Immersive Open Studio: Shared Space, Shared Sound

Sunshiyu Wang*
swang3214@gatech.edu
Georgia Institute of Technology
Atlanta, United States

Changda Ma*
cma326@gatech.edu
Georgia Institute of Technology
Atlanta, United States

Canting Zhu*
czhu348@gatech.edu
Georgia Institute of Technology
Atlanta, United States

Gibran Mobarak*
gmobarak3@gatech.edu
Georgia Institute of Technology
Atlanta, United States

Henrik von Coler*
hvc@gatech.edu
Georgia Institute of Technology
Atlanta, United States

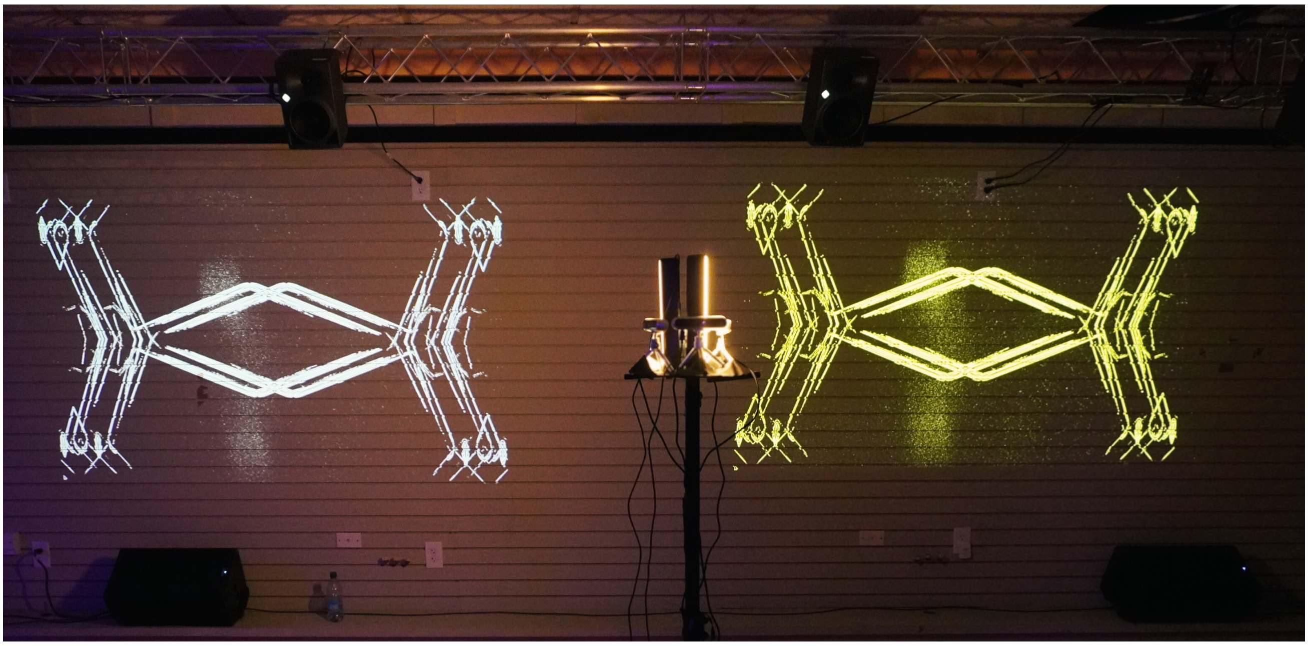

Figure 1: *Since Everyone's a DJ* installation at The Underground Atlanta.

Abstract

We present Immersive Open Studio, an artistic concept built around a course-based shared public space with a spatial-audio infrastructure. Realized at The Underground Art Center in downtown Atlanta, the studio is designed to support multiple student group projects for public presentation. We transported a 32-channel loudspeaker system from the Georgia Institute of Technology and reinstalled it in this public setting, creating a sustainable, repeatable spatial-audio infrastructure for interactive audiovisual projects, which was tested by real-world contingencies. As a case study within our student interactive projects, we dive deeper into *Since Everyone's a DJ*, which integrates camera-based body tracking to support collaborative and accessible electronic music performance within the immersive environment. Overall, this paper documents the realization of a course concept, provides an example of reusable infrastructure for multiple artistic projects, and examines how a public-facing spatial-audio environment supports audience engagement. More broadly, the project outlines a path for bridging technical infrastructure with collaborative artistic practice and public experience, establishing a foundation for future work in this area.

