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Implementation of a Virtual Acoustic Room in the Digital Music Mixing Process

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Abstract:

Advancements in digital technology have driven a shift in music production from physical studios toward Digital Audio Workstation (DAW)–based production supported by virtual acoustic rooms capable of digitally simulating spatial characteristics. This phenomenon enables the engineering of spatial perception, depth, and sound quality without reliance on real acoustic spaces, while also supporting production efficiency, the formation of sonic identity, and the integration of traditional and modern electronic music. This study employs a descriptive qualitative approach with a case study method to examine the application of virtual acousticrooms in the digital music mixing process, with the research subjects consisting of works by Enggar Ardiandi and a comparative mixing result of the song Melangkah by audio practitioner Ridho. Data were collected through literature review, work analysis, observation of the mixing process, and evaluations by listeners and practitioners, then analyzed descriptively and analytically by linking field findings with relevant theories, while data validity was ensured through source triangulation. The results indicate that the application of virtual acoustic rooms in the works of Enggar Ardiandi and Ridho positions virtual reverb as a primary element in shaping spatial perception, depth, and sonic cohesion in digital music mixing, with a comprehensive and immersive approach in Enggar's work and a selective and controlled approach in Ridho's work, underscoring the flexibility of this technology in accommodating aesthetic needs, workflow efficiency, and overall audio quality enhancement.

Keywords: virtual acoustic room, digital music mixing, acoustic simulation

Introduction

Advances in digital technology have brought significant changes to the practices of music creation and production. In the current era, the production process no longer relies entirely on physical studios with specialized acoustic treatment. With the availability of digital devices, music production can be carried out more quickly and practically while still producing high-quality audio (Aditya et al., 2020). Through the use of Digital Audio Workstations (DAWs), a producer can perform all stages of production, ranging from recording and processing to mixing, using only a computer and several additional devices. The presence of digital audio software such as DAWs has radically transformed the way music is created, produced, and presented (Jaohari et al., 2025). Previously, music production could only be conducted in professional studios with expensive equipment; today, these activities can be independently carried out by individuals equipped with a computer and a DAW.

A Digital Audio Workstation (DAW) is software that functions to replace analog audio or music recording systems with computer-based digital recording processes (Aditya et al., 2020). The use of DAWs enables music production to be conducted more effectively and efficiently, as recording processes can be carried out rapidly. Scientists and researchers in the field of technology continue to introduce the latest digital innovations to meet the needs of society and industry (Rumsey & McCormick, 2009). Through ongoing research and development activities, technology-based music production, both in terms of hardware and software, continues to advance by offering increasingly comprehensive multitasking features as well as faster and more accurate data processing capabilities.

In addition, music production is also influenced by the acoustic design of recording studios in order to support sound quality. Acoustic modeling techniques, including auralization, not only support spatial design but can also be applied in virtual environments (Balakrishnan et al., 2023). Studies indicate that well-designed studios not only enhance recording quality but also influence musicians' creativity and productivity. According to Carcagno et al. (2018), evaluations of sound quality conducted by 52 guitarists in a dimly lit room, using anti-glare glasses to eliminate visual identification, produced nearly similar results across six tested guitars. These findings emphasize the importance of proper studio design. This indicates that a studio does not merely function as a recording space but also supports the creativity and productivity of musicians and producers.

For example, in small studio designs, reverberation time and modal activity become the primary determinants of acoustic quality, while reverberation plays a role in creating realistic auralization. Reverb effects are included in the category of time-based delay effects. When direct sound reaches the listener's ears, part of its energy is absorbed. Subsequently, early reflections are heard, followed by layered reflections from various directions, known as reverberation, which describe the character and depth of the space. Reverb does not merely function as an additional effect but also serves as an essential element in shaping depth and spatial perception within a composition. Appropriate use of reverb can convey the impression of a particular room size and indirectly influence the listener's emotional response. This understanding is crucial for studio designers and producers in achieving optimal sound quality (Castillo et al., 2021). These aspects are strongly influenced by ongoing technological advancements.

