

SonicPlay: Bridging Accessibility and Game Development Through a Framework for Blind Players

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Highlights

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- Introduces a new iteration of *SonicPlay*, an Unreal Engine–based framework for audio-driven navigation in 3D games for blind players.
- Demonstrates that blind players achieve higher completion rates and more reliable navigation than blindfolded sighted players.
- Shows that professional game developers can understand and integrate the framework within limited production time.
- Bridges accessibility research and real-world game development through reusable, documented engine-level components.

SonicPlay: Bridging Accessibility and Game Development Through a Framework for Blind Players

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Abstract

This paper presents improvements to *SonicPlay*, an audio-based accessibility framework designed to support navigation and spatial orientation for blind players in three-dimensional games while remaining feasible for professional game development workflows. Rather than introducing new auditory interaction techniques, *SonicPlay* focuses on operationalization established accessibility principles into a reusable engine-level framework implemented in Unreal Engine. The framework provides modular blueprints, structured documentation, and a reference project to lower the barrier to integrating sound-based navigation systems in practice.

The proposed framework was evaluated through two complementary studies. A prototype game evaluation compared blind players and blindfolded sighted players navigating multiple game environments using the framework. The results show that blind players achieved substantially higher completion rates and adapted more effectively to the audio-driven navigation system, indicating that *SonicPlay* supports independent and reliable spatial navigation. A second study involved professional game developers who incorporated the framework into their own workflow. The developers were able to understand and apply *SonicPlay* within a limited time frame and reported high perceived usability, confidence in accessibility-related decisions, and willingness to adopt the framework in future projects.

Together, these findings demonstrate that *SonicPlay* successfully bridges accessibility research and production realities, offering a practical pathway

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to integrate audio-based accessibility into contemporary game development.

Keywords:

1. Introduction

Video games have for a long time been and continue to be the world’s largest entertainment medium, surpassing both film and music in cultural reach and economic impact. Today, nearly 40% of the global population engage in video games in some form, reflecting their growing importance not only as a source of entertainment, but also as a social, artistic, and technological platform. Games function as spaces for socialization, storytelling, creativity, and skill development, and they increasingly influence how people interact with digital systems more broadly. As such, access to games is not merely a question of leisure but of participation in contemporary digital culture.

Despite this ubiquity, millions of people remain excluded from fully participating in gaming experiences. An estimated 253 million people worldwide are blind or have low vision, and while precise figures for blind players are unavailable, the number is likely to be in the tens of millions [5]. For many of these individuals, games remain inaccessible due to the heavy reliance on visual feedback, interfaces, and mechanics that assume sight as a prerequisite for play. This exclusion persists even as audio technologies, spatial sound systems, and advanced interaction tools have matured significantly over the past decade.

Previous research has demonstrated that accessibility tools and design strategies exist for visually impaired players, but their implementation in mainstream games remains fragmented, inconsistent, and highly dependent on individual developer initiative [1], [3]. As a result, accessible experiences are often limited to experimental projects, niche titles, or isolated features, rather than being integrated as a standard part of the development process. The continued exclusion of blind players from mainstream gaming highlights a persistent disconnect between technological capability and industry practice. Modern game engines already provide sophisticated audio pipelines, spatialization tools, and scripting systems that could support non-visual play, yet these capabilities are rarely leveraged due to perceived barriers related to time, cost, expertise, and production risk.

In this article, we present a new iteration of the *SonicPlay* research

project, a framework designed to help bridge this gap by offering game developers an accessible, efficient, and cost-effective means of integrating sound-based navigation and immersion systems for blind players. Rather than proposing a bespoke or experimental solution, *SonicPlay* is built directly within Unreal Engine, aligning with tools and workflows already familiar to professional developers. The framework is accompanied by structured documentation and a ready-to-use example project, lowering the threshold for adoption and reducing the need for specialized accessibility knowledge.

To evaluate the effectiveness and practical viability of the framework, two complementary studies were conducted. The first compared blind players with blindfolded sighted players to assess the navigational design, the clarity of the auditory cues, and the overall immersive qualities of the system. The second study, which forms the core contribution of this journal, involved professional game developers integrating the proposed framework into real-world development contexts to evaluate its usability, flexibility, and feasibility under production constraints. For clarity, these two different methods and results sections, while the discussion and conclusion weave both together.

