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Understanding the Efficiency and Effectiveness of Environmental Visual Effects in UE5 Video Game Cinematic

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Abstract- This study investigated the efficiency and effectiveness of environmental visual effects (VFX) in video game cinematics, examining how they influenced emotional engagement, player perception, and computational performance. It focused on environmental nature such as lighting, weather systems, and particle effects, which enhanced visual realism and strengthened narrative depth. The researcher emphasized the need to maintain visuospatial balance to create immersive cinematic presentations without overloading system resources. The researcher employed a mixed-methods approach, combining quantitative surveys with qualitative comparative analyses among video game enthusiasts and aspiring developers in Metro Manila. Using Unreal Engine 5 as the primary platform, the study explored technical and design considerations related to VFX implementation. Findings showed that environmental VFX significantly improved immersion and storytelling, and participants favored designs that balanced visual fidelity with responsiveness, as revealed by the survey results and exploration simulations. The study offered practical insights for developers particularly in indie or resource-limited contexts on optimizing cinematic quality without compromising performance, contributing to performance-conscious and narratively compelling game design. Moreover, understanding its significant role in video game cinematic helped emphasize the importance of environmental VFX beyond just technical optimization. Although the sample size and geographic scope limited generalization, the study advanced the discourse in game design by underscoring the strategic role of environmental VFX in producing performance-conscious yet narratively compelling cinematic experiences.

Index Terms- Video Games, Cinematic, Visual Effects, Unreal Engine, Environment

I. INTRODUCTION

The efficiency and effectiveness of environmental visual effects (VFX) in video games had been expressed through various visual techniques aimed at enriching player experience. With advancements in technology and artificial intelligence, developers populated expansive scenes with increasingly complex natural elements such as fluid simulations, particle systems, dynamic lighting, and post-processing effects. These enhancements went beyond aesthetics, guiding player attention, setting emotional tone, and shaping gameplay dynamics (Magic Media, 2023). By designing VFX to elevate realism and deepen immersion, developers made virtual worlds feel more believable and emotionally engaging (Media, 2024; MadVFX, n.d.; Polydin Game Studio, 2024). They enriched the spatial distribution of objects and enhanced narrative expression, reinforcing world authenticity, supporting storytelling, and conveying atmosphere and intent.

Despite these innovations, certain effective visual conditions were found to significantly impact player perception and performance. Research indicated that even minimal visual clutter or distractors placed near a focal point could interfere with spatial visual processing, making it harder for players to identify key elements within the environment (Green & Baveliar, 2006, 2007). This phenomenon, commonly known as "crowding", highlighted a critical challenge in VFX design, ensuring visual richness without overwhelming the player's perceptual capacity. When too many effects or visual elements compete for attention, players may experience reduced clarity, slower reaction times, or even cognitive fatigue. As a result, this called for a thoughtful balance in environmental composition and visual pacing.

Green and Baveliar (2007) and Zhou and Forbes (2022) found that visual stimuli within a player's field of view enhanced visuospatial attention, showing that spatial layout, object placement, and overall visual composition directly shaped how players processed and responded to visual cues during gameplay. These studies emphasized the need for intentional environmental VFX design to guide attention and reduce cognitive overload. Similarly, Villegas, Fonts, Fernandez, and Fernandez-Guinea (2023) reported through qualitative assessments of cinematic game trailers that visual storytelling elements—such as lighting, motion, and environmental transitions—often drove both positive and negative emotional responses. Their findings underscored the critical role of environmental VFX in reinforcing narrative structure and deepening player engagement and emotional investment in the game world.

Few studies had specifically examined how environmental visual effects contributed to a game's efficiency and effectiveness from a player-centered perspective. This study therefore explored how environmental VFX in video game cinematics influenced three core variables: visual realism, emotional immersion, and system performance. It specifically aimed to (1) determine how environmental VFX shaped players' perception of visual realism, (2) assess their role in driving emotional engagement, and (3) evaluate the extent to which they affected perceptions of system performance. The study ultimately sought to bridge the gap between technical implementation and user experience, offering insights to inform both design practice and academic understanding.

This study aligned with the values set by the United Nations' Sustainable Development Goals (SDGs), particularly fostering innovation, promoting inclusive technological development, and advancing quality education. By examining how visual technologies shaped user experience in the context of video game design, the research broadened the understanding of responsible digital innovation. It highlighted the importance of accessible and effective visual communication in interactive media, offering insights to inform both industry practices and educational initiatives. In doing so, the study supported SDG 9 (Industry, Innovation, and Infrastructure) by encouraging the development of efficient and immersive design strategies, and SDG 4 (Quality Education) by advancing knowledge to enhance digital literacy and creative learning in technology-driven fields.

This study limited its scope to analyzing environmental VFX specifically within video game cinematics. It intentionally excluded gameplay mechanics, narrative structures, and sound design from the main focus, though these elements may have indirectly influenced the overall player experience. The study prioritized the visual dimension of cinematic presentation to explore how the efficiency and effectiveness of environmental visual effects contributed to visual realism, emotional immersion, and perceived system performance in video game cinematics.

The research operated within practical constraints. A modest participant sample contributed feedback that reflected individual perceptions and preferences. The researcher collected qualitative self-reported responses through structured surveys and monitored performance metrics using Unreal Engine's Stat Unit Graph tool. Because the analysis drew from subjective experience and specific hardware and software conditions, the resulting insights depended on context and may not apply universally across different video game genres, platforms, or development pipelines. Thus, while the findings offered meaningful perspectives on the role of environmental VFX, they served best as exploratory rather than broadly generalizable.

II. REVIEW OF RELATED LITERATURE

Environmental visual effects (VFX) in video games digitally simulated natural phenomena such as fog, rain, fire, lighting, dust, and atmospheric changes within virtual environments. These effects served not merely as aesthetic elements but played a critical role in establishing tone, mood, and immersion, while also supporting environmental storytelling. In cinematic sequences where narrative and visuals converged, environmental VFX evolved significantly. They transitioned from static background details into dynamic, narrative-relevant tools that guided player perception and emotional response. Developers increasingly employed environmental VFX to cue danger, foreshadow events, and enrich worldbuilding. Despite this growing sophistication, researchers had rarely evaluated environmental VFX in academic contexts. Prior studies often examined general gameplay mechanics or narrative design and overlooked how VFX specifically shaped perception, emotion, and immersion. Few investigations assessed how efficiently these effects operated in real-time systems, despite their known impact on hardware load and rendering processes. This lack of focused research underscored the need to examine both the perceptual effectiveness and technical efficiency of environmental VFX in game cinematics—a pursuit supported by the expanding intersection of game design, visual cognition, and performance metrics.

- Efficiency and Effectiveness in Environmental Vfx

As environmental visual effects (VFX) became increasingly integral to the cinematic language of video games, their role evolved from mere aesthetic embellishment to functional storytelling tools. Developers employed dynamic weather, realistic lighting, and atmospheric particles not only to construct immersive worlds but also to guide player attention, convey emotion, and support narrative flow. These effects served a dual purpose: to captivate players visually while also reinforcing narrative clarity and usability. Their integration in cutscenes and real-time sequences shaped players' emotional engagement and interpretation of in-game events.

Within this context, environmental VFX needed to operate both efficiently and effectively. Efficiency was defined as the ability to deliver high-quality visuals while minimizing computational demands—producing strong visual impact without straining system resources or hindering performance (Filmustage, 2023; Fang, Wang, & Wang, 2025). Effectiveness, on the other hand, measured the extent to which these effects enhanced immersion, emotional resonance, and narrative comprehension (Innovecs Games, 2023; MAD VFX, 2024). Maintaining this balance posed an ongoing challenge in modern game design, particularly as hardware constraints coexisted with rising expectations for visual fidelity and real-time responsiveness (iXie Gaming, 2023).

Fang, Wang, and Wang (2025) introduced Aokana, a GPU-accelerated voxel rendering framework that demonstrated how environmental VFX could be rendered in real-time with reduced draw calls and optimized memory usage. Their work underscored how performance-conscious VFX pipelines through methods like dynamic culling and geometry reuse enabled the creation of high-density visuals without overwhelming system resources. Similarly, Filmustage (2023) highlighted how procedural systems and simulation-based tools allowed artists to generate realistic fog, rain, and debris while avoiding static, resource-heavy assets. These strategies reflected the importance of efficiency through modular design, LOD (Level of Detail) usage, and shader optimization.

