

The Role of Acoustic Strategies in Improving Performance Spaces Within Art and Craft Centers

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ABSTRACT

The rapid expansion of the creative industries has transformed contemporary art and craft centers into complex, multi-functional environments where highly incompatible acoustic activities coexist within a shared architectural footprint. While conventional architectural frameworks often treat acoustic design as an engineering afterthought, poor acoustic conditions lead to severe communication difficulties, cognitive distraction, and reduced user productivity. This study examines the role of acoustic strategies in improving the quality, functionality, and user experience of performance spaces within integrated art and craft centers. Adopting a literature review methodology, the paper systematically analyzes and synthesizes global knowledge, building regulations, and environmental standards to bridge the gap between quantitative noise control and qualitative soundscape design. The findings demonstrate that effective acoustic optimization is achieved through an early-stage, multi-pronged passive approach combining strategic spatial zoning (using non-critical buffer zones), irregular room geometries (such as 7° to 12° wall splays), and balanced material absorption and diffusion. Crucially, the study establishes that locally available, sustainable materials including agricultural fiber panels, porous wood-wool boards, and perforated timber facings provide mid-frequency sound absorption coefficients ($\alpha = 0.60$ to 0.80) that match or exceed conventional imported synthetic fiberglass. Ultimately, this research provides a cohesive architectural framework to optimize regional civic and cultural institutions, proving that sustainable, geometry-driven design can resolve acoustic conflicts without compromising the vibrant nature of adjacent creative zones.

Keywords: Architectural Acoustics, Art and Craft Centers, Sustainable Acoustic Materials, Spatial Zoning, Reverberation Time.

INTRODUCTION

The growing expansion of creative industries has transformed contemporary art and craft centers into multifunctional environments supporting artistic production, cultural preservation, education, social interaction, entrepreneurship, and performance activities. Unlike traditional gallery spaces that primarily focus on visual engagement, modern art centers increasingly combine exhibition spaces, creative workshops, fabrication laboratories, rehearsal studios, community theaters, and collaborative spaces within integrated developments. The increasing complexity of these facilities introduces significant environmental challenges. Activities occurring simultaneously within shared environments often possess conflicting acoustic requirements (Baldachini et al., 2026). Workshops generating machine noise may exist adjacent to rehearsal spaces requiring concentration and speech clarity. Exhibition areas intended for contemplation may be positioned near highly interactive social spaces. Performance spaces themselves require carefully controlled sound distribution, reverberation characteristics, and background noise levels to maintain optimum functionality. In modern architectural design since sound directly affects occupant comfort, interpersonal communication, focus, productivity, and artistic creativity. Building occupant comfort and functionality are guaranteed by acoustics the science and practice of controlling sound production, transmission, and perception in enclosed volumes. The comprehensive purpose of architectural acoustics is to reduce intrusive noise, manage reverberation times,

improve speech intelligibility, and create a favourable aural environment by the intentional use of spatial layouts, material choices, construction detailing, and environmental techniques. When deployed properly, acoustic techniques enhance built environments' overall performance, encourage pleasurable experiences, and promote human activities across the entire operational lifecycle of a cultural facility (Mercugliano et al., 2023).