2. Related work

Research on game accessibility for blind and visually impaired players has grown significantly in the past decade, addressing both experiential and technical barriers to participation. Andrade et al. [3] provide an in-depth qualitative account of the lived experiences of blind players, identifying persistent challenges related to navigation, spatial awareness, and the overwhelming dominance of visual feedback in mainstream games. Their findings highlight how accessibility features are often retrofitted, incomplete, or dependent on external assistive technologies rather than being integrated into core game mechanics. Similarly, Agrimi et al. [1] present a comprehensive review of accessibility techniques for visually impaired players, concluding that although there are many technical solutions, ranging from audio cues to screen reader support, their adoption remains fragmented and inconsistent between commercial titles.

A substantial body of work has focused on audio-based and non-visual interaction as an alternative to visually dominant paradigms. Andrade et al. [4] demonstrate that echolocation-inspired auditory cues enable visually impaired users to acquire spatial knowledge of virtual environments, supporting independent exploration and the formation of mental maps. Picinali

et al. [11] further show that spatialized sound in auditory virtual reality allows blind users to construct reliable representations of architectural layouts, reinforcing the potential of sound as a primary navigational modality rather than a supplementary cue. Complementary research by Siu et al. [13] explores combined auditory and haptic navigation systems, demonstrating that non-visual interfaces can support navigation in complex virtual worlds when feedback is coherent and continuous.

Although these studies establish the effectiveness of audio-driven navigation, they are largely implemented as bespoke prototypes or experimental systems, often developed outside of mainstream game engines. As a result, their transferability to professional game development contexts remains limited. Few studies address how such systems can be packaged, documented, and integrated into real-world production pipelines without introducing excessive technical or organizational overhead.

Research on immersion and player experience further supports the relevance of coherent sensory feedback. Jennett et al. [8] argue that immersion emerges from consistent, meaningful interaction rather than visual fidelity alone. This perspective provides a theoretical foundation for audio-first game experiences, suggesting that accessibility-oriented design can maintain, or even enhance, player engagement when sensory feedback is well-aligned with gameplay mechanics.

Another relevant strand of research examines mixed-ability and asymmetric play. Gonçalves et al. [7] demonstrate that asymmetric roles in mixed-visual-ability games can still produce shared enjoyment, competence, and autonomy among players. These findings challenge the assumption that accessibility requires identical experiences for all players and instead emphasize equitable participation. Related work on empathy and perspective-taking in games further suggests that accessibility features can broaden the expressive and social potential of games rather than constrain them.

From a development and production perspective, several studies highlight structural barriers to the adoption of accessibility in practice. Research on industry-academia collaboration in software engineering by Marijan and Gotlieb [9] emphasizes that tools intended for professional use must prioritize usability, documentation quality, and minimal disruption to existing workflows. Despite the availability of advanced audio systems in modern engines such as Unreal Engine, accessibility features are frequently deprioritized due to time constraints, limited expertise, and perceived production risk. This gap between research prototypes and deployable tools remains a key obstacle

to broader adoption.

Taken together, existing research provides strong evidence that audio-based navigation and non-visual interaction can support blind players effectively. However, much of this work remains conceptual or implemented as isolated solutions, limiting its applicability to mainstream game development. There is a clear need for engine-level frameworks that operationalize established accessibility principles into reusable, well-documented components aligned with professional workflows. The proposed framework directly addresses this gap by translating research insights into a practical Unreal Engine framework that supports both player experience and production feasibility.

3. Prototype evaluation

We first present the methodology and results of the prototype evaluation. This is a test of the latest iteration of the technology to evaluate how players react to the latest iteration of the game prototype using *SonicPlay*.

3.1. Methodology

The prototype evaluation used the most recent *SonicPlay* iteration, incorporating several refinements and extensions since the previous work on the project [2]. Although the core design principles of the framework remained unchanged, the updated version reflects iterative improvements based on earlier testing and feedback. The foundational components of the system include an introductory monologue that communicates the rules, mechanics, and objectives of the experience; sonic feedback embedded within ground textures to convey surface changes and movement; audio cues triggered by wall collisions; and the use of spatial audio to support the players’ understanding of position, orientation, and movement within the environment. Central to the system is an adaptive sound cue intended to guide the player toward the level objective without relying on visual input.

