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Enhancing Multiplayer Gaming via Per-Player Visual Theme Selection

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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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The most important thing is to enjoy your life, to be happy, it's all that matter's

—Steve Jobs

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Firstly, I would like to thank my family for all their help and support throughout this dissertation, especially my parents, my sister, my girlfriend, and my grandparents, who were always available to support me in everything I needed.

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Resumo

Nos videojogos multijogador, o componente visual é central para o envolvimento dos jogadores, moldando a imersão, a preferência e as primeiras impressões. Normalmente, todos partilham o mesmo estilo gráfico, uma restrição justificada por custos, limitações técnicas e pela necessidade de preservar a equidade. Esta dissertação apresenta um sistema de visualização assimétrica em jogos multijogador, permitindo que cada jogador experiencie o mesmo mundo através de estilos visuais diferentes, sem alterar regras de jogo. O protótipo foi construído em Unity com Photon Unity Networking (PUN) sobre um jogo de tiro em primeira pessoa, mas a abordagem é independente do género. Para demonstrar a viabilidade, foram implementados dois temas contrastantes, ficção científica e Velho Oeste, mostrando que estéticas distintas podem coexistir na mesma partida com jogabilidade idêntica. O sistema foi desenvolvido de forma iterativa, com testes formativos a pequenos grupos e uma avaliação final com 39 participantes. Esta comparou três cenários: jogar com o estilo preferido, com o estilo não preferido e em livre escolha. Os resultados do Questionário de Experiência de Jogo (GEQ) mostraram que a liberdade de escolha aumentou significativamente a perceção de competência, a imersão e o envolvimento social, ao mesmo tempo que reduziu experiências negativas. No geral, este trabalho demonstra que a visualização assimétrica é viável e bem recebida, ampliando o espaço de design dos jogos multijogador e criando novas oportunidades de personalização, imersão e inclusão.

Palavras-chave: Videojogos; Multijogador; Interface adaptativa; Experiência do jogador.

Abstract

In multiplayer video games, the visual component is central to player engagement, shaping immersion, preference, and first impressions. Typically, everyone shares the same graphic style, a restriction justified by costs, technical limitations, and the need to preserve fairness. This dissertation presents an asymmetric visualization system in multiplayer games, allowing each player to experience the same world through different visual styles, without altering game rules. The prototype was built in Unity with Photon Unity Networking on a First Person Shooter game, but the approach is genre-independent. To demonstrate feasibility, two contrasting themes, science fiction and the Wild West, were implemented, showing that distinct aesthetics can coexist in the same match with identical gameplay. The system was developed iteratively, with formative testing on small groups and a final evaluation with 39 participants. This compared three scenarios: playing with the preferred style, with the non-preferred style, and with free choice. The results of the Game Experience Questionnaire showed that freedom of choice significantly increased the perception of competence, immersion, and social engagement, while reducing negative experiences. Overall, this work demonstrates that asymmetric visualization is feasible and well received, expanding the design space for multiplayer games and creating new opportunities for personalization, immersion, and inclusion.

Keywords: Videogames; Multiplayer; Adaptive interface; Player experience.

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CHAPTER 1

Introduction

1.1. Context

Video games have become one of the most influential and rapidly evolving forms of entertainment in modern culture [1]. With billions of players worldwide, the gaming industry now encompasses a wide range of genres, platforms, and play styles, appealing to both casual and hardcore audiences. Among the many elements that contribute to a game's success, such as gameplay mechanics, narrative depth, sound design, and multiplayer systems, visual presentation remains one of the most defining and impactful components.

The graphic visualization of a game is not only its visual identity but also a powerful tool for conveying atmosphere, tone, and emotion. It sets the stage for the player's experience, often determining their first impressions and expectations. A game's aesthetic style communicates genre cues (e.g., horror, sci-fi, fantasy) and influences how players perceive the world, the characters, and even the gameplay itself. For instance, dark, gritty visuals are often associated with realism and intensity, appealing to players who seek immersion and emotional weight. On the other hand, colorful, cartoonish styles tend to attract players looking for light-heartedness, humor, or accessible visuals [2].

Despite the diversity of preferences among players, most multiplayer games, to the best of our knowledge, are visually fixed to a specific aesthetic identity, targeting a clearly defined demographic. This design choice, while efficient from a production standpoint, inherently excludes players who might enjoy the gameplay but find the visuals unappealing or alienating. For example, a player might love competitive first-person shooters but avoid a title due to its militaristic or overly violent visual tone, preferring a more cartoonish setting. This rigid linkage between gameplay and visual style presents an opportunity for innovation.

Let us suppose if games could decouple core gameplay logic from visual representation, allowing each player to experience the same game mechanics through a personalized visual lens. Such an approach could open the door to highly customizable, inclusive, and adaptive experiences. Players could choose a style that best suits their taste, whether realistic, stylized, futuristic, or historical, without impacting competitive fairness or mechanical balance. This would not only expand the game's reach to broader audiences but also enhance immersion, satisfaction, and engagement by aligning the aesthetic experience with individual player identities.

Although personalization is becoming increasingly common in aspects like character creation or HUD customization, there is currently, to the best of our knowledge, no widely adopted system that allows players to choose the entire visual representation of the game world itself while preserving synchronized multiplayer gameplay. This gap highlights the innovative potential of such a concept, not only for entertainment but also for fields such as educational games, therapeutic experiences, or accessibility-focused design, where visual style may need to adapt to cognitive, cultural, or emotional needs.

The exploration of this idea thus presents a promising step forward in game design, challenging long-standing assumptions about how visuals are tied to gameplay, and proposing a new paradigm of flexible, player-centric visualization.

1.2. Motivation

The video game industry has long excelled in delivering visually stunning experiences, yet it has rarely ventured into the idea of allowing those visuals to dynamically adapt to individual player preferences. While there are countless options for adjusting resolution, brightness, or minor stylistic elements such as skins, the core aesthetic identity of a game is typically fixed. This rigidity overlooks the fact that players have diverse visual tastes, and that visual preference can significantly influence both emotional connection and overall engagement.

Existing examples of asymmetrical gameplay mechanics, where players have differing roles, tasks, or viewpoints, have shown that varying the experience between players can lead to highly engaging and novel designs. One of the most famous examples is *Keep Talking and Nobody Explodes*[1], where one player interacts directly with a bomb interface while others, without seeing the screen, provide instructions using a printed manual. Although both players are participating in the same task, they experience the game through completely different interfaces and roles.

Another relevant example is *Dead by Daylight*[2], a multiplayer horror game where one player controls a killer in first-person view, while the other players assume the roles of survivors in third-person. The difference in perspective creates an asymmetrical tension and pacing between roles. However, despite these innovations, such examples still retain a shared visual style and world design, meaning all players exist within the same aesthetic framework.

These games demonstrate that asymmetry can enhance engagement by creating varied and complementary experiences. Yet, the concept of asymmetrical visualization, where each player can perceive the same game world through a completely personalized visual lens, remains virtually unexplored in commercial titles.

This gap presents an exciting opportunity: let us suppose a game where a parent and child can play together, each seeing the world in a way that suits their preferences or age. The adult might see a realistic, gritty battlefield, while the child experiences the same game mechanics through a stylized, cartoon-like environment, ensuring both enjoy the experience without compromising gameplay rules. This system not only encourages cross-generational play, but also supports diversity, accessibility, and inclusivity, by allowing

[1]https://keeptalkinggame.com
[2]https://deadbydaylight.com

visual environments to be adapted to emotional comfort levels, cognitive needs, or cultural preferences.

Beyond this example, the proposed system opens a broader range of use cases that extend beyond traditional customization, addressing inclusivity, accessibility, and audience expansion. It allows players from different age groups, cultural backgrounds, or aesthetic preferences to share the same multiplayer environment while perceiving it in ways that best resonate with their individual sensibilities. Moreover, it can benefit players with mild perceptual or cognitive challenges by offering visual styles that enhance clarity or reduce visual strain. For instance, simplified textures, increased contrast, or softer lighting could make environments more comfortable for players with color vision deficiencies or attention-related difficulties, all without altering the underlying gameplay mechanics.

Furthermore, by decoupling gameplay logic from aesthetic representation, developers could provide more flexible and modular content, allowing the same game to serve multiple audiences without compromising design integrity.

In short, this work is motivated by the unexplored potential of personalized, asymmetric visualization in multiplayer games, a concept that could redefine how we think about game design, player identity, and inclusivity in digital experiences. Building on this motivation, the present dissertation develops and evaluates a system that enables each player in a multiplayer First Person Shooter (FPS) to experience the same gameplay logic through distinct visual styles. The goal is to demonstrate the feasibility of this approach, assess its impact on player experience, and highlight its potential to make multiplayer games more inclusive and engaging.

1.3. Research Questions

The proposed system developed in this dissertation introduces asymmetric visualization in a multiplayer FPS, where each player can experience the same shared game logic through a personalized visual style (e.g., Sci-Fi or Wild West). The central goal is to decouple aesthetics from gameplay while preserving game rules and balance. To assess the impact of this system on player experience, the following research questions were defined:

(1) Do asymmetrical visualization themes within the same game enhance the overall satisfaction and engagement of players?

(2) Does the freedom to choose one's preferred visualization theme, as opposed to being forced into a specific theme, lead to higher values of satisfaction and engagement of players?

1.4. Objectives

This dissertation defines four main objectives, each addressing a specific aspect of asymmetric visualization in multiplayer games:

(O1) The primary objective is to allow each player to experience the same underlying game logic while perceiving the world through a visual style tailored to their individual preferences. This challenges the traditional notion that all players must share a single, unified visual aesthetic in multiplayer environments.

(O2) Building upon an adapted open-source First Person Shooter (FPS) foundation, the goal is to enable dynamic switching of visual assets based on each player's selected theme, without altering the game rules or mechanics. This includes loading different 3D models, textures, music, sounds, animations, and effects.

(O3) A long-term objective is to design the framework so that new visual styles can be easily integrated, allowing the system to accommodate diverse audiences, including players of different ages, cultural backgrounds, or perceptual preferences.

(O4) Finally, the project aims to investigate whether giving players control over their visual environment enhances immersion, competence, engagement, and emotional response. This was assessed through user testing and structured questionnaires, using instruments such as the Game Experience Questionnaire (GEQ).

1.5. Organization of the Dissertation

This dissertation is structured into six main chapters, each addressing a specific part of the work.

Chapter 1 – Introduction presents the motivation behind the research, defines the problem, and introduces the research questions.

Chapter 2 – Related Work reviews existing literature on game design, immersion, replayability, customization, and asymmetry, highlighting how these concepts inform the proposed system.

Chapter 3 – Proposed System Architecture describes the overall architecture of the system, explaining how gameplay logic is decoupled from visual representation. It also details the mechanisms for asset management, system conceptualization, and the design choices made to ensure scalability and game rules.

Chapter 4 – System Prototype outlines the development of the prototype used to validate the proposed approach. It covers design decisions, integration of visual styles, gameplay mechanics, asset workflows, and other implementation details.

Chapter 5 – Evaluation presents the methodology and results of both formative and summative evaluations. It explains the experimental setup, the use of the Game Experience Questionnaire (GEQ), and the statistical analysis applied to assess player experience.

Chapter 6 – Conclusions and Future Work summarizes the findings, discusses the limitations of the current system, and outlines opportunities for future research in asymmetric visualization and multiplayer personalization.

1.6. Research Methodology

The research conducted in this dissertation followed the Design Science Research Methodology (DSR), a well-established framework for structuring research in the field of information systems. DSR organizes the research process into five stages:

- (1) Problem Awareness;
- (2) Solution Suggestion;
- (3) Development;
- (4) Evaluation;
- (5) Conclusion.

This work aligns with these stages as follows. Chapter 1 introduces the research problem and motivation, fulfilling the Problem Awareness stage (Step 1). A review of relevant literature is presented in Chapter 2, supporting both the contextualization of the problem and the justification for the proposed solution. Chapters 3 present the conceptual and architectural foundations of the asymmetric visualization system, corresponding to Solution Suggestion (Step 2). The implementation of the prototype and supporting systems, described in Chapter 4, constitutes the Development stage (Step 3). Chapter 5 presents the results of the formative and summative evaluations, completing the Evaluation stage (Step 4). Finally, Chapter 6 synthesizes the findings, discusses implications, and outlines future work, fulfilling the Conclusion stage (Step 5).

1.7. Academic Work Dissemination

In September of 2025, a paper was submitted and accepted to be presented at the 2025 International Conference on Computer Graphics and Iteration (ICGI).

The paper builds upon the work developed in this dissertation, introducing the conceptual and architectural foundations of an asymmetric visualization system for multiplayer environments. It discusses the motivation behind enabling individualized visual perspectives within shared worlds and presents the system's structural design, focusing on how the separation between gameplay logic and visual rendering allows for aesthetic flexibility without compromising core functionality.

The publication details the overall system workflow, outlining the client-server communication structure, asset management process, and synchronization strategies that ensure consistency between players experiencing different visual themes. The implementation is described through the construction of a prototype that integrates these concepts into a functioning multiplayer environment.

To evaluate the system, a user study was conducted involving multiple test sessions across three gameplay scenarios, followed by a detailed analysis of player responses and experiential outcomes. Through this process, the paper examines how asymmetric visualization influences perception and engagement in shared multiplayer contexts, contributing to the ongoing discussion on personalization and immersion in interactive digital media.

The code developed for this dissertation is freely available for download[3].

[3]https://github.com/DiogoCGil/Enhancing-Multiplayer-Gaming-via-Per-Player-Visual-Theme-Selection

CHAPTER 2

Related Work

To design a system where more than two players can share the same multiplayer game while perceiving it through different visualizations, it is essential to review prior research across several relevant domains. This includes not only works directly addressing asymmetry in games but also broader perspectives on game design principles, immersion, replayability, customization, and accessibility.

By examining these areas, we establish the theoretical foundation for asymmetric visualization, situating our work within existing literature on asymmetric gameplay and extending it into the underexplored visual dimension. The following sections provide an overview of key studies, organized around core concepts that inform and justify the system proposed in this dissertation.

2.1. Review Methodology

In addition to the DSR framework guiding the structure of the research process, the literature study followed a systematic approach supported by the snowball method. The snowball method consists of identifying relevant academic works through iterative exploration of reference lists and citations, allowing the set of sources to expand organically as new links between topics emerge. This iterative strategy ensured that both foundational contributions and recent developments were captured.

The initial search process relied on identifying peer-reviewed articles and conference papers with substantial citation impact. These were used as anchors for subsequent backwards and forwards snowballing, progressively extending the scope of the review to cover all thematically relevant areas.

The starting points for this exploration were grouped into key thematic domains aligned with the objectives of the dissertation. The main keyword groups used were:

- Game Design
- Dynamic Difficulty Adjustment (DDA)
- Flow and Interest Curves
- Immersion
- Customization and Replayability
- Asymmetric Gameplay
- Visual Embellishments
- Music and Audio Design
- Asymmetric Visualization

This combined methodological approach—DSR for structuring the research process and snowballing for guiding the literature review—ensured both rigor and breadth in the development of the theoretical and technical foundations of this dissertation.

2.2. Game Design

Game design is the discipline that guides how video games are created and developed. It involves defining the rules, objectives, mechanics, feedback systems, visuals, and sounds that work together to build engaging and enjoyable experiences for players.

Costikyan [3] defines a game as an "interactive structure of endogenous meaning that requires players to struggle toward a goal," highlighting three essential aspects: interactivity, challenge, and goals with value only within the game world.

In parallel, Schell [4] frames game design as the design of an experience, an inherently subjective perception that, while impossible to fully control, can be shaped through thoughtful mechanics and presentation.

Game design is therefore both creative and systematic, relying on iterative processes of prototyping, testing, feedback, and refinement. Its purpose is not only to ensure functional gameplay, but also to align player interaction with the intended aesthetic and emotional impact of the game.

Because of this dual nature, different kinds of design principles have proven valuable in shaping engaging player experiences. Conceptual models such as Flow and Interest Curves help designers understand how to balance intensity, pacing, and challenge over time, ensuring that gameplay feels rewarding rather than monotonous or overwhelming. In contrast, Dynamic Difficulty Adjustment (DDA) provides a more concrete framework, offering practical methods to dynamically adapt difficulty to player performance. This adaptability is especially important in multiplayer contexts, where players with varying skill levels coexist. By automatically tuning challenge, DDA helps maintain engagement for both novice and expert players, preventing frustration for the less experienced and boredom for the highly skilled.

In the following subsections, we will analyze these concepts in more detail and conduct an academic literature review on them, establishing the theoretical foundation that later informs the design and implementation choices of this dissertation's asymmetric visualization system.

In the context of this dissertation, game design takes on a specific importance. The central innovation proposed, allowing players to experience the same multiplayer game through different visual styles, demands a careful balance between thematic variety and game rules. It is not merely a matter of aesthetics, but a design challenge that requires ensuring consistency in mechanics and competitive integrity across all visual interpretations of the game world.

2.2.1. Dynamic Difficulty Adjustment

DDA refers to the process of automatically adapting a game's challenge level in real time according to the player's performance, behavior, or physiological state. Instead of offering a static difficulty setting, DDA systems aim to maintain an optimal balance between challenge and skill, preventing boredom when the game is too easy and frustration when it is too hard.

Ang et al. [5], investigated the impact of different DDA approaches on player engagement by comparing conditions with and without adaptive mechanisms. The findings highlighted that DDA can significantly enhance enjoyment and motivation, particularly for less experienced players, as it prevents frustration by lowering the difficulty in critical moments and maintaining a manageable challenge. For more experienced players, DDA helped sustain interest by dynamically scaling difficulty to their skill level, ensuring that gameplay did not become overly predictable or monotonous. However, the study also noted limitations, particularly in capturing the subjective perception of challenge, since frustration and motivation can vary considerably between individuals. Despite these challenges, the results strongly emphasize the value of DDA as a balancing tool in game design, ensuring accessibility while simultaneously preserving engagement through personalized challenge.

