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LINE OF SIGHT LIGHTING EFFECT IN DARK ENVIRONMENT AND ITS IMPACT ON INTERACTIVE HORROR GAME EXPERIENCE

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ABSTRACT

Lighting effects in dark environments represent a fundamental psychological mechanism in horror game design, directly shaping player immersion, emotional tension, and the quality of interactive experience. Although Line of Sight (LoS) technology has been widely adopted across many game genres, empirical investigations examining how LoS-based dynamic lighting specifically affects player engagement, usability, and visual aesthetic perception within single-player horror puzzle contexts remain scarce. This paper presents the design, development, and user evaluation of "No One Left", a three-dimensional top-down horror puzzle game developed using Unreal Engine 4, which systematically employs LoS-based lighting mechanics within a dark environment to restrict player visibility and elevate psychological immersion. The Game Development Life Cycle (GDLC) methodology guided systematic development across concept, design, programming, testing, and deployment phases. User evaluation involved 30 participants (19 male, 11 female; predominantly aged 16 to 21 years) together with two professional game developers, assessed through structured Likert-scale questionnaires across four dimensions, namely usability and playtesting, visual aesthetics, gameplay experience, and engagement. Qualitative expert interviews provided supplementary assessment of technical and design quality. Results yielded a mean gameplay satisfaction score of 3.63 out of 5.0 (SD = 1.10), with 80 per cent of respondents confirming clear game goal comprehension and 69 per cent expressing positive environmental aesthetic experience. Expert evaluation validated the technical effectiveness of the LoS mechanic and commended the interactive narrative design approach, while identifying level layout diversity and multiplayer integration as primary improvement targets. These findings confirm that LoS-based lighting constitutes an effective and computationally efficient mechanism for generating horror immersion in single-player game contexts, and contributes empirically grounded design principles applicable to future dark environment interactive experiences.

Keywords: *Dark Environment, Game Development Life Cycle, Horror Game, Lighting Effect, Line of Sight, Player Immersion.*

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1. Introduction

Horror video games occupy a psychologically unique position within the broader entertainment landscape. Unlike passive horror media such as film, horror games place the player within the threat environment itself, creating first-person psychological stakes that passive viewing cannot replicate. This participatory dimension transforms game design into a precision instrument for fear modulation: every visual, acoustic, and interactive element must be calibrated to produce tension without triggering frustration, disorientation, or disengagement (Clasen *et al*., 2020). Among the most powerful tools available to horror game designers is the controlled manipulation of player visibility through environmental darkness and, specifically, the application of Line of Sight (LoS) technology to dynamically restrict what the player can perceive at any given moment.

Line of sight, in game design terms, refers to the visible region accessible to a game character based on geometry-constrained trace rays emanating from that character's position. Objects, walls, and environmental features act as occluders that terminate the trace ray, producing sharp boundaries between visible and hidden zones (Masuch & Röber, 2005). In horror game contexts, LoS-based lighting translates this computational concept into an experiential reality: the player character illuminates only a cone of space, leaving the surrounding environment in darkness. This perceptual restriction amplifies the psychological significance of every object and enemy within the visible zone, generates uncertainty about threats beyond the visibility boundary, and motivates exploratory behaviour as a means of expanding situational awareness. The result is a gameplay loop driven by tension, curiosity, and risk assessment, which collectively constitute the core experiential pillars of effective horror design.

The commercial horror game market, while thriving, remains dominated by titles that prioritise action mechanics, competitive multiplayer formats, or jump-scare delivery over sustained psychological tension achieved through environmental design. Titles such as Among Us (Innersloth, 2018) leverage LoS technology effectively within social deduction contexts but do not explore the psychological depth achievable through single-player dark environment puzzle exploration. Research affirms that lighting conditions, landmark presence, and auditory cues materially influence player navigation and emotional state in virtual environments (Marples *et al*., 2020), and that familiar real-world architectural contexts heighten horror game tension by activating player recognition (Prasetio *et al*., 2017). A gap therefore exists between the theoretical understanding of these design principles and their systematic empirical evaluation in academic game development contexts.

This study addresses that gap through the development and evaluation of "No One Left", a three-dimensional top-down horror puzzle game built in Unreal Engine 4 that implements a complete LoS-based dark environment lighting system. The game places players in an abandoned multi-storey office building, challenging them to locate three hidden keys per level while evading infected patrol units, all within a dynamically computed LoS field. Three empirical objectives guide this study: first, to analyse how LoS-based lighting effects in dark environments affect interactive gameplay experience; second, to develop a functional interactive horror game implementing LoS technology within the GDLC framework; and third, to evaluate player visual aesthetic experience through quantitative user testing and qualitative expert assessment.

The remainder of this paper proceeds as follows. Section 2 reviews relevant literature on horror game immersion, lighting design, LoS technology, and evaluation frameworks. Section 3 presents the research methodology and game design. Section 4 details the implementation process. Section 5 presents evaluation results. Section 6 discusses the findings in relation to existing literature. Section 7 concludes and proposes directions for future work.

2. Literature Review

2.1 Horror Games and Psychological Immersion

Horror games have been extensively documented as effective vehicles for inducing controlled fear responses and sustained psychological immersion (Zhang *et al*., 2023). Clasen *et al*. (2020) established through a large-scale survey of horror media consumers that the genre operates as a form of threat simulation, providing players with a safe environment in which to encounter and process fear stimuli. This mechanism, rooted in evolutionary psychology, explains why players voluntarily seek out horror experiences despite the negative emotional states they produce. Horror games, unlike horror film, place the player as an active agent within the threat scenario, amplifying both the stakes and the immersive quality of the experience.

