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Immersion by Design: Building a Spatial Audio Infrastructure for Media, Performance, and Pedagogy

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ABSTRACT

This paper offers a comprehensive account of the conceptualization, system design, and implementation of the spatial audio system integrated in the Enhanced Immersion Studio (EIS), a three-story spatial audio and media performance space at Arizona State University's Media and Immersive eXperience (MIX) Center. Designed as an experimental black box and a flexible educational venue, the EIS supports immersive audio creation, transdisciplinary performance, and public engagement. Developed through collaboration between the Sidney Poitier New American Film School faculty, MIX Center's leadership and staff, and architectural and systems integration teams, the EIS was conceived with a community-centered mission and pedagogical vision. The paper details the technical and architectural decisions that shaped the sound system design. Loudspeaker coverage density, spatial imaging needs, acoustic response considerations, and structural constraints were considered while maintaining flexibility for various uses, from spatial music performance and sound installations to immersive cinema and Extended Reality (XR) integration. We highlight early activations of the space, including student- and faculty-led immersive audio projects, as the first creative deployments of Spacemap multi-channel panning for egocentric and allocentric approaches in the EIS. These studies illustrate how spatial technologies and design influence creative approaches, learning outcomes, and collaborative workflows. By connecting system design choices to educational and artistic goals, the paper frames the EIS not only as a technical achievement but also as an evolving platform for immersive storytelling, cultural expression, and research innovation. The paper concludes with reflections on future directions for spatial audio education, community engagement, and the EIS infrastructure.

1 Introduction

In response to a rapidly evolving field, immersive audio environments have become increasingly central to contemporary media production, performance, and education. As universities invest in Extended Reality (XR) and media-rich infrastructure, the demand for flexible, pedagogically aligned spatial audio systems continues to grow. The Enhanced Immersion Studio (EIS), located within Arizona State University's

Media and Immersive eXperience (MIX) Center in Mesa, Arizona, USA, exemplifies this convergence of technical innovation and educational purpose.

Conceived as a three-story black box venue for immersive audio and media performance, the EIS was developed through a cross-disciplinary collaboration involving faculty from the Sidney Poitier New American Film School, MIX Center's leadership and staff, and architectural and systems integration teams. The studio's design reflects a community-centered mission and a commitment to hands-on learning, supporting both creative exploration and curricular integration.

This paper presents a detailed account of the EIS's spatial audio infrastructure, including its loudspeaker configuration, routing architecture, and integration of Spacemap multi-channel amplitude panning. It explores how egocentric and allocentric spatial frameworks [1] are embedded into the system's design and how these frameworks inform artistic practice and pedagogy. Through case studies of early activations—ranging from faculty-led installations to student-driven projects—the paper illustrates how spatial audio tools shape collaborative workflows, immersive storytelling, and educational outcomes.



Figure 1. ASU's Enhanced Immersion Studio (EIS)

2 Design Motivation and Collaborative Context

The Enhanced Immersion Studio was envisioned as a space where immersive audio could serve not only as a technical medium but as a catalyst for creative exploration, interdisciplinary collaboration, and pedagogical innovation. Its development was driven by a shared belief that spatial sound has the power to transform how stories are told, how knowledge is conveyed, and how communities engage with media.

Building on this vision, EIS reflects the institution's broader commitment to integrating emerging technologies into education and public-facing research and creative work. The MIX Center was designed to foster innovation across film, media arts, design, and XR. Within this context, the EIS was conceived as a cornerstone of that mission: a venue where immersive media, with a strong emphasis on audio, could be explored through both experimental and structured approaches.

Developed through a collaborative process shaped by expert input and guided by ASU leaderships' vision, the EIS was conceived to support a wide range of users, from students learning the fundamentals of immersive media and spatial audio to artists and researchers developing and investigating complex, multi-layered sound environments. The design process prioritized flexibility, accessibility, and creative freedom, ensuring that the EIS could evolve alongside the needs of its diverse set of users.

Beyond its technical capabilities, the EIS was shaped by a pedagogical vision. The goal was to embed immersive media performance and installation into curriculum delivery, foster hands-on learning, and support projects that address cultural, ecological, and social themes. Early activations of the space, including faculty-led installations and student showcases, reflect this ethos. These projects demonstrate how spatial audio can be used to amplify underrepresented voices, explore complex narratives, and cultivate immersive media literacy.

