User needs in the Musical Metaverse: a case study with electroacoustic musicians

Alberto Boem
Dept. of Information Engineering and Computer Science
University of Trento
Trento, Italy
alberto.boem@unitn.it

Matteo Tomasetti
Dept. of Information Engineering and Computer Science
University of Trento
Trento, Italy
matteo.tomasetti@unitn.it

Alessio Gabriele
Dept. of Electronic Music
Conservatorio Statale di Musica "A. Casella"
L'Aquila, Italy
a.gabriele@consaq.it

Agostino Di Scipio
Dept. of Electronic Music
Conservatorio Statale di Musica "A. Casella"
L'Aquila, Italy
a.discipio@consaq.it

Luca Turchet
Dept. of Information Engineering and Computer Science
University of Trento
Trento, Italy
luca.turchet@unitn.it

ABSTRACT

The Musical Metaverse (MM) is expected to pave the way for a new era of musical activities in immersive, and technology-mediated environments. However, research on the MM is still in its infancy. Until now, the attention has primarily been directed toward engineering and artistic issues. Few studies have explored the uses and desires of stakeholders in immersive environments, particularly in terms of how these environments can best support musicians' needs for musical composition, performance, and education. This study aims to explore the needs of electroacoustic composers and musicians in a Metaverse dedicated to musical activities. For this, we conducted a half-day workshop with fourteen participants to collect data. Eleven user needs and potential issues were identified and discussed. The reported findings may contribute to enhance the understanding of the user experience in the MM by considering the needs and requirements expressed by specific stakeholders and early adopters, such as electroacoustic practitioners.

Author Keywords

NIME, Musical Metaverse, Musical XR, Electroacoustic Music, User needs

CCS Concepts

•**Applied computing** → **Sound and music computing;** Performing arts; •**Human-centered computing** → *Empirical studies in collaborative and social computing;*

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1. INTRODUCTION

In recent years we have witnessed a resurgence of the idea of the Metaverse, which refers to a vision of a group of technology-mediated collaborative environments that bridge the gap between the physical and the virtual, allowing geographically displaced users to interact together in shared interoperable worlds, through the use of immersive media [71] [55] [11]. While the Metaverse concept has been explored for a variety of scenarios (e.g., education [74] or surgery [12]) musical activities remain an under explored area of application.

A vision for the Musical Metaverse (MM) was proposed to bridge this gap [64]. The MM was defined as the part of the Metaverse dedicated to musical activities. The MM can be viewed as the convergence of areas such as Musical eXtended Realities (XR) [67], Networked Music Performance [57] and Internet Musical Things [65]. The rapid adoption of Virtual (VR) and Mixed Reality (MR) systems has spurred the emergence of several commercial applications dedicated to music. Such applications often focuse on the audience, and on creating an experience as close as possible to the idea of concerts as thought in popular music (e.g., VRRoom, VRChat). Regarding music creativity, existing applications try to simulate the workflow of DJs and EDM producers (e.g., TribeXR, VirtuosoVR), or the creation of audio-visual experiences (e.g., PatchWorld, EXA).

However, in terms of research the MM is still in its infancy. Even if the research on Shared Virtual Environments [72] and Social XR [43] focused on live concerts (i.e., [40] [31]), or collaborative virtual instruments and performance (i.e., [48] [68]), only a few recent examples focused on the idea of the MM [9] [18] [10] [20] [7] [19]. Nevertheless, these works rarely explore user needs, and mostly focus on demonstrating and evaluating systems for specific activities (e.g., learning how to play percussion [27]), with no more than a few musicians simultaneously connected [58] [66] [10], or analyzing the experience of an audience in virtual concerts [53]. Moreover, only a few composers [13] [56] [25] [45] have explored the possibilities offered by shared and multi-user immersive environments. However, to promote and advance the development of the MM, it is crucial to define elements such user needs and expectations, which contribute to shaping the user experience.

The present study aims to explore future applications and requirements useful to create a MM centered on needs of music and sound creators, such as the ones of electroacoustic music practitioners. Because of their acquaintance with electronic and digitally-mediated musical practices, we identified such musicians as early adopters of the MM. To better explore those aspects, we conducted a half-day workshop involving faculty and students of the curriculum of electroacoustic music at the Music Conservatory of L'Aquila, Italy.

