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SPACE GEOMETRY AND ITS IMPACT ON ACOUSTIC PERFORMANCE IN FILM STUDIO DESIGN

OGUNNAIKE, Adekunle O., BALOGUN, Adeiodun Q., BABAMBONI, Adekunle S., ADEMAKINNA, Olasummbo O.

Department of Architecture,

Caleb University, Imota, Lagos State, Nigeria

Corresponding Author:

adedotun.balogun@calebuniversity.edu.ng

Abstract

Acoustic performance in film studios is significantly influenced by the geometry of the space, which determines how sound behaves in terms of propagation, reflection, absorption, and diffusion. This paper explores the role of spatial geometry in optimizing acoustic conditions for film production and post-production environments. Drawing on established acoustic principles and global case studies, the study examines how specific architectural strategies such as non-parallel walls, angled ceilings, and irregular room shapes can minimize sound distortions and enhance audio clarity. The research also considers the contextual challenges faced by Nigeria's film industry, including limited technical expertise and financial constraints, and proposes spatial design interventions that are both effective and locally adaptable. By integrating architectural form with acoustic function, the paper presents a framework for designing film studios that meet international acoustic standards while responding to local design realities. The study emphasizes the importance of considering space geometry from the earliest stages of studio planning to ensure optimal sound quality, production efficiency, and long-term sustainability.

Keywords: *Acoustic design, Film studios, Sound propagation, Space geometry, Architecture acoustics*

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1. Introduction

Acoustic performance is a critical, yet often overlooked, element in the design of spaces intended for film and media production. While the visual aspects of filmmaking have historically dominated architectural considerations for studios, the quality of sound—encompassing dialogue, score, and sound effects is equally fundamental to the final cinematic experience. This paper argues that the geometry of a space is a primary determinant of its acoustic behavior, influencing how sound waves propagate, reflect, and diffuse within an environment.

The foundational principles of architectural acoustics, as explored in works on diffuse reflections and scattering coefficients, underscore the need for deliberate spatial design to control sound. As outlined by Rathsam and Wang (2006), the use of diffusive surfaces and proper modeling of sound behavior are essential for creating controlled acoustic fields. Similarly, research by Kong et al. (2023) has demonstrated that non-traditional geometries, such as non-parallel walls and irregular surfaces, can significantly alter aural perception and mitigate common acoustic flaws. This is further reinforced by studies on sound diffusion and reverberation time, which highlight how architectural form directly impacts the clarity and quality of sound within a room (Garay-Vargas & Rodriguez-Manzo, 2008).

The history of film production studios, such as Rome's pioneering Cines studio, has long shown the complex interplay between the spatial design of production facilities and the broader socio-political and technological context of the film industry (Mereu Keating, 2021). However, a significant gap remains in adapting these established principles to emerging creative economies. This paper specifically addresses this gap by focusing on the context of Nigeria's film industry, Nollywood. As noted by Faidi (2024), Nigeria's creative industries, including Nollywood, have achieved global influence despite facing considerable challenges such as "infrastructural deficiencies." This local context makes the application of cost-effective and locally adaptable design solutions particularly vital. The research on "Spatial Design and Aural Experience in Music Schools in Lagos State" provides a relevant local precedent, demonstrating that aural experiences and spatial design are intrinsically linked within the Nigerian architectural and cultural landscape (Orimoloye & Oluwatayo, 2019).

Therefore, this study aims to synthesize established principles of architectural acoustics with the practical realities of a growing and dynamic film industry. By examining the impact of specific spatial geometries from non-parallel walls to angled ceilings on acoustic performance, this paper proposes a framework for film studio design that minimizes sound distortion and enhances audio clarity. The research will provide effective and locally adaptable spatial design interventions, enabling Nigerian film studios to meet international acoustic standards while working within their unique technical and financial constraints. Ultimately, this study emphasizes the crucial need to integrate architectural form and acoustic function from the very first stages of studio planning, ensuring both production efficiency and long-term sustainability.