Afergan et al. [6], explored the use of physiological signals, specifically brain metrics derived from electroencephalography (EEG), to dynamically adapt difficulty in real time. Their approach sought to go beyond observable performance metrics such as score or error rate, focusing instead on internal cognitive states like workload and mental effort. By leveraging machine learning models, the system continuously analyzed EEG data to estimate whether players were underloaded, optimally engaged, or overloaded, and adjusted game difficulty accordingly. The results indicated that integrating brain-based signals into DDA allowed for a more fine-grained understanding of player experience, offering adaptive adjustments that were not always evident through traditional performance-based methods. This approach had the advantage of reacting to fluctuations in engagement before they manifested as frustration or boredom, potentially leading to smoother and more personalized difficulty curves. However, the study also highlighted significant challenges, such as the practical complexity of using EEG equipment in natural play settings and the difficulty of generalizing workload predictions across diverse players.

Liu et al. [7] proposed an affective-driven approach to DDA by adjusting game difficulty according to the player's anxiety levels measured in real time. The system relied on psychophysiological signals such as heart rate and skin conductance to estimate the player's emotional state and then dynamically tuned gameplay parameters to keep anxiety within an optimal range. The authors argued that this approach goes beyond traditional performance-based DDA, which usually reacts only to visible player success or failure, by incorporating an affective dimension that more accurately captures engagement and stress. However, while the method showed promise in enhancing player immersion and tailoring experiences, it also raised challenges regarding the accuracy and reliability of emotion detection, as well as the feasibility of deploying such biometric systems in mainstream gaming contexts.

Overall, DDA is important to consider adding in games overall because it helps ensure that games do not become repetitive and uninteresting for experienced players while also making them more enjoyable and accessible for less experienced ones. For this reason, DDA was integrated into this dissertation and will be explained in detail later in the work.

2.2.2. Interest Curves

Interest curves, as discussed by Schell [4], describe how the pacing of a game can be represented as a curve of rising and falling intensity over time. Rather than keeping gameplay at a constant level of difficulty or emotional tone, well-designed games alternate between high-intensity moments, such as combat, climactic battles, or difficult challenges, and lower-intensity moments, such as narrative exposition, exploration, or recovery phases. These variations create rhythm and contrast, preventing fatigue from constant action and avoiding boredom from excessive downtime. A successful interest curve builds toward one or more climaxes while integrating smaller peaks and valleys along the way, ensuring that players remain engaged throughout the experience, as shown in Figure 2.1.

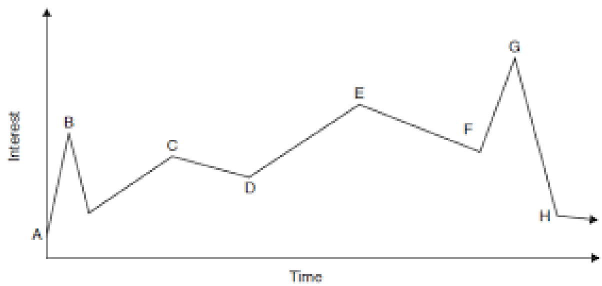


FIGURE 2.1. Example of Interest Curves from (Schell[4]).

Kim et al. [8] conducted a study using Super Mario Maker 2 to evaluate level design with and without interest curves. Two versions of levels were created: one following a sequentially increasing difficulty structure, and another designed according to an interest curve with ups and downs. Twenty participants were divided into two groups and tested on satisfaction and immersion. Results showed that the interest curve-based design produced higher average scores for both satisfaction and immersion. In particular, participants reported greater enjoyment when difficulty spikes were interspersed with easier sections, supporting Schell's claim that "hooks" placed at the right moments maintain long-term engagement.

The study also highlighted how alternating intensity can reduce frustration by giving players periods of relief and recovery, which in turn enhances their sense of control and autonomy. However, the study's limited sample size represents a limitation, suggesting the need for broader testing. Even so, these findings reinforce the importance of interest curves

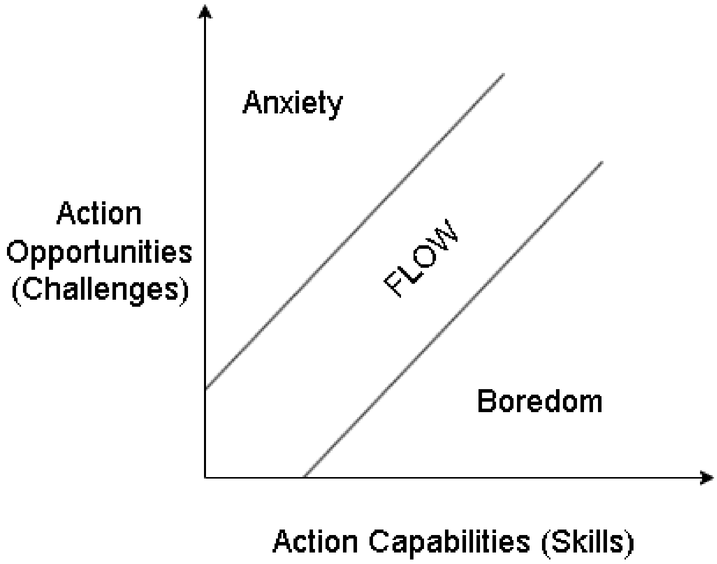


FIGURE 2.2. The flow channel model from (Csikszentmihalyi[9]).

for level design: by balancing challenge and pacing, designers can maintain immersion and deliver more memorable gameplay experiences.

In the context of this dissertation, although the game does not build toward a single final climax or absolute resting point, its design incorporates the smaller peaks and valleys described by Schell. Gameplay alternates between tense combat situations and quieter moments where players can explore their chosen visual theme at their own pace. This respects the logic of interest curves by ensuring contrast and rhythm throughout the match, keeping engagement high without overwhelming players.

2.2.3. Flow

Flow is a psychological concept introduced by Mihaly Csikszentmihalyi [9], describing a state of complete absorption and enjoyment in an activity. In this state, players experience deep focus, a sense of control, and intrinsic satisfaction, often losing awareness of time or external concerns. Flow occurs when the challenge of a task is balanced with the player's skill level: if the task is too easy, boredom arises; if it is too difficult, frustration dominates. The optimal experience is found in the "flow channel," where challenge and ability are in harmony, as shown in Fig. 2.2.

Csikszentmihalyi identifies several characteristics of flow, including clear goals, immediate feedback, concentration on the task, a sense of control, and the merging of action and awareness. Importantly, flow is not only about enjoyment in the moment but also about creating meaningful and memorable experiences that players are likely to seek again. In video games, this concept has become particularly relevant, as developers use it as a framework to design balanced difficulty systems, engaging progression curves, and gameplay loops that keep players motivated and immersed.

For this dissertation, flow is acknowledged as an important principle because it highlights the balance between challenge and skill that sustains engagement. To help maintain this balance, a DDA system was integrated into the game. As explained in detail later, the DDA adapts challenge levels in real time to avoid frustration for less experienced players while still keeping the game competitive for more skilled ones. In this way, the system helps preserve the flow channel, ensuring that players remain motivated and immersed regardless of ability level.

2.3. Game Components

Beyond rules, objectives, and mechanics, video games are also shaped by components that influence how players perceive and engage with the experience. These elements often work on sensory, emotional, or aesthetic levels, complementing the core gameplay by adding enjoyment, sustaining motivation, and reinforcing thematic consistency. Features such as immersion, customization, audio, and visual embellishments do not change the mechanics themselves, but they strongly affect how players connect with a game, making them important for both academic study and practical design. The following subsections review these components through existing research, showing how they contribute to creating compelling and memorable player experiences.

2.3.1. Immersion

Immersion is one of the most discussed concepts in game research, but its meaning is often used in different ways. Brown and Cairns [10] tried to clarify it by interviewing players. Their findings describe immersion as a progressive experience with three distinct levels: engagement, engrossment, and total immersion.

At the first level, engagement, players need to overcome barriers such as learning the controls or investing time. Once these are passed, they can move into engrossment, where visuals, story, and mechanics shape their emotions and focus. At the highest level, total immersion, players feel a strong sense of presence and detachment from the real world. However, this state is fragile and depends on factors such as empathy with characters and the atmosphere created by the game.

The study also highlighted that immersion is not guaranteed, but rather facilitated when barriers are lowered both by the player's effort and the game's design. This layered understanding of immersion offers a useful framework for examining how design choices affect player involvement and highlights that immersion, while powerful, is not always necessary for enjoyment.

Cairns et al. [11] expanded this model by connecting immersion with related concepts such as presence and flow. They emphasized that immersion should be seen as a continuum rather than a binary state, and showed that factors such as narrative coherence, emotional investment, and attention demands influence how deeply players progress along this scale. Their work therefore builds directly on Brown and Cairns' framework, adding nuance rather than redefining the phenomenon.

Cheng et al. [12] investigated immersion by examining the effects of sensory coherence, specifically the alignment between graphical realism (visual fidelity) and behavioral realism (object and character physics). Their study attempted to deliberately break immersion by altering coherence mid-game, such as drastically changing gravity or switching environments from realistic to cartoon-like. Surprisingly, results showed that once players had reached a state of immersion, these incoherences had little to no effect on their experience. In some cases, players did not even notice the changes. This suggests that strong immersion can compensate for inconsistencies, keeping players engaged despite flaws.

Qin et al. [13] proposed a practical model for measuring immersion in story-driven games. They identified seven factors, curiosity, concentration, comprehension, control, challenge, empathy, and familiarity, that capture how players connect cognitively and emotionally with a game. Their work highlighted the importance of narrative and player agency, showing that empathy and curiosity play a key role in sustaining immersion.

Overall, these studies show that immersion depends on both design and player factors, and it can be built, measured, and maintained in different ways. For this dissertation, the expectation is that theme-specific visual styles may influence immersion without altering the underlying mechanics, potentially adapting player experience.

2.3.2. Visual Embellishments

Visual Embellishements (VEs) are design elements that do not change gameplay mechanics but reinforce or highlight information players already perceive in other ways [14].

Hicks et al. [15] showed that effects such as particles, screen shakes, and animations can make games more engaging and immersive, even without changing functionality. These "juicy" elements enrich game feel, the emotional and tactile sense of interaction, by making simple actions like shooting or jumping more rewarding. However, the study also warned that overuse can overwhelm players or hide important information, making balance essential.

Haptic embellishments extend the idea of juiciness beyond visuals and sound by adding tactile feedback to gameplay. These are decorative vibrations or tactile cues that do not change mechanics but reinforce feedback already provided through other channels, aiming to enrich the multisensory experience.

Singhal and Schneider [16] extended juiciness to haptics, introducing decorative vibrations that complement visual or audio cues. Across two studies, they found that haptic embellishments improved enjoyment, immersion, meaning, and aesthetic appeal. They also proposed ten design principles, such as timing, exaggeration, and synchrony, adapted from animation and visual design. Their work shows that haptics can broaden juiciness into a multisensory experience while still requiring careful balance to avoid overload.

Gerling et al. [17] investigated how graphical fidelity affects player experience when mechanics stay constant. In a study with 48 participants, they compared high-fidelity and low-fidelity versions of two casual games. Higher fidelity increased immersion, positive affect, and relatedness in both games. Gains in motivation, competence, and autonomy, however, only appeared in the more challenging game, where visuals mattered more. Performance did not change, confirming that differences came from perception rather than difficulty. This suggests that while high-fidelity graphics can deepen engagement, simpler visuals can still work well in less demanding games.

Overall, these studies show that embellishments, visual or haptic, are powerful in shaping how players feel and connect with games. For this dissertation, they support the idea that asymmetric visual customization can enhance immersion and enjoyment without changing core mechanics.

2.3.3. Replayability and Customization

Replayability and customization are key to keeping players engaged over time, as they provide novelty, challenge, and a sense of personal investment. Thygesen et al. [18] looked at replayability from a structural perspective and proposed a taxonomy of strategies that extend long-term interest. Their analysis pointed to mechanisms like randomization, branching narratives, and multiple solution paths, which make each playthrough different. They also emphasized mastery and progression systems, where challenges that reward skill development and gradual improvement sustain engagement with both short- and long-term goals. Replayability, they argued, is not just about adding more content but about designing meaningful variation that encourages exploration and experimentation. In this sense, customization directly supports replayability by letting players shape their experience through avatars, environments, or mechanics, deepening attachment and investment.

Turkay and Adinolf et al. [19] tested these ideas in a longitudinal study of a commercial Massive Multiplayer Online (MMO). They found that giving players avatar customization tools increased intrinsic motivation (interest and enjoyment) and perceived autonomy, while also reinforcing character identification and persistence. Through the lens of Self-Determination Theory, customization acted as a stable motivational driver because it supported both autonomy and identity.

Ng and Lindgren et al. [20] studied similar effects in Spore: Galactic Adventures with a 2×2 design. They manipulated avatar type (personalized vs. generic) and narrative strength (strong vs. weak) among 48 participants. Personalized avatars significantly boosted presence, attention, and character identification, and also showed positive effects on learning, especially for spatial tasks. Narrative strength had less impact, which the authors attributed to limitations in the game editor and dialogue design. Their findings highlight that avatar personalization plays a stronger role than narrative changes in shaping immersion and engagement.

Dardis et al. [21] approached customization from another angle: memory of in-game brand placements. In a study with 147 participants, they manipulated avatar customization (enabled vs. disabled) and controlled familiarity (familiar vs. unfamiliar) while measuring recall of central and peripheral brands. Customization improved recall across both types, with a particularly strong effect for peripheral brands that usually go unnoticed. This suggests that personalization increases cognitive processing and attention to the game environment as a whole. The best results came when customization was paired with familiar controls, showing that personalization and usability can reinforce one another.

Altogether, these studies show that replayability relies on variety, challenge, and mastery, while customization gives players ownership of their experience. Both reinforce long-term engagement by keeping play sessions meaningful and personally relevant. In the context of this dissertation, asymmetric visual styles are positioned as a novel form of customization that may also enhance immersion and connection, providing players with a stronger sense of agency while preserving game rules.

2.3.4. Music and Sounds

Audio design is a central part of the game experience, shaping atmosphere, immersion, and performance. Sound effects, ambient audio, and music provide feedback that complements visuals, amplifies emotions, and improves awareness. Audio therefore works on both a sensory level, reinforcing presence and immersion, and a functional level, supporting decision-making and effectiveness.

Haehn et al. [22] studied the impact of character and ambient sounds in immersive VR and interactive environments. They found that synchronizing audio with player actions and environmental changes greatly increased both sensory immersion and emotional involvement. Participants reported stronger presence when soundscapes matched gameplay, especially when they responded dynamically to player actions. This shows that immersion depends less on fidelity alone and more on the alignment of sound with gameplay events.

Andersen et al. [23] tested audio in FPS environments by comparing muted sessions with full-sound versions. Players with full audio reported higher excitement and enjoyment, with physiological data confirming stronger arousal. Their performance also improved, with faster reactions and higher accuracy. The study concluded that audio is not just atmospheric but directly affects both experience and outcomes.

Lloyd and Raghuvanshi et al. [24] took a technical perspective, developing a real-time system for impact sound synthesis. Their method combined modal synthesis and spectral modeling to generate dynamic, high-quality sounds while reducing CPU and memory demands. This work showed that audio realism and variation can be improved without heavy resource costs, reinforcing the dual role of audio as both creative and technical design.

Friberg et al. [25] explored audio-only games through the TiM project, originally aimed at visually impaired children but also relevant for mainstream audiences. The project produced three prototypes, Mudsplat, X-Tune, and Tim's Journey, that used layered and spatialized soundscapes to create complex gameplay without visuals. They also identified different listening modes (casual, semantic, reduced) that shaped how players experienced sound as the main medium of play. Their findings show that audio can serve not only as support but as the foundation of rich interactive experiences, expanding both accessibility and creative potential.

Taken together, these studies show that audio uniquely shapes immersion, feedback, and performance. For this dissertation, they support the inclusion of theme-specific sound cues in the asymmetric visualization system, ensuring that audio enhances both sensory and functional layers of experience without depending on visual fidelity.

2.4. Asymmetry

Asymmetry in games refers to situations where players experience the same game world from distinct perspectives, roles, or with different mechanics. Instead of sharing identical capabilities and goals, players may have unique responsibilities, access to different information, or exclusive actions that shape their contribution to the collective outcome. This approach contrasts with the traditional "symmetric" model, where every participant engages under the same rules and mechanics.

In multiplayer design, asymmetry can manifest in several ways: character abilities, available resources, objectives, or even how players interact with the environment. Such differences introduce diversity in playstyles, often requiring coordination and communication, while also catering to varied preferences and skills. Importantly, research suggests that asymmetric play can strengthen social presence, collaboration, and connectedness among players, especially when interdependent roles are tightly coupled [26].

2.4.1. Asymmetric Gameplay

The work of Gonçalves et al. [26] explores the concept of asymmetric gameplay in the context of mixed-ability gaming. The authors argue that mainstream games typically target a stereotypical player with full sensory and motor abilities, leaving individuals with disabilities isolated in separate communities (e.g., sighted players focus on highly visual games, while blind players rely mostly on audio games). To overcome this divide, they propose asymmetric ability-based roles as a way to design inclusive and engaging experiences.

Their approach departs from the idea of universal accessibility where one gameplay is adapted for everyone by instead creating complementary, unequal roles that are interdependent by design. The study introduces two collaborative testbed games built around this principle. In "Rescue: Under Pressure," one player controlled movement visually while the other managed sonar navigation through audio cues. In "Rescue: Mayday," the roles were inverted: one player piloted a rescue aircraft using audio-only interaction, while the other acted as an air traffic controller with strong visual tasks.

The evaluation, conducted with 13 mixed-visual-ability pairs, revealed several key insights. First, asymmetric ability-based design successfully engaged both sighted and visually impaired players, proving that unequal roles could still generate equitable and enjoyable play experiences. Second, interdependence was central: since no player had complete information, communication and trust became necessary for success. Participants reported that this design made both roles feel valuable and essential, fostering collaboration and balance without diminishing the challenge.