Keywords

Spatial Audio, Immersive Installation, Interactive Music Systems, Participatory Performance, Public Space

1 Introduction

Across current audiovisual art practices, spatial audio has become an increasingly popular component, but it still faces limitations due to its complex and resource-intensive build and deployment. Spatial audio systems are usually designed for a single work as one-off installations and are often implemented in conventional venues or laboratory settings, rather than in sustained, publicly accessible contexts. Those limitations not only narrow the range of use cases for spatial audio, but also constrain its broader public adoption and accessibility. This leaves room for exploring an artistic concept that integrates spatial audio into a shared public space for both artists and audiences.

These limitations point to a broader challenge in spatial audio practice: how can immersive audio infrastructure support

*All authors contributed equally to this research.

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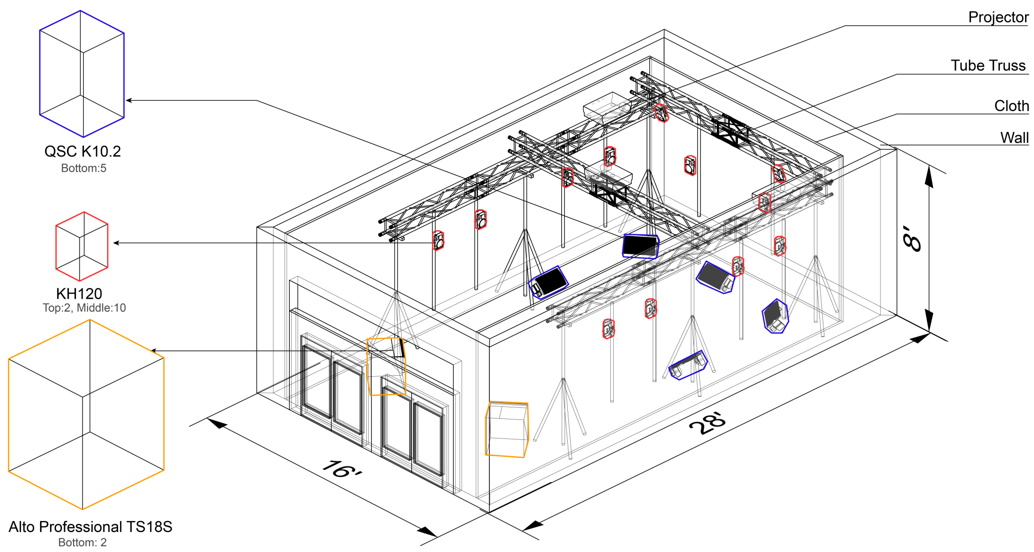

Figure 2: Tunnel Dimension.

multiple works, multiple artists, and repeated public engagement rather than functioning as a one-time technical solution? When spatial audio systems are treated as reusable creative platforms, they can expand the range of artistic possibilities while reducing the technical burden placed on individual artists. This approach also creates opportunities for audiences to encounter spatial audio in more informal and publicly accessible settings, allowing immersive sound to become part of a shared cultural environment rather than an isolated specialist experience. In this sense, spatial audio is not only a technical format, but also a social and spatial practice shaped by where it is installed, who can access it, and how it supports participation.

In this paper, we present *Immersive Open Studio*, a course-based concept realized through a shared spatial-audio infrastructure at the Underground Atlanta. The infrastructure includes a three-layer loudspeaker system, signal patching, and camera setup, designed as a reusable, general-purpose platform for interactive artistic work. Between October and November 2025, we hosted weekly public showcases featuring five student projects: *Immerge*, *Since Everyone's a DJ*, *Audenie*, *MACHINA*, and *Data Mirror: Fragmented Projections of Oneself*. These works were created by five groups of students from Georgia Institute of Technology, totaling 16 members. Each project explored a distinct interactive artistic idea while building on our shared Immersive Open Studio infrastructure [5, 10, 12, 13].