3 Egocentric and Allocentric Frames of Reference

Spatial audio systems can be understood through egocentric and allocentric frames of reference [1]. Egocentric approaches strive to create consistent spatial experiences for all audience members, regardless of their location within the listening area—the prevailing model in cinema and broadcast. Allocentric approaches ground sound objects relative to architectural features, with audience members experiencing unique spatial relationships depending on their position and movement within the environment. The Enhanced Immersion Studio was designed to accommodate both frames of reference in practice.

4 System Design

The EIS provides a 19.7 × 17.0 × 9.75 m volume for loudspeaker placement, accommodating existing infrastructure. Forty-nine point-source loudspeakers and six subwoofers form a coverage pattern balancing high-resolution lateral control with immersive overhead imaging. Placement followed the hemispherical projection model to preserve consistent angular spacing, with refinements to lateral spacing improving panning uniformity near room edges.

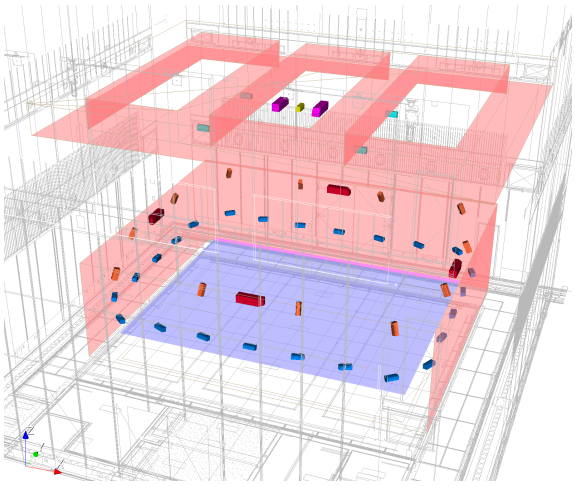


Figure 2. EIS Loudspeaker Positions

The lowest layer, positioned near listener height, was designed with the highest horizontal resolution, with loudspeakers spaced at approximately 15-degree intervals. The second layer, mounted just below the first catwalk, offers a resolution of roughly 30 degrees, while the third layer, placed closer to the truss grid, is spaced at 45 degrees. A quad set of loudspeakers is mounted directly overhead, surrounding a central zenith speaker that anchors the vertical axis. Vertical angles shown in Table 1 are calculated from a seated listener at the room center (ear height 1.22 m, represented by the purple plane in Figure 2) and averaged across each layer.

Layer	Qty	Elevation (m)	Hor. Spacing (°)	Mean vertical angle (°)
1	24	2.20	15	16.33
2	12	4.27	30	31.09
3	8	7.85	45	48.80
Overhead quad	4	9.35	90	67.55
Zenith	1	9.90	N/A	90.00

Table 1. Point Source Loudspeaker Distribution

Two operating modes were implemented for timing. In one, output delays align all loudspeakers to an idealized hemisphere, supporting amplitude-based spatialization techniques such as Spacemap. In another, delays are bypassed to preserve the architectural time-of-arrival relationships among loudspeakers. Internal bass management was configured to extend low-frequency response through subwoofers installed on five walls and the ceiling, with a sixth subwoofer dedicated to low-frequency effects.

The lowest loudspeaker layer is mounted at 2.2m to allow unimpeded egress beneath the array in circulation areas while maintaining consistent speaker density around the room perimeter. Its high density enhances horizontal spatial resolution and takes advantage of the superior localization acuity in the horizontal plane compared to vertical [2]. These speakers provide 50° of vertical coverage and are installed with a 7° downtilt. Given this, corner loudspeakers experience approximately 15 dB of level attenuation at the opposite corner of the room. To extend coverage for lateral sources and support egocentric imaging across a larger shared listening area, a second layer of twelve loudspeakers was installed at 4.27m beneath the existing catwalk, reducing attenuation to the opposite corner to about 8 dB. Two additional overhead layers were positioned at higher elevations to provide vertical resolution and support overhead perception. The attenuation from the third layer's corner loudspeaker to the opposite corner is about 4 dB.