Despite the interests of the research community, a proper and functional MM does not fully exist yet. Nowadays we can only experience independent immersive social environments, or prototypes of experiences dedicated to selected musical activities and practices. However, because of its potential social and economic impact, tech industries are moving in the direction of the creation of a fully functional Metaverse [17].

This situation is a call for music technology community, such as the one of NIME, to start developing a critical discussion about the Metaverse, and consider this as an opportunity to participate in shaping its technological and methodological features at early stage. This is necessary not only for scrutinizing products and visions provided by the industry, but also to prevent techno-solutionism and scenarios where communities of musicians have to adapt to an ecosystem that is not designed for them, and with them in mind [51].

Figure 1: The facilitators are introducing the workshop to the participants.

2. METHODOLOGY

We conducted a half-day workshop centered on a group activity with the purpose of eliciting musicians' needs through a process of personal and group reflection. Involving potential users in an early phase of research can enable researchers to understand opportunities and challenges of new technologies, such as the MM [26]. During the workshop, participants were asked to reflect on three dimensions starting from their musical practice:

- **Composition**, i.e., the processes related to composition and creation of a musical piece;
- **Performance**, i.e., the act of executing a piece in front of an audience and its preparation;
- **Education**, i.e., practices related to music education from theory to history.

Such dimensions have been derived from the research agenda for Musical XR [67], and extended to the MM. Since the MM refers to a vision not yet fully realized, we asked participants to reflect on each dimension *"as if by magic"* the MM already exists. Drawing on previous work from HCI and NIME [1, 34], we used the term "magic" as a device for eliciting subjective experiences from participants, encouraging them to think beyond the limitations of current technologies.

To facilitate the formulation and exploration of their ideas, we provided each participant with a piece of A4 paper, which we referred to as a *sketch sheet*. Participants were instructed to write and/or draw their reflections using a pen.

2.1 Participants

The workshop was attended by 14 participants (13 males, 1 female, mean age = 38, SD = 11.22). They were recruited through an open call. Participants were faculty, current, and former students from the Bachelor's and Master's Degree in *Electronic Music and New Musical Technologies* of the Music Conservatory of L'Aquila (Italy). Its educational curriculum includes subjects such as: electroacoustic music composition, performance, music technology, and psychoacoustics. All participants were native Italian speakers.

2.2 Procedure

The workshop involved three of the authors, two as a facilitator and one as a note-taker. The workshop lasted a total of 4 hours, including a 15-minute break in the middle. At the outset, participants were asked to sign a consent form after having received a comprehensive explanation of the purpose of the workshop. At first, the researchers introduced the MM domain through a 30-minute seminar, presenting foundational concepts including: the Reality-Virtuality Continuum [50], Spatial Computing [60], and immersive audio [24]. Figure 1 shows a picture of the introductory activity made by the facilitators.

Subsequently, for each of the three dimensions, the following activities were conducted. At first, facilitators introduced a dimension (e.g., Performance) and requested participants to reflect on the question: *"How you see your Performance practice in the Metaverse "if by magic" it was available now?"*. Then, participants were given 10 minutes to note their ideas on a *sketch sheet*. Afterwards, one at a time, participants were asked to freely discuss their ideas and reflections with the others.

The workshop was conducted in the Italian language.

2.3 Data Collection and Analysis

All group activities were recorded using audio and video equipment. The facilitators also collected the *sketch sheets*, which were further digitized and transcribed (see Fig. 1).

We then performed a reflexive thematic analysis [8] on the data collected, based on grounded theory [23]. First, we transcribed the audio recordings together with the written notes and the text produced by participants. Second, each author independently extracted keywords from a user experience perspective. Third, we discussed and integrated the different keywords to identify and build coherent themes. After three rounds of analysis, for each of the three dimensions, we reached a consensus on emergent themes. For the benefit of this publication, we translated all the keywords and quotes into the English language.