One digital technological innovation is the virtual acoustic room, an artificially

created acoustic space developed digitally to replicate the acoustic characteristics of physical spaces in music production. Through this technology, the sonic properties of spaces such as concert halls, studios, or auditoriums can be represented virtually, thereby enabling more comprehensive music creation (Purwojatmiko & Salati, 2022). Furthermore, Puglisi et al. (2015) state that spaces with good acoustic quality are capable of providing optimal listening conditions. In simple terms, an ideal acoustic space produces high-quality sound, and these characteristics can be engineered through digital technology (Farina, 2000).

This technology creates digital representations of real acoustic spaces. As a result, producers can present realistic spatial impressions without the need to conduct recordings in specific physical locations (Rumsey & McCormick, 2009). The utilization of various VST plugins, including built-in instruments such as Native Instruments, represents a significant innovation, particularly for music producers who do not have access to professional studios but still require sound quality with natural and authentic spatial characteristics. In modern music production, virtual acoustic rooms not only play a role in enhancing acoustic quality but also contribute to the formation of sonic identity. This technology enables the exploration of various spatial characteristics that support aesthetic needs, both traditional and contemporary, making it an important element in the development of digital music production (Schafer, 1977).

Virtual acoustic rooms play a crucial role in modern music production by digitally simulating the acoustic characteristics of spaces. This technology enables the creation of acoustic environments that resemble physical spaces without requiring the construction of expensive and complex professional studios. According to Rindel (2001), virtual acoustic modeling offers efficient solutions through computer simulations, while the use of technologies such as convolution reverb and digital room modeling provides creative flexibility, allowing producers to replicate real spaces or create imaginary ones. Farina (2020) states that the application of impulse responses in convolution reverb is capable of producing realistic acoustic reproduction, forming the basis for virtual space simulation.

The utilization of virtual acoustic rooms has become increasingly relevant in the digital music industry, particularly for musicians working from home studios who rely on spatial simulations to enhance production quality. According to Gardner et al. (1992), digital room modeling technology is a critical component of modern audio production because it provides high flexibility in sound processing. Therefore, this study is important for understanding the relationship between technological innovation, musical creativity, and the preservation of cultural elements in contemporary works.

One musician and producer who implements this concept is Enggar Ardiandi. In various works, Enggar explores the integration of traditional musical elements and electronic music through the use of digital technology. The use of virtual spatial simulation by Enggar presents unique acoustic characteristics and combines the nuances of natural spaces with contemporary electronic sound textures. This approach demonstrates that virtual acoustic rooms do not merely create spatial illusions but also function as a means to build atmosphere, emotion, and specific musical character. Enggar Ardiandi is a young musician and producer who emphasizes the integration of musical tradition and modern technology. His educational background in music arts provides a strong foundation for understanding structure, aesthetics, and the dynamics of contemporary art. Enggar manages Aksara Musik Production, a creative studio that serves as a center for production, arrangement, and music creation, as well as a

collaborative space for other musicians. Through this studio, Enggar demonstrates professionalism in utilizing digital audio workstations (DAWs) and other sound-processing software.

Enggar Ardiandi is a musician and producer who actively explores musical creativity. One of his works, “Bungong Jeumpa Reimagined in EDM & Traditional Fusion,” combines a traditional Acehnese song with contemporary music production technology. In this arrangement, Enggar maintains Acehnese musical identity through traditional melodic elements and ethnic instruments while presenting them within a modern electronic context. The work integrates multiple layers of EDM plugins and instruments, such as synthesizers, electronic bass, and digital percussion elements, alongside traditional instruments with distinct timbral characteristics and dynamics. This production demonstrates the use of digital acoustic simulation to create realistic sensations of space, depth, and sound reflection.

In addition, the application of virtual acoustic rooms has been shown to make a significant contribution to the formation of spatial perception and the overall quality of mixing outcomes carried out by an audio practitioner named Ridho. Ridho is a music producer from Surabaya who is currently active as both a music producer and sound engineer at Venom Audio. In this role, Ridho is directly involved in various audio production processes, ranging from recording to final mastering. His experience in the field of production enables him to produce works with strong technical and artistic quality.

One of the works he has handled is a song titled “Melangkah,” performed by the band Sans Heliks. This song is composed with a complete instrumental formation, including vocals, guitar, bass, drums, and strings, resulting in a rich and layered musical character. The diversity of instruments requires a careful mixing approach so that each element can be balanced and mutually supportive within the overall composition.