Furthermore, the study showed that asymmetry could help reduce stigma. Sighted participants often reported they could not distinguish whether their partner had a disability, since both roles were equally important and demanding. This finding underlines the potential of asymmetry not only for entertainment but also for raising awareness and promoting social inclusion. However, the work also noted limitations, such as occasional lack of autonomy for less experienced players and the risk of repetitive tasks in prototype implementations.

Complementing this perspective, Kultima et al. [27] provide a broader analysis of asymmetric games, highlighting how distinct roles and perspectives enrich multiplayer experiences. The authors classify asymmetry into several categories, including mechanical asymmetry, where players differ in rules, mechanics, or abilities; narrative asymmetry, where each player experiences unique storylines, motivations, or plot perspectives; perspective or interface asymmetry, where distinct viewpoints or control schemes shape how players access the game world; and objective-based asymmetry, where players pursue divergent but interdependent goals.

Their findings emphasize that asymmetry increases inclusivity by enabling players with different skills, playstyles, or preferences to find suitable roles. It also promotes replayability, as players are motivated to experiment with alternative roles across sessions. Moreover, asymmetric roles reinforce social dynamics by creating interdependence and cooperation. The authors stress, however, that careful balancing is essential, since roles perceived as significantly stronger or more enjoyable risk discouraging players from choosing the weaker options.

Together, these two studies show that asymmetry, whether motivated by accessibility or by design diversity, broadens the appeal of multiplayer games by moving away from the "one-size-fits-all" model. They highlight that unequal roles, when carefully balanced, foster inclusivity, collaboration, and engagement.

Building on these insights, this dissertation expects that similar principles can also apply to the visual domain. Just as gameplay asymmetry enhances inclusivity and replayability by offering players different ways to engage, asymmetric visualization may provide comparable benefits by decoupling mechanics from aesthetics. Allowing players to experience the same mechanics through distinct visual styles could introduce diversity without undermining game rules, extending the potential of asymmetric design into the visual dimension of multiplayer games.

2.4.2. Asymmetric Visualization

While asymmetric gameplay has been widely explored, asymmetric visualization remains far less studied. In most multiplayer games, players share the same aesthetic perspective of the game world, even when their roles or mechanics differ. Existing examples that touch on visual asymmetry usually tie it to role-specific mechanics rather than providing independent aesthetic choice. For instance, in *Evolve*, hunters and the monster have distinct appearances and perspectives, but these differences are directly connected to their mechanical roles. Similarly, *Keep Talking and Nobody Explodes*[1] assigns players different visual perspectives, yet these perspectives exist because of asymmetric tasks, not because of aesthetic freedom.

What these examples reveal, to the best of our knowledge, is that asymmetric visual design has been applied only in contexts where it reinforces mechanical differences or narrative roles. There is no widely adopted system in multiplayer games where players experience the same mechanics but through distinct, personalized visual styles. This gap highlights a missed opportunity: decoupling mechanics from aesthetics could allow players to choose the style that resonates with their preferences, whether futuristic, historical, or fantasy, without impacting game rules or balance.

This dissertation addresses precisely that gap. By enabling players to customize the game's visual representation while preserving identical mechanics, the system expands inclusivity and replayability. It demonstrates that visual asymmetry can enhance immersion, competence, and engagement, much like gameplay asymmetry improves collaboration and diversity. In this sense, this dissertation positions asymmetric visualization as a natural extension of established research on asymmetry, applying its principles to the visual layer of multiplayer design.

2.5. Contributions

Building upon the identified research gap, this dissertation proposes to contribute to the academic and technical understanding of asymmetric visualization in multiplayer games. The goal is not only to demonstrate that such a system is technically feasible but also to provide a conceptual foundation for how visual personalization can coexist with fairness and synchronization in shared digital environments.

First, this work introduces the concept of asymmetric visualization as a new form of asymmetry in game design, one that separates visual representation from gameplay logic. Unlike existing asymmetric systems, which rely on role-based or mechanical differences, this approach allows players to inhabit the same game world while perceiving it through distinct aesthetic styles, preserving equal gameplay conditions for all participants.

Second, it contributes a modular system architecture that operationalizes this idea within a practical multiplayer framework. The architecture, implemented in Unity using Photon Networking, decouples visual assets from shared game state through a tag-based instantiation and dynamic asset loading system. This design ensures scalability and provides a reproducible model for integrating theme-dependent content into other multiplayer projects.

Third, it provides an empirical evaluation of asymmetric visualization through formative and summative user studies. These studies explore how visual choice affects key experiential dimensions such as immersion, competence, and social engagement.

Fourth, this work aims to broaden the perspective of inclusivity and personalization in multiplayer game design. By demonstrating that visual freedom can coexist with

[1]https://keeptalkinggame.com

mechanical game rules, it opens new pathways for accommodating diverse audiences, ranging from players of different ages and cultural backgrounds to those with distinct perceptual preferences, without fragmenting the shared play experience.

Finally, this dissertation aligns with the broader field of Human Computer Interaction (HCI), particularly in the area of configurable and adaptive interfaces. By enabling players to tailor the visual representation of a shared multiplayer environment, the system reflects established HCI principles that emphasize personalization and interface adaptability as pathways to improved usability and engagement [28].

CHAPTER 3

Proposed System Architecture

This chapter presents the architecture of the system developed in this dissertation. The goal is to explain how the game was structured to allow each player in the same multiplayer session to experience the world through a different visual style, while keeping gameplay fair and consistent for everyone.

As previously discussed, DDA plays an important role in maintaining balance between players of different skill levels and ensuring that varied visual experiences do not unintentionally affect game rules. In this system, DDA supports the architectural goal of providing equal challenge across all visualizations, minimizing potential discrepancies in perception or performance caused by aesthetic differences. The detailed implementation and operation of the DDA mechanism are presented in the following Chapter 4.

We describe the main design choices that guided the creation of this system, emphasizing scalability, modularity, and balance between personalization and competitive integrity. The chapter also introduces how storage and management of different visual assets were organized, game map architecture, as well as how the server-side services were implemented to coordinate multiplayer interactions. Together, these aspects provide a complete overview of the system and establish the foundation for the detailed explanations that follow.

3.1. Conceptualization

The goal of the proposed system is to enable asymmetric visualization in multiplayer games, giving each player the ability to personalize how the game world is presented without fragmenting the shared experience. The central idea is to decouple gameplay logic from visual rendering, so that players can choose distinct styles, such as Science Fiction (Sci-Fi) or Wild West, while maintaining game rules, synchronization, and mechanical balance. This approach supports immersive personalization and also provides modular extensibility, allowing new styles to be integrated in the future without altering the core logic or network protocol.

The system was designed to allow players in the same multiplayer session to experience the game world through different visual styles, while ensuring gameplay balance and synchronization remain intact. Traditional multiplayer architectures, where all clients share an identical visual representation dictated by the server, would not suffice for this purpose. Instead, an alternative approach was developed, one that separates the game's core logic from its visual rendering, ensuring that gameplay remains consistent while presentation can vary between players.

The proposed system introduces an innovative architectural model designed to support personalized visual experiences in a shared multiplayer environment, without compromising gameplay consistency or fairness of the game. As depicted in Figure 3.1, the system is structured around a client-server with Peer-to-Peer (P2P) communication and local rendering.

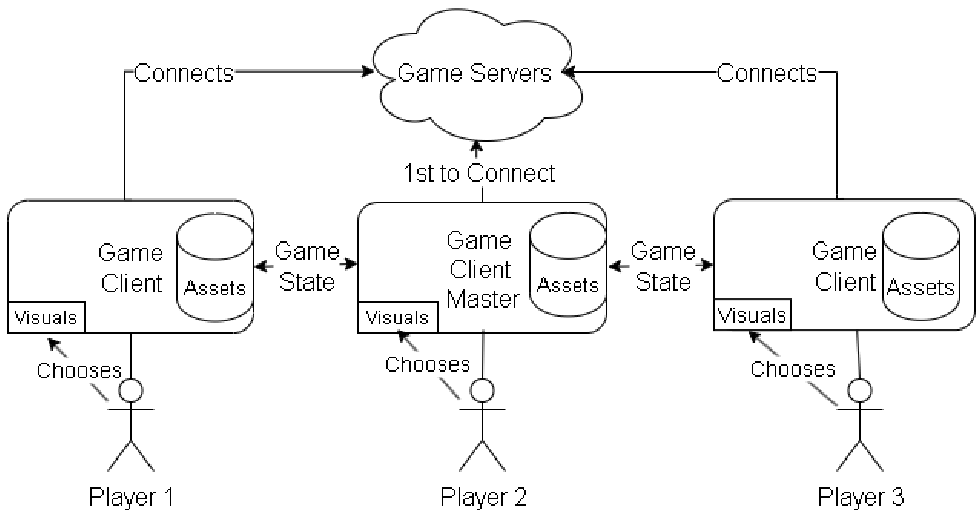


Figure 3.1. System Architecture, where Player 2 connects first turning in to the Master Client, after which all other players enter the room.

Each player runs a dedicated Game Client instance on their machine. Upon launching, the client connects to a central Game Server, which is responsible for managing matchmaking, creating and joining game sessions, and providing basic coordination services, such as player lists and session termination. This server plays no direct role in game logic or rendering, helping reduce server overhead and allowing a more scalable system.

Once a session is established, the first client to join is assigned the role of Game Client Master. This client holds a central authoritative role during the session, acting as the arbiter of gameplay decisions. All critical game state updates, such as shots fired, health changes, eliminations, or point scoring, are sent by the regular clients to the Game Client Master. The Master processes these updates and then redistributes the confirmed state changes to all connected clients to ensure synchronization. During the formative testing phase, no perceptible delay or gameplay priority was observed for the Master Client, suggesting that all players receive the updated game state simultaneously.

Unlike fully centralized server-authoritative architectures, this system employs a hybrid Peer-to-Peer model. While the Game Server facilitates the session, the actual communication of gameplay actions and outcomes happens directly between the clients and the Master Client. This hybrid approach allows for reduced latency, increased responsiveness, and lower infrastructure costs, while still preserving a single source of truth via the Master.

A key innovation lies in how the game content is visualized. Each Game Client includes a local asset bundle containing multiple sets of visual resources, such as 3D models, textures, animations, particle effects, and sounds, grouped by visual theme (e.g., Sci-Fi, Wild West). Upon connecting to a session, each player is allowed to independently select their preferred visualization style, which is then instantiated locally. This means one player may see the game world in a futuristic aesthetic, while another may experience it as a stylized western setting, all in the same session. To make this possible, the core game logic and map data remain decoupled from visual representation. Gameplay state, such as object positions, health, actions, and event triggers is shared and synchronized in a unified format that is interpreted by all clients in the same way. The only thing that changes is how this shared state is presented visually to each player.

Additionally, this architecture allows for modular expansion, as new visual styles can be added in the future without altering the underlying game logic or network protocol, only the asset mappings need to be updated.

3.2. Game Map Architecture

The Game Map Architecture is a key component for delivering a flexible and immersive multiplayer experience, allowing each player to enjoy the same shared world while perceiving it through their own chosen style. By decoupling the environment's functional layout from its visual and auditory representations, the system ensures that gameplay balance and spatial coherence remain intact, while the audiovisual layer adapts to player preferences.

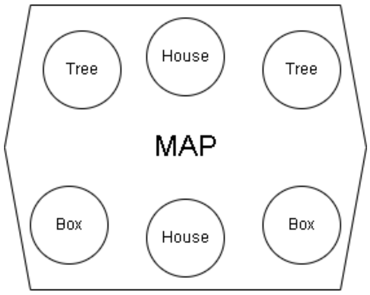
As illustrated in Figure 3.2a, the system adopts a tag-based asset instantiation architecture. On the left side of the figure, the game map is shown as a collection of placeholders: "Empty GameObjects" in Unity that contain only positional data and a semantic tag (e.g., 'House', 'Tree', 'Box'). These placeholders themselves do not define whether they correspond to a 3D model, a sound, or another type of resource. Instead, their tags act as abstract identifiers that are later interpreted by the content management system.

When initializing the scene, the system reads each tag and determines which kind of asset should be instantiated. If the tag corresponds to an environment element (e.g., 'House' or 'Tree'), the appropriate prefab is loaded according to the chosen theme. If the tag represents other categories such as a particle system, a sound, or a 2D background, the system applies the corresponding loading function for that resource type. This ensures that all components of the world, visual, auditory, or interactive, can adapt to the player's selected style in a consistent way.

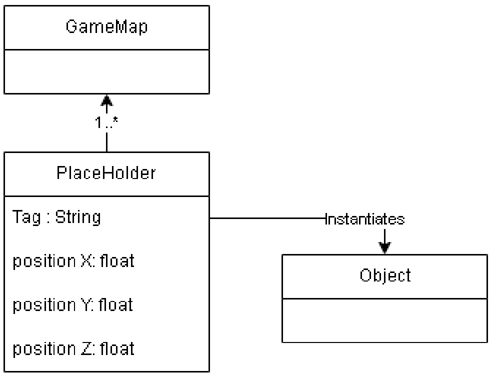
As illustrated in Figure 3.2b, the class diagram shows how this system is organized programmatically. Each placeholder is represented by a PlaceHolder class instance, which stores its tag and spatial location. During initialization, a content manager on each client processes these tags and matches them to a dictionary of assets corresponding to the selected visual theme (e.g., Sci-Fi or Wild West). This structure ensures that each client instantiates and renders the environment elements based on their individual preferences, while the underlying positions and interactive behaviors remain consistent across all players.

This modularity ensures that adding new visual styles to the game requires no changes to the map layout or gameplay logic. Developers only need to provide alternate assets for the existing tags, making it easy to expand the game's aesthetic variety with minimal overhead.

To further exemplify this approach, Table 3.1 presents a selection of used tags and how they are mapped to assets in both the Sci-Fi and Wild West visual themes. This includes not just 3D models, but also audio effects, particle systems, 2D UI backgrounds, and even character representations, allowing for a better immersive and personalized audiovisual experience.



(A) Game map structure where we can see three exemples of tags "House", "Tree" and "Box".



(B) Class diagram where we have multiple objects of type "Placeholder" in the Map object. Within this object, there are characteristics of type float, their X, Y, and Z positions, and the characteristic of type String, their tag.

FIGURE 3.2. Game Map Architecture.

3.3. Storage and Asset Management

Storage and Asset Management is essential to the asymmetric visualization system, as it ensures that players can use distinct visual themes without affecting performance or consistency. The architecture was designed to be flexible, scalable, and modular, supporting any number of visual styles while keeping runtime efficient and maintenance simple. By combining an eXtensible Markup Language (XML) configuration, dynamic runtime loading, and a well-structured Resources folder, the system provides a robust solution

Table 3.1. Examples of Tags used in the game for the different visualizations (e.g.,SCI-FI, Wild-West), we have ten examples of tags that exist in the game in the left column. In the two middle columns the names referenced for the specific visualization, and finally, in the last column, we have the asset type.

Tag	**Referenced SCI-FI**	**Referenced WildWest**	**Type of Asset**
House	House_Futuristic	House_Western	3D Model
Box	Box_Futuristic	Box_Western	3D Model
Lamp	Lamp_Futuristic	Lamp_Western	3D Model
Table	Table_Futuristic	Table_Western	3D Model
Chair	Chair_Futuristic	Chair_Western	3D Model
Bed	Bed_Futuristic	Bed_Western	3D Model
Dust	Partical_Futuristic	Partical_Western	Particle System
Gun Sounds	GunSounds_Futuristic	GunSounds_Western	Sound
2D Background	BackGround_Futuristic	BackGround_Western	2D image
3D Character	Character_Futuristic	Character_Western	3D Character

that allows visual styles to be swapped or extended with minimal overhead. This setup directly supports the project's broader goal of offering personalized visual experiences while maintaining technical performance, extensibility, and ease of maintenance.

The system relies on a single centralized XML file that contains all asset references for every available visualization. Within this file, each game element, such as character models, weapons, environmental props, particle effects, and audio, is represented as a parent tag, which contains one child element per visualization style (e.g., Sci-Fi, Wild West). This structure ensures that all theme data is stored in one place, simplifying maintenance and reducing the risk of inconsistencies between separate configuration files. While this dissertation demonstrates the concept with two contrasting themes, Sci-Fi and Wild West, the architecture was intentionally designed to support additional visualizations without modification to the game logic.

At runtime, the game identifies the player's chosen visualization and dynamically parses the corresponding child element for each asset. Based on these XML entries, the system loads the necessary assets using Unity's built-in `Resources.Load()` method. For this to work efficiently, all visual content is stored under Unity's special Resources folder, which provides direct access to assets at runtime via script. Inside the Resources folder, the project is structured into subdirectories, one per visualization style, as shown in Figure 3.3. Within each theme-specific folder, assets are categorized and stored under meaningful designations, such as Sounds, Music, Materials, 3D models, 2D backgrounds, Particles, and SkyBoxes, allowing for quick identification and easy extension. A simplified graphical representation of the XML structure is shown in Figure 3.4. The image contains only a few example elements to preserve readability.

This design makes the system highly modular and future-proof. To introduce a new visual style, developers simply need to create a new folder under Resources following the same internal structure, and then add corresponding references in the XML file. Once this is done, the new visualization becomes available without requiring any changes to the underlying game logic.

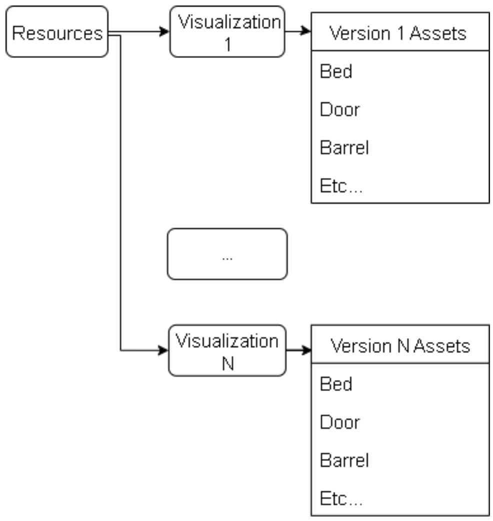


FIGURE 3.3. Organization into folders, as we can see, here are the N example visualizations (e.g.,1 ... to N) chosen and how all their assets are organized.