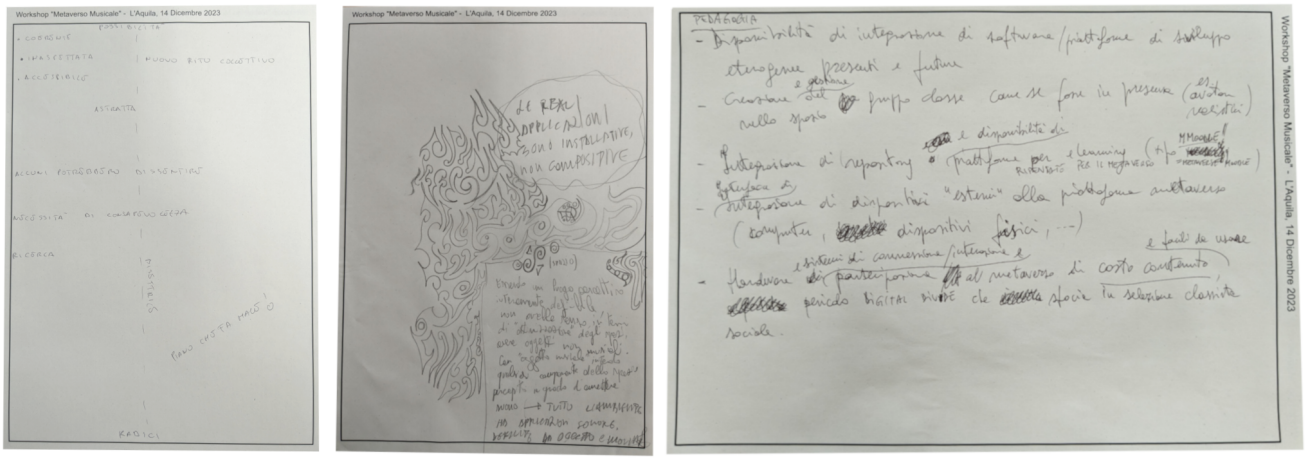

Figure 2: Three examples of the *sketch sheet*, one for each dimension. From left to right: Composition, Performance, and Education.

3. FINDINGS

In this section, we report the main findings that emerged from the thematic analysis. For each dimension, we outline and explore the different themes, which are supported by verbatim quotes of the participants, reported in italic. We refer to participants with the letter P and their corresponding numerical code from 1 to 14.

3.1 Composition

For this dimension, we have identified three essential themes that relate to how participants framed their creative processes in the context of the MM.

- **Space as a compositional dimension.** Eight participants (P3, P4, P6, P7, P9, P10, P13, P14) highlighted the spatial dimension as a central element of the MM. They specifically noted the potential of virtual spaces to serve as non-linear, interactive compositional environments (e.g., P4: *"where users can actually enter inside the work, stay inside the visuals, and inside the sound"*). Similarly, P7 envisioned *"the possibility of simulating an acoustic space in which I can move and where there are nodes, and there are points where there are sound sources from which I can approach and/or move away."* Furthermore, the participants discussed how immersive and virtual spaces could be utilized to create audio-visual installations (e.g., P9: *"Real applications are installations, not composition"*).

- **Virtual interfaces** Seven participants (P5, P6, P7, P10, P11, P13, P14) envisioned the MM as capable of offering novel virtual interfaces for compositional and sound processing, which should be radically different from those available in the physical reality and unique to the virtual world (e.g., P6: *"I imagine it as a medium/interface where I can use tools that I don't have available but which I can virtually obtain."* Such interfaces should be used not only for rapid prototyping of virtual instruments but also for testing compositional structures, and tools for annotation (e.g., P11: *"Annotation tools could be useful in a performance environment, where we are used to taking notes while performing."*) Moreover, participants emphasized the need for these interfaces to be customizable and flexible. This would enable users to tailor their creative environments to better suit their artistic needs and preferences (e.g., P7: *"I would like to have the possibility that this Metaverse is customizable and consistent with my way of creating"*).

- **An immature media space.** According to three participants (P7, P11, P13), an understanding of the technical and conceptual aspects of the MM should precede any attempt to evaluate its impact on compositional practices. P11 raised a pertinent question *"What is the utility we can find in controlling, from an XR environment, a real environment for music production?"*. For these participants, such kind of inquiry reflects the current state of the MM, which P7 describes as *"a field of total experimentation"*, but it is also perceived as far from being a mature and defined medium for compositional practice. This signals a cautious approach to integrating the MM in processes related to music composition.