In the mixing and mastering process of “Melangkah,” Ridho applied the concept of a virtual acoustic room as part of his audio processing strategy. This approach was used to build a more natural and realistic spatial perception, allowing each instrument to be proportionally positioned within the stereo field. The application of virtual acoustic rooms not only helped create sonic depth but also enhanced the overall quality of the final output in terms of clarity, balance, and listening comfort. Works with well-executed spatial simulation tend to be perceived as more natural, balanced, and possessing clear depth, even when produced in virtual or home studio environments. These findings indicate that successful mixing is not solely determined by the presence of a physical space with ideal acoustics, but rather by the producer’s ability to optimize spatial simulation technology (Rindel, 2001).

Overall, based on mixing practices, virtual acoustic rooms can be concluded to be a fundamental element in the mixing workflow. This technology enables the creation of realistic spatial representations, enhances the perceived professionalism of the final output, and supports the integration of traditional and modern aesthetics without dependence on specific physical spaces.

The preceding explanation indicates that traditional music can be integrated with modern electronic music. This condition has encouraged the researcher to conduct a study on the integration of traditional music and modern electronic music. A work is produced by utilizing EDM instruments such as synthesizers, electronic bass, and digital effects, alongside traditional instruments with distinctive timbral qualities. A paradigm

shift in music production is also evident, in which spatial experience can now be digitally engineered through technologies such as virtual acoustic rooms, convolution reverb, and spatial audio processing. This raises questions regarding the extent to which virtual acoustic simulation can replace physical spaces and how it affects production quality. In-depth analysis is required to understand how Enggar aligns traditional acoustic elements with modern digital approaches in his works.

This research is important for analyzing the application of virtual acoustic rooms as well as identifying their impact on quality, texture, and spatial perception in music. The findings of this study are expected to provide deeper insights into the role of virtual acoustic technology in the creative and technical processes of digital music production.

Methods

This study employs a qualitative approach using a case study method to obtain an in-depth understanding of the application of virtual acoustic rooms in the digital music mixing process. A descriptive approach is selected to systematically and contextually present the phenomenon of digital recording technology adoption based on empirical data. Referring to Pawito (2008), descriptive research functions to depict phenomena in detail according to realities found in the field, while Bajari (2015) states that descriptive research is directed toward concept exploration and factual data collection without the intention of testing hypotheses, but rather to reveal fundamental patterns grounded in specific concepts.

The subject of this study focuses on the application of virtual acoustic rooms in the digital music mixing process, with the research objects consisting of musical works produced by Enggar Ardiandi and comparative mixing results conducted by another audio practitioner named Ridho on a work entitled Melangkah. Data collection is carried out through a literature review to obtain a theoretical foundation related to digital music production, room acoustics, and virtual acoustic rooms, musical work analysis to observe musical structure, the use of spatial effects, and the integration of traditional and electronic instruments, as well as observation of the mixing process to identify the application of virtual acoustic rooms, including reverb, early reflection, and decay settings. In addition, evaluations involving listeners and audio practitioners are conducted to obtain perceptions regarding spatial quality, depth, and clarity of the mixing results.

The collected data are analyzed using a descriptive-analytical technique by relating field findings and observational results to relevant theories and literature. The analysis focuses on the role of virtual acoustic rooms in shaping spatial perception, sonic cohesion, and the overall quality of mixing outcomes. Data validity is ensured through source triangulation by comparing the results of musical work analysis, opinions of audio practitioners, and listener responses to ensure consistency and credibility of the research findings in accordance with qualitative research principles (Pawito, 2008; Bajari, 2015).

Results

Sub 1 Practitioner Profile and Works in Digital Music Production

The work “Bungong Jeumpa Reimagined in EDM & Traditional Fusion” is a reinterpretation of a traditional Acehnese song combined with modern electronic music. In this study, Enggar Ardiandi integrates ethnic elements with EDM structures that

emphasize rhythm, layering, and digital textures, making the mixing process a crucial aspect in harmoniously uniting the characteristics of acoustic and synthetic instruments.