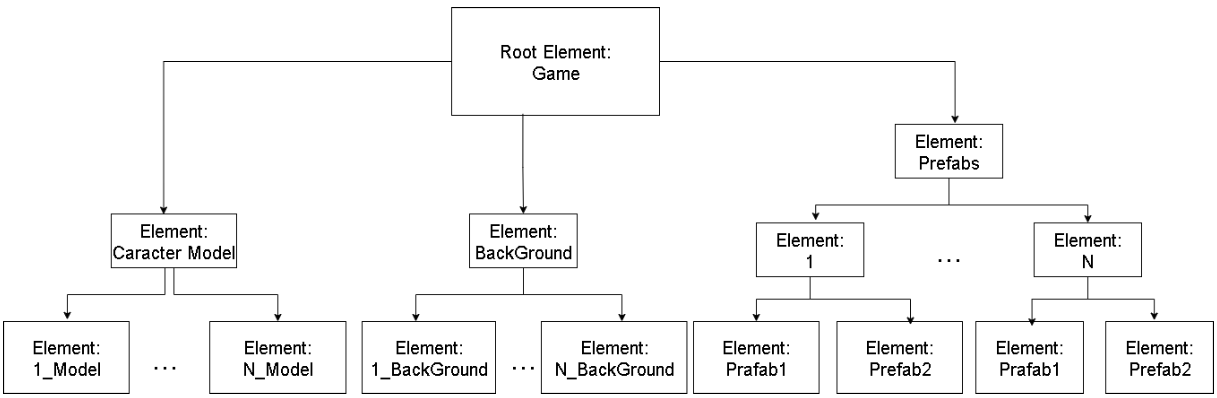


FIGURE 3.4. Simplified XML configuration structure illustrating how assets for different visualization styles (e.g.,1 ... to N) are referenced.

Additionally, this XML-driven approach ensures that only the assets required for the active player's theme are loaded into memory, improving performance and reducing unnecessary resource consumption. This is particularly important in multiplayer scenarios, where players may be using different visual styles simultaneously, and keeping the client-side resource usage optimized is essential for a smooth gameplay experience.

3.4. Game Servers

To enable multiplayer functionality and provide stable real-time communication between clients, the game uses Photon Unity Networking (PUN)[1], a widely adopted and reliable networking framework for Unity-based games. Its integration was fundamental

[1]https://doc.photonengine.com/pun/current/getting-started/pun-intro

for this project, as it provided the robust, synchronized, and scalable environment required to support real-time player interactions. This ensured that multiplayer sessions could remain consistent and competitive, even as each player experienced the game world through different visual styles.

This system offers a user-friendly API along with dedicated regional master servers, as illustrated in Figure 3.5. In this project, the server used was hosted in Europe, to ensure low-latency connections and consistent multiplayer performance for local testers.

Although Unity provides its own multiplayer frameworks, such as the legacy UNet and the more recent Netcode for GameObjects, these solutions were not adopted in this project. Unity's Netcode benefits from deep engine integration, extensive control over networking logic, and flexibility in hosting options, making it a promising long-term solution. However, it remains a relatively young and evolving platform, often requiring additional development effort for advanced features.

PUN, on the other hand, offers a more plug and play system. Its advantages include built-in services such as matchmaking and lobby management, along with scalable infrastructure that can support both small and large scale deployments. The trade-offs mainly concern its pricing model, which is based on concurrent users and can become limiting for larger projects, and the fact that it does not integrate as deeply into Unity's system as Netcode. Even so, for this project's requirements, Photon was the more practical choice, enabling rapid implementation of reliable multiplayer features while minimizing development overhead.

Figure 3.6 illustrates how Photon organizes multiplayer sessions into rooms, where each player connects to the same shared environment.

Photon also supports automatic host migration, ensuring that if the current Master Client disconnects, another player seamlessly takes over the role without interrupting the game session. Networked object synchronization is handled through PhotonView components, which ensure that position, rotation, animations, and status updates are reflected consistently across all clients. Remote Procedure Calls (RPCs) and custom events are used to transmit real-time gameplay data such as weapon fire, health changes, score updates, and player eliminations. Additionally, Photon incorporates lag compensation and interpolation techniques to minimize network jitter and delay, allowing player movement and combat interactions to remain smooth and responsive even under suboptimal connection conditions.

By relying on Photon Cloud's scalable infrastructure, development time is reduced, as there was no need to implement or maintain custom backend systems.

Beyond networking scalability, the system also incorporates modular asset management to support asymmetric visualization. All in-game objects are identified by unique tags (e.g., "House," "Chair," "Box"), which are dynamically linked to prefabs depending on the selected visual theme. This tag-to-prefab mapping ensures that gameplay logic, physics interactions, and map geometry remain identical, while the visual representation

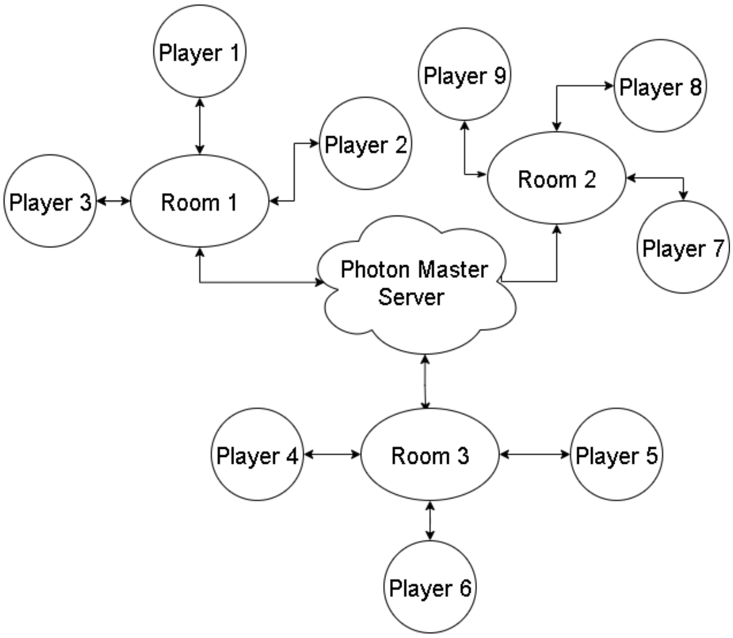


FIGURE 3.5. Example of Master Server, where it is represented in a diagram showing how Photon servers are structured, which contain rooms and ultimately players, and there is a necessary exchange of information between them.

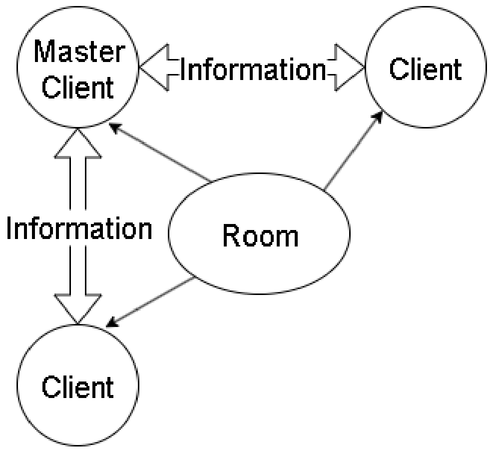


FIGURE 3.6. Rooms, Detailed graphic designation of rooms; within it are the players; the first to connect becomes the Master Client.

can change completely between Sci-Fi and Wild West styles. The same "House" tag, for instance, can appear as a futuristic steel structure or as a wooden saloon without altering collision boundaries or hit detection, since the objects' dimensions and functional properties are dictated by the underlying game rules rather than by their fictional setting.

This decoupling of mechanics from aesthetics provides flexibility and future scalability. Introducing a new visual theme requires only the creation of corresponding prefabs and their registration in the asset mapping configuration (stored in an XML file). No modifications to gameplay code are necessary, making it straightforward to expand the game's visual repertoire while preserving game rules and consistency in multiplayer sessions.

CHAPTER 4

System Prototype

In this chapter, we present the prototype developed to instantiate the proposed system within a multiplayer game, which served as the basis for the experimental validation. The focus is on describing the development process and the main technical and design decisions that enabled the implementation of the asymmetric visualization concept. The prototype integrates multiple components, including gameplay mechanics, user interface, asset management, and real-time multiplayer synchronization.

A special emphasis is placed on the visual embellishments added to the prototype, as these are essential to delivering distinct experiences for each player depending on their selected visual style. This includes modular content, environmental effects, and visual systems designed to reinforce immersion and engagement.

The chapter also addresses the challenges encountered during development, such as maintaining consistent gameplay logic across different visual styles, optimizing performance for real-time synchronization, and dynamically managing assets. In addition, we document key technical implementations such as the dynamic instantiation system and the shield-based difficulty adjustment.

Overall, this chapter details how the proposed system was instantiated in a working prototype, enabling personalized multiplayer gameplay. The following sections cover the different aspects of development in detail: from game genre and visual styles to world building and aesthetic coherence (including lighting, atmosphere, and effects, as well as player avatars and weapons), followed by prefabs and asset integration, map adaptation across visual styles, the core mechanics, the dynamic difficulty adjustment system, and finally the overall game workflow.

Snapshots of the final version of the prototype can be depicted in Figure 4.1. The figure shows how two players, who are playing the same game and have selected different visualization styles, view the game from their own perspective. The figure shows a moment when both players are looking at each other.

4.1. Game Workflow

The gameplay loop of the system follows a deliberately simple workflow, illustrated in Figure 4.2. The objective of this design was not to complicate the mechanics, but rather to create a clear and accessible flow that could properly support the asymmetric visualization system without introducing unnecessary complexity.

The process begins when a player enters a game room. If the match is still underway, the player respawns and can start playing. The cycle then follows a straightforward loop:

(A) Perspective of Player 1, which has selected Wild West style.

(B) Perspective of Player 2, which has selected Sci-Fi style.

FIGURE 4.1. Assymetric Visualisation of the Developed Game.

the player searches for opponents, engages in combat when an enemy is encountered, and either eliminates the opponent or risks being eliminated themselves. If killed, the player returns to the respawn step, provided that the game has not yet ended. This loop continues until the match timer expires, at which point the session concludes.

The workflow highlights the essential elements of multiplayer FPS gameplay-combat, survival, and respawn while intentionally avoiding unnecessary branching logic or secondary systems. This ensures that the asymmetric visualization feature remains the focal point of the project.

4.2. Game Details

This section presents the key design decisions that shaped the prototype used to demonstrate the asymmetric visualization system. The focus is on factors that ensured both a coherent testing environment and an effective validation of the proposed concept. Game genre, game choice, game engine, and core gameplay were defined to balance development efficiency, visual adaptability, and player familiarity. The following subsections explain these decisions and their relevance to the project.

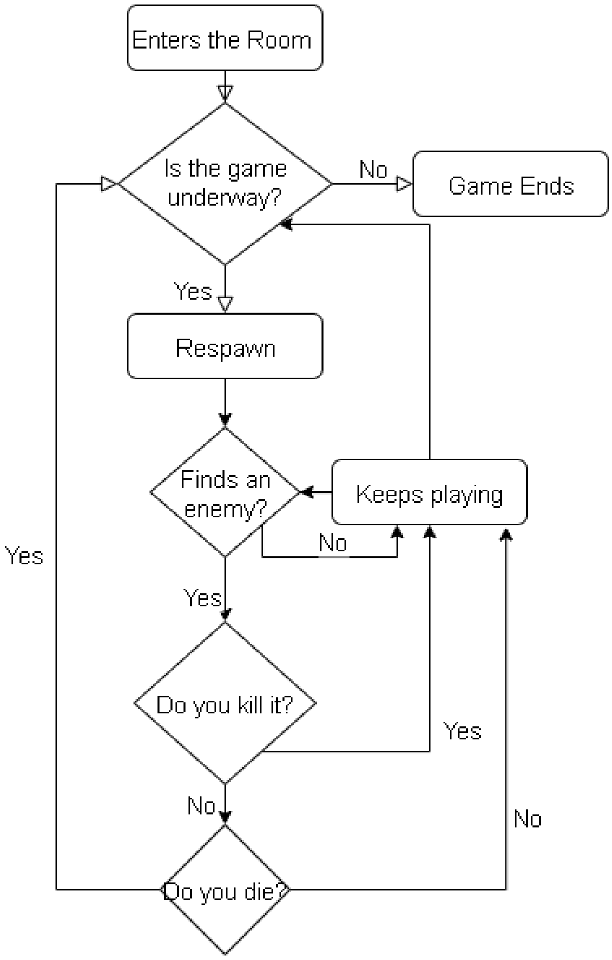


FIGURE 4.2. Game Workflow.

4.2.1. Game Genre

The project required identifying the most suitable genre to demonstrate the asymmetric visualization mechanic. After analysis, the First Person Shooter (FPS) genre was selected as the most effective choice. FPS games are among the most popular and enduring genres [29], consistently engaging large player bases. Their first-person perspective enhances immersion and sensory involvement, making them ideal for studying how different visual paradigms shape perception.

Equally important, FPS games provide flexibility in thematic and environmental design. Core mechanics can be maintained while visual contexts are adapted to different settings, such as a Sci-Fi world or a Wild West environment. This adaptability aligns directly with the research goal of testing visual asymmetry without altering gameplay balance, and it further supports the objectives of this dissertation, namely O1, which focuses on enabling individualized visual experiences, and O2, which ensures that such variations do not interfere with the underlying game rules.

4.2.2. Game Codebase

A key decision at the start of development was selecting the base structure for the system. Instead of building a game from scratch, which would have increased scope and diverted attention from the research focus, the project adopted an open-source FPS framework available online[1]. This choice allowed development to concentrate on implementing and evaluating the asymmetric visualization system.

The selected project already included essential FPS components such as input handling, shooting mechanics, health systems, and network connectivity, providing a functional foundation. The codebase was refactored to support modular theme switching, dynamic asset loading, and content scalability. Core systems including player synchronization, spawn management, UI elements, and damage detection were redesigned to ensure that visual differences across players did not affect game rules or gameplay consistency.

Leveraging an existing codebase accelerated development, enabled iterative testing, and supported multiple formative evaluations, ensuring that the research could focus on asymmetric visualization rather than reinventing standard FPS mechanics.

4.2.3. Game Engine

The Unity engine was selected as the foundation for this project because it aligned directly with the technical requirements of the asymmetric visualization system. Specifically, the project needed a development platform capable of handling modular content structures, dynamic runtime asset loading, real-time multiplayer interaction, and efficient performance profiling. Unity provides built-in support for these aspects through its component-based architecture, robust scene management, prefab system, and asset handling via the Resources and Addressables frameworks.

Another decisive factor was compatibility and familiarity. The base open-source FPS project adopted for this study was originally developed in Unity, which ensured seamless integration with the asymmetric visualization features introduced here. In addition, we have prior experience with Unity, reducing the learning curve and accelerating development.

Unity also offers strong community support, an extensive Asset Store, and comprehensive documentation, all of which facilitated faster prototyping and iterative testing. Furthermore, its profiling and optimization tools were critical for maintaining stable performance, especially when managing multiple asset sets and dynamic content generation across different visual styles.

4.2.4. Core Gameplay

The game maintains a familiar and accessible FPS structure, where each player views the world from their character's perspective and interacts with it using standard controls. Key gameplay actions include:

- Movement using W, A, S, D keys;
- Jumping via Spacebar;
- Sprinting via Shift;

[1]https://github.com/Armour/Multiplayer-FPS

- Shooting with Mouse1 (left click);
- Respawning after death.

These mechanics ensure that the learning curve remains low, particularly for players already familiar with FPS conventions. By relying on this common interaction model, the game focuses attention on evaluating how visual customization affects player experience, rather than introducing unfamiliar gameplay systems.

The match structure was initially based on a kill-count objective, where the game ended once a player reached a specific number of eliminations. However, formative testing revealed that this format was not optimal, as it tended to favor more experienced players and often reduced enjoyment for less skilled participants. As a result, the system was modified to a time-based format, where matches run for a fixed duration rather than ending upon reaching a target score. Under this structure, players aim to achieve the highest number of eliminations possible within the allotted time, emphasizing continuous engagement, enjoyment, and competitiveness across different skill levels. Matches were first tested with a 5-minute duration and later refined to 8 minutes, which was found to provide a better balance between pacing, excitement, and overall player satisfaction.

4.3. Visual Styles

One of the key contributions of this work is the way it handles visual presentation. In most multiplayer games, every player shares the same overall look and atmosphere, regardless of personal preference. However, this system introduces asymmetric visual styles, allowing each player to experience the same rules and mechanics through a different visual theme.

The selection of visual styles was a deliberate choice aimed at testing how flexible and adaptable the system could be. To achieve this, two themes were chosen that are both easily recognizable and visually distinct:

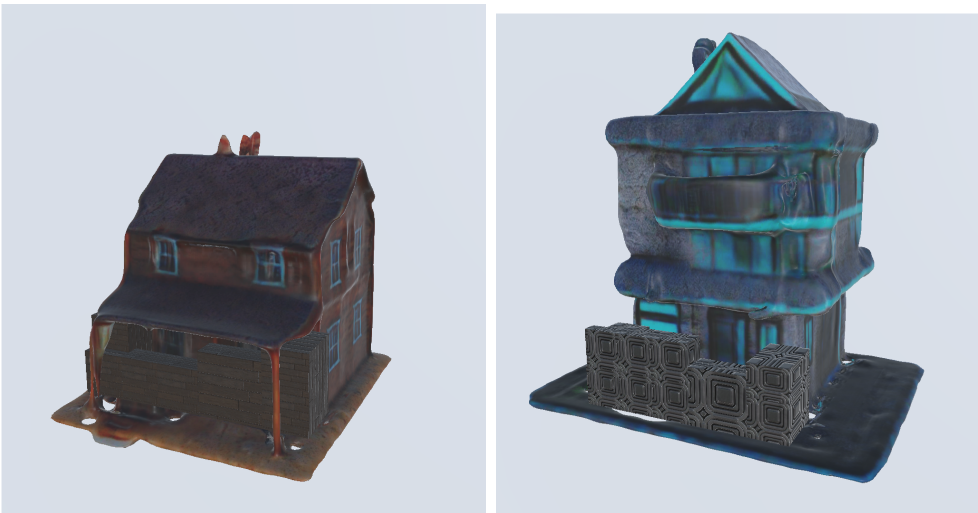
- **Sci-Fi**. A futuristic theme with metallic surfaces, bright lights, advanced weapons, and synthetic ambient sounds. It aims to create a clean, technological atmosphere typical of science fiction worlds.
- **Wild West**. A rustic theme featuring wooden buildings, dusty landscapes, classic revolvers, and harmonica-based background music. It conveys a more natural, historical, and adventurous setting.