Immersion in digital games operates across three progressive levels identified by Brown and Cairns (2004) through grounded theory research: engagement, engrossment, and total immersion (see also Dombrovskis *et al*., 2025). In horror game design, achieving total immersion, wherein the player's awareness of the physical environment largely recedes in favour of the game world, represents the primary design objective. Johnson and Wiles (2003) identified coherence between visual, auditory, and interactive elements as a prerequisite for this level of absorption, observing that inconsistencies across sensory channels disrupt the experiential continuity needed for sustained immersion. This finding directly informs the minimalist user interface philosophy adopted in "No One Left", where conventional HUD elements were deliberately suppressed to preserve environmental cohesion.

Vorobeva (2024) identified the intersection of sound design, lighting manipulation, resource scarcity, and player vulnerability as the four primary design levers through which horror atmosphere is constructed. Restricting player visibility through LoS-based dark environment lighting simultaneously addresses the lighting and vulnerability dimensions, creating a compounded fear effect that is difficult to achieve through either dimension independently. Scrivner *et al*. (2021) further established that engagement with frightening fictional experiences, including horror games, is associated with measurable psychological resilience outcomes, suggesting that the affective processes activated during horror gameplay have functional consequences beyond entertainment.

2.2 Lighting as a Game Design Element

Environmental lighting in game design serves simultaneous functions encompassing mood establishment, player navigation guidance, game-world information communication, and affective state generation. In horror games, the deliberate manipulation of lighting conditions is particularly consequential. Lee (2011) demonstrated that spatial design, including how light reveals or conceals architectural features, functions as a narrative vehicle capable of communicating story and character without explicit dialogue or cutscene intervention. The darkness in which "No One Left" is set is therefore not merely an aesthetic choice but a narrative one, encoding the abandoned office building with environmental tension that the player must actively interpret.

The use of darkness as a primary design material requires careful perceptual calibration. Marples *et al*. (2020) provided experimental evidence that lighting conditions in virtual maze environments significantly affected both path selection and participant emotional state, with reduced lighting conditions correlating with heightened caution and increased affective arousal. Their work provides empirical grounding for the hypothesis that dark environment game design incorporating LoS-based lighting creates measurably different player behaviour compared to fully illuminated equivalents, with the behavioural differences manifesting experientially as heightened engagement and sustained tension.

2.3 Line of Sight Technology in Interactive Contexts

Line of sight computation has a long history in interactive entertainment. Masuch and Röber (2005) traced the evolution of visibility mechanics in game graphics, noting that constrained visibility has been employed as both a technical necessity and a deliberate design choice across game history. The core technical challenge of determining which game world elements fall within an unobstructed trace path from a given origin point has been addressed through multiple approaches including tile-based shadow casting, ray marching, and geometry-constrained trace computation. Contemporary game engines such as Unreal Engine 4 implement collision-based trace channels that enable efficient real-time LoS computation without requiring dedicated lighting hardware.

Silvestri *et al*. (2022) analysed flagrant detection mechanics across ten stealth games and found that cone-of-vision LoS creates the most reliable and interpretable detection experience for players, making it the preferred mechanism in stealth and horror contexts where player understanding of threat detection boundaries is essential to gameplay function. Their analysis is particularly relevant to the enemy detection architecture of "No One Left", where the binary LoS check model provides clear and learnable detection rules that allow players to internalise threat avoidance strategies through iterative play.

Latonov and Tikhomirov (2018) formalised the mathematical formulation of LoS control problems, establishing computational principles applicable to game AI detection systems operating from moving platforms with real-time video data. More recently, research on automated visual perception systems for game agents has incorporated LoS verification supplemented by image comparison methods to create realistic non-player character (NPC) detection behaviour while maintaining acceptable computational overhead (Primachenko & Khafizov, 2025). These technical advances provide context for the Blueprint-based LoS implementation approach adopted in this study.

2.4 Game Development Life Cycle in Academic Game Projects

The Game Development Life Cycle (GDLC) provides a structured iterative process adapted from software engineering methodologies and calibrated for the creative and technical demands of game production. Ramadan and Widyani (2013) formalised the GDLC's six phases, namely Concept, Design, Technical Analysis, Programming, Testing, and Deployment, and demonstrated the framework's effectiveness as a systematic development methodology for academic game projects. The GDLC's explicit separation of design intent from technical implementation enables quality control at each development phase, a particularly valuable property in single-developer academic contexts where design and implementation responsibilities are not distributed across specialised teams.

Bernhaupt (2015) provided a comprehensive taxonomy of user experience evaluation methods applicable across the GDLC, recommending mixed-method approaches that combine standardised quantitative instruments with qualitative expert evaluation. This recommendation directly informs the evaluation design employed in this study, combining Likert-scale questionnaire assessment with structured expert interviews. The GDLC framework's emphasis on iterative refinement through playtesting also supports the integration of participant feedback into development decisions, a process that identified layout diversity and interactive object density as priority improvement areas in this project.