Fang, Wang, and Wang (2025) and Filmustage (2023) emphasized the technical strategies behind efficient environmental VFX rendering, particularly in real-time applications. They demonstrated how optimized VFX pipelines through voxel frameworks, dynamic culling, procedural generation, and LOD management supported the development of visually rich environments without compromising performance. Their findings reinforced the importance of efficiency in environmental VFX design, especially in maintaining frame rate and responsiveness during cinematic sequences. However, these studies focused more on technical implementation than on audience perception. While they advanced rendering workflows, they did not examine how these optimized effects influenced player immersion, emotional response, or narrative comprehension—key aspects at the center of this study's exploration into the effectiveness of environmental VFX in cutscenes and storytelling.

Effectiveness, on the other hand, relied on VFX conveying mood, reinforcing narrative themes, and supporting emotional interpretation. Innovecs Games (2023) emphasized that "effective VFX go beyond eye candy—they evoke emotion, guide player focus, and influence decision-making." Slater, Usoh, and Steed (1995) supported this by showing that even minimal environmental cues (e.g., animated fog or sound-reactive lighting) significantly heightened the sense of presence. MAD VFX (2024) further argued that atmospheric effects like snow or ash did more than decorate scenes—they enhanced thematic weight and influenced how players processed unfolding events.

These statements underscored the narrative and emotional potential of environmental VFX, showing how subtle atmospheric cues could significantly shape player perception and engagement. They reinforced the idea that VFX not only decorated but also actively guided emotional interpretation, focus attention, and strengthen thematic delivery—key concerns in cinematic storytelling. These insights directly supported the study's goal of examining how environmental VFX contributed to player immersion and narrative clarity in game cinematics. However, the cited studies mainly addressed general presence and mood in immersive environments or gameplay contexts rather than isolating cinematic sequences. They did not empirically measure the emotional or interpretive impact of environmental VFX specifically within pre-rendered or in-engine cutscenes. As such, while the findings aligned conceptually with the study's aims, they failed to provide targeted data on cinematic visual storytelling.

The implications of functional VFX design emerged in two recent studies. Zhou and Forbes (2022) examined how in-game VFX functioned similarly to visual aids in analytics—clarifying systems, signaling interactivity, and supporting intuitive decision-making. They introduced the concept of "data feel," emphasizing how polished, responsive VFX improved player awareness during gameplay. Although they focused on functional visual effects integrated into gameplay rather than cinematic sequences, their findings highlighted how effective VFX enhanced cognitive processing, enabling players to quickly and accurately interpret visual cues. This focus aligned with the goals of cinematic VFX in supporting pacing, narrative clarity, and emotional engagement.

Zhou and Forbes (2022) argued that well-designed, functional VFX played a critical role in supporting cognitive processing by improving player awareness and decision-making. They reinforced the idea that VFX were not purely aesthetic but served a communicative function—an insight directly relevant to cinematic environmental VFX, which aimed to guide viewer focus, enhance pacing, and strengthen emotional tone. The concept of "data feel" aligned with the notion that polished VFX fostered intuitive understanding of on-screen events. However, their focus on gameplay-integrated VFX rather than environmental effects in cinematic sequences limited the study's applicability. As such, their findings might underrepresent the expressive, atmospheric, and narrative-driven goals specific to cinematic VFX, which remained central to the current study.

Another study, "Situated Visualization in Motion for Video Games" by Bucchieri, Yao, and Isenberg (2024), offered valuable insights into how motion and placement influenced the readability of UI-based visualizations during gameplay. The authors found that player movement, camera shifts, and surrounding visual clutter often disrupted the clarity of on-screen information, making context-aware design essential. While the research focused primarily on gameplay elements such as health bars and minimaps, it revealed underlying visual principles applicable to environmental VFX in cinematic sequences.

Its implications extended to the design of atmospheric and environmental effects, particularly in cutscenes where visual clarity and emotional tone were tightly integrated. Like UI elements, environmental VFX needed to retain legibility and emotional expressiveness, even amid motion, lighting transitions, or scene shifts. The study highlighted that without careful placement and visual integration, VFX risked becoming distracting or losing their narrative impact. This supported the view that effectiveness in environmental VFX relied not only on aesthetic fidelity but also on how well the effects functioned within the visual flow of the cinematic moment.

In terms of relevance, the findings aligned with this study's focus on how environmental VFX shaped viewer engagement and storytelling clarity. The emphasis on clarity under movement underscored the importance of designing VFX that guided attention without overwhelming the scene, reinforcing the argument that cinematic VFX needed to be both emotionally evocative and technically readable. The study offered a functional lens through which to view VFX effectiveness, particularly in terms of cognitive processing and attention management.

However, the study showed limitations when applied to cinematic VFX analysis. The authors concentrated on heads-up display (HUD) elements during active gameplay, rather than on environmental or atmospheric effects crafted for narrative sequences. They emphasized functional readability over emotional or immersive design, leaving expressive and cinematic aspects underexplored. As such, while their findings transferred in terms of design principles, they did not fully address the aesthetic and emotive goals central to environmental VFX in video game cinematics.

Together, these studies extended the discussion of efficiency and effectiveness in environmental VFX by bridging technical performance with cognitive and emotional perception. The authors demonstrated that well-optimized, context-sensitive VFX design not only improved system performance but also enhanced player interpretation, narrative understanding, and emotional response—critical elements for successful cinematic storytelling in games.

- Theoretical Frameworks Supporting Vfx Analysis

To better understand the role and impact of environmental visual effects in video game cinematics, scholars and designers drew upon a range of theoretical frameworks that illuminated how users perceived, processed, and responded to audiovisual elements. These frameworks offered structured lenses through which the efficiency and effectiveness of environmental VFX could be assessed not only in terms of visual fidelity, but also with regard to cognitive engagement, narrative enhancement, and emotional immersion.

Visual effects in cinematic sequences were not simply technical embellishments; they functioned as narrative devices, emotional triggers, and interaction cues. Theories such as Flow Theory, Media Richness Theory, and the Technology Acceptance Model (TAM) provided critical insight into how players experienced these effects as part of a larger storytelling and engagement process. These models helped explain why certain visual environments felt more immersive, how cinematic cues conveyed complex meaning, and under what conditions players were more likely to accept or reject these technologies as intuitive parts of the gameplay experience.

A. Flow Theory

Flow Theory, developed by Mihaly Csikszentmihalyi (1990), described a psychological state in which individuals became fully absorbed in an activity, losing track of time and external distractions. This state, referred to as "flow," was characterized by deep concentration, a sense of control, and intrinsic enjoyment. In the context of video game cinematics, environmental visual effects (VFX) such as dynamic weather, lighting transitions, and particle effects played a crucial role in maintaining this immersive state by supporting narrative continuity and emotional tone. Flow was most likely to occur when there was a balance between a viewer's cognitive capabilities and the complexity of the cinematic sequence—where the challenge was engaging but not overwhelming.

Csikszentmihalyi (1990) emphasized that "the best moments in our lives are not the passive, receptive, relaxing times... The best moments usually occur when a person's body or mind is stretched to its limits in a voluntary effort to accomplish something difficult and worthwhile" (p. 3). When environmental VFX were well-integrated into game cinematics, they heightened realism and narrative stakes, sustaining the viewer's attention and reinforcing emotional engagement. As such, flow theory supported both the effectiveness and efficiency of VFX, suggesting that well-calibrated visuals could enhance player immersion without cognitive overload. This made flow a valuable theoretical lens in evaluating how and when environmental VFX succeeded in game storytelling.

The theory was particularly relevant in assessing how viewers experienced engagement across different VFX treatments whether certain environmental sequences enhanced or disrupted the balance required for flow. However, a limitation of Flow Theory in this context was its subjective and individualized nature. Flow experiences varied across players depending on prior gaming experience, narrative preferences, or attentional capacity. Therefore, while the theory offered a strong foundation for understanding immersive potential, it did not fully account for variability in player perception or the technical constraints affecting VFX delivery.