Challenges for architects and structural designers. Poor acoustic conditions within creative facilities contribute toward severe communication difficulties, reduced user productivity, acute mental fatigue, cognitive distraction, decreased user satisfaction, and an overall reduction in perceived environmental quality. Conversely, carefully controlled acoustic environments can significantly improve communication effectiveness, spatial comfort, creativity, and emotional wellbeing. Recent developments within architectural research increasingly emphasize human-centered design approaches that prioritize occupant comfort and environmental quality. However, existing literature demonstrates that much of the academic discussion surrounding architectural acoustics remains heavily concentrated within educational facilities, healthcare buildings, office environments, and single-purpose symphonic performance halls, while relatively limited attention has been directed toward integrated art and craft centers despite their profound acoustic complexity (Okoro & Adeyemi, 2024). Despite the growing popularity of integrated cultural hubs worldwide, conventional architectural frameworks often treat acoustic design as a secondary engineering afterthought or seek to isolate performance spaces entirely. This isolation undermines the collaborative, fluid, and democratic nature of modern art and craft centers. The fundamental problem lies in the acute acoustic conflict inherent to these multi-use facilities. Performance spaces fundamentally require low ambient noise levels, controlled reverberation times (SRTs), and optimized sound diffusion to ensure that unamplified speech and acoustic music remain clear, vibrant, and dynamic. Conversely, active craft studios generate high-amplitude, low-frequency airborne and structure-borne noise through equipment operation, heavy material processing, and intense human interaction (Keenan & Pauletto, 2022). Furthermore, performance halls within community art centers are rarely single-use; they must dynamically adapt from deadened, speech-centric lecture layouts to lively, resonant musical configurations. Traditional, static acoustic treatments such as permanent synthetic fiberglass absorption panels completely fail to provide this multi-functional adaptability and frequently clash with the sustainable, biophilic design aesthetics demanded by modern cultural institutions. While significant research exists on specialized, single-purpose concert halls, there is a critical knowledge gap regarding integrated acoustic strategies tailored specifically for the multi-functional, high contrast environments of art and craft centers. In rapidly urbanizing tropical regions, such as Lagos State, Nigeria, these structural and programmatic limitations are severely amplified. Acoustic comfort is rarely prioritized during the preliminary spatial planning phases of public architecture. Rapid urbanization, commercial decentralization, and infrastructural expansion have led to a massive increase in ambient environmental noise pollution (Ouda et al., 2025).

This study aims to examine the role of acoustic strategies in improving the quality, functionality, and user experience of performance spaces within art and craft centers through an exhaustive review of existing literature. The objectives include, to identify major acoustic strategies commonly applied in the design of performance spaces within art and craft centers, to examine the influence of acoustic strategies on the functionality, sound quality, and user experience of performance spaces, to evaluate existing literature on acoustic design approaches in order to establish effective, passive, and sustainable strategies for improving performance spaces within art and craft centers. Moreover, modern architecture styles in developing contexts frequently put aesthetic visual trendiness above environmental functionality, gradually replacing sustainable, historically proven indigenous architectural expressions. Inadequate noise and reverberation management leads directly to poor user experience, decreased community engagement, decreased voice intelligibility, and chronic listener fatigue. There is a deep, unaddressed gap between architectural design intent and actual user satisfaction in many current facilities, as seen by the complete lack of specific acoustic methods including HVAC noise control, efficient sound-absorbing wall systems, treated ceilings, and appropriate structural detailing. The majority of regional cultural and artistic institutions today operate within poorly modified or repurposed buildings that are fundamentally unable to satisfy contemporary standards for acoustic comfort, user engagement, lighting quality, technological integration, and spatial performance. This study bridges this critical gap by synthesizing recent advancements in sustainable material absorption, geometric diffusion, structural isolation, and active variable acoustics into a

cohesive architectural framework designed to optimize performance spaces without compromising the vibrant, productive nature of surrounding craft zones (Bartalucci & Luzzi, 2020).

LITERATURE REVIEW

In contemporary architecture, building acoustics has shifted from a specialised technical issue to a core aspect of environmental design, largely because of the strong link between sound quality and human health. Research increasingly shows that acoustics is not just a background condition but a major determinant of occupants' psychological comfort, cognitive efficiency, and physical well-being. A well-designed acoustic environment does more than control noise; it reduces unwanted external sound while carefully regulating internal sound behaviour, creating spaces that support both focused activity and mental restoration (Yan & Tronchin, 2025). On the other hand, continuous exposure to poorly controlled noise has been associated with heightened stress levels, cardiovascular strain, reduced concentration, and lower productivity. As a result, there is a growing global emphasis on acoustic regulation in building design, with formal standards guiding acceptable limits for sound insulation between spaces, impact noise control across floors, and appropriate reverberation times depending on building function (Arenas, 2020).