Enggar Ardiandi is a musician and producer who integrates traditional Acehnese music with contemporary electronic elements. Aksara Music Production, the studio managed by Enggar, serves as both a production center and a creative laboratory. The studio is equipped with a Digital Audio Workstation (DAW), VST plugins, and audio monitoring facilities that enable the exploration of spatial characteristics through virtual acoustic rooms. As a research subject, Enggar Ardiandi's work is relevant because it exemplifies the integration of traditional Acehnese music with contemporary electronic elements. This study provides insight into the application of mixing techniques and digital spatial processing, including reverb, impulse response, and spatialization, which can serve as a reference for music producers in optimizing creative and technical processes. Consequently, Enggar and Aksara Music Production represent an example of the application of digital technology in traditional-modern music production, where the use of virtual acoustic rooms allows for the creation of realistic digital acoustic spaces, enhances audio quality, and establishes a distinctive sonic identity.

In addition, another practitioner named Ridho also applies the use of virtual acoustic rooms. Ridho is a professional audio practitioner from Surabaya, active as both a music producer and sound engineer at Venom Audio. In his professional activities, he is actively involved in the entire music production process, ranging from recording and audio processing to mixing and mastering. His experience in audio production equips him with technical skills and artistic sensitivity necessary for managing sound quality. This competence is reflected in his ability to balance instruments, control sonic character, and create spatial perception appropriate to the musical needs of a work. One of the works handled by Ridho is a song titled Melangkah, performed by the band Sans Helixs. The song is arranged with a complete instrumental composition, including vocals, guitar, bass, drums, and strings, resulting in a dense and layered musical texture. The diversity of sonic elements requires a structured mixing approach so that each instrument can be clearly presented and function optimally within the overall arrangement.

Sub 2 Application of Virtual Acoustic Room at the Mixing Stage

The application of a virtual acoustic room in the work Bungong Jeumpa Reimagined in EDM & Traditional Fusion was carried out at the mixing stage with the aim of creating a balanced and realistic spatial perception. Enggar Ardiandi utilized Raum plugin technology to simulate specific room characteristics according to the aesthetic needs of the work. Enggar Ardiandi stated that "Put all the reverb on all of your tracks" (Enggar, interview, 28 November 2025)

This statement refers to the comprehensive application of reverb in the mixing process to build a consistent spatial character. Reverb is not used with the same intensity on every track, but is adjusted so that all sound elements exist within a single acoustic space perception, thereby creating unity, depth, and spatial coherence in the musical work. Premitasari (2016) states that reverb is a combination of direct sound and reflected sound that arrives with a time delay, thus forming an impression of space, distance, and depth in sound.

In the process of producing the song "Bungong Jeumpa Reimagined in EDM & Traditional Fusion," Enggar Ardiandi used the DAW software Studio One and the Raum

plugin as the main tools in spatial sound processing. Technically, this work contains a total of approximately 250 instrument tracks, indicating the complexity of the arrangement and the need for precise spatial management. However, this study limits the object of analysis to only 8 tracks consisting of vocals, synth pad, synth pluck, strings orchestra, rapai, suling, talempong, and accordion. The selection of these eight tracks is based on their role in representing the musical character and regional identity of Aceh, particularly through the traditional Rapai instrument. In addition, these instruments require a more dominant ambience formation, thus necessitating a more intensive application of a virtual acoustic room at the mixing stage.

The application of the virtual acoustic room carried out by Enggar was implemented using a single shared reverb bus, but with different send settings. This application creates variations in depth and distance between instruments, maintains spatial consistency, facilitates ambience control, and helps prevent frequency buildup so that the mix sounds cleaner and more balanced. Fornia (2023) states that the use of a single main reverb contributes to controlling frequency masking and preventing excessive energy buildup, particularly in the low and mid-frequency ranges.