2.5 Player Experience Evaluation Instruments

Rigorous evaluation of player experience requires validated psychometric instruments capable of capturing the multidimensional nature of game satisfaction (Takatalo *et al*., 2008). Phan *et al*. (2016) developed and validated the Game User Experience Satisfaction Scale (GUESS), a comprehensive fifty-five-item instrument assessing nine constructs including usability and playability, narratives, play engrossment, enjoyment, creative freedom, audio aesthetics, personal gratification, social connectivity, and visual aesthetics. The GUESS was validated

against assessments of over 450 unique game titles across multiple genres, establishing its applicability as a cross-genre evaluation instrument. Keebler *et al*. (2020) subsequently developed the GUESS-18, a shortened eighteen-item version for use in iterative design contexts, demonstrating excellent construct validity relative to the full instrument.

The evaluation dimensions adopted in this study, specifically usability and playtesting, visual aesthetics, gameplay experience, and engagement, were selected from the GUESS framework to align with the specific design objectives and target horror game experience of "No One Left". Ermi and Mäyrä (2005) identified three components of gameplay immersion through their SCI model, comprising sensory immersion, challenge-based immersion, and imaginative immersion. The evaluation instrument used in this study addresses all three dimensions: sensory immersion through visual aesthetics assessment, challenge-based immersion through gameplay experience rating, and imaginative immersion through narrative engagement feedback. Hughes and Cairns (2021) further established that player experiences are contextually specific and cannot be fully captured by genre-generic instruments alone, supporting the mixed-method approach employed in this study.

2.6 Research Gap

The reviewed literature collectively establishes that horror game immersion is driven by psychological tension mechanisms including visual restriction; that LoS technology provides an effective and computationally efficient mechanism for dynamic visibility restriction; that dark environment lighting design materially influences player navigation and emotional state; that the GDLC framework and GUESS-based instruments are appropriate for academic game development and evaluation; and that real-world architectural contexts enhance horror game tension. However, the intersection of these principles, specifically the systematic empirical evaluation of LoS-based dark environment lighting in a single-player horror puzzle context developed under GDLC methodology, has not been addressed in the existing literature. This study fills that gap through the development and evaluation of "No One Left", providing both an empirical dataset on player responses to LoS-based horror design and a documented implementation approach for independent developers.

3. Methodology

3.1 Research Framework

This study adopts a mixed-method research design that combines quantitative user survey assessment with qualitative expert interview evaluation. The quantitative component employed a structured Likert-scale questionnaire adapted from the GUESS framework (Phan *et al*., 2016), providing numerical measures of usability, visual aesthetics, gameplay experience, and engagement. The qualitative component comprised semi-structured interviews with two professional game developers, providing domain-expert assessment of technical implementation quality and design effectiveness. This mixed-method approach is consistent with Bernhaupt's (2015) recommendations for game UX evaluation and enables triangulation between player experience data and expert assessment.

3.2 Game Development Life Cycle

The GDLC framework (Ramadan & Widyani, 2013) was selected as the development methodology, providing a structured six-phase process tailored to game development contexts. The Concept phase defined the game's core premise as a single-player horror puzzle game leveraging LoS-based dark environment lighting to restrict player visibility and generate psychological tension. The target audience of players aged eighteen to twenty-five years, the horror-puzzle genre combination, and the primary technology of LoS computation within Unreal Engine 4 were all defined at this stage. Although the game was designed for

this age group, recruitment for the user evaluation (Section 5.1) was not restricted by age, and the evaluation sample therefore also included younger players. Figure 1 illustrates the GDLC phases as applied in the development of "No One Left".

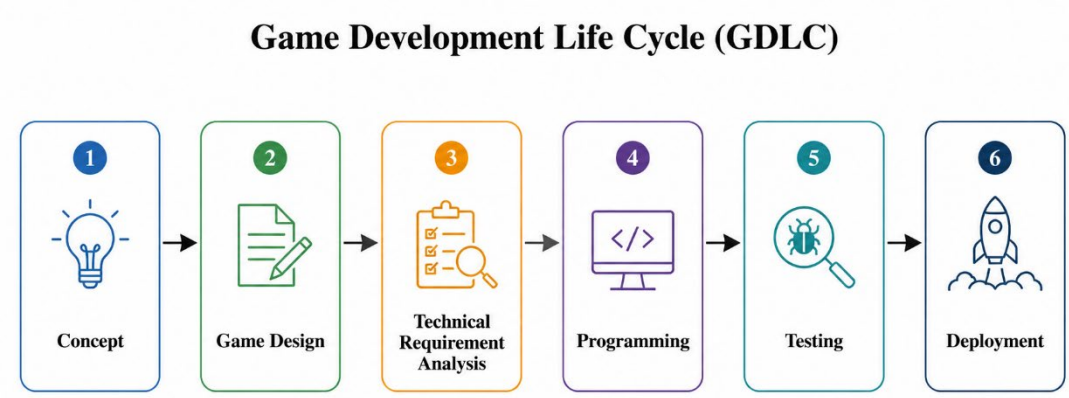


Figure 1. The Game Development Life Cycle (GDLC) Framework Adopted in this Study (adapted from Ramadan & Widyani, 2013)

The Game Design phase produced a comprehensive Game Design Document encompassing the narrative framework, level architecture, core mechanic specifications, character design guidelines, the control scheme, and the audio framework. The Technical Requirement Analysis phase established hardware and software specifications for the development environment and target deployment platform, and designed the LoS computation architecture, Blueprint scripting frameworks, Navigation Mesh parameters, and post-processing volume configurations. The Programming phase implemented all game mechanics within Unreal Engine 4, including LoS computation via Blueprint-based collision trace channels, collision-response NPC detection, the interactive board widget system, key-collection and door-unlock mechanics, and level progression triggers. The Testing phase conducted user evaluation with thirty participants and two professional game developers across structured questionnaire and interview protocols, with results analysed to identify design strengths and improvement priorities. Finally, the Deployment phase packaged the game executable via Unreal Engine 4's Windows 64-bit packaging pipeline and distributed it via cloud storage link shared through a Facebook gaming community group.