Rather than selectively focusing only on a single artwork or technical system, we examine the relationship between infrastructure, pedagogy, artistic production, and audience engagement. After introducing related work in Section 2, we document the infrastructure design, concept, and technical setup in Section 4, and briefly discuss the artistic works developed within it. In Section 4, we examine one of these works as a use case: *Since Everyone's a DJ*, a multi-user, DJ-inspired immersive audiovisual piece. By analyzing Immersive Open Studio and its use case, we show how our concept is realized in practice and how this realization shapes both artistic presentation and public engagement.

2 Related Work

A recurring goal in many artistic installations and interactive systems is to foster participant engagement and interpersonal connection. In audio and music contexts, this goal has often been explored through group-oriented systems that support shared participation, co-creation, and collaboration among multiple participants. In developing our immersive open studio, we reviewed research on prior installations and interactive systems that align with our focus on collaboration, shared experience, and reusable infrastructure. *Jam-O-Drum* is an early multi-user system that embodies this idea by allowing up to six participants to collaboratively improvise with drums through a shared tabletop interface. It lowers the entry barrier for musically untrained users while encouraging social engagement within the group [2].

Beyond percussion-based collaboration, subsequent tabletop systems explored how tangible objects and shared visual surfaces can support richer forms of co-located music-making. The *reacTable*, for example, is an interactive musical system that emphasizes collaboration and social connection by allowing multiple users to manipulate physical objects on a shared tangible interface. These objects represent sound generators, effects, and control modules, enabling participants to collectively shape the musical output in real time [6]. Similarly, *ToneTable* supports collaborative music-making through physical interaction with a shared tabletop surface. Rather than assigning explicit roles to individual users, it allows multiple participants to co-perturb a shared virtual fluid surface, with collaborative behaviors emerging from the dynamics of the medium itself [3].

Other systems extend collaborative music-making beyond a single shared surface. *Daisyphone* is a collaborative environment for remote group music improvisation that allows distributed users to create and modify short looping patterns in real time. The system uses a client-server architecture, in which up to ten clients exchange note events and graphical annotations through a central server [4]. Body movement has also emerged as an important interaction mechanism in collaborative musical systems. For example, *The Music Room* maps couples' body movements and dance gestures to real-time music generation, treating bodily

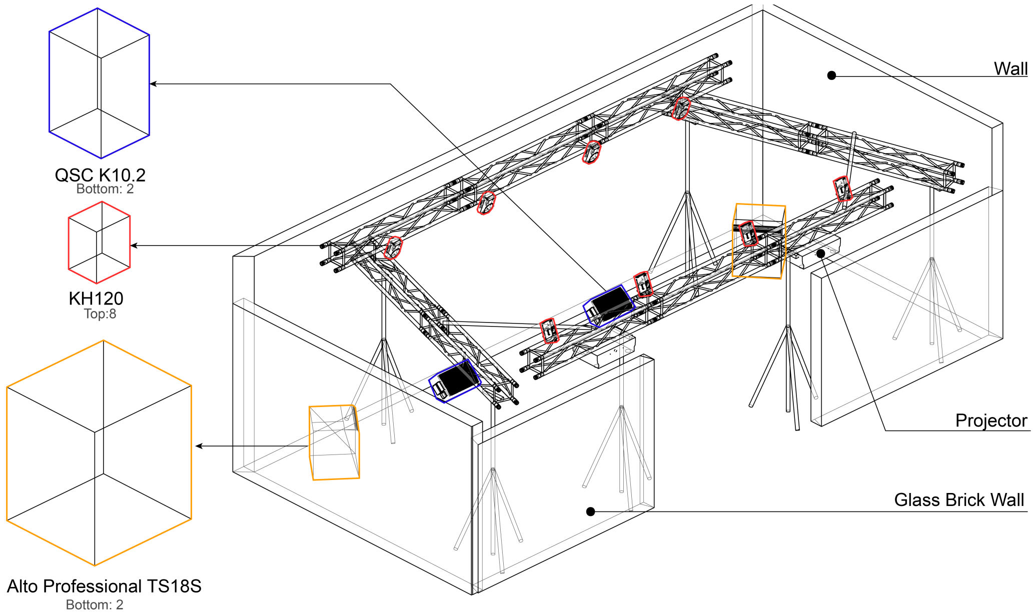

Figure 3: Adapted layout.

movement and emotional expression as its primary interaction metaphor [7].