Below is an example image of the plugin treatment applied by Enggar Ardiandi:

Source: Pranata, 2026

Figure 1. Vocals

The use of the Raum reverb plugin in Enggar Ardiandi's work demonstrates the utilization of reverb as a structural element in shaping sonic space. A decay setting of 4.8 s with a mix value of 67.0% emphasizes the dominance of a wide and immersive spatial character, while a pre-delay of 0 ms allows the reverb reflections to be present immediately so that the sound source feels integrated with the space from the outset. The feedback parameter set to 0 ms indicates that the reverb is not used as a repetition effect, but rather as a continuous spatial layer. From a spectral perspective, the high cut setting at 57.3 kHz maintains clarity and openness in the high frequencies, while the low cut of -4.50 dB functions to keep the mix clean from low-frequency buildup. Modulation and damp values of 25.0% each provide a reverb character that is dynamic yet controlled, supported by size settings of 50.0% and diffusion of 25.0%, resulting in a medium-scale virtual space with reflections that are not excessive. Below is an example table of the application of the virtual acoustic room implemented by Enggar:

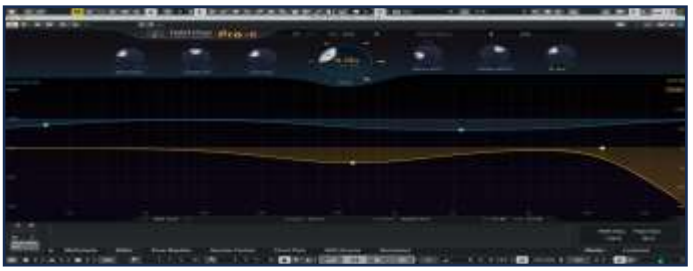
Parameter	Grade

Decay	4.8s
Pre delay	0 ms
Feedback	0 ms
Reverb	100%
High cut	57.3 kHz
Low cut	-4.50 dB
Modulation	25.0%
Damp	25.0%
Size	50.0%
Diffusion	25.0%

Instrument	Panning	Send Reverb
Vocal	Center	-12 dB
Synth Pad	wide	-8 dB
Synth Pluck	L 50%	-14 dB
Strings Orchestra	Wide	-10 dB
Rapai	L+R 25%	-10 dB
Suling	Wide 80%	-8 dB
Talempong	L+R 60%	-6 dB

The statement that the results of the application of a virtual acoustic room have achieved good quality was obtained through a process of comparing the mixing results with professional reference works. Differences in depth and distance of each drum element were achieved through the adjustment of different send levels. The reference used by Enggar as a comparison for the success of this mixing was works by Alffy Rev. Alffy Rev's works are widely accepted by the public because they raise national themes and apply proper mixing treatment, so that the message conveyed can be received by the audience (Ratnasari, 2021). The comparison process was carried out auditively by paying attention to aspects of spatial perception, instrument clarity, and cohesion among sound elements.

In addition, another practitioner named Ridho also applied a different use of a virtual acoustic room. In the mixing process of the song Melangkah by Sans Helixs, the application was carried out selectively and functionally, where only 5 out of 15 instrument tracks were given spatial effect treatment. This decision was based on considerations of the musical role of each instrument, the need for sound clarity, and the management of spatial perception in the mixing process. These tracks include vocals, strings, kick drum, snare drum, and overhead. Through the use of the Cubase DAW and FabFilter plugins, Ridho applied a natural virtual acoustic room treatment. However, Ridho placed one shared reverb for the strings, kick drum, snare drum, and overhead instruments, and one additional reverb for the vocals. The aim was to create a consistent unity of acoustic space. Differences in depth and distance of each drum element were achieved through adjustments of different send levels, not through the use of separate reverbs. The following is an explanation of the virtual acoustic room in Ridho's work:



Source: Pranata, 2026

Figure 2. Vocals

The image above shows the reverb treatment for vocals. Ridho applied a Brightness setting of 30% to maintain the level of vocal clarity. The Character parameter was set to 50% in order to produce soft and controlled reflection quality. A Distance value of 20% was used to preserve the perception of vocal proximity within the acoustic space. Space at 50% functions to shape a natural spatial dimension, with a Decay Rate of 2.0 seconds so that the reverb duration remains proportional. Furthermore, a Stereo Width of 60% was applied to widen the vocal stereo image, while a Mix setting of 30% was used to balance the direct signal with the reverb effect.