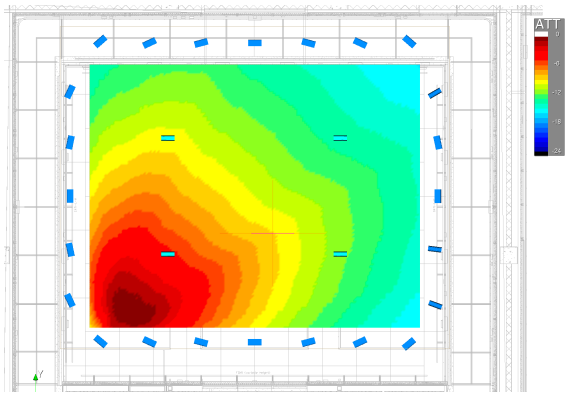


Figure 3. First Level Corner Loudspeaker Coverage

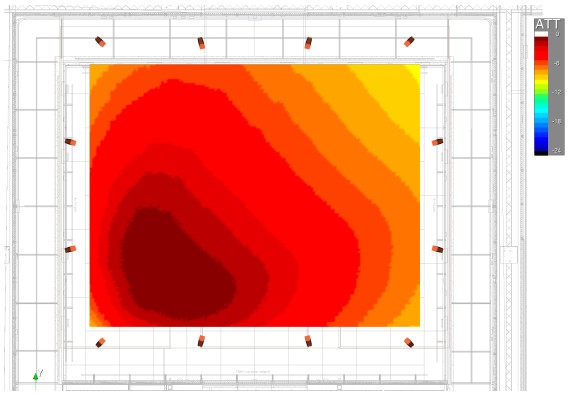


Figure 4. Second Level Corner Loudspeaker Coverage

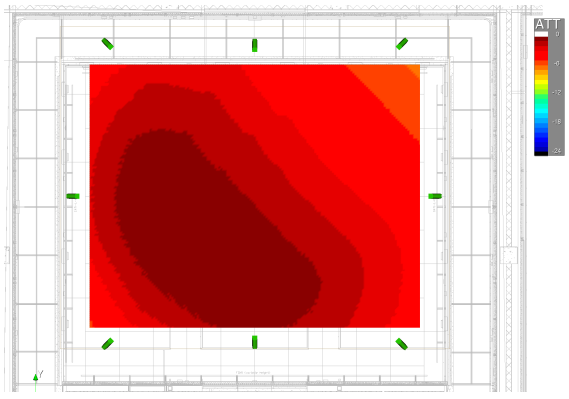


Figure 5. Third Level Corner Loudspeaker Coverage

This approach differs from cinema systems such as Dolby Atmos, which position side surround speakers in a straight line from the screen speakers (at approximately two-thirds screen height) to rear surrounds (recommended at one-quarter of auditorium width), typically mounting lateral speakers well above ear level [3]. The EIS design provides denser lateral resolution at near-ear heights while maintaining transitions to overhead movement.

A key design goal was to deliver audio from multiple sources to every loudspeaker with lossless, low-latency performance. All routing is carried over Milan AVB, which provides deterministic timing and identical latency across the system. Each self-powered loudspeaker connects directly as a Milan AVB endpoint, eliminating external interfaces and analog conversions. The network uses a distributed star topology, placing AVB switches near loudspeaker groups to reduce cabling compared to conventional point-to-point layouts. This architecture enables individual addressing of each loudspeaker while maintaining consistent system timing.

A Meyer Sound NADIA-CP processor manages routing and distribution as the central hub of the network. All audio I/O is carried via Milan AVB, providing deterministic, low-latency transport with fixed timing across the system. The processor supports 128 inputs and outputs and includes embedded Spacemap processing for direct spatial panning. Its dual-matrix architecture allows upstream tools such as SPAT Revolution to address individual loudspeakers using approaches including Ambisonics transcoding and other delay- and gain-based panning methods. Spacemap operates within the first matrix, while a separate delay-and-gain matrix manages timing and routing to the loudspeakers. This design enables embedded Spacemap processing to operate concurrently on additional sources, allowing multiple spatialization methods to coexist within the system. The infrastructure also provides a pathway to Active Acoustics [6,7], with loudspeaker placement and the Milan AVB network designed to support both immersive audio and electronically adjustable room acoustics.