These two themes were selected to clearly show how different the same game can look and feel while maintaining identical gameplay. Their strong contrast, modern technology versus old tradition, provides an effective way to demonstrate the system's ability to handle completely different aesthetics. At the same time, both settings are familiar enough to most players, which helps reduce confusion and ensures that the evaluation focuses on how visual choice affects experience rather than on learning new environments. The intention was that at least one of these visual styles would likely appeal to each participant, offering a fair chance for everyone to find a preferred option.

4.4. World Building and Aesthetic Coherence

After defining the two visual styles, the next step involved integrating them consistently into the same playable environment. The goal was to ensure that each theme delivered a distinct atmosphere while preserving identical gameplay conditions across both representations.

To achieve this, every major element of the map, including houses, crates, fences, and lamps, was created in two stylistically different versions: one matching the futuristic tone of the Sci-Fi theme, and another reflecting the rustic character of the Wild West. Despite their visual differences, both versions share the same dimensions, placement, and physical interactions. This guarantees that gameplay mechanics such as navigation, collisions, and cover behave exactly the same in both visualizations. Figure 4.3 shows an example of this principle, where a wooden house in the Wild West theme corresponds precisely to a metallic structure in the Sci-Fi style.



(A) Wild West version. (B) Sci-Fi version.

FIGURE 4.3. 3D Model for the Houses Placeholder.

Maintaining thematic authenticity required careful attention to materials, lighting, and overall composition. The Sci-Fi environment uses reflective surfaces, neon illumination, and structured geometry to evoke a sense of technological advancement. In contrast, the Wild West environment relies on muted, earthy tones, weathered textures, and traditional architecture to convey a historical and grounded atmosphere.

When suitable assets were unavailable, particularly for large structures such as buildings, AI-assisted generation tools like Luma AI's Genie[2] were used to produce consistent models aligned with each theme's visual identity.

4.4.1. Lighting, Atmosphere, and Effects

Lighting and environmental effects play a crucial role in shaping the emotional tone and aesthetic identity of each visual theme. Beyond visual fidelity, these elements directly

[2]https://lumalabs.ai/genie (accessed Jun. 25, 2025).

impact the player's perception of space, mood, and immersion, particularly important in a system where each player may be experiencing the same gameplay through a different visual lens.

In the Sci-Fi style, lighting was conceived to evoke a high-tech, synthetic atmosphere. Cold bluish tones, glowing panels, and reflective materials helped create a futuristic environment. Subtle fog and luminous details reinforced the sense of advanced technology and controlled artificiality.

By contrast, the Wild West visualization was designed around a warm, natural palette, reminiscent of a desert sunset. Soft, diffused lighting and earthy tones brought out the textures of wood and dust, while a hazy atmosphere suggested the heat and dryness of the frontier.

To further distinguish each atmosphere, particle systems were developed to react to the environmental style. The Wild West environment featured sand particles drifting with the wind. In contrast, the Sci-Fi style included pollution particles and atmospheric glow effects, like thin fogs around houses or fluorescent particles simulating energy leaks.

Audio design also played a very important role in reinforcing the atmosphere created by the lighting and effects. Each theme was paired with custom ambient soundtracks: the Sci-Fi world featured rain, while the Wild West environment employed sandstorm sounds.

Importantly, these elements were not only aesthetic choices but were selected to be non-intrusive to gameplay. They preserved performance across computers by being optimized and were carefully placed so as not to obstruct player visibility or interfere with core mechanics.

4.5. Prefabs and Assets Integration

In Unity, *prefabs* are reusable, pre-configured game objects that can store not only their geometry and textures but also components such as scripts, physics properties, and animations. They are essential for creating consistent, easily manageable elements, allowing developers to update all instances of an object simply by modifying its original prefab.

The term *assets* in Unity encompasses all the external resources used to build the game, including 3D models, polygon meshes, textures, materials, shaders, audio clips, background music, sound effects, particle effects, animations, and even UI elements. Each of these asset types plays a crucial role in shaping the immersive quality of the game. For example, polygon count and texture resolution directly influence visual fidelity, while carefully selected music and sound effects help convey the mood and atmosphere of each style.

In this project, assets were downloaded, customized, and integrated with a focus on flexibility and modularity, enabling the same logical game object to take on different forms depending on the player's selected visualization style.

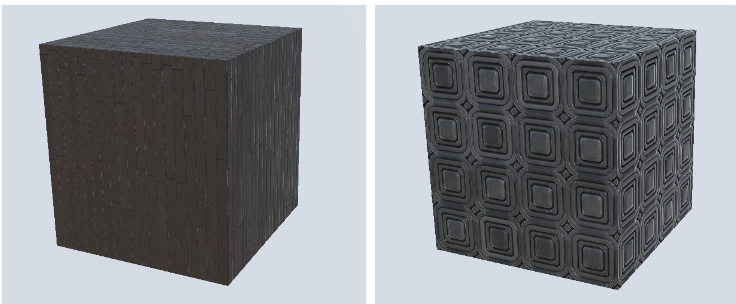
The following sub-sections detail this process, covering the integration of 3D models and environment assets, the design of sound effects and music, the implementation of character models and animations, and the modular structure that ensures scalability for additional visual themes in future iterations.

4.5.1. 3D Models and Environment Assets

To efficiently populate the game world with multiple assets, a broad range of 3D models was freely acquired from free online resources such as the Unity Asset Store[3], TurboSquid[4], and Free3D[5]. These websites provide a wide variety of high-quality assets, including buildings, props, furniture, weapons, vegetation, and other decorative elements essential for creating an engaging and believable game environment. A complete list of the prefabs and objects integrated into the system can be found in Appendix 6.2.

Once imported, all models underwent a preparation phase to ensure compatibility between the two styles. This included adjusting polygons if necessary, applying consistent scaling, setting up materials compatible with Unity's rendering pipeline, and configuring proper collision meshes for gameplay interactions. Any textures requiring improvements were reworked to match the intended aesthetic of each visual style, ensuring visual coherence across the environment.

Every core asset in the game was developed in two stylistic variations, one designed for the Sci-Fi setting and another for the Wild West theme. This meant that objects were not merely re-skinned but often re-imagined to reflect the cultural and technological context of each style. For instance, a generic "Box" prefab was represented as metallic in the Sci-Fi setting, while its Wild West counterpart took the form of a rugged wooden crate, as we can see in Figure 4.4. Similarly, street lamps in the Sci-Fi world featured metallic designs with LED-like lighting, whereas in the Wild West, they appeared as oil lanterns, as we can see in Figure 4.5. Although the 3D models differed slightly in scale and form, these objects were purely decorative and did not interfere with gameplay. For this reason, the stylistic differences were preserved to maintain authenticity and reinforce the thematic contrast between the two visual styles. Other decorative prefabs with similar dimension differences are also documented in Appendix 6.2.

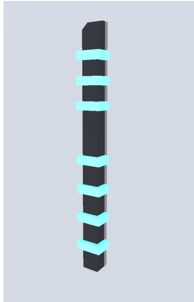


(A) Wild West version. (B) Sci-Fi version.

FIGURE 4.4. 3D Model for the Box Placeholder.

[3]https://assetstore.unity.com (accessed Jun. 25, 2025).
[4]https://www.turbosquid.com (accessed Jun. 25, 2025).
[5]https://free3d.com/3d-models/ (accessed Jun. 25, 2025).

(A) Wild West version.



(B) Sci-Fi version.

FIGURE 4.5. 3D Model for the Lamp Placeholder.

4.5.2. Sound Effects and Music

Audio design played a pivotal role in enhancing the thematic immersion of each visualization mode. While visual elements establish the appearance of a world, it is often the audio that breathes life into it, influencing the player's emotional engagement and sense of place. For this reason, careful consideration was given to the selection, processing, and integration of both background music and sound effects, ensuring that each style conveyed a distinct and cohesive atmosphere.

All audio assets were downloaded from free websites such as Pixabay Music[6] and Pixabay Sound Effects[7], which offer high-quality files to use. These platforms provided a diverse selection of audio content, enabling the creation of both the Sci-Fi and Wild West sound environments without incurring licensing restrictions.

For the Sci-Fi setting, Sci-Fi ambient tones and subtle electronic pulses were chosen to evoke a high-tech, supernatural atmosphere. Background tracks often incorporated spatial audio effects to simulate advanced machinery. Sounds of weapons, as mentioned earlier, were equally adapted, featuring energy blasts to match the visual aesthetic of the futuristic weapons seen on screen.

Conversely, the Wild West theme utilized an entirely different sound. Acoustic guitar sounds, harmonica melodies, and slow rhythmic percussion were selected for background tracks, evoking the feel of classic Western films. Environmental effects such as wind and the creaking of wooden floorboards were added to further reinforce the rustic atmosphere.

4.5.3. Player Avatars, Weapons, and Animation

The asymmetric visualization system extends beyond the environment to include player avatars, weapons, and their animations. This ensures that each participant not only experiences a distinct visual world but also perceives their own character and equipment in a style consistent with their selected theme, reinforcing immersion and visual identity.

Upon joining a match, each player locally loads the character and weapon models corresponding to their chosen visualization style, either Wild West or Sci-Fi. For example,

[6]https://pixabay.com/music/ (accessed Jun. 25, 2025)
[7]https://pixabay.com/sound-effects/ (accessed Jun. 25, 2025)

a player using the Wild West theme may see themselves as a rugged cowboy, while another in the Sci-Fi theme perceives a futuristic soldier equipped with high-tech armor. Despite these aesthetic differences, both character and weapon models share identical game rules. Attributes such as damage, fire rate, accuracy, recoil, and reload time remain consistent across all styles, ensuring that the visual variation is purely cosmetic and does not affect balance or game rules.

All models were developed and animated using Mixamo[8], a platform offering rigged humanoid 3D models and motion-captured animations, as shown in Figure 4.6. This approach ensured high-quality, performance-optimized assets while maintaining consistent motion across both visual styles. Animations such as running, jumping, shooting, crouching, and dying are identical in timing and behavior for all characters, guaranteeing mechanical equivalence and preventing discrepancies in collision or hit detection. To support modularity, Unity's humanoid rig system and shared animation controllers were employed, allowing new animations to be integrated seamlessly into all visual themes without duplicating setup work.

The same design principles apply to weapons. While the Sci-Fi weapon appears as a plasma blaster and the Wild West version as a classic rifle, both share the same firing logic, projectile speed, and damage model. Each weapon also features theme-specific audio cues[9], with laser shots in the Sci-Fi version and traditional gunfire in the Wild West setting. These audio effects are processed locally to preserve synchronization and ensure that aesthetic diversity does not interfere with core gameplay mechanics.

Model selection and alignment were carefully adjusted to maintain consistent first-person perspectives, ensuring that weapon positioning, recoil animations, and hand placements match across themes. Figures 4.7 and 4.8 illustrate these differences, showing how visual identity varies while gameplay mechanics remain entirely equivalent.

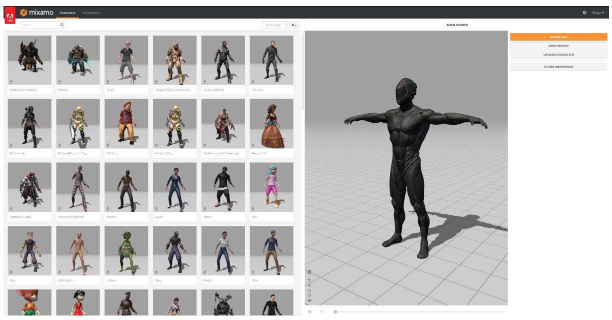


FIGURE 4.6. Character animation and rigging workflow using Mixamo.

4.6. Map Adaptation Across Visual Styles

Adapting the game map was a crucial step in bridging visual customization with consistent gameplay. Visual variety alone would not be enough to create a compelling multiplayer session, so the environments had to be reworked in a way that preserved

[8]https://www.mixamo.com
[9]https://pixabay.com/sound-effects/

(A) Wild West version. (B) Sci-Fi version.

FIGURE 4.7. Player avatars for each visualization style.

(A) Wild West version. (B) Sci-Fi version.

FIGURE 4.8. Weapon models for each visualization style.

balance while also supporting the asymmetric visualization approach. This meant maintaining a shared layout for game rules, while adapting assets, lighting, and effects to fit the two chosen styles: Sci-Fi and Wild West.

Before the system was implemented (Figure 4.9), the map offered limited variety, consisting mainly of warehouses, generic buildings, and scattered boxes and containers. The central area, dominated by two adjacent warehouses, acted as the natural focus of encounters. In front of these warehouses, a main road ran across the map, framed by repeated building types with little visual diversity. While functional, this layout lacked atmosphere and environmental richness.

After introducing the new system (Figure 4.10), the map was redesigned to preserve the original combat dynamics while enriching both its structure and aesthetics. The two warehouses were maintained at the center of the battlefield as the primary focal point, but additional prefabs were introduced inside them to increase variety without disturbing gameplay balance. Around the perimeter, the repetitive buildings were replaced with a wider range of houses and thematic structures appropriate to each style. Environmental prefabs and other decorative elements were added to further differentiate the settings.

A new perimeter barrier was also introduced around the central warehouses, featuring three distinct entrances. This design created additional points of contention and tactical movement, ensuring combat remained engaging and dynamic. Finally, thematic effects were layered onto the environments, pollution and neon highlights for the Sci-Fi style, sandstorms and dust for the Wild West variant, making the two visualizations distinct while keeping the gameplay layout identical.

Figures 4.10a and 4.10b illustrate these adaptations, showing how the same shared structure can provide two contrasting yet balanced experiences.

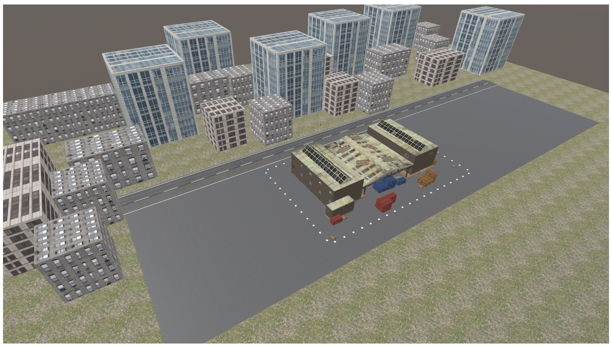
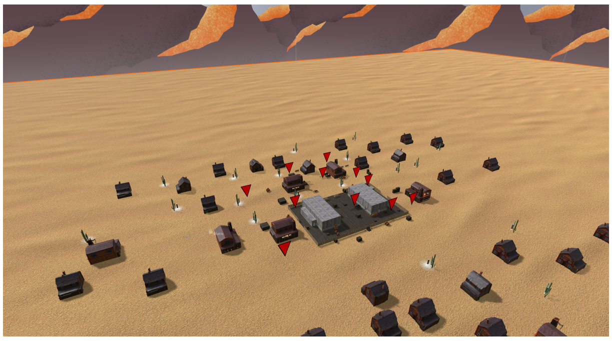
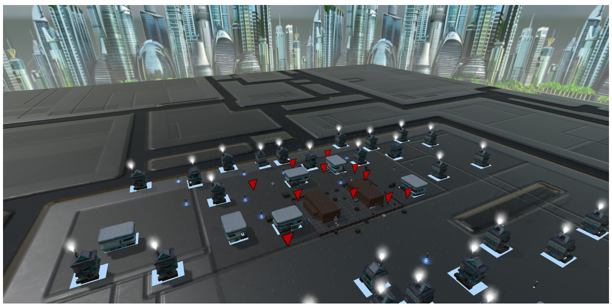


FIGURE 4.9. Game map before having the new system



(A) Wild West.



(B) Sci-Fi.

FIGURE 4.10. Game maps after having the new system. Red Arrows indicates spawn points.

4.7. Gameplay Systems

4.7.1. Game Mechanics

Although the base game already provided a functional framework for a multiplayer FPS[10], several key mechanics were redesigned or significantly enhanced to align the gameplay experience with modern FPS standards. These improvements aimed to deliver a more

[10]https://github.com/Armour/Multiplayer-FPS

immersive, competitive, and responsive environment, addressing player expectations while maintaining the technical requirements of the asymmetric visualization system.

One of the first areas of improvement was the sprinting system. In the original version of the game, sprinting was non-existent. This mechanic was extended to include a stamina bar, visually represented in the UI, which depletes as the player sprints and regenerates over time when the player is idle or walking. The addition of audio feedback, such as heavy breathing during recovery, further enhanced immersion by simulating the fatigue of the in-game character. These additions not only made the mechanic more intuitive and realistic but also introduced a layer of tactical decision-making, players now had to manage stamina during combat and exploration.

Another significant update involved the damage and feedback system. The original game applied damage without much visual or audio feedback, making it difficult for players to understand their condition in the heat of battle. In the improved version, whenever a player takes damage, blood splatter effects appear on the screen and are combined with dynamic audio cues, such as a rising heartbeat, this is implemented identically across both visual styles. These effects intensify as health drops, alerting the player that they are close to elimination without having to constantly look at the health bar. This kind of layered, diegetic feedback is inspired by industry-leading games such as Call of Duty[11], where minimal HUD use is supported by strong environmental and character cues.