B. Media Richness Theory

Media Richness Theory, introduced by Daft and Lengel (1986), proposed that different communication media varied in their ability to effectively convey information, depending on the complexity of the message and the context. Richer media were described as those that provided immediate feedback, multiple cues such as visual and auditory signals, personalization, and the use of natural language. According to the authors, "rich media are more capable of facilitating shared meaning in equivocal communication" (Daft & Lengel, 1986, p. 560). In the context of video game cinematics, environmental visual effects functioned as rich media elements, enhancing the storytelling by adding visual cues that conveyed tone, atmosphere, or emotional shifts—often without the need for words.

The application of Media Richness Theory to environmental visual effects suggested that these effects enhanced narrative communication by increasing the sensory and emotional density of a scene. By offering multiple nonverbal cues such as changes in lighting, atmospheric shifts, and particle-based effects, VFX enabled players to interpret tone, character emotion, or narrative developments even in the absence of explicit dialogue or narration. This supported the view that environmental VFX contributed not only to visual immersion but also to storytelling effectiveness, particularly in cinematic sequences that relied heavily on visual language.

The theory, introduced by Daft and Lengel (1986), proposed that richer media—those offering more cues, feedback, and personal context—were more effective at conveying complex or ambiguous messages. In the context of video game cinematics, environmental VFX functioned as such rich media, as they layered visual information that guided emotional interpretation and narrative comprehension. Effects such as fog, rain, or volumetric lighting often served as context-enhancing elements that clarified character motivations or mood shifts without the need for verbal explanation. This aligned with the focus of the study on how VFX improved effectiveness through emotional engagement and visual clarity.

This framework proved especially relevant to the investigation of how players processed and interpreted cinematic environments. The theory supported the idea that environmental VFX reduced ambiguity and enriched player understanding, especially in emotionally charged or visually complex scenes. As narrative demands grew and cinematics became more expressive, the use of such rich visual effects became critical in ensuring that players could follow and feel the emotional arc of the story without confusion. Their integration into cutscenes and transitions demonstrated how technical and artistic elements worked together to create meaning and immersion.

However, the use of Media Richness Theory also presented limitations. Originally developed within the domain of organizational communication, the theory was not designed to account for interactive, audiovisual media such as video games. It did not consider the hardware limitations, real-time rendering constraints, or interactive dynamics that affected the deployment and perception of VFX. Additionally, the theory prioritized the clarity of information exchange over the stylistic and atmospheric functions of VFX. As a result, it potentially underrepresented the artistic intentions behind environmental effects, such as evoking mood or symbolic meaning. Despite these constraints, the theory offered a useful lens for analyzing how VFX contributed to communication and emotional resonance in video game cinematics.

C. Technology Acceptance Model (Tam)

Davis (1989) developed the Technology Acceptance Model (TAM) to explain how users accept and use a particular technology. In the context of environmental visual effects in video game cinematics, researchers applied TAM as a useful lens to understand how players evaluated and responded to cinematic enhancements. The model states that two factors largely determine users' acceptance: perceived usefulness—the degree to which a person believes that using the system will enhance their experience—and perceived ease of use—the extent to which the user believes that engaging with the system will be free of effort. Davis (1989) emphasized that "perceived usefulness [is] the strongest determinant of intention" and that "system characteristics influence acceptance primarily through their effect on perceived usefulness and perceived ease of use."

When applied to cinematic VFX in games, TAM suggested that players were more likely to embrace advanced environmental effects (such as realistic lighting, weather changes, or particle simulations) if they found these elements improved narrative understanding or emotional immersion. Furthermore, if these effects were smoothly integrated—without distracting from gameplay or overwhelming cognitive load—players perceived them as both useful and easy to process. As Venkatesh and Davis (2000) expanded, "when users perceive a system as useful and easy to use, their intention to use it increases significantly." This theoretical framework, therefore, helped explain why well-executed environmental VFX in game cinematics were both effective in enhancing immersion and efficient in being accepted by players without resistance.

The Technology Acceptance Model proved relevant to the study by offering a structured lens through which to understand how players evaluated and responded to environmental VFX in cinematic sequences. Its emphasis on perceived usefulness and ease of use aligned with the study's investigation into effectiveness (how VFX enhanced immersion and narrative comprehension) and efficiency (how intuitively and seamlessly the VFX were processed by players). The model's core proposition—that users were more likely to embrace a system when it was both beneficial and cognitively effortless—helped clarify why participants responded positively to VFX that improved emotional resonance without causing distraction or confusion. This reinforced the idea that player acceptance of cinematic effects depended not only on aesthetic quality but also on functional clarity and integration. However, TAM's primary limitation in the context of this study was its original design for productivity systems rather than expressive or artistic media. While useful in explaining cognitive and behavioral acceptance, the model lacked sensitivity to the emotional, atmospheric, and aesthetic nuances specific to cinematic VFX. It also did not fully account for subjective interpretations or the impact of artistic direction, which were critical in evaluating visual storytelling. Nonetheless, TAM contributed to the study by linking technical design to player reception, particularly in framing how VFX were judged not just for beauty, but for narrative clarity and experiential coherence.

D. Visual Cognition And Emotional Salience

Understanding how players processed visual and emotional information played a crucial role in analyzing the effectiveness of environmental VFX in video game cinematics. Visual cognition describes the brain's ability to interpret and respond to complex visual stimuli, while emotional salience involves how certain elements capture attention through their emotional significance. Together, these processes shape how players perceive and emotionally engage with visual effects. Green and Bavelier (2007) found that repeated exposure to visually rich environments, such as those in action video games, increases spatial resolution and sensitivity to detail. This finding suggests that players familiar with high-fidelity VFX experience deeper perceptual engagement when viewing cinematic sequences. Similarly, in their 2006 research, they showed that video games train the visual system to distribute attention more efficiently across the visual field. These results support the idea that environmental VFX, when aligned with known patterns of visual attention, more effectively guide perception and reinforce narrative clarity.

In the study "Action-Video-Game Experience Alters the Spatial Resolution of Vision", C.S. Green and D. Bavelier (2007) demonstrated that action video game experience improved spatial resolution, enabling players to distinguish visual elements in crowded scenes more effectively. Two experiments demonstrated that this effect reflected enhanced visual processing, not just strategy or practice. The improvements extended across the visual field and suggested applications in visual rehabilitation.

Researchers found that action video game experience enhanced spatial resolution, enabling players to distinguish visual elements more effectively in visually dense environments. The two experiments showed that this improvement stemmed from enhanced visual processing rather than merely strategy or repeated practice. These gains extended across the visual field and suggested potential applications in visual rehabilitation. The findings related to the present study by supporting the idea that players with greater video game experience perceived environmental visual effects more clearly, particularly in visually complex cinematic scenes. This reinforced the importance of designing environmental VFX that were not only visually rich but also legible and well-structured to accommodate varying levels of visual processing ability among players.

Moreover, the study emphasized that visual clarity significantly influenced how environmental VFX contributed to emotional engagement and narrative comprehension. In this sense, improvements in spatial resolution indirectly enhanced the effectiveness of VFX in shaping the player's cinematic experience. However, the study limited its scope to low-level visual perception rather than emotional or aesthetic responses. It neither examined cinematics or environmental VFX directly nor considered narrative impact or the design of visual storytelling elements. Its emphasis on player training and skill development limited its applicability to passive viewing experiences, such as watching cinematic cutscenes, where visual processing functioned differently from interactive gameplay.

In their 2006 publication, "Effect of Action Video Games on the Spatial Distribution of Visuospatial Attention", C.S. Green and D. Bavelier investigated how action video game play influenced visuospatial attention across the central and peripheral visual field. They found that action video game players (VGPs) demonstrated broader and more accurate attention, and they showed that training non-gamers produced similar improvements, confirming the effects were trainable.

The findings supported the idea that player experience influenced how they perceived environmental VFX, especially those placed in peripheral areas like lighting, weather, or background motion. They reinforced attention as a valid lens for evaluating the efficiency of visual effects and emphasized that perception varied not only by design but also by cognitive skill.

The study focused on cognitive performance rather than cinematics or environmental aesthetics, and it did not directly address environmental VFX. It examined how action video game play influenced visuospatial attention across the central and peripheral visual fields. It found that action VGPs demonstrated broader and more accurate attentional distribution, and that exposure trained similar improvements in non-gamers. These findings supported the idea that environmental VFX—particularly those situated in the periphery, such as ambient lighting, weather effects, or background movement—were perceived differently depending on a player's prior gaming experience. This reinforced the value of attention as a lens for evaluating the efficiency of VFX, as it showed that perceptual response to environmental details was influenced not only by design but also by a player's cognitive readiness to detect and interpret such stimuli.