Our concept is realized through spatial audio, with the spatialization infrastructure playing a central role in the design. We draw on prior research in two areas: spatial audio as a medium for interpersonal connection, and spatial audio as a medium for artistic presentation. A growing body of work suggests that spatial audio can meaningfully enhance interpersonal connection, communication, and interactivity. Oviedo et al. found that spatial audio supported greater social connectedness than traditional monaural calling, particularly by increasing participants' sense of presence [11]. Similarly, Nowak et al. reported that spatial audio in a video task increased perceived interactivity, a shared sense of space, and ease of understanding compared with a conventional audio setup [9]. Taken together, these findings suggest that spatial audio is not only an improvement over conventional remote audio setups, but also a medium that can support engagement and a sense of shared space, which are central goals of our open studio.

A parallel line of work has explored how spatial audio can serve as an expressive medium for artistic presentation, moving beyond passive reproduction toward authoring and performance. Wozniewski et al. propose a framework that views spatial audio as part of an interactive instrument, enabling performers to shape sound in three-dimensional space through tracked gestures [15]. Berdahl et al. similarly explore spatial audio as an embedded performance medium, proposing compact loudspeaker line arrays that achieve immersion through localized wave-field control and close coupling between spatial sound, physical objects, and listener proximity, rather than architectural-scale sound-field reproduction [1]. At another scale, *SeamLess* presents a hybrid spatial-audio workflow implemented in the Humboldt Forum Listening Room by TU Berlin's Audiocommunication Group, integrating multiple sound-field reproduction methods by combining Wave Field Synthesis (WFS) and Higher-Order Ambisonics (HOA) within an object-based virtual sound-source model [14]. This approach helps make large-scale spatial reproduction more robust and accessible for artists.

3 The Immersive Open Studio Design

3.1 Open Studio Concept

The Immersive Open Studio concept is a course-based, open artistic space that builds a shared spatial-audio environment for artists and audiences, with the goal of supporting the development and public presentation of interactive audiovisual projects by students. This public-facing space, located in the Underground art center in Atlanta, offers an acoustically contained environment while remaining open and accessible to visitors. The audiovisual infrastructure installed in the space allowed students to focus on interaction design and compositional choices, rather than rebuilding the underlying technical setup for each work. As this was the first time that some students worked within a spatial medium, the fixed infrastructure allowed for rapid prototyping, experimentation, and iterative exploration of immersive interaction and composition.

During the initial public presentation of the concept, five interactive projects were presented at the space: *Immerge*, *Since Everyone's a DJ*, *Audenie*, *MACHINA*, and *Data Mirror: Fragmented Projections of Oneself.* Each project ran as a roughly 90 minutes interactive session open to the public, ranging in aesthetic from ocean sonification to techno-futurism and short films. Together, these works demonstrated how a shared technical platform can support diverse creative practices while lowering barriers to participation in spatial audio performance.

3.2 Exhibit Infrastructure

3.2.1 Setup I. The spatial audio infrastructure was initially developed at the Georgia Institute of Technology, where the 3D-Box system at the Rich Computer Center provided the basis for a recreatable Ambisonic setup adapted for public exhibition. This system was subsequently transported and installed at the Underground Atlanta. Within an original MARTA station tunnel, we constructed a cuboid space measuring 14 ft wide, 28 ft long, and 8 ft high, enclosed by cloth walls. A door is located at one end of the 14-ft side, so as audiences enter, they move into a deep, tunnel-like space. We used 6 truss stands and tubes to support a three-layer loudspeaker array: a top layer with two Neumann KH120 monitors, a middle layer with ten KH120 monitors, and a bottom layer with five QSC K10.2 loudspeakers and two Alto subwoofers. For the visual component, three projectors were fixed to the upper truss and aimed at the three canvas-covered sides to create a 270° projection field. For system control and routing, a MIDAS M32 digital console worked as the central mixer. The artists' computers were plugged into the mixer which routed audio through two Behringer stage boxes to the loudspeakers (Figure 2).

3.2.2 Flooding and Relocation. Trouble came to the original infrastructure design after three weeks: we had already hosted three performances when sudden flooding caused water to enter the subterranean space. The flood not only made the original installation unstable, but also introduced a high risk of loudspeaker damage, electrical hazards, signal instability, and unsafe conditions caused by slippery floors. Under these conditions, continuing to use the original venue would have exposed both students and audiences to unnecessary safety risks.