2. Literature Review

The design of architectural spaces for optimal acoustic performance has been a central focus of acoustical engineering and architectural design for decades. The fundamental premise of this field is that a space's physical geometry and material properties directly govern the behavior of sound waves, a relationship that is particularly critical in environments such as

film studios. This review synthesizes key research on acoustic principles, the impact of spatial geometry, and the unique challenges and opportunities presented by emerging creative industries like Nollywood.

A substantial body of research has investigated the core principles of sound behavior in enclosed spaces. Rathsam and Wang (2006) provide a comprehensive review of diffuse reflections, highlighting how the scattering coefficient of surfaces is a critical factor in room acoustics modeling. Their work emphasizes that accurate sound modeling, including the implementation of edge diffraction, is essential for predicting and controlling acoustic outcomes in spaces like opera halls and, by extension, film studios. This notion is further supported by Garay-Vargas and Rodriguez-Manzo (2008), who explored the impact of sound diffusion on reverberation time. Their research underscores the importance of characterizing diffusive surfaces, even through methods like scale models, to understand how architectural form directly influences sound clarity and quality.

Expanding on these principles, Kong, Ma, Kang, and Wang (2023) conducted a systematic review of acoustic perception in special-shaped spaces. Their findings demonstrate a strong link between non-traditional geometries, such as non-parallel walls, and altered aural perception. This research provides a crucial theoretical basis for using irregular room shapes and angled ceilings as deliberate design strategies to mitigate common acoustic distortions like standing waves and flutter echoes. By moving beyond simple rectangular volumes, designers can create environments that are more acoustically "transparent" and better suited for precise sound capture and playback.

To provide a historical and contextual foundation, Mereu Keating (2021) examined the spatial history of Rome's pioneering film studio, Cines. This work reveals the intricate connection between the physical layout of production facilities and the broader historical, political, and technological factors of the film industry. While Cines operated in a different era and context, its history illustrates that a studio's physical space has always been integral to its creative and economic function. The study's focus on "the politics of urban planning" and the "spatiality of film production" offers a valuable lens through which to view contemporary studio design challenges.

On a global scale, major facilities like Pinewood Studios in the United Kingdom serve as a modern benchmark for acoustic design in film production. The design of its sound stages goes well beyond basic requirements, prioritizing extreme acoustic isolation to create a "dead" environment for high-fidelity audio recording (B&K Structures, n.d.). To combat external noise from sources like nearby motorways, Pinewood has implemented bespoke solutions using advanced materials and construction methods, such as timber and precast cassettes with specialized acoustic insulation (Acoustiblok, n.d.; B&K Structures, n.d.). This commitment to technical excellence is further demonstrated by the studio's practice of engaging with acoustic consultants to perform audits and ensure performance standards are met in its new facilities (HGC Acoustics, n.d.). This focus on both the geometry and the material science of sound stages highlights the global industry standard for technical excellence, providing a valuable point of comparison for the design aspirations of other creative economies.

Finally, this paper addresses the specific context of Nigeria's rapidly growing film industry, Nollywood. Faidi (2024) notes that Nigeria's creative industries have achieved significant global influence, largely driven by a "do-it-yourself mindset." However, this success has occurred despite "infrastructural deficiencies," a challenge that makes the application of

resourceful and locally adaptable design solutions paramount. A relevant local precedent is found in the work of Orimoloye and Oluwatayo (2019), who explored the link between spatial design and aural experience in music schools in Lagos State. Their research confirms that the aural environment is a key component of architectural experience within the Nigerian context. This body of work collectively highlights the need for a framework that not only applies international acoustic standards but also pragmatically responds to local design realities, ensuring that architectural forms can serve their acoustic function effectively and sustainably.

3. Methodology

This paper employs a qualitative, descriptive research design centered on a systematic literature review and comparative case study analysis. The research aims to synthesize established principles of architectural acoustics and apply them to the specific challenges of designing film studios within emerging creative economies.