The study related to the current research by providing a cognitive framework for understanding how experienced and inexperienced players processed VFX differently. However, it focused on cognitive performance in interactive gameplay contexts rather than on cinematic sequences or environmental aesthetics. It did not directly explore environmental VFX, so its findings, while supportive, applied only indirectly to the specific focus on cinematic visual storytelling and emotional engagement.

These theoretical frameworks collectively supported the view that environmental VFX fulfilled both functional and narrative purposes in video game cinematics. They highlighted how immersion, emotional response, and cognitive processing intertwined with the design and placement of visual effects. By grounding the analysis in flow theory, media richness, and visual cognition research, the study established a basis for evaluating the efficiency of VFX in terms of perceptual clarity and their effectiveness in enhancing emotional engagement and narrative understanding. With these foundations, the discussion turned to how environmental VFX directly influenced player experience.

- Impact of Environmental VFX on Player Experience

Environmental VFX significantly influenced player immersion by simulating lifelike and responsive virtual environments. Elements such as dynamic weather, fog, lighting, and terrain interactions contributed to a heightened sense of realism, making game spaces feel alive, reactive, and believable (de Dinechin et al., 2021). This realism played a crucial role in reinforcing the player's sense of presence within the game world, which in turn elevated the overall gaming experience.

Beyond immersion, environmental VFX shaped the emotional tone and atmosphere of gameplay. Jennett et al. (2008) showed that specific environmental cues like stormy skies or calm sunlight triggered corresponding emotional responses. Dark, foggy environments often increased tension and vulnerability, especially in horror or suspense genres, while bright, open scenes conveyed safety and tranquility. These emotional cues enabled players to connect more deeply with the narrative and mood of a scene, even in the absence of explicit storytelling. Similarly, the eye-tracking study by Bucchieri et al. (2024) demonstrated how specific visual elements in game trailers guided viewer attention and triggered emotional responses, reinforcing the narrative tone. This supported the idea that environmental VFX in cinematics could serve as subtle yet powerful storytelling devices.

Environmental VFX also served as non-verbal narrative tools. Strategically placed effects directed attention, built tension, and emphasized narrative transitions. The "Designing Game Feel" survey emphasized the role of amplification—visual and auditory cues that communicated gameplay significance. This aligned with the role of VFX in environmental storytelling, where visual polish enabled players to intuitively interpret unfolding events. These findings underscored the relevance of VFX not only as aesthetic enhancements but also as tools that shaped perception, guided attention, and enriched emotional engagement.

However, the impact of environmental VFX depended on thoughtful implementation. Overly dense or unbalanced effects confused or overwhelmed players, disrupting gameplay rather than enhancing it (MadVFX, n.d.). The eye-tracking study also found that excessive motion or visual noise fragmented viewer attention, reducing clarity and emotional impact. This finding implied that designers needed to carefully calibrate VFX to support focus and coherence, particularly during high-intensity scenes or rapid transitions.

From a technical standpoint, high-fidelity environmental rendering required significant system resources, presenting challenges for performance optimization across diverse hardware (Chebanyuk & Mushynskyi, 2021). In immersive environments such as VR, misaligned or exaggerated effects sometimes reduced comfort or immersion (de Dinechin et al., 2021). These limitations were important for this study to consider, as participants' emotional and visual responses to environmental VFX might have been influenced by factors such as hardware constraints, prior gaming experience, or screen size.

In relation to this study, these findings reinforced the significance of environmental VFX as emotional and perceptual stimuli. Their design influenced visual attention, emotional resonance, and narrative interpretation—key aspects measured through survey responses. While this research did not employ eye-tracking or analyze game feel mechanics directly, it drew upon these insights to evaluate how VFX influenced player perception within cinematic experiences.

- Challenges and Future Directions in Environmental Rendering

One of the central challenges in environmental VFX rendering arose from the need to maintain visual continuity between gameplay environments and cinematic cutscenes. Unlike film, where visuals remained fixed and passive, video games demanded interactivity, requiring cinematic sequences to blend seamlessly with gameplay both aesthetically and functionally. Atmospheric elements such as lighting, fog, terrain, and weather had to remain coherent across both real-time and pre-scripted contexts. As MadVFX (n.d.) noted, visuals in cutscenes needed to match the game's broader visual identity—a task that required precise coordination across rendering pipelines.

This issue had direct relevance to the present study, which examined the perceived realism and emotional impact of environmental VFX in game cinematics. The coherence (or lack thereof) between cinematic and gameplay visuals could affect how players experienced immersion and narrative flow. Disparities in environmental rendering between scenes risked drawing attention to technical inconsistencies, thus weakening emotional engagement and the illusion of continuity.

Another significant challenge involved the separation of VFX assets across different parts of the game's development process. Developers often created separate versions of environmental effects optimized for gameplay versus cutscenes. Effects like dynamic lighting or weather systems, while visually compelling, had to function under real-time constraints in gameplay and still deliver cinematic quality during narrative sequences. This separation complicated asset pipelines and increased production overhead. These concerns were aligned with insights from "Designing Game Feel: A Survey" (M. Pichlmair and M. Johansen, 2020), which emphasized the importance of "amplification" and polish in-game visuals to sustain responsiveness, emotion, and narrative clarity.

The shift from pre-rendered to real-time rendering further intensified this challenge. While pre-rendered cutscenes allowed for high-fidelity effects, modern engines increasingly supported real-time cinematics to preserve immersion. This trend pushed developers to optimize volumetric fog, particle systems, and lighting in real time—a process that often introduced performance trade-offs, especially on lower-end hardware (Chebanyuk & Mushynskyi, 2021). From the perspective of this study, such constraints could influence how effectively environmental VFX delivered the intended emotional and perceptual impact, especially in visually demanding scenes.

Looking forward, developers projected a shift toward fully real-time cinematic pipelines, aiming to unify environmental rendering between gameplay and storytelling without visual or performance compromises. Emerging tools and engines enabled simulations like dynamic time-of-day cycles, realistic weather, and global illumination to run in real time. These innovations promised richer, more interactive environments that could heighten both immersion and narrative coherence—a trend directly supporting this study's interest in how visual effects shaped emotional response and perceived realism.

Participants also saw procedural generation and AI-based optimization as key solutions. These methods provided scalable, automated ways to maintain high visual standards across diverse scenes without increasing production strain (Chebanyuk & Mushynskyi, 2021). In this study, such tools hinted at new possibilities for crafting emotionally resonant and technically efficient environmental effects, particularly in indie development settings where resources were limited.

However, the reviewed literature showed clear limitations. Much of the existing discussion centered primarily on technical and pipeline challenges from a developer's standpoint, such as rendering fidelity, asset management, and engine limitations, rather than exploring how these factors influenced player perception or emotional engagement. While researchers thoroughly documented the importance of visual continuity, frame rate stability, and performance optimization, they often stopped short of connecting such challenges to experiential outcomes. In particular, they rarely conducted empirical research examining how inconsistencies or achievements in environmental VFX impacted players' immersion, narrative comprehension, or emotional resonance during cinematic sequences. This gap highlighted the need for more player-centered investigations. Thus, the present study contributed to this underexplored area by examining user reactions and subjective interpretations of environmental VFX within cutscenes, offering insights into the experiential dimension often overlooked in technically driven discussions.

The next section detailed the procedures, instruments, and strategies used to conduct this investigation.

III. METHODOLOGY

This study employed a descriptive exploratory research design using a mixed-methods approach to investigate the impact of environmental visual effects on the player experience in video game environments. By combining both quantitative and qualitative methods, the research aimed to assess three key areas: visual realism, emotional engagement, and system performance during interactive and cinematic gameplay sequences. Unlike purely observational experiences, participants were asked to actively navigate through VFX-rich game environments to simulate authentic player interaction. This design allowed for the collection of numerical performance data and subjective user feedback, providing a holistic understanding of how environmental VFX influenced realism, immersion, and technical performance across varying hardware conditions.