We therefore view flooding as an unplanned hazard that required us to relocate the installation to a second-floor room. The new site was selected for its structural safety and its suitability for rapid reassembly under time pressure, prioritizing the protection of students and audiences over the convenience of remaining in the original space. Fortunately, none of the speakers were damaged and they were able to be reused in the new venue.

3.2.3 Setup II. As for our new installation, some minor design changes were made to accommodate the lower ceiling and the different layout of the room. The revised spatial audio system used a two-layer configuration: an upper layer of ten Neumann KH120 monitors and a lower layer consisting of two Alto subwoofers and two QSC loudspeakers placed on the floor. We also simplified the visual setup to two parallel projectors, replacing the original 270° projection (Figure 3), due to the limitations of the architectural configuration of the new room. Two sides were composed of glass blocks, and another side was a short wall, leaving only the long wall suitable for projection.

Risk management and adaptability are not separate, but are woven together. Although emergency relocation increased the installation burden for each group and delayed the exhibition schedule, it also demonstrated the resilience and capacity of the system for safe reconfiguration. Adaptability, in this case, was proved to rest on equipment choices, alternative spatial layouts, and plans for quick and safe reassembly.

4 "Since Everyone's a DJ" System Design

Since Everyone's a DJ is one of five projects developed and presented within the Immersive Open Studios. We use it as a case study to examine how the studio's infrastructure shapes the project's interactive system, and how this integration reflects the concept's broader design principles. Leveraging the spatial audio and visual rendering capabilities, Since Everyone's a DJ transforms electronic music performance into a shared, collaborative practice, allowing up to four participants to manipulate sound through intuitive embodied gesture and movement. The system architecture can be divided into a camera-based interaction system and an audiovisual synthesis system (Figure 4). Together, they explore an approach to lowering barriers to musical participation while enhancing immersion for electronic music performance.

4.1 Artistic Goals

This project aims to challenge the conventional performer-listener divide that structures many electronic music concert settings. In these contexts, the musical experience is often shaped by a relatively small group of performers, while the audience remains in a primarily receptive role. Although the rise of DJ culture and electronic music tools has expanded access to music making, a separation still often persists between those who control the experience and those who observe it.

Artistically, this work seeks to blur that boundary by allowing eventgoers to move beyond passive spectatorship and directly influence the sound and visuals around them. By lowering barriers to participation, the project invites a broader range of people into the creative process and treats musical interaction as something collective, immediate, and embodied.

The choice to work within an electronic music and techno-oriented sound is central to these artistic goals. Electronic music is deeply tied to repetition, gradual transformation, timbral manipulation, and immersive physical energy, making it especially well suited for participatory and interactive performance environments. Techno in particular offers a strong structural foundation through pulse, groove, and evolving texture, allowing participant interaction to shape the experience in ways that remain musically coherent while still feeling open-ended and dynamic. Its emphasis on sound design also creates space for subtle as well as dramatic forms of interaction, where changes in texture, spatialization, density, and intensity can become meaningful compositional gestures.

4.2 Camera-Based Interaction System

The interaction system captures body movement and interpersonal distance using four Intel RealSense D455 depth cameras and the MediaPipe Hands model. Four cameras were installed at the center of the Immersive Open Studio and arranged at 90-degree intervals to provide full room coverage (Figure 5). Depth sensing and RGB-based hand pose estimation are integrated to extract two types of interaction parameters: the minimum depth within the Region of Interest (ROI) and gesture-based trigger signals. The system supports up to four concurrent participants.

Camera messages are transmitted using Open Sound Control (OSC) over User Datagram Protocol (UDP) through the python-osc package. Each camera has two OSC clients: the main endpoint sent to audio and a clone endpoint sent to the visual part. The volume is a scalar value between 0 and 1, which is mapped based on the user's distance from the camera. There are four gestures that can be detected by the camera, dependent on the fingers that are shown in front of them. Each gesture message consists of normalized horizontal position, vertical position, and average landmark depth. The design separates continuous and discrete control streams, which leads to smooth interaction.