3.3 Game Design

3.3.1 Concept and Narrative

"No One Left" is set in an abandoned multi-storey office building. The player controls a survivor who must navigate each level, locating three hidden keys and escaping through a locked exit door while evading infected antagonist patrol units. Rather than delivering narrative through cutscenes or explicit dialogue, the game employs an interactive narrative approach in which story content is revealed through information boards positioned throughout each level. Players must physically interact with these boards to receive map layout information and location-specific story fragments, incentivising thorough environmental exploration. This approach is consistent with Lee's (2011) documented principle that spatial design serves as a narrative vehicle in horror games, transforming the act of exploration itself into the primary narrative mechanism.

3.3.2 Line of Sight Lighting Mechanics

The LoS lighting system constitutes the central technical contribution of this project. Player vision is dynamically restricted to a cone-shaped region emanating from the character's current position, with the field of view determined by collision geometry distributed

throughout the level. Static assets including office furniture, walls, and architectural elements function as occluders that interrupt the LoS cone, producing realistic shadow regions and visually restricting player awareness of enemy positions and key locations. The same LoS computation architecture governs enemy detection: each infected patrol unit maintains a forward detection cone and continuously executes LoS checks against the player character. Binary detection, where the player is either fully hidden or fully detected, creates the high-stakes tension characteristic of stealth-horror gameplay identified by Silvestri *et al*. (2022) as the most interpretable detection model for players.

3.3.3 Level Design and Progression

The game comprises one tutorial level providing step-by-step mechanic guidance and three main levels of escalating difficulty. Difficulty scaling is achieved through three independently adjusted variables. Map area size increases navigation complexity across levels, whilst infected unit density heightens evasion challenge, and information board frequency decreases to reduce navigational support and increase spatial memory demands. All levels share the abandoned office building aesthetic and core LoS mechanic, maintaining thematic and gameplay consistency whilst varying challenge parameters (Fabricatore, 2007). The tutorial level introduces the LoS concept, key collection mechanic, and board interaction system in a controlled environment before exposing players to the full difficulty of the main game.

3.4 Technical Specifications

The hardware and software requirements for both development and target deployment are specified in Table 1 and Table 2.

Table 1. Hardware Requirements for Development and Deployment

Hardware Component	Specification
Operating System	Windows 7 64-bit or above
GPU	DirectX 10 compatible, minimum 1 GB VRAM
CPU	SSE2 instruction set support, quad-core 2.5 GHz or equivalent
Storage	500 MB available space (solid-state drive recommended)
RAM	4 GB minimum; 8 GB recommended for development environment

Table 2. Software Requirements

Software	Role and Justification
Unreal Engine 4	Primary development engine; provides Blueprint visual scripting, Navigation Mesh AI pathfinding, post-processing volumes, collision response system, and Windows 64-bit packaging pipeline
Blender 3D	Three-dimensional asset creation and modification; adapted royalty-free Unreal Marketplace assets for game environment fidelity and collision volume optimisation
Audacity	Audio editing; preparation and normalisation of background music and interactive sound effects prior to import into Unreal Engine 4

4. Implementation

4.1 Line of Sight System Architecture

The LoS-based dark environment lighting system was implemented through a four-component architecture within Unreal Engine 4. In the first component, trace channel assignment, each environmental asset in the game world was configured with a custom collision object type through Unreal Engine 4's Collision Response settings. All static environment assets, including walls, office furniture, structural columns, and architectural elements, were assigned as blocking geometry for the custom LoS trace channel, whilst open spaces such as corridors and doorways were left transparent to the trace, allowing LoS rays to propagate freely through navigable areas.

The second component, collision-based occlusion, governs the real-time computation of the visible polygon. From the player character's world position, a dense fan of trace rays is emitted across the player's visible field of view arc each frame. When a ray intersects a collision boundary of a blocking asset, the ray terminates at that point, establishing the visible boundary edge at that angular position. The complete set of termination points across all emitted rays defines the visible polygon boundary, which is rendered as an illuminated mesh overlay positioned at the player's elevation.

The third component is the real-time LoS cone computation, in which the visible polygon mesh is updated every frame to track player position and rotation continuously. Enemy characters use an architecturally analogous computation, with a narrower detection cone that continuously checks for player presence within an unobstructed forward arc. This architectural consistency between player vision and enemy detection creates a unified LoS model that players can internalise and apply to both self-navigation and threat-avoidance decision-making across all game levels.

The fourth component is post-processing darkness rendering. World areas outside the player's LoS polygon are rendered using a post-processing volume configured to apply maximum exposure reduction and colour desaturation to all geometry outside the visible polygon boundary. This approach creates the characteristic dark environment aesthetic, producing the visual impression of absolute darkness, without requiring per-pixel real-time lighting computation. The technique maintains consistent frame rate performance within the minimum hardware specification targets whilst delivering the intended atmospheric quality.