3.2 Performance

In the domain of performance, four central themes emerged from our analysis:

- **Multisensory enhancements.** Four participants (P1, P4, P6, P10) emphasized the importance of multisensory experiences in the context of performance. P10 commented: *"The goal is: the performer not only has control over a musical parameter but over multisensory parameters"*. According to participants, integrating visual, auditory, and tactile stimuli could provide musicians with vital information about their physical and emotional state, and the auditory components of a live performance, which are typically the main focus of both composers and performers. (e.g., P6: *"I imagine something that can support that part of the performance that cannot be communicated through sound or body movement like the performer's emotions, and therefore thanks to this, the listener's thoughts on what I am communicating in the act is also clarified performative."*).

- **Performance preparation in the physical-virtual space.** Four participants (P1, P5, P10, P13) recognized the significance of allowing performers to use Spatial Computing technologies to arrange virtual instruments, con-

trollers, and parameters in both VR and MR environments to meet their specific needs in the preparation of a concert (e.g., P1: *"I imagine myself having greater control over performance practice, thanks to spatial computing and therefore the possibility of placing the controls I want wherever I want in space"*). Furthermore, this approach includes the positioning and arrangement of sound sources in MM environments (e.g., P13: *"I would like to place my virtual loudspeakers based on how the room is displayed"*).

- **XR as a tool for behavioral research.** An element that emerged from four participants (P1, P9, P10, P13) was the use of XR as a sensing technology, that can monitor the physical state, posture, and expressivity of a performer, thereby enhancing and extending their capabilities.(e.g., P9: *"achieving an augmented performer"*; P1: *"study and in-depth analysis of posture and movements"*. This was described by P10 as a form of *"performance's ethnography"*.

- **Performers' Skepticism.** During the discussion phase, several participants questioned the validity and utility of the Metaverse for musical performance. Six participants (P3, P7, P8, P12, P13) expressed doubts about the MM's ability to realistically substitute for a physical performance, at least in a VR-only setting (e.g., P9: *"I can't imagine a performance practice in the Metaverse capable of replacing the physicality, or direct contact with an instrument, whatever it is..."*). Building on this, P12 suggested that performances might be more effectively executed in Augmented Reality (AR), explaining that *"it guarantees a co-presence of real bodies and therefore guarantees this feedback"*. This perspective highlights a preference of composers for AR and MR environments over completely virtual ones, emphasizing the importance of physical presence in performance settings.

3.3 Education

Within this dimension, we identified four main themes:

- **Immersive learning.** Most participants (P1, P2, P3, P4, P5, P6, P7, P9, P10, P11, P12, P13, P14) articulated their vision of education within the MM in terms of *"immersive learning"*. Both P1 and P9 highlighted that the MM could facilitate a remote learning environment that is *"more immersive and multisensory, without all the problems that classic 2D software such as Zoom introduces"* (P1). Furthermore, P6 and P7 envisioned the MM as a space where immersive audio-visual recordings of classes could be accessed, revisited, and re-experienced later. Additionally, other participants (P10 and P13), emphasized the social dimension of the MM, viewing it as particularly conducive for teaching group improvisation.

- **Learning simulators.** Eight participants (P1, P2, P5, P6, P7, P10, P11, P12) conceived the MM as a space well-suited for providing *"Virtual classrooms"* (P5), tailored to specific activities and learning materials. For example, these classrooms could enable students —either alone or with teachers— to analyze and rehearse virtual versions of electroacoustic compositions. (e.g., P11: *"I would like to build a multimodal environment where together we can comment, analyze, and better understand a particular piece or performance"*).

  Additionally, the MM could facilitate the study of specific topics such as acoustics. Participants noted that through virtual replicas of physical spaces, such as auditoriums or concert halls, students could experiment with the relationships between sound and space in a controlled setting. Similarly, five participants (P3, P4, P9, P11, P12) recognized the potential of the MM for studying the history of electroacoustic music. They suggested that the MM could be used to replicate studios that no longer exist or to model historical instruments that are difficult or costly to replicate in real life *"as a sort of simulators"* (P9). As expressed by P12: *"a VR environment that allows me to visit places, decayed or no longer existing places that allow me to review/retrace historical moments"*. This may be particularly useful with spatial-based historical works of electroacoustic music, such as Luigi Nono's "Prometheus" (P4). Participants felt that immersive experiences, which integrate learning about the history of electroacoustic music, as more effective compared to more accepted means like listening to audio recordings or watching video documentation of specific pieces.