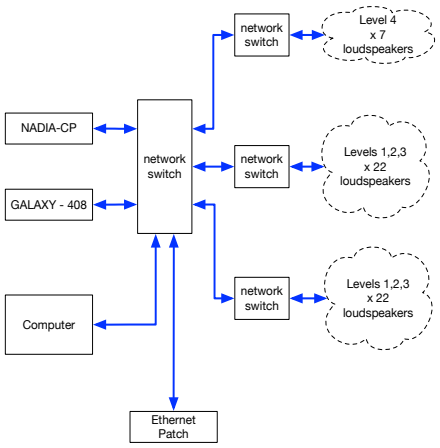


Figure 6. AVB Network

5 Spacemap Multichannel Panning

Spacemap, first commercialized in 1993, is a multichannel amplitude panning algorithm that serves as the primary spatial interface for the EIS. It distributes power to nodes arranged in a triangular mesh, with power within each triangular region ("Triset") apportioned to three member nodes via areal barycentric coordinates. These nodes may represent individual loudspeakers ("Speaker Nodes"), groups of loudspeakers ("Virtual Nodes"), or null positions ("Silent Nodes"). The algorithm maintains constant power while providing continuous control and scales from small systems with only a few loudspeakers to installations with more than a hundred. Spacemap also provided the model for MIAP (Manifold-Interface Amplitude Panning), later implemented for Max and Pure Data [4,5].

Conventional panning interfaces typically represent the sound object placement with respect to a forward-facing torso icon. Spacemaps can also be configured for a front-facing mix surrounded by loudspeakers. This approach is emblematic of egocentric spatial mixing. However, Spacemaps can also be configured for subsets of the system. In this case, a central torso icon is not the guide; rather, the triangular mesh itself serves as the spatial reference. Spacemap Go, a dedicated iPadOS app, serves as the primary user interface, offering control over multi-channel routing and spatial movement. Object position can also be controlled via Open Sound Control (OSC), supporting both real-time manipulation and automated scene transitions from DAWs such as Pro Tools, Ableton Live, and Logic Pro X.

In the EIS, custom Spacemaps mirror the multi-layer loudspeaker geometry, including lateral-only, overhead-only, full-surround, and individual-wall configurations. These Spacemaps represent different loudspeaker subsets for content-specific spatial control. This manifold abstraction supports allocentric design strategies by allowing users to directly address specific architectural elements - such as individual walls or overhead arrays, enabling sound objects to be anchored to areas of the room where, for instance, satellite video screens may be installed.