Research Design

This study employed a descriptive exploratory design utilizing a mixed-methods approach to investigate the role of environmental VFX in video games. The research combined quantitative data on system performance such as frame rate, memory usage, and rendering behavior with qualitative insights from participants regarding perceived realism, emotional engagement, and immersion. The goal was to provide a holistic understanding of how environmental VFX contributed to cinematic game experiences from both technical and experiential perspectives. Given the limited sample size of eight participants, the study did not aim for broad generalizability. Instead, it prioritized detailed, individual-level analysis, focusing on identifying observable patterns and user experiences that could inform future, larger-scale research. This design allowed for rich descriptive insights, especially useful for exploratory investigations into performance variability and perceptual impact across diverse computing environments.

A purposive sample of eight participants was selected for the study, each with prior experience in viewing or interacting with video game cinematics. To ensure varied system responses, participants used their own personal computers, which ranged from low to high-end hardware specifications. This variation in system capabilities allowed the research to observe how environmental visual effects performed across different technical setups and how these differences influenced user perception and experience.

Three structured survey instruments were developed to collect data using a 5-point Likert scale. Each instrument targeted a specific dimension of the cinematic experience. The Visual Realism Survey focused on participants' perceptions of lighting accuracy, shot composition, and the authenticity of environmental details. The Emotional Reaction Survey aimed to measure the degree of immersion, emotional engagement, and the perceived narrative impact of the environmental visual effects. Finally, the System Performance Feedback form assessed technical aspects such as frame rate stability, visual clarity, and playback smoothness during the cinematic sequence. Together, these tools provided a balanced view of both experiential and performance-related responses to environmental VFX.

As part of the research procedure, participants were asked to interact with the game environment by navigating through scenes featuring environmental visual effects, simulating the experience of walking through the game as a character. Following this interaction, they completed a three-part survey designed to assess visual realism, emotional impact, and system performance. Data were collected using digital forms, which included both numerical ratings and optional comment sections to capture more detailed user insights. All responses were gathered in an environment designed to minimize distractions, allowing participants to concentrate fully on evaluating the environmental VFX elements of the experience.

To gain a comprehensive understanding of participants' experiences with environmental visual effects, the study analyzed both quantitative and qualitative data. Unlike traditional cinematic viewing alone, participants actively navigated through the game environment, experiencing the VFX as if controlling in-game characters. Quantitative responses from the three-part survey—focused on visual realism, emotional reaction, and system performance—were analyzed using descriptive statistics such as mean, mode, and range to identify trends. Due to the small sample size, no inferential statistical tests were applied. Optional comment sections allowed for the collection of qualitative feedback, which was analyzed through basic content analysis to identify recurring themes related to realism, emotional engagement, and technical playback. To integrate findings, individual participant profiles were developed, comparing system performance metrics with subjective experiences. This method provided insight into how technical and emotional responses were shaped by the interactive VFX environment.

The study adhered to ethical research standards to ensure the protection and well-being of all participants. Informed consent was obtained prior to participation, with each individual fully briefed on the purpose and scope of the research. To maintain confidentiality, all responses were anonymized and stored securely. Participants were also informed of their right to withdraw from the study at any point without penalty, ensuring voluntary and informed participation throughout the research process.

Data Collection Methods

The study adopted a descriptive exploratory design within a mixed-methods framework to investigate the role of environmental VFX in video game cinematics. This approach allowed for a comprehensive examination of both technical efficiency and user experience. Data collection integrated quantitative system performance metrics such as frame rate stability, memory usage, and rendering behavior with qualitative user feedback on perceived realism, immersion, and emotional engagement. By combining these two dimensions, the study aimed to present a holistic understanding of how environmental VFX contributed to the cinematic quality and emotional resonance of game environments.

Eight participants were purposively selected for the study due to their prior familiarity with video game cinematics. Each participant used their personal computer, representing a range of hardware configurations from low- to high-end systems to capture varied performance responses and technical capabilities.

The study utilized three structured surveys based on a 5-point Likert scale to comprehensively gather data on participants' visual, emotional, and technical experiences with environmental visual effects in video game cinematics. Each instrument was carefully designed to align with specific dimensions of the research.

The Visual Realism Survey focused on participants' perceptions of the authenticity and believability of visual elements, particularly lighting behavior, camera composition, and the realism of environmental features such as terrain, vegetation, and atmospheric effects. This survey aimed to assess whether the VFX convincingly mirrored real-world visual cues and cinematic techniques.

The Emotional Reaction Survey explored the psychological and affective responses elicited by the environmental visuals. Participants were asked to rate how strongly they felt emotions such as awe, tension, or calmness, and whether these effects enhanced immersion and narrative connection. This helped determine the extent to which environmental VFX influenced mood and engagement beyond visual fidelity.

The System Performance Feedback Form captured participants' technical experiences during cinematic playback. It included statements measuring perceived frame rate stability, rendering smoothness, GPU and CPU responsiveness, and the clarity of complex environmental effects. The goal was to evaluate how efficiently each participant's system handled the VFX under varying hardware conditions.

Each of these instruments also featured optional open-ended sections, allowing participants to elaborate on their responses and provide nuanced qualitative feedback. These open comments offered deeper insights into individual experiences and helped contextualize the quantitative data, contributing to a more comprehensive understanding of environmental VFX impact.

The respondents engaged with a preloaded, VFX-intensive game environment designed to simulate first-hand interaction with cinematic sequences. This interactive experience allowed them to observe and respond to various environmental visual effects—such as dynamic lighting, fog, and particle systems—in real time, mimicking in-game exploration. Following the session, each participant completed three structured surveys assessing visual realism, emotional impact, and system performance. Data were collected through digital forms that enabled both numerical scoring using a Likert scale and the inclusion of open-ended responses, offering a balance of measurable and descriptive feedback to enrich the overall analysis.

The study collected both quantitative and qualitative data to evaluate the efficiency and experiential impact of environmental VFX in video game cinematics. Quantitative data included system performance metrics such as frame rate stability, GPU and CPU usage, memory consumption, and the presence of any rendering issues such as lag, overheating, or stuttering. Additionally, structured surveys using a 5-point Likert scale were administered to capture participants' ratings on visual realism, emotional engagement, and system performance.

Complementing this, qualitative data were obtained through open-ended survey responses, in which participants shared reflections on their emotional experience, perceived immersion, and the realism of cinematic visuals. These qualitative inputs provided narrative depth to the numerical data, enabling a more comprehensive interpretation of how environmental VFX influenced user experience both technically and perceptually.

Quantitative responses from the structured surveys were analyzed using descriptive statistics, including measures such as mean, mode, and range, to identify observable trends in system performance and user perception. To interpret the qualitative data, content analysis was employed, enabling the identification of recurring themes and patterns related to participants' perceptions of realism, emotional engagement, and immersion in relation to environmental visual effects. Additionally, individual participant profiles were constructed by integrating each respondent's technical performance metrics with their emotional and perceptual feedback. This allowed for comparative analysis across varying hardware specifications, highlighting how system capability influenced both the technical and experiential dimensions of cinematic gameplay.

- Data Analysis Methods

The study employed both quantitative and qualitative data analysis methods to examine the technical and experiential impact of environmental visual effects in video game cinematics. Quantitative data including survey ratings and system performance metrics were analyzed to identify trends in rendering efficiency and visual fidelity across different hardware setups. In parallel, qualitative feedback gathered from open-ended survey responses was examined to capture participants' emotional reactions, perceptions of realism, and sense of immersion. By integrating these two types of data, the research aimed to present a comprehensive understanding of how environmental VFX influenced the cinematic game experience from both a technical and perceptual perspective.

Quantitative data in this study were gathered from two main sources: Likert-scale survey responses and system performance metrics recorded using the Stat Unit Graph feature in Unreal Engine. The surveys captured participant evaluations of environmental VFX elements—including lighting realism, emotional impact, and environmental believability—using a 5-point scale. Meanwhile, the Stat Unit Graph monitored real-time technical data during cinematic playback, including frame rate (FPS), GPU and CPU usage, memory load, and rendering behavior such as stuttering or lag.