The interactive system supports up to four people controlling the music simultaneously. When a user faces one of the four cameras and holds up one to four fingers, each instrument group plays a distinct voice and phrase. When the user maintains

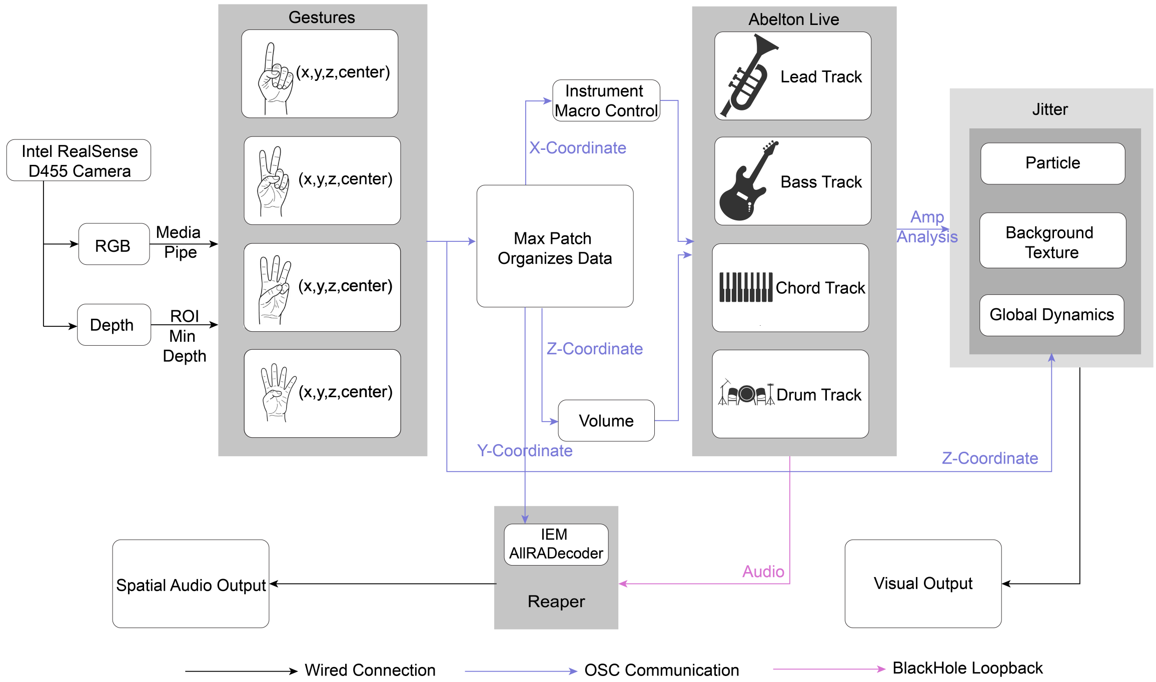

Figure 4: Diagram of "Since Everyone's a DJ" System implementation.

the gesture and moves their hand up or down the Y-axis, various audio effects, such as filter parameters, change according to the movement coordinates, resulting in different sound effects. Similarly, the X-axis controls the spatial azimuth of the sounds.

The gesture interaction with the camera is a low-barrier, walk-up participation that makes users to engage through simple finger-count gestures and hand movements. In addition, the separation of discrete gesture triggers and continuous spatial control supports both clear sound event activation and smooth modulation of different sound parameters.

However, the current interaction system has a few limitations. Interaction is restricted to a small set of hand gestures and gesture recognition depends on clear hand visibility with respect to each camera, making performance sensitive to field-of-view (FOV) constraints, camera angle, participant position, and the ambient illumination. The four-camera arrangement supports interaction by up to four users in real time but creates overlapping sensing regions. When participants move between neighboring fields of view, these overlaps may produce ambiguous transitions and unexpected changes in sound triggering. Future improvements could introduce transition or buffer zones between neighboring camera regions to smooth cross-view transitions and reduce accidental activation. Also future versions could incorporate higher-level movement data such as body posture, acceleration, and orientation, drawing on prior work in capturing and representing whole-body movement for performance and choreography[8]. On the hardware side, future improvements could include cameras with better low-light performance to maintain robust tracking under conditions where lighting is insufficient for stable vision-based sensing.