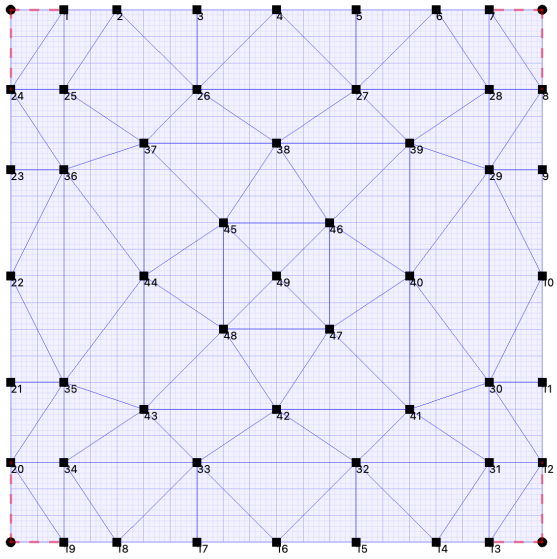


Figure 7. Spacemap, All Loudspeakers, Top-down

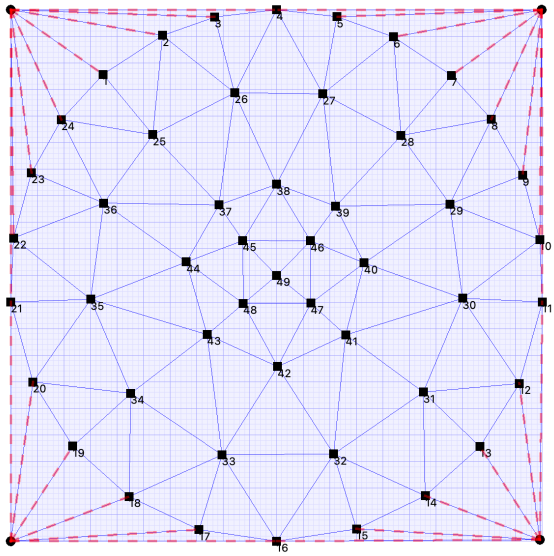


Figure 8. Spacemap, All, Circular Projection

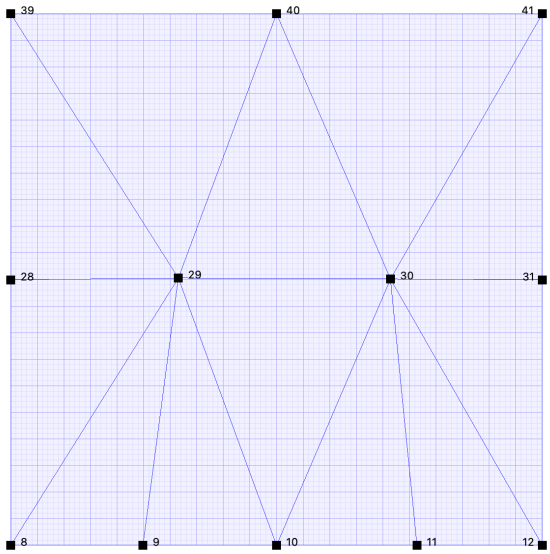


Figure 9. Spacemap, East Wall

6 Creative Activations

In its first year of operation, the Enhanced Immersion Studio has enabled a wide range of creative activations, each illustrating how spatial audio infrastructure can influence artistic expression, collaborative workflows, and pedagogical engagement. From faculty-led immersive installations to student-driven showcases, the EIS has served as both a technical platform and a conceptual laboratory, allowing users to explore, on an embodied and large scale, how spatial design informs narrative, perception, and audience experience.

From a creative standpoint, the EIS has become an evocative sonic canvas [8], where the exploration of sound in space transcends the technical craft of spatial audio. It evolves into a holistic creative-pedagogical ecosystem, one in which space is not merely a physical environment but an emotionally and imaginatively constructed field. This reinforces the notion that space is not just physically occupied but emotionally and imaginatively constructed [9].

Lamentation at the Liesbeek: A Spatialized Act of Resistance

One of the earliest immersive sound projects in the EIS was *Lamentation at the Liesbeek* [10]: an interdisciplinary installation and documentary hybrid co-created by ASU faculty, students, and South African artists and Indigenous collaborators [8]. This installation combined immersive sound design with visual and poetic elements to explore themes of colonial violence, Indigenous resilience, and ecological justice. Using allocentric spatial storytelling, sound objects were anchored to architectural elements in the space, transforming listeners' perception based on their orientation and movement. The sound design process was purposefully sound-driven, reversing the usual media production logic where visuals guide audio. This process-oriented, sound-first approach aligns with a lineage of multisensory experimentation in media architecture. Early examples, such as Le Corbusier's Poème Électronique, demonstrated how spatialized sound, visuals, and architectural design could converge to explore new modes of sensory engagement. In a contemporary context, Lamentation at the Liesbeek leverages tools like Spacemap Go and object-based audio to pursue similar questions, foregrounding immersive sound as both a narrative framework and a spatial composition strategy.

The installation featured five custom-designed screens arranged to emulate the flow of the Liesbeek River. The sonic composition incorporated field recordings, breath performances, chants, ritual lamentations, and spatialized textures—layered using a beds-and-objects approach rendered through Spacemap Go and amplitude panning across the 49-speaker system. The experience culminated in a "click symphony" constructed from Khoekhoe click consonants, co-created with South African partners

[8]. Rather than a passive archival gesture, the clicks were transformed into living, spatialized sonic expressions, amplifying Indigenous agency through immersive sound, giving spatial form to historically silenced voices.

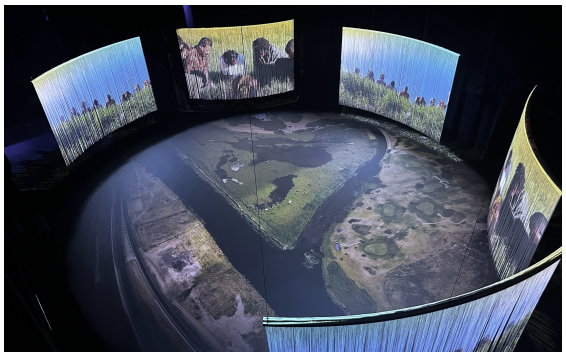


Figure 10. Lamentation at the Liesbeek Installation

Technical Infrastructure and Creative Flexibility

For the object-based approach, additional sound objects were programmed with custom Spacemap Go trajectories that engaged the entire loudspeaker array. These trajectories allowed for both precise vector panning and generative spatial behavior. As each trajectory was independent of the sound file, playback loops would begin from different positions in the array, encouraging audience movement and ensuring each visit provided a unique auditory path through the installation. This method enhanced the installation's immersive potential by blending deterministic design with real-time variation, expanding the sonic narrative across both physical space and time.