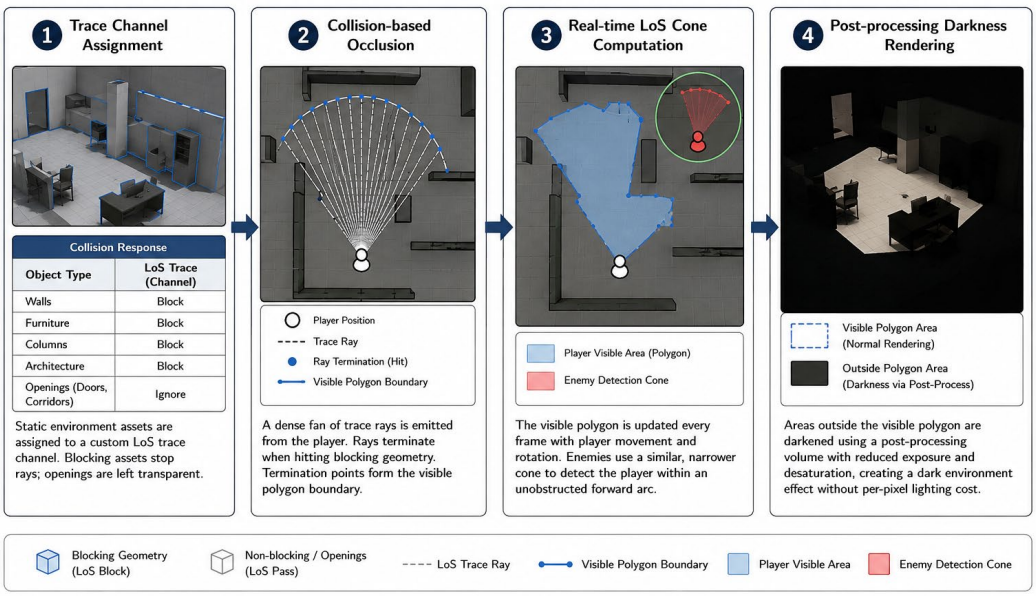


Figure 2. Four-Component Architecture of the Line-of-Sight (LoS)-Based Dark Environment Lighting System Implemented in Unreal Engine

4.2 Enemy Artificial Intelligence and Navigation

Infected patrol units navigate the game world using Unreal Engine 4's Navigation Mesh system, which automatically generates a walkable surface map from the level geometry. Each enemy unit is assigned a patrol path consisting of a sequence of waypoints through the level, with the NavMesh pathfinding computing obstacle-avoidant routes between waypoints. Detection is implemented as a binary LoS check executed at ten checks per second by default. The check traces a ray from the enemy's eye-level position toward the player character's centre. If the trace returns a clear path with no blocking geometry intersection, and the player falls within both the enemy's detection cone angle and maximum detection range, the detection flag is set, and the loss-state transition is triggered. This binary detection model creates the high-stakes navigation tension characteristic of stealth-horror gameplay whilst remaining computationally efficient within the target hardware specifications.

4.3 Interactive Environment System

Information boards are implemented as interactive Actor components with a collision trigger zone and an interaction prompt widget. When the player character enters the trigger zone, an on-screen prompt becomes visible, indicating that the E key will trigger interaction. Player activation of the E key displays a widget showing the board's text content together with a schematic map fragment. Widget content is authored individually per board, enabling level designers to control the distribution and pacing of navigational and narrative information across each level. Key pickups are implemented as Actor components with a spherical trigger zone; player entry into the trigger zone automatically collects the key, triggers an audio confirmation sound, and updates the in-memory key count. When the key count reaches three, the exit door actor's locked state is updated to enable the collision trigger that advances the game to the victory state.

4.4 Asset Production

Game assets were sourced from the Unreal Marketplace under royalty-free licences and subsequently modified using Blender 3D to meet specific environmental requirements. Modifications included texture adjustments to convey environmental deterioration consistent with the abandoned office narrative, scale corrections for spatial plausibility at the top-down camera perspective, and geometry simplification to optimise collision volume computation

performance. Audio assets were selected from royalty-free sound libraries and processed in Audacity following Garner *et al*.'s (2010) findings on fear value in survival horror contexts. Background music features irregular low-frequency tonal variation to sustain atmospheric tension, whilst interactive sound effects provide clear confirmatory signals for key collection and door interaction events.

5. Evaluation

5.1 Evaluation Design

The evaluation employed a mixed-method design consistent with Bernhaupt's (2015) recommendations for game UX evaluation. The quantitative component comprised a structured Likert-scale questionnaire distributed to thirty user participants and assessed four dimensions: usability and playtesting, visual aesthetics, gameplay experience, and engagement. Usability and visual aesthetics items were presented as statements that respondents selected when they agreed with them, while overall gameplay was rated on a five-point scale from 1 (Poor) to 5 (Excellent). The qualitative component comprised structured expert interviews with two professional game developers, each session lasting approximately eighty minutes, including thirty minutes of observed gameplay and a thirty-minute interview, and covering six thematic areas: title and visual identity, gameplay quality, game mechanic assessment, level design quality, storytelling and narrative design, and improvement recommendations. Participants were recruited through an open call in an online gaming community on Facebook. Although the game was designed for players aged eighteen to twenty-five years, recruitment was not restricted by age, and the sample therefore also included younger players (Table 3). Participants received a cloud-hosted executable download link and were permitted forty-eight hours to complete the game before responding to the questionnaire. For participants unable to access the executable, a gameplay walkthrough video was provided as an equivalent stimulus. Expert interviews were conducted online via Discord.