3.1 Data Collection

A systematic search of academic and industry literature was conducted using keywords related to architectural acoustics, sound diffusion, reverberation time, film studio design, and the creative industries of Nigeria and Italy. Sources included peer-reviewed journal articles, conference papers, technical reports, and policy briefs. The collected data focuses on the following key areas:

- Fundamental principles of architectural acoustics, including the behavior of diffuse reflections and sound diffusion.
- Methodologies for measuring acoustic performance, such as the use of scale models and acoustic audits.
- Historical and contemporary case studies of film studio design, including Cines in Rome and Pinewood Studios in the UK.
- Socio-economic analyses of Nigeria's creative industries (Nollywood and music) and the challenges of infrastructural development.

3.2 Analytical Framework

The analysis proceeds in three stages:

1. **Principle Synthesis:** Key acoustic principles are extracted and synthesized from the technical literature to form a theoretical foundation for optimal sound design in architectural spaces. This includes an examination of how geometry, materials, and specialized techniques (like scattering surfaces) influence sound quality.
2. **Comparative Case Study:** An analysis of historical and modern film studios is conducted to understand the evolution of design practices. By comparing the spatial history of Cines with the advanced acoustic solutions of Pinewood Studios, the framework identifies both enduring design challenges and contemporary best practices.
3. **Contextual Application:** The synthesized principles and comparative insights are applied to the local context of Nollywood and the broader Nigerian creative industry. This analysis draws on local research to highlight the specific infrastructural and creative constraints that must be considered. The goal is to develop a framework for

architectural solutions that are both technically effective and pragmatically adaptable to local conditions.

4. Results and Discussion

The research successfully synthesizes key principles of architectural acoustics and applies them to a comparative and contextual framework. The primary findings and their implications are discussed below.

4.1 Synthesis of Acoustic Principles

The literature review established a foundational understanding of how sound behaves in enclosed spaces. The work of Rathsam and Wang (2006) and Garay-Vargas and Rodriguez-Manzo (2008) confirms that a space's reverberation time and the quality of its diffuse reflections are critical determinants of aural quality. The key takeaway is that architectural form and material properties are not merely aesthetic choices but are functional elements in controlling sound. Furthermore, Kong et al. (2023) demonstrated that non-traditional geometries, such as non-parallel walls, can be deliberately employed to mitigate acoustic defects, proving that creative architectural forms can be acoustically superior to conventional designs.

4.2 Comparative Analysis of Cines and Pinewood Studios

The comparative analysis revealed a clear trajectory in film studio design. The historical case of Cines (Mereu Keating, 2021) shows that the spatiality of film production has always been tied to a studio's operational and creative identity. In contrast, the modern Pinewood Studios (Acoustiblok, n.d.; B&K Structures, n.d.) represents the culmination of technical excellence, where architectural design is fundamentally driven by the need for extreme acoustic isolation. The "dead" environment of a Pinewood sound stage, achieved through advanced materials and bespoke solutions, stands as the global benchmark for high-fidelity audio capture. This comparison highlights that while the core function of a studio remains constant, the technical sophistication of its acoustic design has evolved to become a central pillar of its competitive advantage.

Table 1: Comparison of Cines and Pinewood Studios

Aspect	Cines (1905-1937)	Pinewood Studios (Modern)
Design Philosophy	Tied to operational and creative identity, urban planning context	Driven by extreme acoustic isolation, technical excellence
Acoustic Strategy	Implicit, part of overall architectural form	Explicit, bespoke solutions with advanced materials and construction
Key Feature	Spatial history and political context	Acoustic isolation and a "dead" environment
Role in Industry	Pioneering film studio, foundational	Global benchmark, competitive advantage

4.3 Application to the Nollywood Context

The research successfully bridges the gap between global standards and local realities. The "do-it-yourself" ethos of Nollywood (Faidi, 2024), while a source of its creative dynamism, also points to the "infrastructural deficiencies" that are a major design challenge. This is where the local research from Orimoloye and Oluwatayo (2019) becomes crucial, confirming that the aural environment is a key aspect of architectural experience in the Nigerian context.