To support the screen configuration, five independent LCR Spacemaps were created, each corresponding to a projection surface, and mirrored within Pro Tools using folder track structures. Pre-produced stems—ranging from First-Order Ambisonics (1OA) to 9.1.6 and stereo beds—were layered into the installation. The infrastructure's flexibility allowed both egocentric (uniform) and allocentric (site-based) spatial strategies to coexist. This approach, which emphasized the exploration of spatial subsets, fostered a nuanced spatial understanding that is more fully realized within a system of this scale.

This creative capacity is embedded within the broader MIX Center ecosystem, which includes two Dolby Atmos theatrical screening rooms, three 5.1 and 7.1.4 mixing rooms, and a 19-speaker immersive studio-classroom and research space. The proximity and accessibility of these spaces allow artists to pre-produce, preview, and deploy spatial content within the same building, accelerating iteration, workflow design and pedagogical integration.

7 Pedagogical Impact and Experiential Learning

The Enhanced Immersion Studio (EIS) fosters an educational environment where students are not merely learning about immersive audio, they are actively shaping it. In these experiential settings, students become authors of their own inquiry, engaging with immersive media as a mode of expression, analysis, and transformation. They take on roles as authors, designers, and collaborators, assuming creative and conceptual agency in the learning process. This model resists the traditional "banking" concept of education, where knowledge is deposited into passive learners. As Paulo Freire asserts, "The more students work at storing the deposits entrusted to them, the less they develop the critical consciousness which would result from their intervention in the world as transformers of that world. The more completely they accept the passive role imposed on them, the more they tend simply to adapt to the world as it is and to the fragmented view of reality deposited in them" [11]. The EIS instead becomes a site for what Freire calls liberatory education, where learning functions not to reinforce conformity but to cultivate creative freedom and critical engagement. The following examples illustrate how this philosophy has taken shape through student-centered immersive audio projects at the Sidney Poitier New American Film School throughout the MIX Center.

This progression can be traced in earlier teaching and learning strategies outlined in our 2021 AES case study, which explored transdisciplinary, student-centered audio workflows across film and music composition courses during COVID-era remote learning [12]. There, the emphasis was on cultivating agency and critical engagement through collaborative post-production environments in Film. Now, with access to advanced spatial infrastructure like the Dolby Atmos workflows, and the EIS, these principles have evolved into place-based immersive pedagogy, where students experiment with tools like Spacemap Go, SPAT Revolution, larger scale loudspeaker arrays, and object-based audio in media, performances and installations.

Lamentation at the Liesbeek as Transmedia Learning Environment

Lamentation at the Liesbeek also serves as a pedagogical example of transmedia collaboration and mentorship, functioning simultaneously as a spatialized sound installation and a Dolby Atmos documentary, bridging multiple media platforms through a unified transmedia narrative design. The sound design team included one PhD student and one undergraduate, both of whom were offered a rare opportunity to engage with a multifaceted spatial workflow, from sound sourcing and poetic adaptation to Spacemap trajectory authoring and site-based deployment. Through this process, students explored the potential of allocentric storytelling, working across documentary, installation, and ritual performance as immersive narrative formats.

The "Immersive Aspects of Sound" Course

The *Immersive Aspects of Sound* course has become a curricular anchor for these practices. Within this class, students explore immersive storytelling through diverse formats—VR/XR, cinematic sound, spatial audio drama, and sound installation—developing a sonic language of space as part of their creative toolkit. For their Fall 2024 semester midterm, students designed and deployed site-specific Halloween-themed sound-only installations, exhibited in the EIS and open to the public. The event connected students' creative output to the local Mesa public, reflecting the MIX Center's mission of community engagement.