4.3 Audiovisual Synthesis

The audiovisual system is implemented using a combination of Ableton Live, Max/MSP, Max for Live OSC mapping devices, Jitter, Reaper, and the IEM AllRADecoder plugin (from the Institute of Electronic Music and Acoustics). The audiovisual system begins with a Max patch dedicated to organizing and parsing OSC messages coming from the camera vision python script. The patch separates the OSC stream into four instances, one for each musical voice (Bass, Chords, Lead, Drums). For each voice, OSC messages are sorted according to the corresponding finger message (/1,/2,/3,/4) and x,y,z coordinates are unpacked from the corresponding message to map to spatial position, instrument macro, and volume. The max patch also creates the logic for instrument switching within a given voice group through boolean logic.

The x,z coordinates and track switching logic are sent to Ableton, which serves as the primary audio engine, organizing the session into four track groups—Bass, Chords, Lead, and Drums—each containing four individual instrument tracks. Each instrument track features a custom macro control that maps multiple synthesis and processing parameters, including note sequence variation, distortion, wavetable position, redux, filter cutoff and resonance, oscillator mix, and delay, enabling expressive transformations of sonic texture and musical structure. The y coordinates from the max patch get sent over OSC directly to the IEM ambisonic encoder plugin in Reaper to control spatial azimuth. Moreover, the audio gets sent from Ableton to Reaper through BlackHole Loopback for ease of spatialization.

The visual engine is implemented in Jitter and receives OSC signals from both the camera system and Ableton Live. Camera-derived OSC data representing participant distance and audio amplitude-related data from Ableton Live jointly control a two-layer visual system, modulating texture, color, spatial distortion, feedback, and temporal delay in real time.

Table 1: Summary of User Reflection.

	Theme	Key Findings
Q1	Spatial Parameters	The tunnel length exaggerated depth perception, movement shaped visuals and engagement, spatial constraints informed design decisions, and sound cues reinforced a sense of submersion.
Q2	Immersion	The speaker array supported immersion, gesture-based interaction increased engagement, ambisonic depth mapping strengthened affective impact, and immersion was integral to the concept.
Q3	Audience Understanding	The clear movement-sound mapping promoted exploration, enabled both static and dynamic engagement styles, and revealed slight entry hesitation.
Q4	Reflection	Reflections pointed to the need for clearer visual feedback, noted technical setup constraints, and underscored positive community reception.

Figure 5: Camera-based audience tracking system setup.

5 Reflection and Evaluation

5.1 Feedback Collection

The Immersive Open Studio and its infrastructure have been tested by student groups and public audiences through a series of interactive showcases and preparation. Due to the project's format and public presentation context, we draw on a mixed set of formative evidence rather than a formal user study. This includes in-situ observations of audience behavior and preferences, voluntary open-response feedback, and follow-up reflections from a small number of students who experienced the installation, presented work, or contributed to the system design. We acknowledge that this overlap of roles means that responses should be read as reflective practitioner accounts rather than independent user evaluations. The reflection questions were organized around three topics: perception and use of spatial sound parameters, immersion and expressive quality, and the communication of project ideas to an audience.

5.2 Design Reflections on "Since Everyone's a DJ" Spatial Audio System

In showcases of the "Since Everyone's a DJ" system, we observed that participants were particularly excited to see how their own movements produced immediate audiovisual changes. A common pattern we noticed was that participants first watched others' movements, then joined in by imitating the gestures to control the audio and visuals. Three participants asked how it worked, but a brief explanation was enough for them to understand the basic interaction, especially once they started playing, received feedback, and began exploring on their own. Therefore, our camera-based gesture interaction provided a low-barrier entry point for audience participation.

However, the low-barrier interaction did not translate into a clear understanding of the specific mapping strategies. Participants could perceive that their gestures and positions controlled audiovisual changes, but they were less clear about the specific audio layer to which they were switching or the visual parameter being changed. For example, when one or two finger gestures switched between different bass layers, participants could hear that the bass layer changed, but could not tell what distinguished the two states, such as whether the change involved timbre, spatial position, intensity, or rhythmic emphasis.