To further enhance combat depth and reward precision, the hit detection system was refined to differentiate between body shots and headshots. The base version of the game applied uniform damage regardless of hit location, but the new system assigns higher damage to headshots. This encourages skillful aiming and makes the combat feel more impactful. Technically, this was implemented using multiple colliders on the character's rig, typically one for the head and one for the body, with each associated with different damage values.

The crouching mechanic was another essential feature that was missing in the original implementation. It was added to improve both realism and tactical movement. The crouch function reduces the character's height and movement speed, allowing players to navigate low obstacles or adopt a stealthier profile. The default key binding for crouching was set to Left Ctrl, consistent with standard FPS conventions.

Lastly, the respawn system was change to prevent spawn-related frustration. In the base version, players would respawn at random points, occasionally near enemies, which could lead to spawn killing, an unfair situation where a newly respawned player is instantly eliminated. The updated system includes logic to calculate the furthest available spawn point from active enemy players, greatly reducing the chances of immediate re-engagement and giving the player time to reorient themselves after respawning.

[11]https://www.callofduty.com/pt

4.7.2. Dynamic Difficulty Adjustment

To ensure a balanced and engaging gameplay experience, particularly in multiplayer test scenarios where skill levels may vary significantly, a DDA system was implemented. This mechanism continuously monitors player performance and provides temporary support to underperforming players, thereby reducing frustration and promoting fairness without drastically altering the competitive balance.

The DDA relies on a simple yet effective performance metric: the Kill Ratio. This metric is defined as the ratio between a player's kills (`myKills`) and their deaths (`totalDeaths`),

$$\text{KillRatio} = \frac{\texttt{myKills}}{\texttt{totalDeaths} + \epsilon}, \tag{4.1}$$

where $\epsilon = 1e - 4$ avoids division by zero in cases where no deaths have yet occurred. Higher values of the Kill Ratio indicate stronger performance, while lower values reveal that the player is struggling.

To determine when assistance should be granted, a threshold value of 0.2 was established. If a player's Kill Ratio falls below this threshold, the system activates a compensatory mechanism by assigning a temporary shield worth 50 points to the player's shield bar, totaling 150 health points. This shield, visualized through the in-game UI (sliders and an icon overlay), absorbs incoming damage before affecting the player's main health pool. The value of 50 was chosen based on tests conducted during the formative evaluation sessions (explained in the next chapter). This value ensures meaningful support without conferring excessive advantage.

By integrating these elements, the performance metric, its variables, and the corresponding threshold and shield values, into a unified mechanism, the DDA system remains transparent, fair, and non-intrusive. The shield is not permanent, can be depleted through normal combat, and is only activated when the precise performance condition is met. Moreover, beyond balancing differences in player skill, this system also mitigates potential unintended imbalances arising from the asymmetric visualizations. Subtle differences in perception, such as color contrast or object visibility, might otherwise favor one theme, but the situational assistance ensures that no visualization consistently grants a competitive edge.

4.7.3. Data Collection

At the end of each match, the system records detailed performance data for every player. These data is exported into a `CSV` file, providing a structured dataset that can be analyzed in the evaluation phase (Chapter 5).

The collected metrics include:

- **Kills:** Number of opponents eliminated;
- **Deaths:** Number of times the player was eliminated;
- **BodyShoots(BS):** Number of shots fired against the body;

- **HeadShoots(HS):** Number of shots fired against the head;
- **Misses(M):** Number of shots missed;
- **Head Shoot Accuracy(HSA):** Percentage of successful hits in the Head compared to shots fired, HSA = HS/(BS+HS+M);
- **Body Shoot Accuracy(BSA):** Percentage of successful hits compared to shots fired, where it was directly calculated in the game code, BSA = BS/(BS+HS+M);
- **Longest time alive:** Longer survival time during the game.

These statistics serve both to evaluate player performance and to validate the consistency of the gameplay experience across different visual styles, ensuring that the choice of visualization has no unintended effect on competitive balance.

CHAPTER 5

Evaluation

5.1. Methodology

The proposed system was designed following an iterative design approach. Five major iterations were carried out. Each iteration involved a formative evaluation phase, whose results guided the design of the next iteration.

Participants for the formative evaluation section were recruited on the university campus and invited to take part voluntarily. All sessions were conducted remotely using Discord[1], since this provided the most practical and familiar environment for playtesting. Each session lasted around 30 minutes, except for the final formative evaluation, which lasted approximately one hour to allow extended testing of the full prototype. Groups of 7 to 8 participants were included in each iteration, balanced by gender and aged between 18 and 24. Data collection methods included direct observation, post-session discussions, and responses to the GEQ [30], which measures affect, flow, competence, and related factors using a 5-point Likert scale.

After the development phase, a summative evaluation was conducted with 39 adults. This evaluation began with a questionnaire to characterize the participants, covering demographics (age, gender), gaming habits (casual, hardcore), prior experience with FPS games, and their preferred visualization style. Following this, playtesting sessions were carried out with groups of 4 participants at a time, across 10 separate sessions.

5.2. Formative Evaluation Results

Throughout the development process, a total of five formative iterations were conducted. Each iteration involved structured play testing sessions, followed by the collection of feedback through observations, informal interviews, and the GEQ. These sessions helped identify usability issues, balance concerns, and opportunities for improved engagement. Below, we outline the major focus areas and outcomes of each iteration.

5.2.1. Iteration 1

The first iteration focused on validating the basic controls and the main gameplay. At this stage, it was important to ensure that players intuitively understood the standard controls of an FPS and that actions responded fluidly.

The first sessions revealed some difficulty on the part of the players in perceiving their physical state during the game, such as when they were low on life or tired. Based on this

[1]https://discord.com

feedback, visual indicators such as the reddish screen effect were introduced to signal low health, as well as sound effects such as wheezing to simulate tiredness after running.

Small improvements to the graphical interface, such as the visibility of the crosshairs and the ammunition indicator, have also been implemented to increase visual clarity.

5.2.2. Iterations 2 and 3

In the second and third iterations, the focus shifted to fixing bugs and reinforcing visual immersion and gameplay balance. During this phase, one of the system's most innovative mechanics was introduced: the dynamic shield.

The mechanic monitors each player's kill-to-death ratio in real time and, when performance falls below a defined threshold, automatically activates a temporary shield. The goal is to reduce the competitive gap and increase the motivation of less experienced players. At the same time, the boundaries of the map were visually enriched with elements such as sandstorms and toxic fog, contributing not only to the atmosphere but also to discouraging players from staying outside the combat zone.

Different thematic music was also introduced depending on the visual style chosen by the player (e.g., futuristic electronic music or classic western), reinforcing sensory immersion. The damage system was further refined by distinguishing between shots to the head and to the body, adding more strategic depth to combat.

5.2.3. Iteration 4

The fourth iteration focused on changes to the movement system and redefining the match objectives. A recurring request from players was the possibility of crouching, which led to the implementation of this feature with dedicated animations and speed penalties to maintain gameplay balance. At the same time, the way the match is won has been rethought.

Originally, the game ended when a player reached a pre-defined number of eliminations, which quickly proved demotivating for lower-performing players. So this logic was replaced by a time-based system, eight minutes per match, which ensured that all players remained active and had clear objectives from start to finish.

5.2.4. Iteration 5

The fifth and final iteration focused on validating the overall stability of the game with a new group of users. This phase was essential to confirm that all the elements, from the custom visualization logic, to the dynamic loading of assets, to the synchronization between clients and the shield mechanics, worked robustly.

In addition, final adjustments were made to the interface, visual effects, and network synchronization. The experience of the new players in this phase confirmed that the system was ready for the final phase of summative evaluation.

5.3. Analysis User Experience

Out of the participants, 27 (69,2%) were male and 12 (30.8%) were female, as represented in Fig 5.1, and 31 were between 18 and 24 and 8 were between 25 and 34 years old, in Fig 5.2.

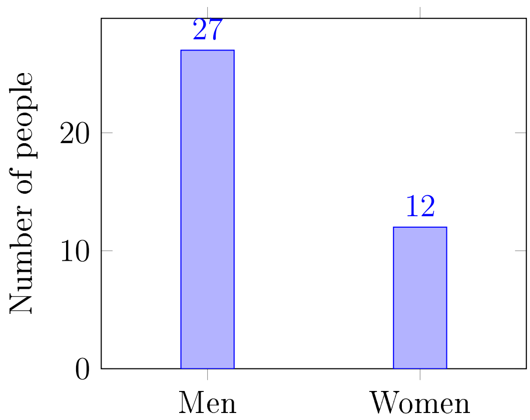


Figure 5.1. Sample Results for gender.

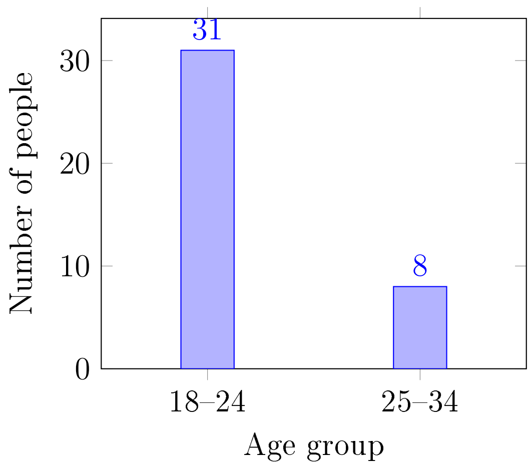


Figure 5.2. Sample Results for age group.

Participants were also asked about their familiarity with FPS games. To assess their general playing habits, they answered how often they played video games. As illustrated in Figure 5.3, 2 participants played daily, 10 several times a week, 15 several times a month, and 2 rarely, indicating that the majority had at least moderate familiarity with the genre.

In terms of self-perceived experience with multiplayer FPS games, participants reported varying skill levels. According to Figure 5.4, there were 8 beginners, 15 intermediates, 14 advanced players, and 2 professionals. A related question asked participants to rate how good they believed they were at such games (i.e., self-perception of skill level), with results shown in Figure 5.5. 20 participantes rated themselves as intermediate, followed by 10 beginners, 7 advanced, and 2 rated themselves professionals.

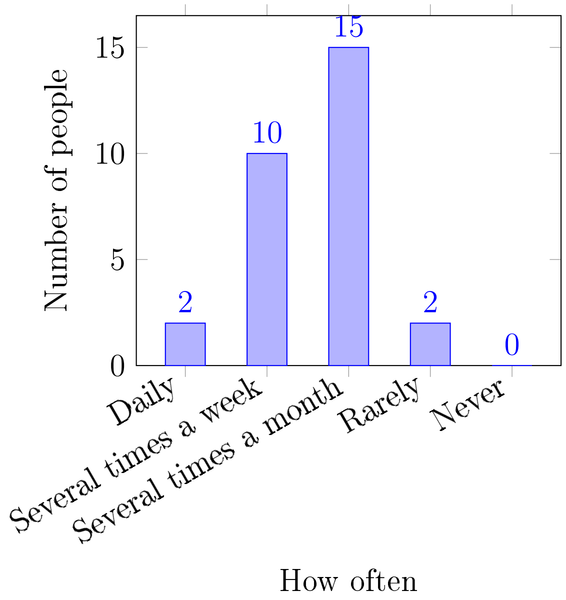


FIGURE 5.3. Sample Results for “How often do you play video games?”.

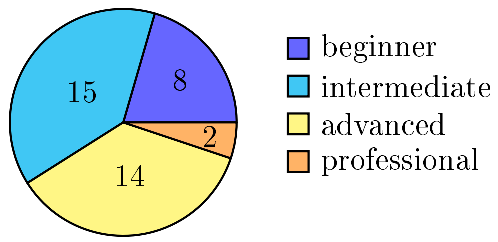


FIGURE 5.4. Sample Results for “How experienced are you in multiplayer FPS?”.

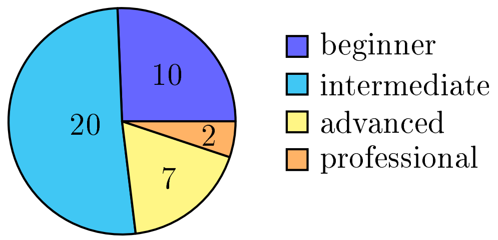


FIGURE 5.5. Sample Results for “How good do you think you are at this type of game?”.

Additionally, the evaluation explored participants interest in the core idea of having a multiplayer FPS where each player could experience a different visual style. As shown in Figure 5.6, 15 participants found the idea “Very Interesting,” and 22 found it “Interesting,” indicating a strong positive reception. No participant rated the concept as “Slightly” or “Not at all Interesting.”

To evaluate visual preferences, participants were asked to choose between the two visual themes available in the game. The results, shown in Figure 5.7, revealed an almost even split: 20 participants preferred the Sci-Fi theme, while 19 preferred the Wild West

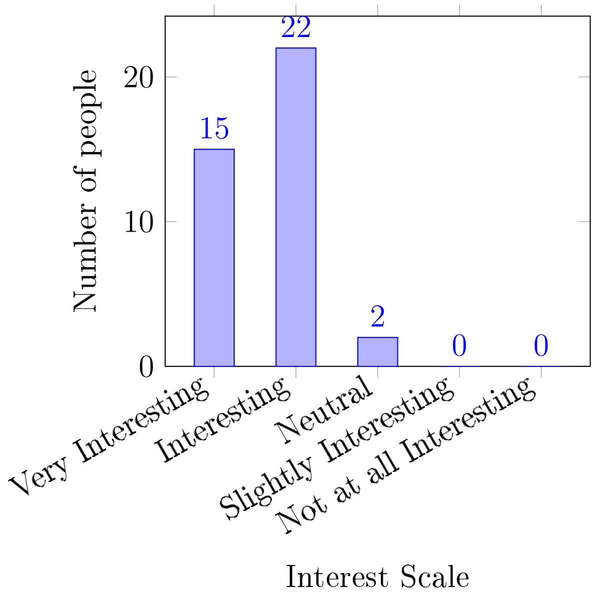


Figure 5.6. Sample Results for “What do you think of the idea of a multiplayer FPS game where each player can choose a different visual style without affecting the gameplay?”.

style. This balance was essential to ensure both styles were tested thoroughly in the upcoming interesting.

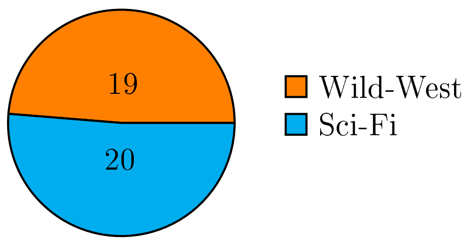


Figure 5.7. Sample Results for “Which visual style do you like?”.

Participants were also asked about their general attitude toward innovation in game mechanics. According to Figure 5.8, 27 participants stated they enjoy experimenting and learning with new systems, 10 appreciated innovation if well explained, while only 2 preferred traditional mechanics. None indicated resistance to innovation.

Another question evaluated the impact of personalization on replayability. As seen in Figure 5.9, 20 participants agreed or strongly agreed that being able to choose their visual style would encourage them to play the game more often, while 17 remained indifferent, and only 2 disagreed. This suggests personalization could positively influence long-term engagement.

Participants were also asked about their familiarity with common FPS mechanics, such as sprinting, crouching, aiming, and respawn systems as seen in Figure 5.11. The results revealed a very high level of familiarity across the sample: all 39 participants reported knowing the sprint and jump mechanics, 38 were familiar with crouching, and at least 36 participants recognized respawn mechanics. Aiming, the use of separate health and shield

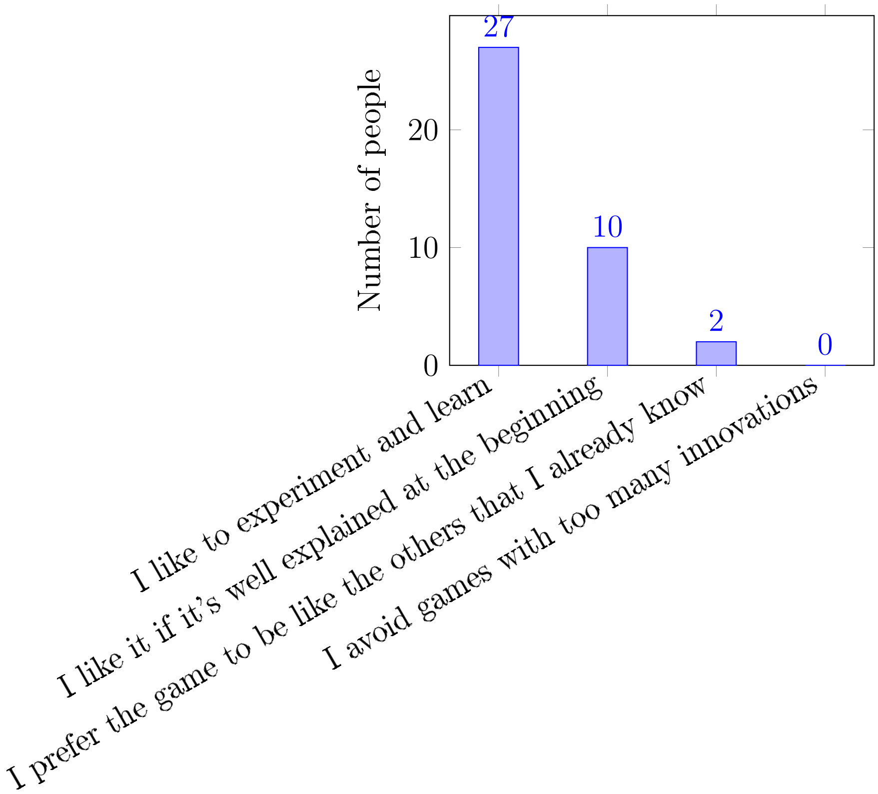


Figure 5.8. Sample Results for "What do you think of the idea of a multiplayer FPS game where each player can choose a different visual style without affecting the gameplay?".