Students were organized into interdisciplinary groups, taking on roles such as field recordists, writers, editors, and spatial audio designers. Using technology as a support, they learned to design space as a compositional element, where the sonic canvas is understood not just as spatially dynamic but imaginatively charged [8]. Their commitment extended beyond the classroom: several groups created original posters and installation marketing materials unprompted, illustrating a high degree of ownership and creative immersion in the process.

EIS as a home for Interdisciplinary Collaboration

Final projects for the Immersive Sound class and research groups under the Sonora Immersive Audio Lab at ASU were exhibited during the Spring 2025 MIXibition, in collaboration with the *Design & Prototyping 360 Degree Immersive Spaces* class. These showcased how spatial sound education can foster transdisciplinary storytelling: *Harmony of the East* fused Chinese and Indian cultural symbols through synchronized visuals and egocentric spatial mixing, with allocentric cues rewarding audience movement. *Golden Record* imagined an alien encounter with Earth's sonic legacy via Voyager, using ambient textures and orbital trajectories to evoke scale and mystery. *Fading Corals* offered a spatialized underwater journey exploring climate impact on coral ecosystems, with immersive beds and dynamic panning used to guide the listener's body and attention. Each project utilized the EIS's real-time control and object-based panning capabilities, providing a practical platform where technical fluency and creative authorship intersected.

These educational activations underscore the pedagogical value of a spatial audio infrastructure that is flexible, participatory, and intellectually generative. Students engage with the EIS not merely as operators of technology, but as authors of space, articulating spatial intent, making design decisions based on narrative and emotion, and switching between egocentric and allocentric frameworks as expressive tools.

By embedding immersive spatial audio into curriculum across disciplines within the Herberger Institute for Design and the Arts, ASU cultivates immersive media literacy while preparing students for emerging roles in film, XR, performance, and installation art. The system's adoption by faculty, researchers, and students confirms its efficacy not just as a technical environment, but as a transformative pedagogical platform for storytelling and cultural engagement.

8 Future Developments and Scalability

The EIS infrastructure was designed with expansion capabilities in mind. The NADIA-CP processor's 128-input/128-output capacity currently supports the 49-point source loudspeakers and six subwoofers and has the capacity to add more in the future, such as on the floor. Future developments may include integration with Active Acoustics processing for electronically adjustable room acoustics. The system's Milan AVB networking foundation ensures compatibility with emerging spatial audio formats and provides pathways for remote collaboration workflows. As spatial audio techniques continue to evolve, the EIS serves as a testbed for new approaches to immersive storytelling and

pedagogical applications, with the flexibility to adapt to technological advances while maintaining its core educational mission.

From a research standpoint, the EIS provides fertile ground for exploring underexamined art forms while equipping students for emerging industry roles. Its flexible, high-resolution spatial configuration enables investigations into auditory perception across diverse contexts, supporting studies on spatial awareness, perceptual engagement, and the sensorial impact of immersive environments. As such, the EIS functions not only as a creative and pedagogical platform, but also as a site for advancing sound perception and media research.

9 Conclusions

The Enhanced Immersion Studio (EIS) represents a convergence of architectural foresight, technical precision, and pedagogical vision. Its spatial audio infrastructure was designed with deliberate attention to how sound behaves in space, how users engage with immersive tools, and how the system can support educational, research and artistic goals. By supporting authoring from both egocentric and allocentric frames of reference, the EIS accommodates a broad spectrum of creative practices, from uniform audience experiences to exploratory, site-responsive installations.

The system's layered loudspeaker configuration, AVB-based routing, and Spacemap integration provide a foundation for immersive storytelling, collaborative research, and hands-on learning. Students and faculty alike have used the space to explore spatial intent, refine technical workflows, and produce works that reflect cultural, ecological, and speculative themes. These activations demonstrate that spatial audio is not just a technical domain—it is a medium for inquiry, expression, and community engagement.

As immersive media environments become more central to academic and public institutions, the EIS offers a model for how spatial audio infrastructure can be integrated with curricular, cultural, and inquiry-based objectives. Future developments may include audience perception, remote collaboration, electronically adjustable acoustics, and expanded interoperability across XR platforms.

More broadly, immersive sound in this context becomes a practice of embodied spatial engagement, enhancing not only aesthetic experiences, but also critical listening, reflection, and pedagogical depth. Sonic immersion in cinema and media is not merely acoustic or aesthetic, but experiential and transformative, positioning the listener as a co-author of meaning and space [13,14]. The EIS thus offers a platform for such transformative engagement, bridging spatial audio education, research, and creative practice in ways that center experience, authorship, and agency.