5.2 Participant Demographics

Among the thirty survey respondents, 63.3 per cent (n = 19) were male and 36.7 per cent (n = 11) were female. The age distribution of participants is presented in Table 3.

Table 3. Participant Age Distribution (N = 30)

Age Group	Frequency (n)	Percentage (%)
Younger than 12 years	2	6.7
13 to 15 years	3	10.0
16 to 18 years	11	36.7
19 to 21 years	10	33.3
Older than 22 years	4	13.3

Note: Age categories are reproduced as defined in the original questionnaire. Ages 12 and 22 were not available as separate response options, and the individual responses are no longer available for re-categorisation.

With regard to gaming behaviour, 33.3 per cent of participants reported playing four to six hours per day, indicating a moderately engaged cohort. In terms of horror game affinity, 53.3 per cent (n = 16) self-identified as horror game fans, 33.3 per cent (n = 10) expressed neutral preference, and 13.3 per cent (n = 4) reported non-preference for the horror genre. This distribution provides a balanced evaluation perspective spanning dedicated horror game players and genre-neutral participants, strengthening the ecological validity of the evaluation findings.

5.3 Usability and Playtesting Results

Usability evaluation results are summarised in Table 4. The highest positive response rate was recorded for game objective comprehension at 80.0 per cent (n = 24), indicating that the LoS mechanic's gameplay function was communicated effectively despite the deliberate suppression of conventional user interface overlay indicators. Notably, menu user-friendliness received lower endorsement at 43.3 per cent (n = 13), suggesting that the minimalist UI approach, while immersion-supporting by design, created navigation challenges for some participants who expected more explicit interactive affordances. Overall level design quality was rated positively by 60.0 per cent of respondents (n = 18).

Table 4. Usability and Playtesting Results (N = 30)

Usability Criterion	Agree (n)	Agree (%)
Game objective is easy to understand	24	80.0
Game menu is user-friendly	13	43.3
Game instructions are clear and understandable	14	46.7
Level design quality is satisfactory	18	60.0

5.4 Visual Aesthetics Evaluation

Visual aesthetics were evaluated across five criteria from a subset of twenty-nine respondents, as one participant did not select any of the visual aesthetics statements. Results are presented in Table 5. The game world environment setting received the highest positive endorsement at 69.0 per cent (n = 20), affirming the effectiveness of the abandoned office building aesthetic in communicating the intended horror atmosphere. Game animation smoothness was rated positively by 65.5 per cent (n = 19) of respondents, indicating that the Unreal Engine 4 default character animations were perceptually acceptable at the top-down camera perspective. The lower colour tone appropriateness rating of 37.9 per cent (n = 11) points to a calibration gap in the post-processing darkness rendering approach, suggesting that the contrast between illuminated and unilluminated regions may not have achieved the intended horror visual register uniformly across participant hardware configurations.

Table 5. Visual Aesthetics Results (N = 29)

Visual Criterion	Positive (n)	Positive (%)
Game world environment setting	20	69.0
Game animation smoothness	19	65.5
Overall graphic quality	17	58.6
GUI clarity and interface usability	13	44.8
Colour tone appropriateness for horror theme	11	37.9

5.5 Gameplay Experience

Overall gameplay experience was assessed using a five-point rating scale. Table 6 presents the full rating distribution together with descriptive statistics. The mean gameplay rating of 3.63 (SD = 1.10) positions the game above the neutral midpoint of 3.0, with 63.3 per cent of respondents assigning ratings of four or five out of five. The modal response was four (Good), endorsed by 43.3 per cent of participants (n = 13), followed by three (Neutral) at 23.3 per cent (n = 7). The presence of lower-end ratings, with ratings of one and two combined accounting for 13.3 per cent of responses, is attributable to participants unfamiliar with LoS-based navigation mechanics, a finding consistent with expert evaluator observations regarding the layout comprehension challenges experienced by novice players. Figure 3 shows the distribution of gameplay experience ratings.

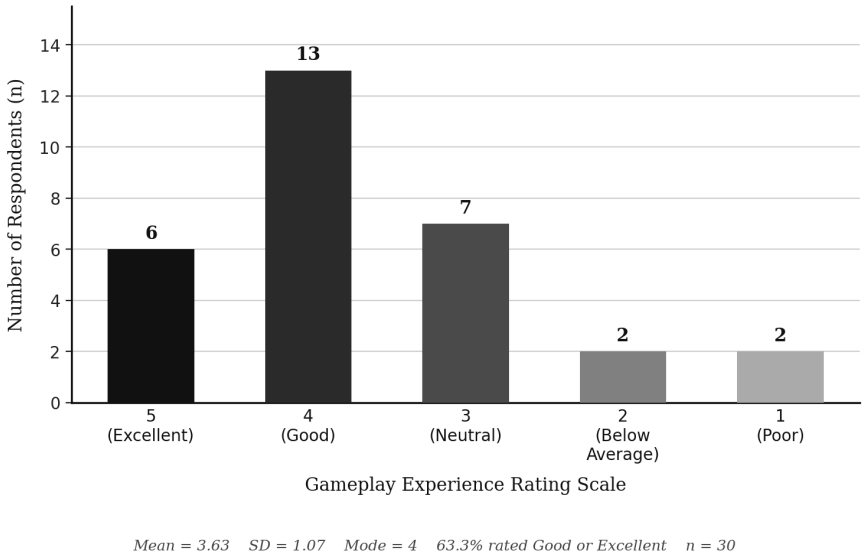


Figure 3. Distribution of Gameplay Experience Ratings among Survey Respondents (n = 30)