- **Perceptual aids.** Five participants (P4, P9, P12, P13, P14) suggested psychoacoustics as a subject that could be effectively studied in the MM. Psychoacoustics was considered a critical aspect of electroacoustic music education (e.g., P4: *"It would be much more practical to understand acoustic phenomena [...] such as diffraction or reflection."* According to participants, in MM environments acoustic phenomena could be experienced through the use of real-time 3D visualizations, which serve as perceptual aids that could facilitate the learning of complex theoretical processes (e.g., P14: *"Visualize theoretical processes that require a level of abstraction and which perhaps are not so direct to learn in the early stages. I think that through a 3D visualization in a multi-user environment, these concepts can be learned more easily"*).

- **Inclusiveness.** Five participants (P1, P7, P9, P10, P11) emphasized the necessity of designing the MM as inclusively as possible, particularly for teaching and learning purposes. Firstly, they proposed that the MM should primarily serve as a social space, where *"one can do research or talk about music, [..] or meet new people, which is a classic thing that always happens in typical conservatories* (P1). Secondly, the MM could provide off-site students an access to virtual replicas or "digital twins" of their music institution, which *"would allow for great economic advantages"* (P7). Thirdly, participants stressed the importance that a MM should support and foster *"critical thinking"* (P10), which was seen as a fundamental component of musical education. However, there was the concern that a heavily technology-mediated environments like the MM could exacerbate the digital divide between students and institutions. As expressed by P10: *"We should think about low-cost and easy-to-use hardware/software systems [...] because this could lead to a big danger that could result in a social division between whose can access these technologies and those that cannot"*.

3.4 General Remarks

During the discussion phase, participants offered several reflections that, although not aligning directly with the three dimensions, were still considered valuable for our analysis.

Two participants emphasized the need for the MM to provide compatibility and integration with existing music technologies, such as Digital Audio Workstations and programming languages (i.e., Pure Data or Supercollider) that should be used seamlessly within the MM environment (e.g., P13: *"Possibility to use both real-life products and products available on the Metaverse [...] as a musician and composer, I cannot use Max in XR"*). Similarly, other participants commented on the importance of ergonomics and accessibility of hardware: *"that must have the least possible impact on the user and must allow free movement, by avoiding the use of cables and invasive interfaces"* (P11).

These factors were seen as essential for creating a MM that is well-suited for composers. Currently, the lack of appropriate tools represents a significant barrier, as it is preventing composers and sound artists proficient in audio programming from fully engaging with the MM.

4. DISCUSSION

Our analysis revealed that the MM, as envisioned by the workshop participants, should:

- support and extend collaborative educational activities on topics related to electroacoustic music, including psychoacoustics, acoustics, and history;
- enrich understanding through the *perceptualization* of sound and its interactions within virtual and physical spaces;
- provide composers with an environment where creation and performance of musical pieces can take immersive and multisensory forms, that moves beyond traditional concert and sound installation formats.

4.1 Is Education the "killer app"?

The main findings from the workshop indicate that among the three dimensions investigated, Education emerged as the one characterized by the most developed and consistent ideas.

Participants envisioned education within the MM incorporating XR technologies to support, enhance, and create new avenues for educational activities. This aligns with the concept of *immersive learning* [42] that is the use of XR technologies for supporting, enhancing, and creating avenues for educational activities. Despite being explored in music education contexts like learning electronic instruments or practicing conducting skills, immersive learning has mostly been limited to single-use scenarios [30] [54].

While the context of a Conservatory might have introduced a bias, the emphasis on collaborative education underpins the reflections and use cases provided by participants, which should be carefully considered when develop an MM oriented towards educational purposes.

Several participants emphasized that in the context of education, the MM should support and foster critical reflections by providing a suitable space for idea exchange and group work. Studies have shown that shared VR environments effectively enhance students' general research and inquiry skills [32] [6]. Furthermore, these immersive environments have been shown to significantly improve motivation and sociability among distance learners [21] [37]. While these studies have been conducted outside the musical domain, they provide a starting point for further research on musical education, especially regarding curricula such as the one of electroacoustic music.