Based on this synthesis, a framework for architectural solutions in Nollywood is proposed. Instead of solely pursuing the expensive and resource-intensive bespoke solutions of Pinewood, Nollywood studio design can leverage the principles of acoustic diffusion and non-traditional geometries (as described by Kong et al., 2023). This would involve:

- **Creative use of geometry:** Designing studios with angled walls, sloped ceilings, and irregular room shapes to naturally diffuse sound and reduce echoes without relying on costly acoustic panels.
- **Resourceful material selection:** Prioritizing the use of locally sourced and cost-effective materials that can be adapted to serve both structural and acoustic functions.
- **Modular and adaptable design:** Creating studio spaces that are flexible and can be reconfigured for different production needs, reflecting the agile nature of Nollywood's filmmaking process.

This approach offers a pragmatic and sustainable path forward, enabling the creation of acoustically superior spaces that are technically effective, economically viable, and culturally resonant.

Table 2: Proposed Framework for Nollywood Studio Design

Principle	Description	Rationale
Creative Use of Geometry	Design studios with angled walls, sloped ceilings, and irregular room shapes.	Naturally diffuses sound, reduces echoes, and avoids reliance on costly acoustic panels.
Resourceful Material Selection	Utilize locally sourced and cost-effective materials.	Ensures economic viability and sustainability, adaptable to local infrastructural conditions.
Modular and Adaptable Design	Create flexible spaces that can be reconfigured for various production needs.	Reflects the agile, "do-it-yourself" nature of Nollywood's filmmaking process.

5. Conclusion and Recommendations

5.1 Conclusion

This paper has demonstrated that effective architectural acoustic design is a critical, yet often overlooked, component of film studio infrastructure, particularly within emerging creative industries. By synthesizing foundational acoustic principles, analyzing the evolution of studio design through a comparative case study of Cines and Pinewood Studios, and applying these insights to the unique context of Nollywood, a pragmatic and innovative design framework has been established. The core finding is that achieving high-quality acoustic performance

does not require a direct, resource-intensive replication of global benchmarks. Instead, by strategically leveraging architectural geometry, resourceful material selection, and modular design principles, film studio spaces can be created that are both acoustically superior and economically viable. This approach moves beyond the traditional "four-walled box" model to propose a more intelligent and contextual form of architectural design that directly addresses the challenges and celebrates the strengths of the local creative economy.

5.2 Recommendations

Based on the findings of this research, the following recommendations are provided for architects, designers, and industry stakeholders involved in the development of film studio infrastructure in the Nollywood context:

1. **Prioritize Form over Expensive Materials:** Embrace non-traditional geometries, such as non-parallel walls, angled ceilings, and complex surface profiles, as the primary method for controlling sound diffusion and mitigating acoustic defects. This is a cost-effective alternative to relying heavily on prefabricated or imported acoustic treatment panels.

2. **Conduct Local Material Studies:** Investigate and test locally available materials for their acoustic properties. By understanding and adapting local resources, it is possible to develop sustainable and culturally relevant solutions for sound absorption and diffusion that reduce reliance on costly imported products.

3. **Adopt a Modular Approach:** Design studio spaces with a focus on modularity and adaptability. This allows for flexible reconfiguration of spaces to suit a variety of production needs, from small-scale shoots to larger sets, and aligns with Nollywood's agile production style.

4. **Integrate Acoustic Consulting Early:** Engage with acoustical consultants at the initial design phase of a project. Early collaboration can prevent costly acoustic problems and ensure that design choices are guided by sound principles, rather than being an afterthought.

5. **Foster a Culture of Documentation and Best Practices:** Encourage the documentation of successful local studio designs and their acoustic performance. Building a repository of case studies will help to establish a set of best practices tailored specifically to the Nigerian context, fostering continuous improvement and innovation within the industry.

By implementing these recommendations, the Nollywood industry can enhance its infrastructural capabilities, improve the technical quality of its productions, and solidify its position as a global creative powerhouse through a uniquely local and sustainable architectural approach.

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