Building upon this foundation, the latest iteration of *SonicPlay* introduced multiple enhancements aimed at strengthening spatial awareness and navigational clarity. These changes were informed by previous research that demonstrated that well-structured auditory feedback can effectively support spatial orientation and movement in virtual environments [4], [13], [11]. In particular, the adaptive navigation cue was redesigned to dynamically follow the player’s movement rather than being anchored to static checkpoints.

This approach ensures a continuous navigational reference that responds in real time to player positioning, reducing cognitive load, and minimizing the risk of disorientation.

In addition, a progression-based volume system was implemented to communicate proximity to the goal, allowing players to read distance through gradual changes in volume intensity. Directional awareness was further reinforced by introducing muffled audio when the player was oriented away from the target, encouraging active reorientation without explicit instruction. A responsive wall-sound system was also added, producing subtle auditory feedback as players approached obstacles, thereby enabling anticipatory navigation rather than reactive collision avoidance. Due to the discontinuation of the previously used acoustic model, the system transitioned to the built-in reverb functionality in Unreal Engine. This solution successfully replicated the intended environmental acoustics while ensuring long-term maintenance and engine compatibility.

To examine the robustness of the framework across varied contexts, two new levels were developed: one set in a forest environment and one in an urban setting. These levels were designed to introduce different soundscapes, material compositions, and spatial configurations, allowing the control test to assess how the proposed framework performs in different biomes and game-play scenarios.

The control test was conducted with a total of eight participants, consisting of four blind individuals and four sighted individuals wearing blindfolds to serve as a control group. This setup mirrored previous studies [2] and allowed for direct comparison between the groups of participants. The evaluation focused on two primary quantitative metrics:

- **Completion time** per level, with a maximum limit of five minutes.
- **Number of wall collisions** occurring during navigation.

These metrics were selected to capture both efficiency and navigational accuracy, providing insight into how effectively auditory signals supported independent movement through environments.

3.2. Results

The results of the prototype evaluation revealed a clear and consistent difference between the two participant groups, highlighting how prior experience with non-visual navigation influenced performance within the *Sonic-Play* framework. As illustrated in **Figure 1**, blindfolded sighted participants

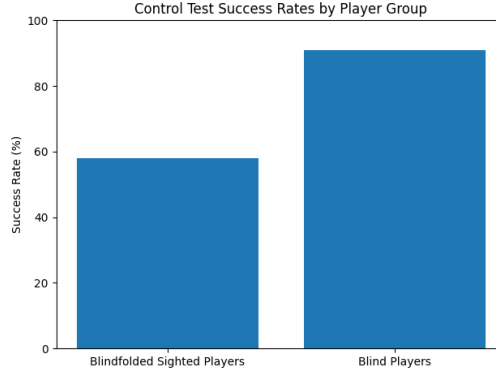


Figure 1: Caption

achieved a completion rate of 58% across the three test levels, while blind participants demonstrated a substantially higher success rate of 91%. This difference suggests that blind players were not only able to navigate the environments effectively using the auditory signals provided, but also adapted more intuitively to the underlying design logic of the system.

Across all levels, blind participants exhibited greater confidence in interpreting spatial audio, adaptive navigation cues, and environmental sound feedback. Observational notes indicate that blind players more readily trusted the audio-based guidance, maintaining forward momentum even in unfamiliar spaces. In contrast, blindfolded sighted participants frequently hesitated, paused to reassess orientation, or relied on trial-and-error movement patterns, particularly in the early stages of each level. These behaviors contributed to longer completion times and a higher frequency of wall collisions among the blindfolded sighted group.

Although one blind participant did not complete a level within the five-minute time limit, the majority of blind players finished comfortably within the allotted time. On average, blind participants also demonstrated shorter completion times than their blindfolded counterparts. While the sample size was too small to support statistically significant claims, the consistency of the observed trends across participants and levels strengthens the validity of the findings. The results align with previous research indicating that people who routinely rely on auditory information for spatial orientation often develop a heightened sensitivity to directional and environmental sound cues.