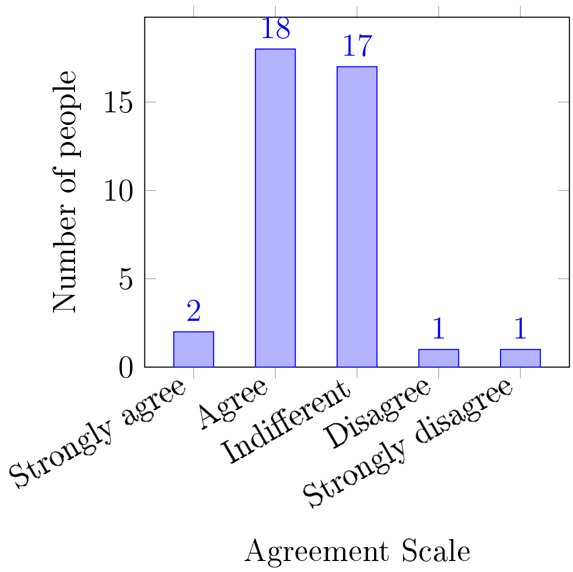


Figure 5.9. Sample Results for "Do you think the possibility of choosing different viewing styles would make you play the same game more often?".

bars, and minimaps also scored highly, with 37 participants reporting prior knowledge in each case.

Beyond the direct experimental results, participants also expressed the belief that this mechanic could extend beyond the FPS genre. As illustrated in Figure 5.12, genres such

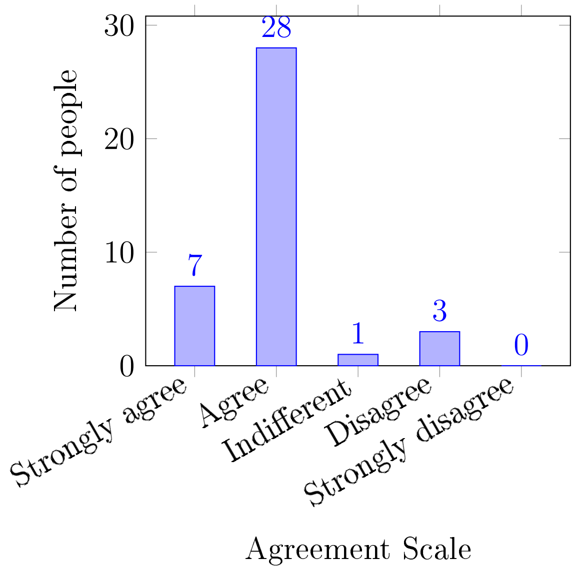


FIGURE 5.10. Sample Results for "Did you feel that this approach could make the game more inclusive for different types of players (age, preferences, styles, etc.)?".

as adventure, action, RPG, and strategy were frequently mentioned as suitable contexts for asymmetric visualization. This indicates that the approach has broader applicability and may serve as a foundation for innovation in diverse multiplayer experiences.

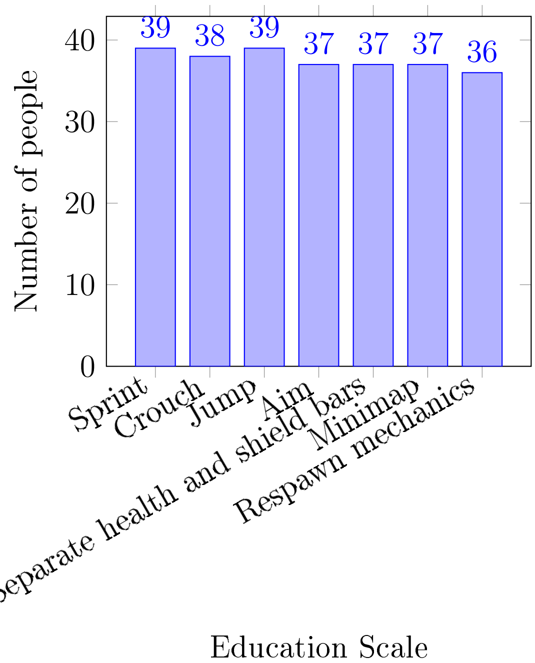


FIGURE 5.11. Sample Results for " Are you familiar with the following game mechanics?(check the ones you know)".

Finally, participants were asked if they believed that this system could make the game more inclusive for players of different ages, backgrounds, and preferences. The overwhelming majority, as shown in Figure 5.10, agreed with this statement, 7 strongly agreed, 28 agreed, while only 3 disagreed and 1 was indifferent. These responses reinforce the idea that asymmetric visual customization can help make games more adaptable and welcoming to a wider audience.

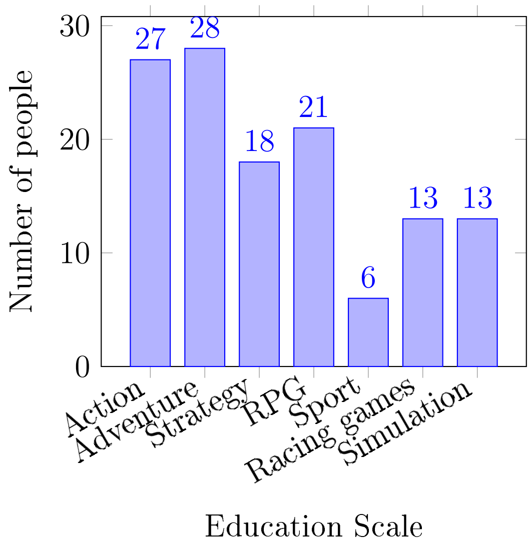


FIGURE 5.12. Sample Results for "What other types of games do you think have benefited from this new visualization mechanic?".

5.4. Summative Evaluation Results

The summative evaluation was designed to test the two central hypotheses of this work. The first examined whether asymmetrical visualization modules within the same game enhance overall satisfaction and engagement among players. The second investigated whether giving players free choice over the game's visual style improves subjective experience (e.g., competence, immersion, behavioural involvement, and negative affect) compared to being forced to play with either a preferred or a non-preferred style.

To address these hypotheses, we recruited a sample of 39 adults (27 male (69.2%), 12 female (30.8%)) and conducted the experiment across multiple multiplayer sessions. Each session grouped up to four participants (ten sessions in total, with one session having three participants) and was run remotely via Discord[2]. A typical session lasted approximately 60 minutes.

The experimental procedure began with a short pre-game questionnaire collecting demographics and prior gaming experience, followed by three play scenarios administered in sequence: first play using either the participant's reported preferred or reported non-preferred visual style (order counterbalanced and randomized to avoid order bias), second play using the alternate style, and third play with free choice of visualization. After each scenario participants completed the Game Experience Questionnaire (GEQ), producing three GEQ responses per participant. In parallel, objective in-game metrics (kills, deaths, and so on.) were recorded for exploratory analysis.

[2]https://discord.com

TABLE 5.1. Average scores ± Standard deviation and standard deviations of the GEQ Core Module module across the three test conditions. The "Bias" column indicates the favorable direction for better results, where "+"/"-" indicates whether a higher or lower score is better.

GEQ Core Module					
GEQ Scale	**Bias**	**Free choice**	**Preferred 1st**	**Preferred last**
Competence	+	3.55 ± 0.82	3.44 ± 0.86	3.39 ± 0.92
Sensory and Imaginative Immersion	+	3.54 ± 0.70	3.60 ± 0.66	3.39 ± 0.83
Flow	+	3.39 ± 1.06	3.31 ± 1.02	3.33 ± 0.92
Tension / Annoyance	-	1.41 ± 0.82	1.41 ± 0.85	1.38 ± 0.88
Challenge	-	2.31 ± 0.73	2.38 ± 0.64	2.22 ± 0.67
Negative Affect	-	1.37 ± 0.56	1.43 ± 0.56	1.41 ± 0.50
Positive Affect	+	4.19 ± 0.72	4.09 ± 0.75	4.12 ± 0.79

The analysis strategy was chosen to reflect the data properties and the research goals. Normality was assessed using the Shapiro–Wilk test; since the data did not consistently meet Gaussian assumptions, non-parametric paired tests (Wilcoxon signed-rank) were used for condition comparisons. The following section presents the GEQ aggregates, the statistically significant contrasts, and an interpretation that connects the observed differences to the research questions (including checks for relationships with prior experience and short-term performance). The aim is not only to report which scales differ across conditions, but to explain what those differences imply for player experience and for the feasibility of asymmetric visualization in multiplayer contexts.

In interpreting statistical outcomes, it is also important to clarify the confidence level associated with significance claims. Throughout the analysis, results were considered statistically significant at the 95% confidence level, which corresponds to a threshold of $p < 0.05$. Thus, whenever the text reports that a difference between conditions is "significant," it indicates that the probability of observing such a result under the null hypothesis is below this 5% threshold. Values above this cutoff were treated as non-significant, meaning that the available evidence was insufficient to reject the null hypothesis, even if the data suggested a potential trend.

The following results are presented across the three modules of the GEQ: Core Module, Social Presence Module, and Post-game Module. Each module captures a different dimension of player experience, ranging from immediate gameplay feelings (competence, immersion, flow), to social interaction (empathy, behavioural involvement), and post-session reflections (positive/negative experience, tiredness). For each scale, averages and standard deviations are reported under the three experimental conditions: Free Choice, Preferred 1st, and Preferred Last.

By examining the three GEQ modules separately, it becomes possible to identify both general patterns and condition-specific effects. The tables below provide the descriptive results, which are later followed by statistical tests and interpretations that connect the observed differences to the research questions.

TABLE 5.2. Average scores ± Standard deviation and standard deviations of the GEQ Social Presence module across the three test conditions. The "Bias" column indicates the favorable direction for better results, where "+"/"-" indicates whether a higher or lower score is better.

GEQ Social Presence Module				
GEQ Scale	**Bias**	**Free choice**	**Preferred 1st**	**Preferred last**
Empathy	+	3.82 ± 0.88	3.70 ± 0.94	3.73 ± 0.94
Negative Feelings	-	2.83 ± 0.86	2.63 ± 0.83	2.69 ± 0.94
Behavioural Involvement	+	3.71 ± 0.94	3.53 ± 0.83	3.44 ± 0.88

TABLE 5.3. Average scores ± Standard deviation and standard deviations of the GEQ Post Game module across the three test conditions. The "Bias" column indicates the favorable direction for better results, where "+"/"-" indicates whether a higher or lower score is better.

GEQ Post-game Module				
GEQ Scale	**Bias**	**Free choice**	**Preferred 1st**	**Preferred last**
Positive Experience	+	3.29 ± 1.03	3.22 ± 0.83	3.23 ± 0.91
Negative Experience	-	1.27 ± 0.36	1.41 ± 0.37	1.38 ± 0.48
Tiredness	-	1.22 ± 0.50	1.17 ± 0.41	1.13 ± 0.35
Returning to Reality	-	1.84 ± 0.81	1.83 ± 0.70	1.91 ± 0.75

The Core Module captures immediate, game-related experiences such as competence, immersion, flow, affect, and challenge. Table 5.1 shows that values across conditions were generally mid-to-high on positive scales (competence, immersion, positive affect) and low on negative scales (tension, negative affect), indicating an overall enjoyable experience. The Free Choice condition consistently performed as well as or better than the forced conditions, with particularly notable advantages in competence and immersion. The relatively small differences in flow, tension, and challenge suggest that the underlying mechanics were perceived as stable across styles, while visualization choice primarily affected subjective engagement and emotional tone.

The Social Presence Module reflects how players felt connected to others during the multiplayer sessions. As shown in Table 5.2, empathy values were moderate to high across all conditions, indicating that participants felt attuned to other players regardless of style. Behavioural involvement, however, was notably higher in the Free Choice condition, suggesting that personalizing the visual context encouraged players to engage more actively with their peers, perhaps by making them feel more comfortable or motivated. Negative feelings were slightly elevated overall, but remained relatively low, showing that asymmetry did not generate major frustration in the multiplayer interaction.

The Post-game Module evaluates how participants felt immediately after play, focusing on overall experience, fatigue, and the transition back to reality. Table 5.3 shows that positive experiences were moderate, while negative experiences were consistently low, especially in the Free Choice condition. This suggests that being allowed to choose visuals reduced post-game irritation or dissatisfaction. Tiredness and "returning to reality" values were low and stable across all conditions, which is expected given the relatively short sessions. The small but consistent advantage of Free Choice in reducing negative experiences reinforces the idea that autonomy in visualization translates into a more pleasant overall memory of the game.

When looking at the Core Module, one of the clearest effects appeared in perceived competence. Participants reported higher competence in the Free Choice condition (3.55 ± 0.82) than in the Preferred Last condition (3.39 ± 0.92), a difference confirmed by the Wilcoxon test ($p \approx 0.0088$) and associated with a small-to-moderate effect size (Cohen's $d = 0.25$). This indicates that being able to configure one's own visual environment can enhance confidence and task engagement, most likely because choice supports autonomy and identification with the avatar and world.

Sensory and imaginative immersion showed a similar pattern: immersion was higher both when participants used a preferred visualization (Preferred 1st mean = 3.60) and when Free Choice was compared with Preferred Last (Wilcoxon $p \approx 0.036$, Cohen's $d = 0.26$). The Preferred 1st vs. Preferred Last comparison narrowly missed significance ($p \approx 0.0584$), suggesting a tendency for non-preferred aesthetics to weaken immersion.

The Social Presence Module also revealed a meaningful effect on behavioural involvement, with Free Choice producing significantly greater scores than both Preferred 1st ($p \approx 0.020$, Cohen's $d = -0.23$) and Preferred Last ($p \approx 0.003$, Cohen's $d = 0.34$). These small-to-moderate effects suggest that giving players autonomy over visualization may strengthen their social engagement, whether through communication, cooperation, or attentiveness to others.

Finally, negative experience scores were lowest in the Free Choice condition, significantly below both forced conditions ($p \approx 0.002$, Cohen's $d = -0.65$ vs Preferred Last and $p \approx 0.0018$, Cohen's $d = -1.11$ vs Preferred 1st). These results correspond to large effect sizes, confirming that the freedom to choose one's own visualization strongly reduces frustration and annoyance. In practical terms, players experienced fewer negative emotions when they had agency over their visual style, highlighting the protective role of choice against negative affect.

Several scales did not show significant differences across conditions, including Flow, Positive Affect, Challenge, and Tiredness. Moreover, objective in-game performance metrics (kills, deaths, and so on.) did not show any statistically meaningful effects, and no evidence was found that participant background factors (such as self-reported skill or play frequency) influenced subjective experience. Importantly, the absence of statistically significant results does not imply that the null hypothesis is true, but rather that the available data do not provide sufficient evidence to reject it. These null findings are still meaningful: they suggest that the benefits of Free Choice are not explained by prior skill or performance, but instead by the psychological value of autonomy and personalization itself.

Conclusions and concrete takeaways:

- Free choice of visualization produced statistically significant benefits in perceived competence, sensory immersion (vs. forced non-preferred), behavioural involvement, and reduced negative experience.
- These benefits were not attributable to prior gaming experience or short-term performance differences (kills/deaths), suggesting the choice effect is psychological rather than performance-driven.
- The findings are promising but preliminary: larger samples, corrections for multiple comparisons, and longitudinal measurements are recommended to confirm robustness and probe long-term effects (e.g., retention, replayability).

CHAPTER 6

Conclusions and Future Work

6.1. Conclusions

This dissertation set out to explore the underdeveloped concept of asymmetric visualization in multiplayer games and demonstrate its feasibility through the design, implementation, and evaluation of a working prototype. The motivation arose from the observation that while games often provide graphical settings or cosmetic customizations, the core visual identity of a multiplayer game is typically shared by all players, leaving little room for deeper personalization. This work argued that by decoupling visual rendering from core gameplay logic, it is possible to give each player a distinct visual experience without compromising game rules or synchronization.

To pursue this idea, a novel system architecture was proposed. The architecture separates gameplay state from presentation, enabling different players to perceive the same multiplayer world through contrasting visual styles. The system was instantiated in a multiplayer prototype implemented in Unity with Photon Unity Networking (PUN). Two highly distinct visual styles were developed, Sci-Fi and Wild West, to demonstrate the flexibility of the approach and to create a strong contrast that could be clearly perceived by participants. The prototype also included several supporting systems, such as tag-based instantiation for map elements, dynamic asset loading, theme-specific audio, and adaptive mechanics like a shield-based balancing feature.

The development followed an iterative process across five major iterations. Each iteration combined implementation with formative testing involving small groups of players recruited from the university campus. These sessions, carried out remotely via Discord[1], provided continuous feedback that guided refinements to usability, mechanics, and immersion. Iterations not only improved stability and balance but also introduced key innovations such as theme-dependent music, enhanced environmental effects, and improved combat systems.

The prototype was then evaluated through a summative study with 39 participants across ten multiplayer sessions. Participants experienced three test conditions: playing with their most preferred style, playing with their least preferred style, and freely choosing their style. After each condition, participants completed the GEQ. The results provided clear evidence that freedom of choice enhanced subjective experience. Free choice significantly improved competence, behavioural involvement, and immersion, while also reducing negative experiences compared to being forced into a non-preferred visualization.

[1]https://discord.com

Effect size analysis (Cohen's d) further confirmed these trends, showing small-to-moderate effects for competence ($d = 0.25$) and immersion ($d = 0.26$), a moderate effect for behavioural involvement ($d = 0.34$), and a strong effect for reduction of negative experience ($d = -0.65$) when comparing Free Choice to the least preferred visualization and a small to moderate effect for behavioural involvement ($d = -0.23$), and a strong effect for reduction of negative experience ($d = -1.11$) when comparing Free Choice to the preferred visualization.

Importantly, these findings directly address the second research question: "Does the freedom to choose one's preferred visualization theme, as opposed to being forced into a specific theme, lead to higher values of satisfaction and engagement of players?" The collected data clearly supports an affirmative answer. Players who were granted freedom of choice consistently reported higher satisfaction, competence, and immersion, alongside fewer negative emotions. The magnitude of these effects, as shown by the Cohen's d values, reinforces that the psychological benefits of autonomy and personalization meaningfully enhance player experience. Moreover, the absence of significant associations between these outcomes and in-game performance metrics (such as kills or deaths) indicates that the improvements arise from the perception of agency itself rather than from gameplay success.