The primacy of the educational dimension might be explained by the unique social dynamics of the classroom. Echoing the theories of Lefebvre regarding the production of space [33], we can consider a classroom as a socially constructed space, actively shaped by interactions among students and between students and teachers. This concept extends to the virtual classrooms within the MM, where social features crucial to education are not only replicated, but also expanded upon. In the MM, social interactions can transcend physical and geographical limitations, fostering a new dimension of collaborative and immersive learning that reshapes our understanding of educational environments.

Participants provided concrete examples of novel educational approaches in the MM. One such example is the use of immersive environments as dedicated spaces for the exploration of music history. These environments should be used not only to support the analysis of significant compositions, but also to explore the material and technical aspects of electroacoustic music culture. An idea expressed by many participants was the recreation of key places that have been pivotal in the history of electroacoustic music. These spaces, described by Di Scipio as *technological environments* that have influenced music since the 1950s [15], such as iconic buildings like the "Philips Pavilion" [38], or studios like Milan's "Studio di Fonologia." However, these spaces should not only be studied, but also creatively utilized to explore electroacoustic music's rich repertoire by leveraging the MM's spatial, social, and multimodal characteristics.

Moreover, the discussion on education highlighted the value of inclusiveness. Participants voiced hopes to make learning accessible to all students, regardless of economic or geographic constraints, and expressed concerns about the potential barriers introduced by an over-reliance on ubiquitous technology. This is essential to counteract issues like the digital divide, which became particularly apparent during the COVID-19 pandemic [3, 70]. Today's sociopolitical landscape shows that such learning modes might perpetuate inequalities, making this a critical consideration not only for music technology education but also for the broader design and implementation of socially responsible immersive platforms for a "Good Metaverse" [73].

4.2 Perceptualization of sound qualities

The use of interactive and multisensory characteristics of the MM for data *perceptualization* emerged prominently in the dimension regarding Education. The term *perceptualization*, originating from the field of biomedical studies, refers to techniques used to recast scientific data into engaging and informative expressions based on phenomenology [36].

Participants noted that through XR technologies sound can be made perceptible through visual and tactile channels and, therefore, enhancing the understanding of sound phenomena, like how a sound wave propagates in a space. While the spectral and physical qualities of sound are traditionally analyzed using electronic and digital equipment, XR technologies offer a novel approach by allowing these qualities to be explored in three dimensions, and within the actual spaces (or its replica) where the sound originates (i.e., a sine-wave played inside a cathedral).

Data *perceptualizations* have been applied to 3D visualizations of sound fields in enclosed spaces across Augmented [2], Mixed [29], and Virtual Realities [14]. In the context of the MM, these *perceptualizations* can provide a valuable tool for both students and teachers. This approach not only complements theoretical explanations of acoustics, but also offers opportunities for testing hypotheses by directly manipulating variables in ways that might be difficult

to achieve in physical realities (i.e., position of the sound source, the size of the space).

4.3 Composers/Performers in the Metaverse

While we initially treated composition and performance as separate activities, participants indicated that in their practice these are not entirely decoupled experiential dimensions. Often, these dimensions are blurred, leading some individuals to identify themselves as composers/performers.

Moreover, beyond the exploration of musical structures or the live execution of compositions, many participants were also actively engaged in designing their tools, encompassing both software and hardware within the broader performance ecosystem [62, 47]. This blending of roles reflects a significant redefinition of what it means to be a composer or performer, a process that has evolved over the last century [61]. This evolution has culminated in the concept of *composing the instrument*, a practice widely pursued by practitioners in the field of NIME [69] [41].

Such integration of roles represents a crucial element to consider in the development of a MM that aims to meet the roles and expectations of contemporary electroacoustic music practitioners.

4.4 The Metaverse as a musical "space"

While composers/performers are accustomed to manipulating elements of sound such as frequency, dynamics, and tempo, our results indicate that in the MM, "space" is perceived to play a prominent role in shaping the musical experience. In electroacoustic music, there is a longstanding tradition of "composing with the space" [39] [16], where the focus extends beyond the mere spatialization of sounds to exploring and creating new relationships between sound and physical spaces. This approach often involves linear compositional methods interacting with non-linear phenomena, such as the movements of the audience or musicians within the space [5]. Prominent composers like Ciciliani [13], Hamilton [25], Lüneburg, and Ressi [56] have explored these ideas by using shared virtual spaces not only as a "score" that can be interpreted, but also as an instrument to be played. Moreover, virtual spaces can be used to find new ways to explore and interact with graphic scores, and new forms of musical notation [46].