Survey results were analyzed using descriptive statistics, including the mean, mode, and range for each item. These measures helped identify trends in user perception across all participants. For system performance analysis, Stat Unit Graph readings were reviewed frame by frame to determine consistency in frame rendering, spikes in processing load, and signs of overheating or delay. This data provided insight into how environmental VFX influenced the technical performance of cinematic playback within the game engine. Results were visualized through bar graphs to represent survey averages and annotated screenshots to illustrate real-time performance fluctuations tracked via Unreal Engine.

The qualitative data were derived from open-ended responses provided by participants at the end of each survey section. These responses captured personal reflections on key dimensions such as the perceived realism of the visuals, the degree of immersion experienced, and the emotional impact of environmental visual effects in the game cinematics.

The qualitative data were examined using thematic analysis to uncover patterns and recurring sentiments across participants. Individual responses were coded and then organized into broader thematic categories such as atmosphere, mood, realism perception, and technical frustration. These themes highlighted the

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subjective dimensions of the user experience and provided rich, descriptive context that supported and deepened the interpretation of the quantitative findings. This integration allowed the study to present a more holistic understanding of how environmental VFX influenced both system performance and emotional engagement.

To achieve a comprehensive understanding of the impact of environmental visual effects, the study employed cross-phase triangulation by comparing quantitative system performance data with qualitative user perceptions. This integration allowed for the examination of how technical metrics such as frame rate stability, rendering smoothness, and memory usage aligned with participants' emotional and perceptual responses, including feelings of immersion, realism, and narrative engagement. Individual participant profiles were developed to map hardware performance indicators against self-reported experiences, offering a layered perspective on the interplay between technical efficiency and subjective satisfaction. By synthesizing findings from both data types, the study provided a holistic interpretation of how environmental VFX functioned not only as graphical components but also as immersive storytelling tools within video game cinematics.

IV. ETHICAL CONSIDERATION

All participants received a comprehensive explanation of the study's purpose, procedures, and scope prior to their involvement. This orientation covered what data would be gathered and how it would be used. Each participant gave informed consent, acknowledging that participation was voluntary and that they could withdraw at any time without repercussions. This ensured respect for their autonomy and comfort throughout the research process.

To protect privacy and maintain confidentiality, participant identities were anonymized. No personal identifiers appeared in any survey or performance logs; instead, each individual was assigned a unique code (e.g., R1, R2) for reference in data analysis. All collected data were securely stored in password-protected digital folders, accessible only to the primary researcher. Data security was further reinforced by encrypting all files—survey responses and system metrics alike—to prevent unauthorized access. Only the researcher handled the raw data, thereby upholding standards for confidentiality and responsible data management.

While the study involved minimal risk, participants were asked to run a standalone executable file that showcased preloaded environmental VFX. To address safety concerns, the file was scanned for malware and shared via a secure, reputable platform. Participants were informed of the nature and safety of the file, provided clear installation instructions, and given the freedom to decline participation without consequence. The entire research process complied with institutional ethical standards for studies involving human subjects. No coercion or undue influence was used to secure participation, and all instruments (i.e. surveys, screen captures, and software) were deployed in accordance with data protection laws and academic research ethics. Anonymity, voluntary participation, and secure data handling were prioritized at every stage of the study.

V. RESULTS AND DISCUSSION

This study employed both quantitative and qualitative data collection methods to provide a comprehensive understanding of participants' experiences with environmental VFX in a simulated gameplay environment. Quantitative data were gathered through structured Likert-scale surveys, which captured participant ratings on visual realism, emotional response, and perceived system performance. In addition, technical performance data were collected using Unreal Engine's Stat Unit Graph, which recorded key system metrics such as frame rate, draw time, game thread time, and GPU performance during the VFX sequence. Complementing these numerical findings, qualitative data were obtained through open-ended survey responses, allowing participants to describe their impressions of immersion, realism, and emotional impact in greater depth. This combination of data sources enabled a layered analysis of how visual fidelity and system performance influence user experience.

Data Type	Instrument / Tool	Purpose
Quantitative	Likert-scale surveys	Measure visual realism and emotional response
Quantitative	Likert-scale surveys Unreal Engine Stat Unit Graph	Measure system performance Collect real-time system metrics: frame rate, game thread, draw time, GPU performance
Qualitative	Open-ended responses in surveys	Capture participant reflections on immersion, realism, and emotional impact

Table 4.1: Summary of Data Sources and Instruments Used

To analyze the survey data, responses were encoded numerically (e.g. 1 = Strongly Disagree to 5 = Strongly Agree). Descriptive statistics were calculated manually. The mean was computed by summing individual item responses and dividing by the total number of responses. The mode was identified as the most frequently occurring value. The range was derived by subtracting the lowest score from the highest. To support clarity in interpretation, results were presented using constructed graphs and summary tables inserted in the Results and Discussion section. For instance, a summary of all data sources and tools used were presented in Table 4.1. These visual representations helped link the numerical patterns with qualitative insights, strengthening the integration of findings in a mixed-methods framework.

- Quantitative Findings

All eight respondents viewed Video 1 and Video 2, rating them based on two primary dimensions: Visual Realism and Emotional Response. Their feedback was gathered through a structured survey designed to capture their perceptual and emotional reactions to the visual and atmospheric elements presented in each video. Each dimension targeted a specific aspect of the viewer's experience. Visual Realism focused on how accurately lighting, composition, and environmental details were perceived. Emotional Response evaluated the viewer's sense of immersion and connection to the narrative. These dimensions provided a balanced framework for capturing both subjective engagement and technical performance, allowing for meaningful comparisons between the two videos. Unreal Engine's Stat Unit Graph was also utilized to collect technical performance data. Frame rate, draw time, thread time, and GPU performance data were recorded for analysis to gauge if visual accuracy and system performance would influence user experience. Simulation results together with Stat Unit Graph data were analyzed to demonstrate the impact of system performance on user experience.

A. Presentation of Survey Dimensions

The results from Video 1 revealed generally favorable perceptions of the visual realism and emotional impact.

Survey Dimension	Survey Item	Mean	Mode	Range
Visual Realism	Lighting Realism	3.53	4	3
	Environmental Realism	3.71	4	3
	Cinematic Composition Realism	4.04	4	3
Emotional Response	Sense of Immersion	3.98	4	3
	Connection to Narrative	4.00	4	3

Table 4.2a: Survey Results on Video 1 (Mean, Mode, Range)

Note: Scores are based on a 5-point Likert scale (1 = Strongly Disagree, 5 = Strongly Agree).

In terms of Visual Realism, the highest mean score was observed in Cinematic Composition Realism (M = 4.04), suggesting that participants appreciated the framing and shot design of the video. Environmental Realism and Lighting Realism followed closely with means of 3.71 and 3.53, respectively. Under Emotional Response, both Sense of Immersion and Connection to Narrative received strong ratings (M =

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3.98 and M = 4.00), indicating a positive emotional engagement among viewers.

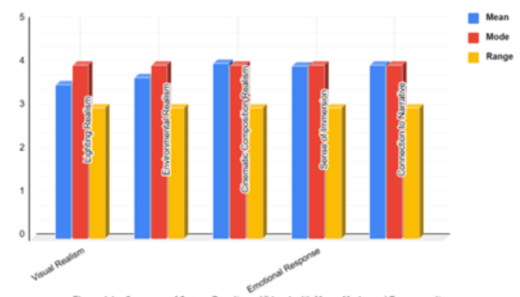


Figure 4.1a: Summary of Survey Results on Video 1 with Mean, Mode, and Range per Item

Table 4.2b presented the descriptive statistics for Video 2, summarizing participant responses across the two key dimensions: Visual Realism and Emotional Response.

Survey Dimension	Survey Item	Mean	Mode	Range
Visual Realism	Lighting Realism	3.47	4	4
	Environmental Realism	3.54	4	3
	Cinematic Composition Realism	3.5	4	3
Emotional Response	Sense of Immersion	3.6	4	4
	Connection to Narrative	3.53	4	4

Table 4.2b: Survey Results on Video 2 (Mean, Mode, Range)

Note: Scores are based on a 5-point Likert scale (1 = Strongly Disagree, 5 = Strongly Agree).

The Visual Realism items showed moderate averages, with Environmental Realism receiving the highest mean (3.54) and Lighting Realism the lowest (3.47). All items shared a consistent mode of 4 and ranges between 3 and 4, indicating a fair degree of agreement but some variability in perception. Emotional Response yielded slightly stronger scores, with Sense of Immersion at a mean of 3.6 and Connection to Narrative at 3.53, both with a mode of 4. These results suggested that the participants generally perceived the second video as immersive and visually coherent.