This pedagogical and experiential framework also aligns with Lee's proposed conceptual model of immersive experience in extended reality (XR) [15]. By centering embodied spatial engagement through sensorimotor interaction, the EIS enables Sensorimotor Engagement and fosters a strong sense of Physical Presence. Simultaneously, its emphasis on narrative sound design and student-driven storytelling cultivates Narrative Engagement and deeper Involvement, supporting Task/Motor Engagement and Social/Self Presence, particularly in collaborative or community-centered projects. Its capacity for both allocentric and egocentric spatial design further amplifies interactivity and internal reference, allowing students to co-create meaning through sound. In this way, the EIS delivers a layered and holistic immersive experience, where technical infrastructure and conceptual depth converge to foster presence, agency, reflection, and creativity in immersive media environments.

References

[1] S. Ellison and R. Schwenke, "Integrating Spatial Audio with Active Acoustics Through the Lens of Egocentric and Allocentric Frames of Reference," *Proceedings of the Institute of Acoustics* vol. 47, no. 1 (2025).

[2] D. W. Grantham, "Auditory spatial resolution in horizontal, vertical, and diagonal planes," *J. Acoust. Soc. Am.*, vol. 114, no. 2, pp. 1009-1022 (2003).

[3] Dolby Laboratories, "Dolby Atmos Specifications Issue 4" (2024). [Online]. Available: https://professional.dolby.com/siteassets/cinema-products—documents/dolby-atmos-

specifications.pdf

[4] Z. Seldess, "MIAP: Manifold-Interface Amplitude Panning in Max/MSP and Pure Data," 137th Convention of the Audio Engineering Society (2014).

[5] E. Bates, "SpaceMaps, Manifolds and a New Interface Paradigm for Spatial Music Performance," BEAST FEaST 2015. Birmingham (2015).

[6] M. A. Poletti, "Active Acoustic Systems for the Control of Room Acoustics," Keynote, Proceedings of the 10th International Symposium on Room Acoustics (ISRA), Melbourne, Australia (2010)

[7] S. Ellison and R. Schwenke, "The Case for Widely Variable Acoustics," Proceedings of the 10th International Symposium on Room Acoustics (ISRA), Melbourne, Australia (2010).

[8] R. Meirelles, S. Ortel, C. Yang, and M. Keita, "Redefining Spaces: Immersive Storytelling through Multi-Screen Media and Spatial Sound – A Case Study of Lamentation at the Liesbeek," SOCIETY. SPACES.SCREENS, Conference Proceedings (2024).

[9] G. Bachelard, M. Jolas, and J. R. Stilgoe, *"The Poetics of Space: The Classic Look at How We Experience Intimate Places,"* Beacon Press, Boston (2009).

[10] M. Espinosa and S. Matchett (dirs.), *Lamentation at the Liesbeek*. Featuring T. Jenkins, N. Callahan, and R. Abraham, Arizona State University & University of Cape Town (2024). https://asuevents.asu.edu/event/lamentation-liesbeek?id=0/?eventDate=2024-11-08

[11] P. Freire, The Pedagogy of the Oppressed," translated by Myra Bergman Ramos, 30th anniversary edition Continuun: NY (2005)

[12] R. Meirelles, F. Navarro, and J. Cedanna, "Transdisciplinarity in Sound Design and Music Composition for Film Post-Production: An Experiential Remote Learning Case Study," presented at the Audio Engineering Society Convention 151, Paper 21527 (2021).

[13] R. Carreiro, D. Opolski, and R. Meirelles, A Imersão Sonora no Cinema. São José dos Pinhais, PR: Editora Estronho e Esquesito (2022).

[14] R. Carreiro, D. Opolski, and R. Meirelles, "Sound of Metal," Music, Sound, and the Moving Image, vol. 17, no. 2, pp. 111–135 (2023). https://doi.org/10.3828/msmi.2023.9

[15] H. Lee, "A Unified Conceptual Model of Immersive Experience in Extended Reality," Computers in Human Behavior Reports, vol. 18, 100663 (2025). https://doi.org/10.1016/j.chbr.2025.100663