEQ Core Module.

These findings offer valuable insights for game designers on the inclusion of hint delivery strategies, suggesting a preference for On-Failure Hints as a means to improve player experience, while emphasizing the importance of accommodations diverse player preferences through flexible hint option such as On-Demand approval.

5.2. Future Work

For a better evaluation, in some analysis it was noted that a bigger sample size would be beneficial. Increasing the sample size could improving the results and increasing the possibility of achieving statistical significant ($p < 0.05$).

For future work, it would be beneficial to investigate the correlation between participant responses from the GEQ Core Module and their Hexad type. This approach could help determine whether the GEQ Core Module aligns with each participant' Hexad type, offering deeper insights into how different player types engage with and respond to various game elements, resulting in the impact of their player experience.

Improvements should be made to improve even further the player experience. One issue identified was the lack of a hint to pause the game in case the participant failed repeatedly. A helpful improvement would be to provide a hint encouraging players to click the pause button to check the controls if they encountered difficulties. Additionally, when participants were heading the wrong way, there was no warning on the screen. To resolve this, followed by a respawn in the correct direction.

Further improvements include the players having the ability to change the controls and the keys for each action in the game menu. It was also observed the car occasionally behaves unpredictably when jumping the second to last ramp, sometimes landing in a way that causes it to get stuck or goes through it. Another improvement is to ensure the game does not start without the participants picking a hint system. Lastly, there was a tendency for the nitro to occasionally become infinite.

In Chapter 4 "Evaluation", subsection 4.4 "Debriefing User Feedback", participants provided feedback in terms of visual aspects, hint systems, gameplay and controls. Enhancing these elements could lead to an improve on player experience.

For a better game overall, more helpful hints could be added to expand the hint system, incorporating multiple tracks to better test each mode, and adding more obstacles to the

track. Introducing different types of cars and setting time goals for each track, based on the selected car, would add variety to the gameplay experience.

Since this game is currently for PC only, it would be interesting to explore its potential on consoles, such as Playstation and Xbox. The usage of the analog stick and the adaptive triggers could provide players with enhanced controls over keyboard, could make the gameplay experience more immersive and could allow players to feel more comfortable and engaged.

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Appendices

APPENDIX A

Game Experience Questionnaire (GEQ)

1. Please indicate how you felt while playing the game *

	Not at all	Slightly	Moderately	Fairly	Extremely
I felt content	○	○	○	○	○
I felt skillful	○	○	○	○	○
I was interested in the game's story	○	○	○	○	○
I thought it was fun	○	○	○	○	○
I was fully occupied with the game	○	○	○	○	○
I felt happy	○	○	○	○	○
It gave me a bad mood	○	○	○	○	○
I thought about other things	○	○	○	○	○
I found it tiresome	○	○	○	○	○
I felt competent	○	○	○	○	○
I thought it was hard	○	○	○	○	○

It was aesthetically pleasing	○	○	○	○	○
I forgot everything around me	○	○	○	○	○
I felt good	○	○	○	○	○
I was good at it	○	○	○	○	○
I felt bored	○	○	○	○	○
I felt successful	○	○	○	○	○
I felt imaginative	○	○	○	○	○
I felt that I could explore things	○	○	○	○	○
I enjoyed it	○	○	○	○	○
I was fast at reaching the game's targets	○	○	○	○	○
I felt annoyed	○	○	○	○	○
I felt pressured	○	○	○	○	○

I felt irritable	○	○	○	○	○
I lost track of time	○	○	○	○	○
I felt challenged	○	○	○	○	○
I found it impressive	○	○	○	○	○
I was deeply concentrated in the game	○	○	○	○	○
I felt frustrated	○	○	○	○	○
It felt like a rich experience	○	○	○	○	○
I lost connection with the outside world	○	○	○	○	○
I felt time pressure	○	○	○	○	○
I had to put a lot of effort into it	○	○	○	○	○

2. Please indicate your preference (a single option): *

- ◯ I prefer that hints appear in the game only when I fail to progress.
- ◯ I prefer that hints appear in the game even when I don't fail to progress.

3. Please explain your preference given in Point 2:

Your answer

4. Please indicate your preference (a single option): *

- ◯ I want the game to ask for my approval before showing each hint.
- ◯ I do not want the game to ask for my approval before showing each hint.

5. Please explain your preference given in Point 4:

Your answer

6. First mode played *

- ◯ 1
- ◯ 2
- ◯ 3
- ◯ 4

APPENDIX B

Post-Game Demographics Survey

1. Please indicate your gender: *

- ◯ Male
- ◯ Female

2. Please indicate your age: *

Your answer

3. Please classify your experience in playing video games: *

- ◯ None
- ◯ Few
- ◯ Moderate
- ◯ Fair
- ◯ A lot

4. Please classify your experience in playing racing games: *

- ◯ None
- ◯ Few
- ◯ Moderate
- ◯ Fair
- ◯ A lot

5. Please classify your experience in playing video games that provide hints: *

- ◯ None
- ◯ Few
- ◯ Moderate
- ◯ Fair
- ◯ A lot

6. On average, how many hours per week do you play videogames: *

Your answer

7. Please pick the option that best suites you: *

	Strongly Disagree	Disagree	Somewhat Disagree	Neither	Somewhat Agree	Agree	Strongly Agree
It makes me happy if I am able to help others	○	○	○	○	○	○	○
The well-being of others is important to me	○	○	○	○	○	○	○
I like being part of a Team	○	○	○	○	○	○	○
I enjoy group activities	○	○	○	○	○	○	○
I like mastering difficult tasks	○	○	○	○	○	○	○
I enjoy emerging victorious out of difficult circumstances	○	○	○	○	○	○	○
If the reward is sufficient, I will put in the effort	○	○	○	○	○	○	○
Rewards are a great way to motivate me	○	○	○	○	○	○	○
It is important to me to follow my own path	○	○	○	○	○	○	○
Being independent is important to me	○	○	○	○	○	○	○
I see myself as a rebel	○	○	○	○	○	○	○
I dislike following rules	○	○	○	○	○	○	○