Although the overlapping fields of view between the four cameras did not appear as a major issue in the participant feedback, this should be interpreted with caution. One possible explanation is that the spatial audio changes triggered by different camera regions were not perceptually distinct, especially when four instrumental layers were sounding together. Because four instrument layers overlapped and masked one another, participants may not have noticed unintended transitions between camera zones. Therefore, the absence of negative feedback does not necessarily mean that the camera handoff problem was resolved. Verifying this would require targeted listening tests, for example, by isolating individual layers or temporarily disabling subsets of cameras.

For the spatial audio part, participants found it easier to perceive discrete changes between gestures and instruments than continuous controls, such as distance-based volume changes and hand position in azimuth and elevation. Continuous spatial audio controls were likely masked when all four instrumental layers sounded simultaneously. Future iterations could make them more audible by reducing simultaneous layers, increasing timbre contrast between instruments, or introducing brief isolated demonstrations before presenting the full system.

The visual system also presented opportunities for further improvement. Although the projected visuals supported interaction feedback, they remained screen-based and two-dimensional rather than fully integrated into the physical room. Compared with the spatial audio system, the visuals functioned more as a projected response surface than as a spatial environment. Future iterations could incorporate AR, projection mapping, or distributed visual cues to connect the visual layer more directly with the three-dimensional space.

5.3 Survey Responses and Audience Experience in the Immersive Open Studio

Beyond the evaluation of our own project, student survey responses provided a broader reflection on the Immersive Open Studio infrastructure as a shared public setting. The survey was distributed through Qualtrics on February 9 and collected five responses. The questions covered three main topics, and Table 1 summarizes participants' responses.

For the "Underground" space, all respondents described the venue as a long, tunnel-like space that exaggerated depth and encouraged the audience to move back and forth through the installation. One respondent noted that the more participants moved into the exhibit, the "deeper" they felt within the environment. This spatial condition supported projects that used distance, movement, and scale as part of the expressive experience. At the same time, the fixed dimensions of the room forced designers to consider speaker placement, camera coverage, projection, and audience flow.

For immersive experience, three respondents connected immersion to the speaker array and the ambisonic setup, noting that the sound could move around the room and respond to participant movement. In one project, spatialized water sounds followed the average depth of the participants, while the audio and visuals became darker as visitors walked deeper into the room. Respondents described this kind of gradual, position-coupled response as encouraging exploration rather than passive viewing.

Audience understanding appeared to depend on the clarity of interaction feedback. In the feedback responses, three respondents mentioned audience behavior during their performances. Some audience members quickly understood that movement affected the sound and encouraged them to walk around the room and continue exploring. Others indicated that stronger camera feedback could have made the interaction clearer, especially for audience members trying to understand how their gestures or positions were being tracked. One respondent also noted that some visitors paused at the entrance, seemed interested but did not enter, suggesting that the installation could benefit from entry cues or stronger signals that audiences were invited to participate.

The reflections also point to practical constraints in presenting spatial audio work in a public environment. One response noted that some speakers, safety clips, and both subwoofers had to be omitted because of setup time limitations. Even with these constraints, respondents described the Atlanta community as receptive to the work and emphasized that collaboration with the Underground made the installation possible. Taken together, these responses suggest that the Immersive Open Studio is beginning to function as a shared environment for multiple interactive audiovisual works. However, this evidence remains formative and is drawn partly from contributors to the project; a more independent audience evaluation would be a valuable next step.

6 Conclusion

This paper presented Immersive Open Studio as a course-based concept for turning spatial-audio infrastructure into a shared public platform for multiple interactive audiovisual works. Through its deployment at The Underground Atlanta and the case study of Since Everyone's a DJ, we show how a public setting and reusable infrastructure can lower technical barriers for student artists, support diverse forms of audience engagement, and remain adaptable under real-world constraints such as relocation and rapid reassembly. At the same time, our reflections identify several areas for future development, including clearer audio-visual interaction feedback, stronger audience entry cues, and a more independent audience evaluation. Overall, Immersive Open Studio suggests a path for connecting technical infrastructure, collaborative artistic practice, and public-facing immersive experience.

7 Ethical Standards

Our research involves a course-based artistic concept realized through a public installation with voluntary audience participation. The work did not involve a formal user study; evaluation was based on informal observations during performances and voluntary anonymous feedback from student project contributors No personally identifiable information was collected. The work adheres to the ethical guidelines outlined in the NIME Principles & Code of Practice on Ethical Research, and the authors declare no conflicts of interest.

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