To ensure consistency in practice, international bodies such as the International Organization for Standardization (ISO) have developed comprehensive acoustic guidelines that provide a shared framework for researchers, designers, and engineers. Similarly, regional institutions like the European Committee for Standardization have aligned these principles with local building regulations to ensure uniform application across different countries. Through collaborative frameworks such as the Vienna Agreement, the process of testing, certifying, and approving construction materials and systems has become more streamlined and reliable (Olatunbosun, 2024). This standardised system also places responsibility on manufacturers to produce building materials that meet increasingly demanding acoustic performance criteria. As a result, architects are better equipped to make informed material choices, relying on tested data that reliably reflects real-world performance rather than theoretical assumptions alone. However, despite these advancements, achieving optimal acoustic control in practice remains complex. Sound behaviour is influenced by multiple variables including spatial volume, architectural form, surface geometry, and material porosity. While digital simulation tools now allow designers to predict acoustic outcomes before construction, the challenge of accurately translating theoretical models into real-life performance continues to be a critical area of ongoing research and professional refinement (Mu et al., 2022).

Art And Craft Centers As Complex Acoustic Environments

Art and craft centers represent one of the most acoustically complex and high-contrast typologies in contemporary architectural practice. This complexity stems from their fundamentally multi-functional and hybrid nature, where highly incompatible human activities occur simultaneously within a shared architectural footprint. Unlike single-function buildings such as offices, warehouses, or specialized symphonic concert halls, an art and craft center must integrate spaces requiring absolute silence and contemplative serenity with industrial-grade environments that generate substantial, high-amplitude noise. Within these facilities, raw creative fabrication coexists with public exhibition, academic instruction, and delicate performance activities, creating a layered acoustic ecosystem that demands careful architectural mediation (Keenan & Pauletto, 2022).

Active workshop zones typically accommodate carpentry, metal fabrication, ceramics production, stone sculpture, textile manufacturing, and digital fabrication processes. These operations rely on continuous use of heavy machinery, power tools, pneumatic systems, kilns, and intense human interaction, producing persistent high-amplitude, low-frequency airborne and structure-borne noise that often ranges between 70 dBA and 85 dBA. If not properly contained, these vibrations propagate through the building structure and intrude into adjacent spaces. In contrast, exhibition galleries, research archives, private studios, digital media labs, and lecture rooms require highly controlled acoustic environments, with galleries demanding near-silent conditions (not exceeding 40 dBA) to support contemplation and visual engagement, while lecture and training spaces require optimized reverberation control for speech intelligibility and reduced listener fatigue (Rodriguez, 2024). This complexity is further intensified by the inclusion of performance spaces such as multi-use cultural halls

and auditoriums, which must flexibly accommodate contrasting acoustic demands ranging from highly “dead” environments for spoken word and theatrical clarity to more “live” acoustic conditions for music and choral performances that require warmth, resonance, and spatial envelopment. Managing these conflicting requirements within a single facility necessitates sophisticated passive acoustic strategies, including spatial zoning, structural isolation, and careful selection of material performance systems to ensure that the energetic soundscape of production areas does not compromise the serenity required for exhibition and performance zones (Secchi et al., 2023).

Architectural Acoustics

Architectural acoustics is a specialized, interdisciplinary field within building science that focuses on controlling and optimizing sound behaviour in built environments. Its scope goes beyond noise reduction, extending to the intentional design of spaces that achieve specific acoustic outcomes based on their function and use. At its core, the discipline examines how sound fields are formed and how humans perceive them within architectural spaces. This means acoustics is not only about physical sound behaviour but also about how occupants experience and interpret sound. Effective acoustic design therefore requires a balance between physical principles, spatial configuration, and human perception. Designers must understand how room geometry, dimensions, and material properties collectively shape the overall acoustic environment (Starowicz & Zieliński, 2024). Sound in buildings originates from mechanical vibrations that travel through air and structural elements. When these waves encounter surfaces, they behave in different ways: they may be reflected, absorbed, transmitted, or diffused. Reflection occurs when sound bounces off hard surfaces; absorption happens when materials convert sound energy into heat; transmission allows sound to pass through partitions; and diffusion spreads sound evenly across a space (Mu et al., 2022). The balance between these processes defines the acoustic character of any room.

In professional practice, building acoustics addresses several interconnected concerns, including internal sound quality, sound isolation between spaces, control of mechanical and environmental noise, and reduction of structural vibration. According to Vigran, acoustics should be understood as a comprehensive field that covers all sound and vibration-related phenomena within buildings. This highlights the importance of designing building elements that simultaneously block unwanted noise and support desirable sound conditions. To predict acoustic behaviour, researchers rely on mathematical models such as the wave equation to estimate sound pressure distribution within spaces. Because real architectural forms are often too complex for analytical solutions, numerical methods like the finite element method are widely used to simulate how sound interacts with structures and air. Ultimately, the goal of architectural acoustics is to ensure that spaces perform optimally for their intended use whether for quiet reflection, artistic expression, or dynamic production activities. In complex environments such as an Art and Craft Center, this requires careful coordination of sound insulation, noise control, and vibration management to create a balanced and functional acoustic environment (Megas-Recalde & Márquez, 2021).