The wall collision data further supports this interpretation. Blindfolded

sighted participants tended to collide repeatedly with the same obstacles, suggesting difficulty forming stable mental maps of the environments. Blind participants were more likely to adjust their movement after an initial collision, using the responsive wall-sound system as a predictive rather than reactive cue. This indicates that the auditory feedback not only communicated the presence of obstacles, but also supported learning and adaptation over time.

Qualitative feedback collected during and after the test suggests that adaptive navigation cue played a central role in maintaining orientation. Blind participants frequently described the cue as a “constant reference” that reduced disorientation and allowed them to focus on exploration rather than recovery from navigational errors. The progression-based volume system was also noted as particularly effective in communicating proximity to objectives without explicitly revealing location, preserving a sense of challenge and discovery.

The introduction of multiple biomes appeared to have minimal negative impact on performance, indicating that the system generalized well across different soundscapes. While the forest level introduced more diffuse ambient noise and the urban level featured sharper, more reflective acoustics, blind participants were able to adapt quickly to these changes. This suggests that *SonicPlay*’s core design principles are robust to variations in environmental context, an important consideration for broader applicability.

Overall, the control test results indicate that the improved iteration of the proposed framework provides a coherent and accessible navigational experience for blind players. The higher success rate, reduced collision frequency, and faster adaptation observed among blind participants demonstrate that audio-first navigation systems can support independent exploration in three-dimensional environments. While blindfolded sighted participants were able to complete some levels successfully, their lower performance underscores the importance of familiarity with auditory navigation strategies.

4. Developer Evaluation

This section describes the methodology used to evaluate how well the new iteration of the *Sonic Play* framework supports developers in including this accessibility system in their games followed by the results of this test.

4.1. Methodology

To evaluate the *SonicPlay* framework from a production and usability perspective, a separate developer-focused study was conducted with two senior game developers from Snowcastle Games, an Oslo-based studio not affiliated with the project. Both participants had extensive professional experience with Unreal Engine and commercial game development, making them well suited to assess the framework’s practicality within real-world workflows.

Each developer received the latest version of the the proposed framework implementation guide, which included written documentation and a sample Unreal Engine project. They were first instructed to review the documentation and explore the example project to evaluate clarity, structure, and overall comprehensibility. Rather than following a rigid step-by-step tutorial, developers were encouraged to treat the example project as a showcase intended to demonstrate best practices and design intent, reflecting how such tools are typically encountered in professional settings. Developers were then given about two hours to test the example project for *SonicPlay* to determine if this would be adaptable to one of their own projects,.

The study design and data collection model were inspired by the industry–academia collaboration framework proposed by Marijan and Gotlieb [10], which emphasizes ecological validity, practitioner relevance, and iterative feedback over tightly controlled laboratory conditions. The framework is designed to support empirical evaluation of software engineering artifacts in real-world contexts, prioritizing usability, learnability, and integration effort as primary evaluation dimensions. Rather than isolating variables in artificial settings, the model encourages lightweight studies conducted within authentic workflows, allowing researchers to capture how tools are actually understood, adopted, and adapted by practitioners.

In its original formulation, the framework advocates close collaboration with industry partners, flexible study protocols, and qualitative data collection methods such as observation, reflective feedback, and practitioner self-reporting. These elements are intended to reduce disruption to professional workflows while still producing actionable insights into tool effectiveness and adoption barriers.

This framework was adapted to the context of accessibility-focused game development by tailoring the evaluation to Unreal Engine–specific workflows and time constraints typical of professional studios. Instead of long-term deployment, the study focused on short, time-bounded engagement with the the proposed framework, reflecting realistic scenarios in which developers

assess new tools during the prototyping or early design phases. Data collection emphasized time-to-understanding, qualitative feedback on documentation and blueprint structure, and developers’ perceived confidence in making accessibility-related decisions. By aligning the study design with the principles outlined by Marijan and Gotlieb while adapting them to the realities of game development, the evaluation aimed to balance methodological rigor with practical relevance. Data collection focused on two main dimensions: the **time required for understanding** and **qualitative feedback** related to usability, learnability, and perceived value. Qualitative feedback was further structured around four evaluation categories:

- **Readability and clarity** of the documentation and instructional materials.
- **Ease of implementation** and integration within existing Unreal Engine workflows.
- **Quality and relevance** of the guide provided and the example project.
- **General feedback and suggestions** for improvement and future development.