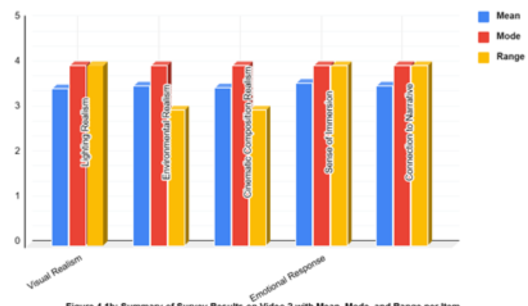


Figure 4.1b: Summary of Survey Results on Video 2 with Mean, Mode, and Range per Item

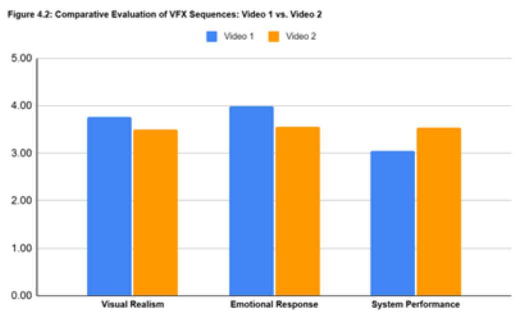
To help show the results more clearly, Figure 4.1b showed a column graph of each participant's scores for all questions related to Video 2. The graph revealed that scores for Emotional Response were mostly similar across participants These patterns helped explain how both the visual features of the video affected how participants felt and responded.

VIdeo 1				VIdeo 2			
Survey Dimension	Mean	Mode	Range	Survey Dimension	Mean	Mode	Range
Visual Realism	3.76	4	3	Visual Realism	3.50	4	4
Emotional Response	3.99	4	3	Emotional Response	3.57	4	4

Table 4.3: Comparative Summary of Results on Videos 1 and 2 (Mean, Mode, Range)

Note: Scores are based on a 5-point Likert scale (1 = Strongly Disagree, 5 = Strongly Agree).

Comparing the survey results for Video 1 and Video 2 revealed notable differences in participant evaluations across the dimensions of Visual Realism and Emotional Response. The participants indicated that Video 1 was more visually polished and more engaging than Video 2, scoring higher on Visual Realism (3.76) and Emotional Response (3.99). While Visual Realism remained fairly consistent across both videos, with Video 1 at 3.76 and Video 2 at 3.50, a wider range of 4 in Video 2 under Emotional Response compared to 3 in Video 1 implied greater variability in individual responses especially in immersion and lighting aspects. These showed that while Video 2 maintained visual and technical consistency, to respondents, it lacked the narrative and emotional depth that made Video 1 more engaging for viewers.



B. Performance Monitoring using Unreal Engine's Stat Unit Graph

Unreal Engine's Stat Unit Graph was utilized to track frame time, Game, Draw, and GPU performance while participants viewed VFX-intensive cinematic scenes. It offered a breakdown of how each component handled real-time rendering tasks.

Figure 4.3a: System Performance and Visual Optimization of Simulation 1 at Low Resolution

Figure 4.3a ran at 51.9 FPS, which was above the general 30 FPS baseline and indicated a relatively smooth performance especially for cinematic game or exploration. The frame time values were within acceptable real-time rendering thresholds, but suggested a bottleneck performance on the GPU. The GPU time was notably higher than the CPU threads at 19.92 ms with the scene containing visual effects like particle systems and dynamic lighting. The thread graph showed stable thread performance with no major spikes nor erratic frame timing during rendering.

As shown to the respondents, the dry ice-like airy volumetric cloud mimicked gravitational pull using low particle density. Based on the recorded data, the GPU load was effectively reduced by minimizing heavy volumetric calculations while using minimal VFX detail. Real-time responsiveness was retained while interacting with the environment.

Respondents	Smooth Playback & Responsiveness	GPU & Resource Management	Quality of Rendered Effects	Overall, Hardware Satisfaction
R1	4.00	4.00	4.00	4.00
R2	4.00	4.00	4.00	4.00
R3	4.25	4.50	4.50	4.50
R4	4.00	4.00	4.00	4.00
R5	2.00	2.00	2.00	2.00
R6	3.50	4.00	4.00	4.00
R7	2.00	2.00	1.00	2.00
R8	5.00	5.00	3.00	5.00

Table 4.4a: Summary of System Performance Ratings from Respondents on Simulation 1

Based on the data shown in Table 4.4a, there was a clear correlation between the objective system strain observed in the stat unit graph and the subjective dissatisfaction reported by users with lower-spec hardware namely R6 and R7. In contrast, respondents like R3 and R8, who likely had better GPU performance, experienced smoother playback and expressed higher levels of satisfaction. Among all the performance metrics, "Smooth Playback & Responsiveness" and "Overall Hardware Satisfaction" showed the widest range of ratings, indicating that these aspects were the most sensitive to fluctuations in frame rate and GPU usage.

In Figure 4.3b: System Performance and Visual Optimization of Simulation 2 at High Resolution, however, the stat unit graph revealed that the system running the scene was significantly bottlenecked by the GPU, with real-time performance dropping below 10 FPS—well into unusable territory.

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Figure 4.3a: System Performance and Visual

Optimization of Simulation 1 at High Resolution

This technical strain was reflected in user feedback, particularly from respondents like R6 and R7, who rated both responsiveness and hardware satisfaction poorly. In contrast, the high satisfaction scores from R3 and the moderate responses from others suggest considerable hardware variability among participants. While some systems appeared capable of managing the rendering demands, others struggled considerably.

Respondents	Smooth Playback & Responsiveness	GPU & Resource Management	Quality of Rendered Effects	Overall Hardware Satisfaction
R1	4.00	4.00	4.00	4.00
R2	4.50	4.50	3.00	4.50
R3	4.50	4.00	4.50	5.00
R4	4.00	4.00	4.00	4.00
R5	2.00	2.00	2.00	2.00
R6	1.00	1.00	1.50	1.00
R7	1.50	2.00	1.50	2.00
R8	2.00	3.00	4.00	2.00

Table 4.4b: Summary of System Performance Ratings from Respondents on Simulation 2

Qualitative Findings

A portion of the survey included open-ended questions to gather the respondents' personal thoughts and feelings about the material presented. They were given the freedom to share their impressions and provide feedback related to their visual, emotional, and interactive experiences with the file. These responses were documented for research purposes.

A. Participant Perception of Environmental Authenticity and Visual Detail

The general perception and mood setting varied across the two videos. In Video 1, the lighting and composition effectively enhanced a cinematic mood, contributing to a mysterious atmosphere that evoked a fantasy dungeon-like setting. Viewers regarded the overall visual tone as engaging and story-driven. In contrast, Video 2 utilized particle effects to bring the environment to life, creating a more organic feel. Although the level of detail was lower, the visuals still successfully communicated the intended narrative. However, this video was perceived as less cinematic and atmospheric when compared to Video 1.

In terms of visual details and effects, Video 1 was praised for its realistic lighting and consistent environmental design, contributing to an immersive viewing experience. However, some criticism was directed at the fog animation, particularly during its descent, which detracted slightly from the overall polish. Despite this, the visual presentation was widely considered “realistic” and “good” in its overall look and feel. Video 2 elicited mixed reactions regarding its particle effects; while they were commended for adding liveliness to the scene, their oversized and blocky appearance raised concerns. Compared to Video 1, it was perceived as less visually detailed, with some elements appearing blurry or rendered at low resolution.

Technical limitations were a shared concern across both videos, with pixelation issues frequently reported by viewers. These visual disruptions were largely attributed to the use of low-spec or mid-spec hardware. Despite this, many participants remained visually engaged, expressing curiosity about how the videos might appear on higher-end systems. Overall, the pixelation did not significantly hinder the storytelling, as both videos were still perceived as compelling and effectively presented.

Video 1 delivered a stronger cinematic and immersive impact, largely due to its effective use of lighting and environmental design. While the particle behavior and fog realism presented minor flaws, they did not significantly undermine the visual experience. Video 2 was appreciated for its dynamic quality, primarily achieved through the use of particle effects. However, its technical and visual shortcomings—such as inconsistencies in detail and realism—were noted to affect the overall perception of authenticity.