Source: Pranata, 2026

Figure 3. Kick Drum, Snare, Overhead dan Strings

The image above shows the reverb treatment for the kick drum, snare drum, overhead, and strings. Ridho applied a Brightness setting of 30% to maintain high-frequency clarity, a Character setting of 20% to shape natural reflection density, as well as a Distance setting of 0% and Space at 30% to create a realistic perception of drum space. A Decay Rate of 1.5 seconds functions to control the reflection duration so that it does not interfere with the groove, while a Stereo Width of 0% is used to keep the sound centered. The Mix was set to 15% on the Aux channel, and the reverb intensity was controlled through the send. The following is an example table of the application of the virtual acoustic room implemented by Ridho:

Instrument	Panning	Send reverb	Brightness	Character	Distance	Space	Decayrate	Stereowidht	Mix
Vokal	Center	-13 dB	30%	50%	20%	50%	2.0s	60%	30%
Strings	L 30%	-12 dB	30%	20%	0%	30%	1.5s	0%	15%
Kick drum	Center	-18 dB	30%	20%	0%	30%	1.5s	0%	15%
Snare drum	Center	-15 dB	30%	20%	0%	30%	1.5s	0%	15%
Overhead	L 30%	-15 dB	30%	20%	0%	30%	1.5s	0%	15%

Based on the mixing practices applied by Ridho, the workflow indicates that the virtual acoustic room is used not merely as an effect, but as a spatial foundation in the mixing process. This approach is in line with Sunarsa (2018), who states that instruments playing an important role in the formation of depth and atmosphere receive optimal spatial effects, while other instruments remain clear and controlled within the context of the overall mix, thereby supporting time efficiency, result consistency, and audio quality in Ridho's work.

The application of a virtual acoustic room in the mixing process carried out by Enggar Ardiandi and Ridho can be analyzed using the Diffusion of Innovations framework proposed by Rogers (2003). From the aspect of relative advantage, the use of virtual reverb technology has been proven to improve the quality of spatial perception, sound depth, and the efficiency of ambience management compared to conventional approaches, both in Enggar's immersive-character works and in Ridho's works that emphasize clarity and spatial control.

In terms of compatibility, the application of a virtual acoustic room by both practitioners demonstrates alignment with aesthetic needs and modern digital music production workflows. Enggar integrates this technology to strengthen a musical identity based on Acehnese tradition within an EDM format, while Ridho adapts it to a more minimal and functional arrangement character.

From the perspective of complexity, although reverb parameter settings are relatively complex, the use of a single shared reverb bus with different send settings in both approaches actually simplifies the mixing workflow. This indicates that technical complexity can be effectively managed through efficient routing strategies.

The aspect of trialability is reflected in the flexibility of reverb parameter settings, which allow for gradual experimentation and adjustment processes without disrupting the main structure of the mix. Both Enggar and Ridho utilize this feature to adjust depth and distance between instruments according to musical needs.

Meanwhile, observability is clearly evident through differences in spatial quality that can be perceived auditively, such as increased cohesion between instruments, clarity of main elements, and consistency of acoustic space. These results can be compared with professional reference works, thereby strengthening evidence of the successful adoption of virtual acoustic room technology in the mixing practices of both practitioners.

Conclusion

The application of a virtual acoustic room at the mixing stage in the works of Enggar Ardiandi and Ridho shows that virtual reverb functions as a spatial foundation in shaping the perception of space, depth, and sonic cohesion in digital music production. Enggar Ardiandi applies a comprehensive approach using a single shared reverb bus with different send settings for each instrument to produce an immersive and consistent spatial character, particularly in integrating Acehnese traditional elements with EDM aesthetics. Meanwhile, Ridho applies a more selective and functional approach by applying reverb treatment only to certain instruments that play an important role in shaping the atmosphere, resulting in a cleaner and more controlled mix. These differences in approach emphasize that the virtual acoustic room is flexible and can be adapted to aesthetic needs and arrangement complexity, while also providing relative advantages in workflow efficiency, spatial consistency, and overall audio quality

improvement.

Suggestion

Based on the findings of this study, it is recommended that future research expand the scope of analysis by involving a larger number of works, practitioners, and musical genres in order to obtain more comprehensive insights into the application of virtual acoustic rooms in digital music production. Subsequent studies may also integrate quantitative approaches, such as perceptual testing or psychoacoustic analysis, to measure listener responses to spatial depth, clarity, and immersion resulting from different reverb strategies. In addition, comparative research between virtual acoustic rooms and real acoustic recording environments, as well as the exploration of emerging spatial audio technologies, could further enrich theoretical frameworks and practical guidelines for effective spatial design in music mixing.

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