During the task, developers’ progress was observed informally, noting questions, points of hesitation, and deviations from recommended practices. Following implementation, developers completed their written responses and participated in reflective feedback, offering candid assessments of the framework. Their feedback addressed issues such as asset organization, blueprint reference, scope of documentation, and balance between guidance and flexibility. Developers also commented on how prior user testing with blind players increased their confidence in the framework, reducing the need for extensive internal accessibility testing.

In general, the developer evaluation was designed to assess not only whether *SonicPlay* could be implemented successfully, but also whether it meaningfully lowered the barrier to creating accessible navigation systems and increased developers’ confidence in making informed accessibility decisions within professional game development environments.

4.2. Results

The developer evaluation provided insight into the practical viability of the proposed framework within professional game development workflows.

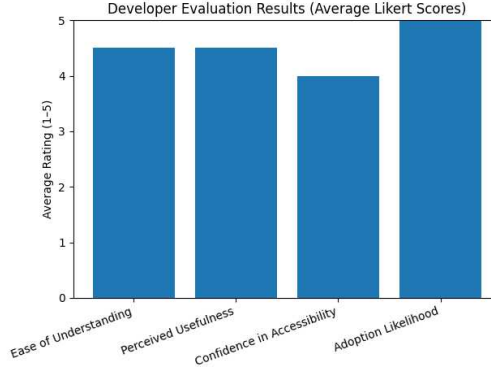


Figure 2: Caption

Both participating developers from Snowcastle Games successfully understood the framework within the allotted two hour time frame, meeting the predefined task objectives without requiring external assistance. This outcome supports the core goal of the framework of reducing the barrier to implementing accessible navigation systems in Unreal Engine.

Quantitative ratings collected through post-task surveys indicated generally high levels of perceived usability and usefulness. The developers rated the ease of understanding and overall clarity of the framework between 4 and 5 on a 5-point scale, with similar scores reported for perceived usefulness and confidence in accessibility-related design decisions. These ratings suggest that experienced developers were able to quickly form accurate mental models of the framework’s structure and intent, even without prior specialization in accessibility design.

Qualitative feedback further contextualized these scores. Both developers emphasized that the availability of concrete Unreal Engine blueprints was particularly valuable. Rather than abstractly presenting accessibility concepts, *SonicPlay* provided tangible, reusable components that could be inspected, modified, and extended. One developer noted that having “concrete code (blueprints)” significantly reduced uncertainty, making it easier to trust that the system was in line with established accessibility best practices.

A recurring theme in the feedback was the perceived time savings provided by the framework. The developers highlighted that previous testing with blind players, as documented in the framework materials, increased their confidence in the design decisions embedded in *SonicPlay*. This reduced the

perceived need for extensive in-house user testing in the early stages, allowing developers to focus on integration rather than validation. One participant explicitly stated that the framework felt like “a fantastic starting point” that could realistically be implemented within a single workday.

The developers also commented on how *SonicPlay* altered their perspective on accessibility. Both participants acknowledged that accessibility considerations are not typically foregrounded in their usual workflows and that the framework prompted them to think differently about navigation, feedback, and player orientation. Importantly, this shift was not described as disruptive. Instead, developers reported that the system was naturally integrated into existing Unreal Engine practices, reinforcing the idea that accessibility can be embedded rather than appended.

Beyond general positive reception, the developer test also highlighted several areas for improvement. Both participants noted that parts of the documentation could be clearer, particularly with respect to references to specific blueprints. One developer suggested that the asset structure felt fragmented and would benefit from consolidation into a single, clearly labeled folder. Another recommended clarifying that the example project was intended as a showcase rather than a step-by-step tutorial, as initial expectations influenced how the documentation was interpreted.