Taken together, these results demonstrate that asymmetric visualization is both technically viable and positively received by players. By enabling personalization at the level of world representation, the system broadens the design space of multiplayer games and introduces new opportunities for inclusivity, immersion, and player agency. This dissertation therefore makes three main contributions: it proposes and implements a system architecture that decouples gameplay logic from visual rendering, it delivers a functional prototype that instantiates this system in a multiplayer game with two contrasting visual styles, and it provides initial findings from user studies suggesting that visual freedom of choice enhances engagement, competence, and enjoyment.

6.2. Future Work and Limitations

While the work demonstrates feasibility and provides promising results, several limitations remain that must be addressed before asymmetric visualization can be adopted in production-level systems. These limitations span technical, design, and experiential dimensions.

Technical Limitations

First, the reliance on Photon Unity Networking (PUN) introduces constraints in both scalability and robustness. PUN operates on a pricing model based on concurrent users, which is suitable for prototypes but could quickly become unsustainable at scale. Moreover, the hybrid architecture relies heavily on the Master Client as the authority for game logic. While lightweight, this design risks instability: if the Master Client disconnects, the game requires host migration, creating potential desynchronization and temporary inconsistencies. Compared to server-authoritative models, this approach also limits security and control, leaving the system vulnerable to cheating or malicious manipulation.

Second, runtime asset management in the prototype depended on Unity's `Resources.Load()` system. Although it functioned reliably within the scope of this prototype, its performance under larger-scale asset libraries, such as projects with hundreds or thousands of models, textures, and audio files, remains untested. This introduces a potential scalability concern not in terms of the number of visualizations, but in the overall volume of assets loaded at runtime. More advanced systems, such as Unity Addressables or asset bundles with version control, would likely provide better performance and memory management for future expansions.

Third, the system assumes that all visual assets are carefully aligned in terms of colliders, pivot points, and dimensions. This dependency introduces fragility into the workflow: any mismatch between styles could unintentionally create gameplay advantages or disadvantages. Although this was controlled in the prototype, scaling to multiple themes or player-generated content would require automated validation and quality assurance pipelines.

Finally, advanced networking requirements such as large concurrent lobbies, authoritative anti-cheat mechanisms, and cross-platform synchronization were not addressed. While unnecessary for the prototype, they are essential for real-world applications.

From an experiential standpoint, the evaluation confirmed short-term benefits of asymmetric visualization, but longer-term effects remain unknown. It is unclear whether novelty effects may diminish with repeated play or whether extreme stylistic contrasts could eventually fragment the shared sense of atmosphere. Accessibility was also not deeply explored, while the system may support inclusivity by catering to different aesthetic preferences, more research is needed to determine how visual asymmetry interacts with players of different cognitive, sensory, or cultural backgrounds.

Future Work

Future research should therefore address these technical and experiential challenges. On the technical side, integrating fully server-authoritative architectures would improve scalability, security, and stability. Asset management pipelines should migrate to scalable solutions such as Addressables, with automated validation tools ensuring asset consistency across styles. Network features like anti-cheat measures, larger lobby support, and cross-platform play would also strengthen applicability.

On the experiential side, future studies should explore long-term use through longitudinal experiments, testing whether the observed benefits persist over time. Research should also expand to other genres beyond FPS games, such as role-playing, strategy, or educational titles, to examine how asymmetric visualization interacts with different mechanics. Additional visual styles, including player-generated or procedurally generated ones, could further test the system's modularity and inclusivity potential. Finally, future work should explicitly investigate accessibility, studying whether asymmetric visualization can support diverse audiences, including younger players, older adults, or individuals with sensory differences.

An additional direction for future research concerns haptic embellishments. Prior work has shown that decorative tactile feedback, while not altering core mechanics, can heighten immersion and emotional engagement. Extending the asymmetric visualization framework to include per-player haptic effects would open promising avenues: for instance, one player might perceive weapon recoil through vibration, while another experiences environmental feedback such as wind or impact pulses. Such integration would broaden the system beyond visual asymmetry, creating multimodal personalization while preserving game rules.

In conclusion, this dissertation introduced and validated a new paradigm for multiplayer game design: separating gameplay logic from visual rendering to allow asymmetric but fair visual experiences. While the prototype has limitations inherent to its scale and technology, it demonstrates that this idea is both technically achievable and positively received by players. By laying a foundation that connects personalization, inclusivity, and fairness, the work opens avenues for future exploration that can reshape how multiplayer experiences are designed and perceived.

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Appendices

CHAPTER A

Assets

This appendix is divided into two parts. The first section presents the questions and corresponding answers from the initial questionnaire used in the summative assessment. While relevant for context, these results did not have enough variety or prominence to be included in the main body of the dissertation.

The second section provides a complete overview of the assets used in the game, including their variations across the two visual themes. To avoid overloading the core chapters with excessive detail, all prefabs are documented here for reference.

A.1. User experience Questionnaire

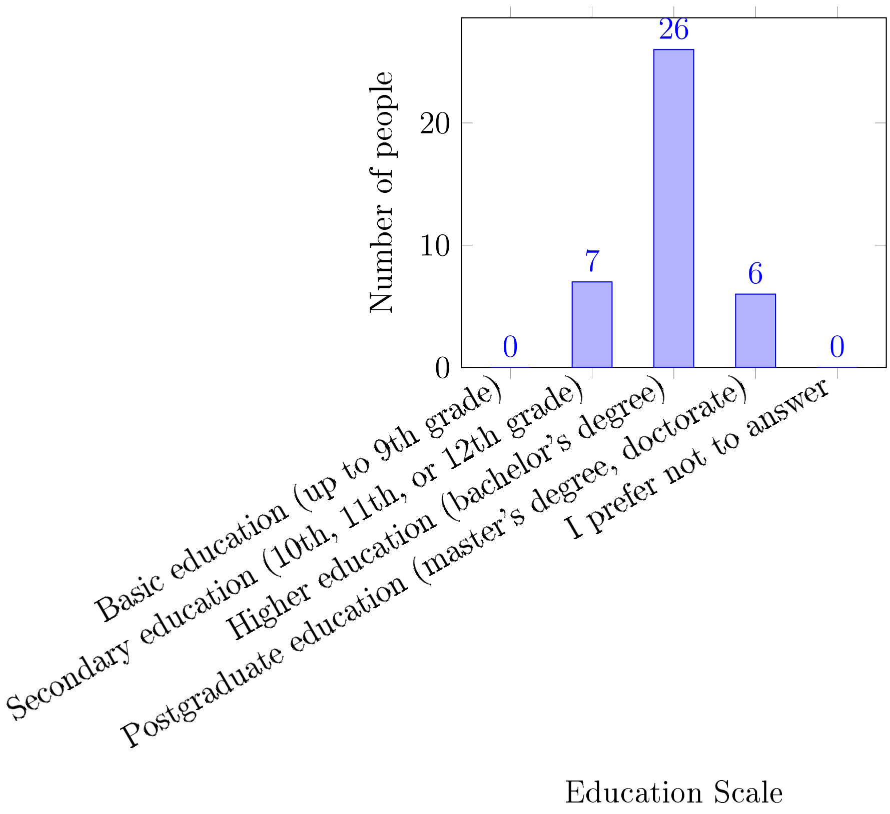

FIGURE A.1. Number of people per education level

A.2. Game Prefabs

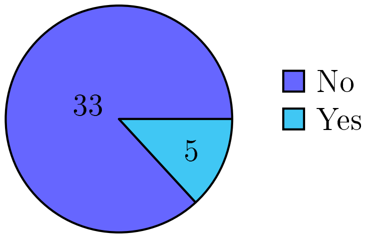

FIGURE A.2. Sample Results for "Do you have vision problems that make it difficult to view content on your computer? "

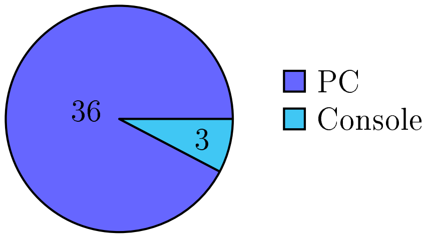

FIGURE A.3. Sample Results for " On which platform do you usually play these same games? "

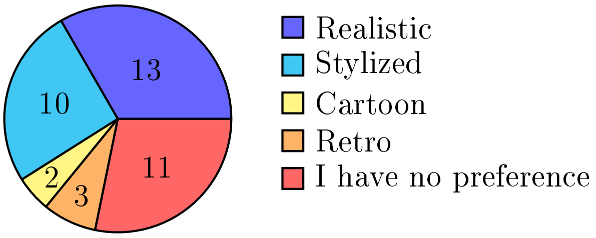

FIGURE A.4. Sample Results for "What kind of visual style do you usually prefer in games?"

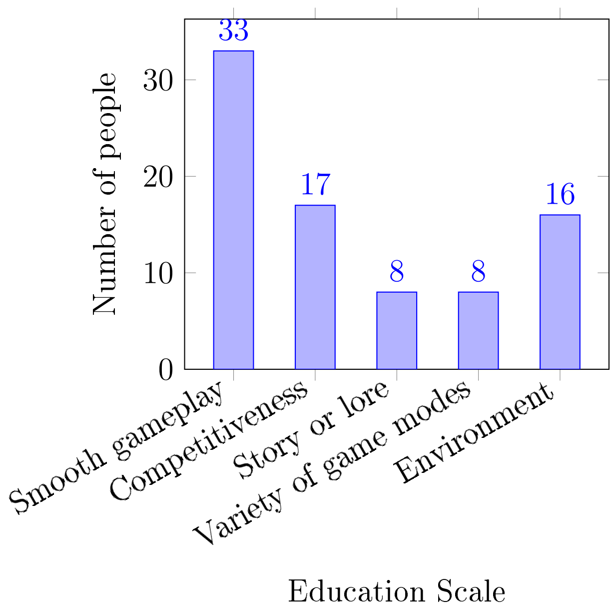

FIGURE A.5. Sample Results for "What do you value most in a multiplayer FPS? (choose more than one option)"

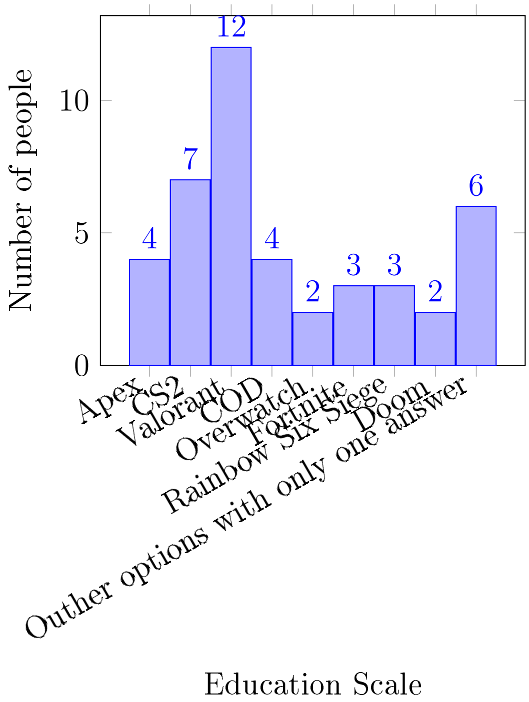

Figure A.6. Sample Results for "What FPS games have you played recently?"

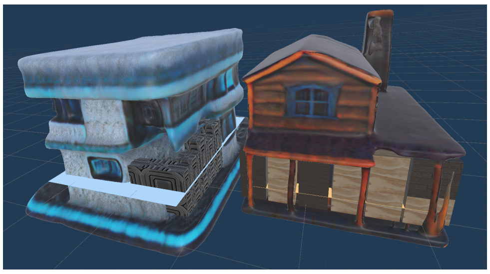

Figure A.7. Houses version 2

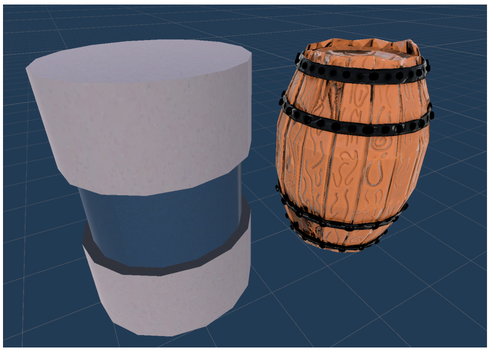

Figure A.8. Barrels

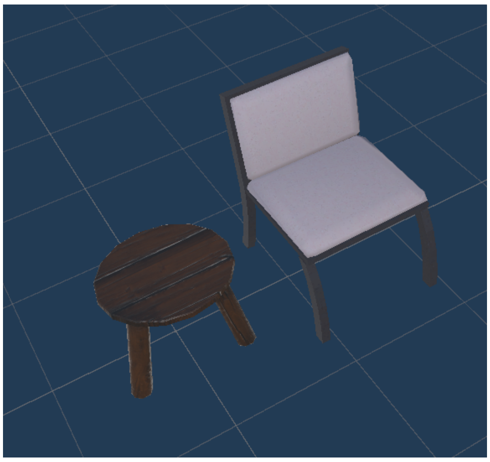

FIGURE A.9. Chairs

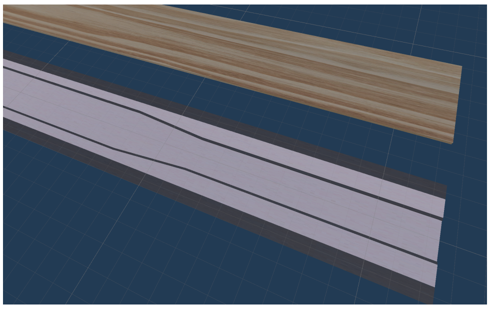

FIGURE A.10. Floor

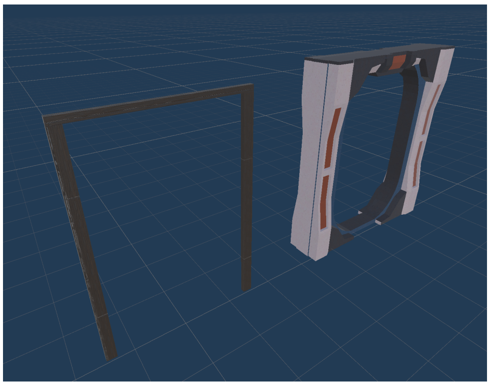

FIGURE A.11. Doors

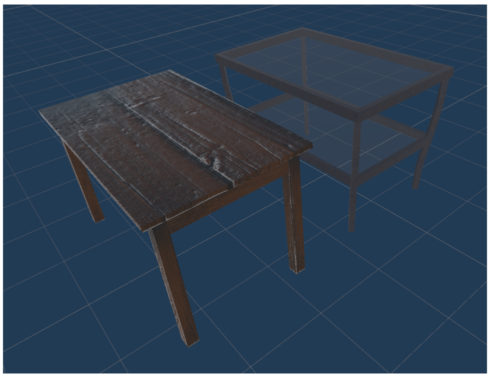

FIGURE A.12. Tables

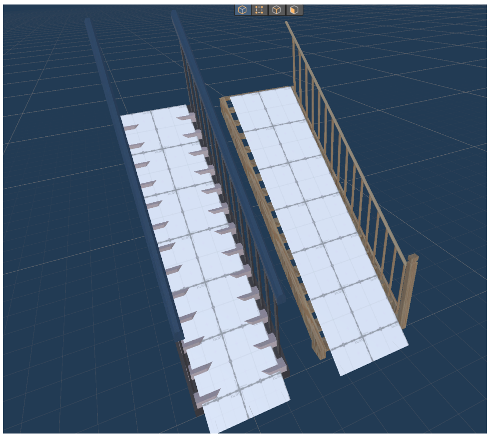

Figure A.13. Stairs

Figure A.14. Cabinet

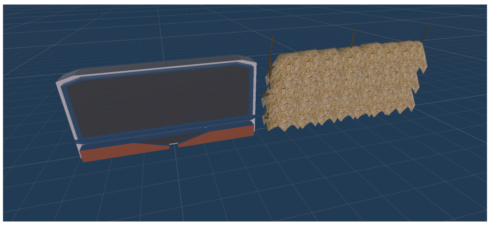

Figure A.15. Hay

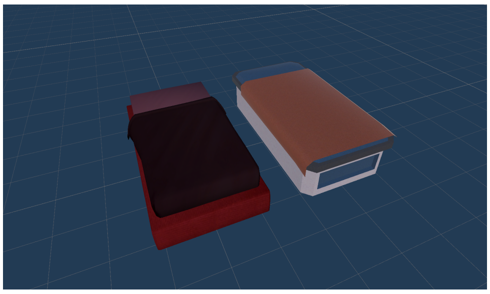

Figure A.16. Beds

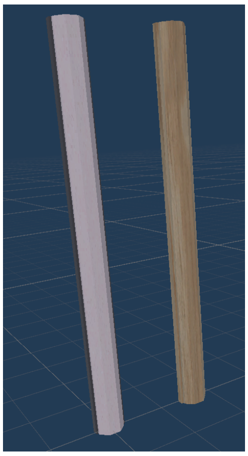

FIGURE A.17. Pillar

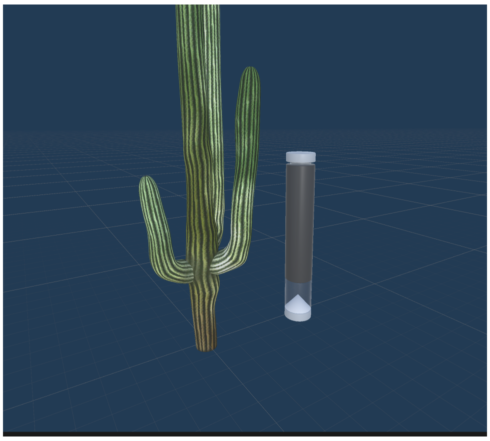

FIGURE A.18. Cactus And Street Lamps