Table 6. Gameplay Experience Rating Distribution (N = 30)

Rating	Description	Frequency (n)	Percentage (%)
5	Excellent	6	20.0
4	Good	13	43.3
3	Neutral	7	23.3
2	Below Average	2	6.7
1	Poor	2	6.7
Mean (SD)	3.63 (1.10)	30	100.0

5.6 Player Improvement Feedback

Open-text improvement suggestions from survey respondents were categorised thematically and are presented in Table 7. The most frequently recurring themes concerned narrative depth, with respondents requesting more content across the interactive board system to support a more complete horror narrative; multiplayer functionality, which respondents believed would amplify tension through human unpredictability relative to AI patrol behaviour; game mechanic variety, with suggestions for additional interactive object types beyond the key-collection loop; asset variety, noting that repeated desk and chair assets reduced environmental distinctiveness across levels; navigation support, with several participants suggesting a mini-map or additional directional indicators for players unfamiliar with LoS-based navigation; and enemy variety, with recommendations for multiple enemy types featuring different detection radii or patrol speeds to diversify threat patterns.

Table 7. Player-Identified Improvement Categories

Improvement Category	Representative Feedback Themes
Narrative Depth	Interactive boards need more content; story fragments are too sparse for a fully immersive interactive narrative experience
Multiplayer Mode	A multiplayer mode would heighten tension through human player unpredictability relative to AI patrol behaviour
Game Mechanic Variety	Additional interactive object types are needed to expand gameplay beyond the single key-collection mechanic loop
Asset Variety	Repeated desk and chair assets reduce environmental distinctiveness and spatial orientation across levels
Navigation Support	Level layout is confusing for players unfamiliar with LoS navigation; a mini-map or additional directional cues would assist
Enemy Variety	A single enemy type limits challenge diversity; different detection radii and patrol speeds are suggested

5.7 Expert Interview Findings

Both professional game developers provided structured assessments across the six interview themes. With regard to title and visual identity, the dark colour scheme, logo design, and overall visual presentation were affirmed as thematically appropriate and effective in establishing horror atmosphere prior to gameplay commencement. The gameplay quality was assessed as commensurate with an academic single-developer project, with the fundamental gameplay loop functioning effectively. The LoS mechanic received unambiguous positive assessment from both evaluators, with the detection radius, object interaction responsiveness, and vision cone computation described as technically correct and capable of generating genuine tension. Level design repetitiveness was identified as the most significant design limitation, attributed to asset constraints inherent to single-developer academic development. The interactive narrative design approach was specifically commended by both evaluators as a fresh and effective mechanism for story delivery within the game. Improvement recommendations from both experts centred on multiplayer integration for enhanced tension, expanded interactive object density, and additional three-dimensional asset variety.

6. Discussion

6.1 LoS Lighting as a Horror Immersion Strategy

The evaluation findings provide empirical support for LoS-based dark environment lighting as an effective horror immersion strategy in single-player game contexts. The 80 per cent game objective comprehension rate among participants demonstrates that the game mechanics communicated their function clearly despite the deliberate suppression of conventional user interface elements. This result is consistent with Johnson and Wiles' (2003) finding that immersion-oriented UI design can successfully balance informativeness and experiential transparency when environmental cues are sufficiently rich. The mean gameplay satisfaction of 3.63 indicates broadly positive reception, particularly noteworthy given that the evaluation cohort included participants with no prior horror game affinity and potentially limited familiarity with LoS-based navigation conventions.

The strongest positive visual aesthetic rating for game world environment setting at 69.0 per cent supports Prasetio *et al*.'s (2017) argument that familiar real-world architectural contexts intensify horror game tension. The abandoned office building, a setting recognisable from real-world experience for most participants, created the uncanny tension documented in location-based horror research. This effect was achieved with a minimal asset set, suggesting that architectural familiarity is a more cost-effective tension driver than visual complexity, a practically significant finding for independent and academic game developers operating with constrained asset budgets.

The lower colour tone appropriateness rating of 37.9 per cent reveals a perceptual calibration gap in the dark environment rendering implementation. Post-processing volume configurations achieving maximal darkness in the development environment may not translate consistently across participant hardware configurations where GPU colour profiles, monitor brightness calibration, or display resolution differences affect the perceived contrast between the LoS-illuminated zone and the surrounding darkness. Future implementations should expose darkness intensity as a player-adjustable accessibility setting to accommodate hardware variability and ensure that the intended atmospheric quality is achievable across diverse display environments.

6.2 Line of Sight Technical Implementation

The Blueprint-based LoS computation approach demonstrated feasibility for academic game development contexts, achieving real-time per-frame LoS polygon computation within the minimum hardware specification range without requiring specialised lighting hardware or dedicated rendering pipelines. The architectural consistency between player LoS and enemy detection LoS, using the same trace-and-block computation model for both, created a unified visibility model that players could learn and apply to both self-navigation and threat-avoidance decision-making. The absence of a graduated detection state, in which partially visible or suspicious states trigger distinct NPC behaviours prior to full detection, was noted by expert evaluators as limiting the nuance of threat response opportunities. Graduated detection with associated NPC behavioural states would constitute a significant enhancement for future iterations, consistent with Silvestri *et al*.'s (2022) analysis of advanced stealth detection models across commercial titles.