Room Acoustics

Room acoustics is a core area of building science that focuses on how sound behaves within enclosed spaces and how those behaviours influence human experience. In a complex facility such as an Art and Craft Center, it becomes the link between architectural form and functional performance. It ensures that a workshop environment supports clear communication—so instructors can give safety instructions effectively while gallery spaces remain calm, immersive, and suitable for reflection. Rather than focusing only on reducing noise, room acoustics considers how people actually perceive sound within a space. In the context of an Art and Craft Center, it helps define whether a room feels clear, overly echoic, or comfortably balanced for its intended use. A key concept in this evaluation is how sound energy behaves after it is produced, especially how it reflects and decays within the room. Early reflections can enhance speech understanding and spatial awareness, while late reflections may increase a sense of depth and enclosure but can also lead to muddiness if not properly controlled. Designing a successful creative environment therefore requires careful tuning of these acoustic effects so that different spaces workshops, galleries, and event halls each support their specific activities without acoustic conflict (Almagro-Pastor et al., 2022).

Reverberation Time

Reverberation time is one of the most important indicators of acoustic quality in any enclosed space. It refers to the time it takes for sound to reduce by 60 decibels after the source has stopped. This single measurement strongly influences how sound is perceived within a room. When reverberation time is too long, sounds overlap excessively, making speech unclear and creating a blurred auditory environment. When it is too short, the space can feel acoustically flat or unnatural, stripping away the warmth and resonance that make communication feel comfortable. In a facility like an Art and Craft Center, different spaces require different reverberation conditions: workshops need shorter reverberation for clarity, while exhibition or performance spaces may benefit from slightly longer reverberation to enhance atmosphere and richness (Raja et al., 2024).

THEORETICAL REVIEW

A strong understanding of sound behaviour is essential for effective acoustic design, particularly in complex facilities such as an Art and Craft Center. Sound is fundamentally a mechanical wave produced by vibrating objects and transmitted through media like air or solid building materials. In creative environments, these vibrations arise from everyday activities such as sculpting, pottery work, or instruction sessions (Secchi et al., 2023). As sound travels, it creates pressure variations in the air in the form of longitudinal waves, which require a physical medium to propagate. This knowledge is crucial for architects because it allows them to predict how sound will move across different spaces, such as how noise from active workshops might affect quieter gallery zones. Without this scientific foundation, acoustic design becomes speculative rather than intentional and precise. To properly understand and control sound in architectural spaces, three key properties must be considered: frequency, amplitude, and wavelength. Frequency determines pitch and is measured in Hertz, with high frequencies perceived as sharp sounds and low frequencies as deep tones. Amplitude refers to the strength or loudness of sound and is measured in decibels, while wavelength is the distance between successive wave peaks and is inversely related to frequency. In practical terms, low-frequency sounds travel farther and can pass around obstacles or through dense materials, whereas high-frequency sounds are more easily absorbed or blocked. This distinction is especially important in an Art and Craft Center, where different craft activities generate varying sound profiles that require tailored acoustic solutions (Bem et al., 2025).

When sound interacts with building surfaces, it undergoes four main processes: reflection, absorption, transmission, and diffusion. Reflection occurs when sound bounces off hard surfaces such as concrete, glass, or sandcrete blocks, which are common in Nigerian construction. While controlled reflection can help distribute sound in large spaces, excessive reflection may lead to noise buildup and communication challenges. Absorption occurs when sound energy is reduced within porous or fibrous materials, such as acoustic tiles, wood wool panels, or natural fibre boards, which convert sound energy into heat and help control reverberation (Bravo-Moncayo et al., 2025). Transmission refers to sound passing through building elements like walls and floors, making it a critical concern when separating noisy workshops from quiet galleries; this is managed through dense, well-sealed partitions to ensure acoustic privacy. Diffusion, on the other hand, involves scattering sound in multiple directions when it strikes irregular or textured surfaces, helping to break up strong reflections and create a more even sound field. This is particularly useful in performance and training spaces where clarity and balance are important. Together, these four processes determine the overall acoustic character of a space, and their careful control ultimately decides whether the Art and Craft Center provides a comfortable, clear, and immersive environment or becomes acoustically dysfunctional (Raja et al., 2024).