In particular, both developers expressed interest in the broader applicability of the proposed framework. One participant suggested that, if implemented elegantly, the system could also benefit sighted players by adding informational audio layers without breaking immersion. This observation aligns with universal design principles, suggesting that accessibility features need not be exclusive or segregated to specific user groups.

When asked about the likelihood that they would adopt this framework in their own games, both developers indicated a willingness to integrate the proposed framework into future projects, particularly during prototyping or early design phases. Their responses suggest that the framework successfully positioned itself as a practical tool rather than a purely academic artifact.

Taken together, the developer test results indicate that *SonicPlay* is not only technically feasible but also aligns well with professional expectations regarding usability, documentation quality, and integration effort. The combination of quantitative ratings and rich qualitative feedback provides strong evidence that the framework reduces the cognitive and practical barriers associated with the implementation of accessible navigation systems.

5. Discussion

In both studies, the results demonstrate that *SonicPlay* effectively addresses accessibility from complementary perspectives. The prototype evaluation confirms that blind players can navigate three-dimensional environments independently and efficiently using audio-driven systems, while the developer evaluation shows that such systems can be implemented within realistic production constraints. Together, these findings support the central premise of the project: that accessibility and practical game development are not competing priorities, but mutually reinforcing goals.

This stage of the research demonstrates that the proposed framework effectively addresses a longstanding gap between accessibility research and practical game development. The results of the prototype evaluation show that blind players are able to navigate three-dimensional game environments independently and efficiently using audio-based cues, while remaining immersed in the game world. At the same time, the developer evaluation indicates that the framework can be integrated into professional workflows without imposing excessive time, cost, or technical overhead. Together, these findings suggest that accessibility and production feasibility need not be competing priorities but can be meaningfully aligned through well-designed frameworks.

The player study highlights the effectiveness of *SonicPlay*'s core design principles. Blind participants consistently demonstrated higher completion rates, fewer navigational breakdowns, and faster adaptation compared to blindfolded sighted players. These results reinforce the importance of designing navigation systems that take advantage of auditory spatial cognition rather than trying to replicate visual paradigms through audio substitution alone. The adaptive navigation cues of the system, spatialized sound, and responsive environmental feedback collectively supported orientation, learning, and sustained engagement in varied soundscapes.

Equally important, the developer study confirms that the proposed framework is not only functional for players but also viable from an industry perspective. Professional developers were able to understand and apply the framework within a limited time frame and reported increased confidence in their ability to implement accessible navigation. Feedback emphasized the value of concrete Unreal Engine blueprints, prior validation through blind user testing, and the modular structure of the system. These elements reduced uncertainty and reduced the perceived barrier to incorporating acces-

sibility features into existing projects.

At the same time, the developer evaluation revealed clear opportunities for refinement. Participants identified the need for improved clarity in the example project structure, more consistent naming conventions for blueprints and assets, and clearer wording within the documentation and implementation guide. While these issues did not prevent understanding of the framework, addressing them represents an important next step in improving learnability, reducing initial friction, and supporting broader adoption. Future iterations of *SonicPlay* or similar work should therefore prioritize reorganizing structures, standardizing terminology, and refining documentation to better communicate design intent and usage expectations.

6. Conclusion and Future work

The results indicate that *SonicPlay* is both effective for blind players and practical for developers, offering a scalable approach to accessibility that aligns with principles of universal design. By addressing both the experiential needs of players and the technical realities of development, this work aims to advance inclusive game design and contribute toward a more equitable digital future in which no player is left behind.

Finally, future research will focus on fostering community engagement and long-term adoption. By encouraging developers to adopt, adapt, and contribute to the framework, *SonicPlay* can evolve in response to real-world use cases and diverse production contexts. In doing so, the framework aligns with the principles outlined in the European Accessibility Act [6] and contemporary work on the social accessibility of assistive technologies [12]. Through continued refinement and collaboration, *SonicPlay* contributes to a growing movement within entertainment computing that positions universal design as a fundamental expectation of digital play, ensuring that no player is excluded by default.

Acknowledgments

Writefull AI has been used as a proofreading and editing aid throughout the writing process¹. However, no part of the text can be considered "written by AI".

¹writefull.com

The rest of this section has been redacted for anonymization.

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