6.3 Evaluation Instrument Adequacy

The GUESS-framework-aligned questionnaire demonstrated adequate measurement coverage for the study objectives, capturing the four primary dimensions relevant to "No One Left's" design intent. The Likert-scale format enabled straightforward quantitative analysis, and the open-text improvement feedback generated actionable, categorisable design guidance consistent with qualitative findings from expert interviews. Nevertheless, the absence of a validated immersion-specific instrument such as the full GUESS (Phan *et al*., 2016) or the GUESS-18 (Keebler *et al*., 2020) limits the comparability of these findings with published game evaluation literature. Future studies should incorporate a validated instrument to enable cross-study comparison and provide stronger evidence of LoS-based lighting's specific contribution to immersion ratings independent of overall gameplay satisfaction.

6.4 Limitations

Several limitations of this study warrant acknowledgement. The sample size of thirty participants is modest for quantitative generalisability, and online recruitment through a Facebook gaming community may introduce self-selection bias toward participants with positive prior gaming attitudes. The evaluation was conducted exclusively on the released executable without a within-subjects comparison against a control condition such as a full-illumination version, limiting the causal attribution of evaluation outcomes specifically to the LoS mechanic. The single-developer context constrains asset variety and level design complexity in ways that may confound evaluation of the core LoS mechanic with perceptions

of production quality. Additionally, the evaluation instrument did not include a validated horror-specific fear or immersion measure, preventing assessment of whether LoS-based lighting specifically elevated horror-genre experiential outcomes relative to a baseline condition. Finally, recruitment was not restricted by age, so the sample included participants younger than the intended target audience of 18 to 25 years, and the age categories in the original questionnaire did not cover ages 12 and 22 as separate options.

7. Conclusion

This study presented the design, implementation, and evaluation of "No One Left", a three-dimensional top-down horror puzzle game employing line of sight-based dark environment lighting to restrict player visibility and drive psychological immersion. The three research objectives were addressed fully. With regard to the first objective, the systematic implementation of LoS-based lighting in Unreal Engine 4 using Blueprint-based collision trace computation demonstrated measurable positive impact on gameplay experience, with 63.3 per cent of participants rating gameplay as good or excellent and expert evaluators affirming the technical effectiveness of the mechanic. With regard to the second objective, a complete interactive horror game was developed under GDLC methodology, with all six development phases executed to yield a deployable executable distributed and evaluated with members of an online gaming community. With regard to the third objective, player visual aesthetic experience was quantitatively evaluated across five dimensions, revealing that environmental setting and animation quality were primary aesthetic strengths whilst colour tone calibration and menu usability were identified as priority areas for iterative improvement.

The key contributions of this work are threefold. First, this study provides an empirical dataset on player responses to LoS-based lighting in a horror game context, encompassing usability, visual aesthetic, and gameplay satisfaction measures obtained from a demographically relevant evaluation cohort. Second, a documented Blueprint-based implementation architecture for real-time LoS computation in Unreal Engine 4 is presented, applicable to independent and academic developers targeting dark environment horror game designs. Third, design recommendations are offered for single-player horror puzzle games, emphasising the importance of architectural familiarity, interactive narrative delivery through environmental exploration, and post-processing darkness calibration across hardware configurations.

Future work should address the identified limitations through a controlled between-subjects experiment comparing LoS-based lighting against a full-illumination condition to isolate the LoS contribution to immersion outcomes. Expanded level design with greater asset diversity and structural complexity would address the layout repetitiveness identified in both player feedback and expert assessment. Graduated enemy detection states with associated NPC behavioural response sequences would add strategic depth to the evasion mechanic. Integration of validated horror immersion instruments such as the GUESS or the Game Experience Questionnaire would enable cross-study comparability. Finally, multiplayer mode implementation would permit investigation of social horror dynamics (Kowert, 2020) within the established LoS framework, addressing the most consistently recommended enhancement from both player and expert evaluation. This study provides an empirical foundation for that future research programme and establishes that LoS-based dark environment lighting is both a technically feasible and experientially effective strategy for psychological horror immersion in academic game development contexts.

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Author Contribution

Heng Fuyen designed and developed the game, conducted user evaluation, and prepared the initial manuscript draft. Hamzah Asyrani Sulaiman supervised the research direction, guided the methodology and evaluation design, and critically reviewed and revised the manuscript.

Declaration of Generative AI in the Writing Process

During the preparation of this work, the author(s) used Claude (Anthropic) to improve the language, readability, and formatting of the manuscript. After using this tool/service, the author(s) reviewed and edited the content as needed and take(s) full responsibility for the content of the publication.

Data Availability/Supplementary Materials

The datasets used and/or analysed during the current study are available from the corresponding author on reasonable request.

Ethics Statement

This study involved 30 volunteer participants recruited through an online gaming community and two professional game developers who took part in expert interviews. The evaluation was conducted in 2021 as part of an undergraduate final year project, and formal approval from an institutional research ethics committee was not obtained at that time. Participation was voluntary. For participants under 18 years of age, permission was obtained verbally from a parent or guardian prior to participation; no written consent forms were used. The questionnaire was anonymous, no personally identifiable information was collected, and all data were reported in aggregate form only.

Conflict of Interest

The authors declare no conflicts of interest in relation to this work.

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