Reflecting on these advancements, our results suggest that the MM should support a broad spectrum of compositional practices including the larger palette of sound art [35], which can also embrace virtual sound installations [44] but in the case of the MM, designed for multi-user and social interactions. This represents a potentially interesting territory of exploration of emerging practices that necessitates the development of specialized tools and compositional strategies.

4.5 Alone, together?

Contrary to our initial assumption that considered the social aspect as foundational for the MM, our observations revealed a different picture. Participants positioned the three dimensions along different points of an hypothetical social axis. While the classroom is a space prominently shaped by social interactions, participants viewed Composition and Performance dimensions through the lens of their view of how composers/performers operate.

Composition was described as a solitary activity. Despite early works on networked music performance and social XR that have emphasized co-creation and collaboration (i.e., [4] [45]), participants highlighted a need within immersive environments to have separate spaces, one dedicated to solitary dimensions like Composition, and other ones oriented towards more social dimensions (Performance, and Education). Interestingly, this finding echoed the research of Men and Bryan-Kinns on musical Shared Virtual Environments [49]. They highlighted the need to have a virtual space composed of a group and a personal territory. While the first is designed to support collaboration, the second should be centered on the single user, which can provide a more private space useful for exploring and developing own personal ideas.

Therefore, for musical activities in immersive and social environments, a balance between these two territories should be found. Similar aspects have also been explored in the literature of Cooperative Supported Collaborative Work [22] [59]. While our findings might be explained by the limited experience of our participants with multi-user immersive systems, they also suggest that compositional practices that involve social interactions have not been fully explored in the field of electroacoustic music. Nonetheless, the immersive, collaborative, and embodied dimension of the MM might open new avenues of research regarding the next-generation of music composition and performance as well.

4.6 Limiting Factors

Our analysis identified several factors that could deter composers and musicians from fully engaging with the MM, which urgently need to be addressed. Firstly, there is a significant gap in the integration of XR systems with computational and hardware tools commonly used by electroacoustic composers. Secondly, current immersive systems and virtual environments currently lack sufficient level of customization options to meet the diverse needs of practitioners. These aspects highlight a fundamental mismatch: a Metaverse primarily designed as a "service" -as it is commonly considered in literature- does not adequately support creative endeavors for music. To truly benefit practitioners, the MM should be developed based on identified needs, focusing on fostering a platform that is adaptable and conducive to the unique processes of artistic creation.

5. LIMITATIONS AND FUTURE WORK

Notably, our study presents some limitations.

First, when introducing the workshop to participants, we relied solely on presentation slides and videos, without using any supporting physical materials. We hypothesized that showing examples of existing XR musical applications with Head-Mounted Displays or other devices could have influenced participants, potentially affecting the results of this preliminary exploration. To address these aspects, future studies should focus on developing and testing prototypes of novel systems based on the values and ideas analyzed in this paper.

Second, the diversity of our pool of participant was limited, in terms of nationality, gender, and background. The results discussed here should be considered preliminary, and limited to the needs of electroacoustic musicians. This calls for further explorations with a larger and more diverse type of participants in subsequent studies.

Third, all participants in our workshop were able-bodied. Thus, future work should aim to involve musicians with physical and neurological impairments to ensure broader representation and accessibility.

Fourth, although involving potential users in defining the needs of new technologies has proven beneficial, previous research has shown that users might not always be aware of

their own needs and desires [28, 63]. To mitigate this issue, future studies should include a wider array of stakeholders, such as classically trained instrumentalists and sound technicians, and also involve experts who have developed and used multi-user immersive systems for musical creativity.

6. CONCLUSION

In this paper, we presented a preliminary study aimed at understanding users' needs and expectations for the Musical Metaverse. Our findings show potential directions based on the requirements identified from the analysis of a series of group activities conducted with 14 electroacoustic musicians. While we have identified Education as the most prominent dimension, a better understanding of the use of the MM for Composition and Performance will pave the way toward new research questions and artistic possibilities.

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8. ETHICAL STANDARDS

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