B. Subjective Reactions to Mood, Atmosphere, and Engagement

Participants expressed varied emotional reactions to both video demonstrations, with recurring themes of mystery, curiosity, and cinematic atmosphere. For Video 1, several respondents noted that the scene felt like a cutscene for a boss reveal, evoking mystery and intrigue, though others reported minimal emotional change from previous scenes. One participant found the smoke effect distracting, while others were drawn to the cold, cave-like ambiance. Despite acknowledging the visual quality, emotional engagement appeared moderate, with some respondents stating they felt more curious than emotionally moved.

In contrast, Video 2 elicited slightly stronger and more vivid emotional responses. Several users described feelings of anticipation, wonder, and fantasy immersion, with references to cinematic inspirations such as the “Feast” scene from Berserk. The atmosphere was consistently noted as magical, mysterious, and more narratively engaging, giving users the sense of entering a fantasy dungeon or cave. While some comments echoed those made about Video 2—such as visual appeal and curiosity—the emotional descriptions in Video 2 were generally more elaborate and immersive.

In comparison, both videos succeeded in establishing a mysterious tone, but Video 2 was perceived as more emotionally compelling and cinematic, potentially due to stronger environmental design and atmosphere coherence. While Video 1 introduced intrigue, Video 1 expanded on this by fostering a deeper sense of narrative curiosity and environmental immersion.

C. User Feedback on Playback Fluidity and Hardware Responsiveness

Participant feedback highlighted clear differences in performance between the two simulations. Simulation 2, the low-resolution version, was consistently praised for its smooth playback and efficient hardware responsiveness. Respondents noted that it ran better than Simulation 1, even on mid-range to low-spec systems, with minimal frame drops and acceptable frame rates. One participant remarked that it “ran a lot better despite the high quality of the environment,” indicating effective optimization. In contrast, Simulation 1, the high-resolution version, received mixed responses regarding performance. While visually impressive, it was described as “unplayable with mid-range systems” and “heavy to run,” requiring substantial optimization to improve usability. Several users suggested lowering particle density, compressing textures, and simplifying effects to enhance accessibility across varying hardware capabilities. Overall, the feedback emphasized the importance of balancing visual quality with system performance to ensure a responsive and inclusive user experience.

Theme	Description	Sample Participant Quote
Atmospheric Visuals	Respondents appreciated the use of lighting, composition, and environment to create a cinematic or mysterious feel.	"The lighting and composition on the environment enhanced the mood for a cinematic shot." (R1)
Curiosity and Intrigue	Many participants expressed a sense of wonder or curiosity sparked by the scene.	"A feeling of curiosity and wonder about the story behind the environment’s style." (R2)
Particle Effects Issues	Some found particle and fog effects distracting, unrealistic, or poorly optimized.	"The smoke/fog is a bit blurry but the experience is better overall." (R3)
Hardware Limitations	Users with lower-spec PCs experienced performance issues affecting their experience.	"It's heavy on my computer. Maybe I should change computer." (R8)
Desire for Interactivity	A few respondents suggested adding	"The scene can use some interactive objects (organic

	interactive elements for greater immersion.	vegetation) to give a complete immersive experience." (R1)
Technical Suggestions	Participants provided feedback on how to optimize effects or adjust visuals.	"Optimized the particle size and emission source should be less dense." (R2)

Table 4.5: Coded Themes and Supporting Participant Quotes

Summary of Findings

The findings implied that users prioritized smooth and responsive gameplay over high visual quality, especially when system performance was affected. While the lower-resolution file delivered average visuals, it allowed for smoother interaction and wider hardware accessibility, making it more playable even on lower-end systems. In contrast, although the high-resolution version achieved impressive realism particularly through volumetric effects, it introduced system strain that impacted the user experience. Participants' feedback emphasized the importance of optimizing performance to ensure that visual enhancements did not compromise usability, especially across devices with varying capabilities.

CONCLUSION

This study explored how environmental visual effects impacted player experience using both qualitative feedback and quantitative data. Participants compared two pre-rendered videos and two real-time exploration simulations—Simulation 1 (high-resolution) and Simulation 2 (low-resolution)—to assess visual realism, emotional response, and system performance. Results showed that while Video 1 and Simulation 1 offered higher visual fidelity, especially in lighting and atmospheric VFX, they also introduced noticeable performance issues such as frame rate drops and GPU strain, particularly during fast interactions. In contrast, Video 2 and Simulation 2, despite offering slightly less visual detail, delivered smoother playback and greater hardware compatibility across mid- to low-spec systems. Survey responses and Stat Unit Graph analysis confirmed that users favored a balance of quality and performance, often prioritizing responsiveness and stability over hyper-realistic effects. These findings emphasized the importance of optimizing VFX to maintain immersion without compromising playability.

The results indicated that system optimization played a crucial role in shaping user experience. High-fidelity visuals significantly enhanced immersion and deepened narrative engagement, but hardware limitations hindered usability and made the experience less accessible for some participants. Respondents consistently emphasized the importance of balancing visual realism with system responsiveness, suggesting that designers should prioritize scalability and adaptability in environmental VFX. Elements such as particle size, lighting accuracy, and atmospheric consistency influenced emotional engagement; however, technical issues like lag and frame rate drops often disrupted immersion. Overall, participant feedback revealed that developers could still achieve strong emotional and narrative depth through moderately detailed visual effects, provided that performance remained stable across varying hardware capabilities.

Limitations of the Study

Several limitations were encountered that likely affected the scope and generalizability of its findings. First, the small sample size of only eight participants restricted the ability to draw broader conclusions across diverse user groups. This limited the study's statistical power and made it difficult to confidently apply the results to a wider population of video game players with varying backgrounds and preferences. Additionally, the researchers did not standardize or control hardware specifications, which likely introduced variability in system performance data and affected the reliability of the findings. This inconsistency hindered the ability to isolate the impact of environmental VFX from hardware-related factors. The analysis also relied on only two video demonstrations, which may not have fully represented the wide variety of environmental VFX techniques or gameplay styles commonly encountered in real-world scenarios, thus restricting the generalizability of the results. Furthermore, participants provided data through self-reported survey responses, which individual biases or perceptual differences might have influenced, potentially limiting the objectivity of the data. Lastly, because participants viewed pre-recorded cinematic sequences, the study could not assess dynamic interactivity or its effects on user experience during fully interactive real-time gameplay. This limitation prevented the research from capturing how dynamic interactivity influenced player engagement and immersion during active gameplay.

Recommendations for Future Research and Sustainability

Future studies recommended recruiting a larger and more diverse participant pool to increase statistical power and improve the generalizability of findings across various player demographics and gaming backgrounds. Researchers advised standardizing or controlling hardware specifications to reduce variability caused by different systems and to isolate the effects of environmental visual effects more clearly.

They also recommended including a wider variety of video demonstrations featuring diverse environmental VFX techniques and gameplay styles to better reflect real-world scenarios and provide a more comprehensive understanding of their impact. To address the limitations of self-reported data, researchers suggested combining subjective surveys with objective measures such as physiological monitoring, behavioral tracking, or expert evaluations to enhance data objectivity.

Finally, because the study used pre-recorded cinematic sequences, future research encouraged employing fully interactive real-time gameplay environments. This approach could allow future researchers to examine how dynamic interactivity affected player experience and to capture the real-time influence of environmental VFX on immersion, emotional engagement, and user behavior more accurately.

Final Remarks

This paper revealed a critical trade-off between visual fidelity and system performance in environmental visual effects, showing that while realistic VFX enhanced emotional engagement and immersion, system efficiency strongly influenced overall user experience. These findings underscored the need for user-centered VFX design that balances artistic quality with technical accessibility.

However, the study faced limitations including a small sample size, uncontrolled hardware variability, limited demonstration scope, reliance on self-reported data, and use of pre-recorded cinematics instead of interactive gameplay. These factors constrained the generalizability and depth of the conclusions.

Future research should address these limitations by expanding participant diversity, standardizing hardware, incorporating a wider range of VFX and gameplay styles, integrating objective measures alongside subjective feedback, and employing fully interactive environments. By doing so, developers and researchers can better understand how to optimize environmental VFX for immersive, efficient, and inclusive gaming experiences.

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