CONCEPTUAL FRAMEWORK

The study of acoustic strategies in cultural and creative buildings is guided by two closely related but distinct approaches: the Noise Control Model and the Soundscape Design Model. The Noise Control approach focuses on reducing unwanted sound that interferes with human comfort, concentration, and well-being. In an urban setting this involves limiting external noise from traffic, industrial activity, and generators, as well as controlling internal issues such as echo and reverberation. In contrast, the Soundscape approach views sound not only as a problem but also as a meaningful part of human experience. It emphasizes how people perceive and interpret their acoustic environment in context. Similarly, the idea of aural architecture suggests that sound is deeply tied

to how people emotionally and cognitively experience space, meaning that buildings shape not just what we see, but also what we hear and feel. Both approaches are essential in designing an Art and Craft Center, as they address different but complementary aspects of acoustic quality (Kampen et al., 2023).

Research Gap

Although architectural acoustics and performance space design have been widely studied, there remains a significant gap in understanding how acoustic strategies can be effectively applied within Art and Craft Centers. Existing studies largely focus on isolated acoustic parameters or conventional performance spaces, often overlooking the complex, multi-functional nature of creative environments that combine production, exhibition, learning, and performance activities. Current literature also reveals a disconnect between quantitative noise control approaches and qualitative soundscape theories, limiting the development of integrated acoustic frameworks. Furthermore, most acoustic standards and material performance studies are based on single-use spaces and controlled environments, creating limited design guidance for hybrid cultural facilities. There is also insufficient synthesis of practical, design-oriented strategies that combine spatial planning, material selection, and sound management within one framework. Consequently, a need exists for a more comprehensive literature-based understanding of how acoustic strategies can improve performance spaces within Art and Craft Centers.

METHODOLOGY

This study adopted a structured literature review methodology to examine the role of acoustic strategies in improving performance spaces within Art and Craft Centers. The methodology was selected because the study sought to synthesize existing knowledge rather than generate primary data. A total of twenty (20) relevant literatures comprising peer-reviewed journal articles, conference papers, academic books, professional reports, theses, and building standards were systematically reviewed. Literature was sourced from academic databases using keywords related to architectural acoustics, performance spaces, soundscape design, creative environments, and acoustic strategies. The selected studies were screened based on relevance to building acoustics, spatial planning, material performance, and user experience within built environments. Following selection, the reviewed literature was critically analyzed and synthesized using thematic categories including spatial zoning, room geometry, sound absorption, diffusion strategies, and sustainable acoustic interventions to establish an integrated understanding of effective acoustic design approaches for multi-functional creative environments.

FINDINGS & ANALYSIS

Spatial Planning As An Acoustic Strategy

Spatial organization and architectural arrangement are consistently highlighted in building science as some of the most efficient, sustainable, and cost-effective passive strategies for controlling sound in architecture. Rather than relying on expensive acoustic fixes after construction such as adding wall-mounted panels or synthetic insulation Hamouta, (2025) shows that real acoustic quality is achieved much earlier, through thoughtful spatial planning during the initial design stage. When spaces are carefully zoned from the outset, architects can separate noisy and quiet functions using distance, layout, and form, reducing the need for heavy material-based interventions that often increase cost and environmental impact. At the heart of this approach is the use of buffer zones spaces that are not acoustically sensitive but strategically placed to absorb and interrupt sound travel. These include corridors, storage rooms, administrative offices, restrooms, service areas, loading zones, small retail spaces, and even internal courtyards. When arranged properly, these spaces act as acoustic cushions between loud and quiet zones. For instance, positioning a series of storage rooms and a long circulation corridor between a noisy woodworking studio and a quiet performance hall can significantly reduce sound transmission before it reaches sensitive areas. In this way, sound is gradually weakened as it passes through multiple layers of non-critical spaces rather than moving directly between functions (Starowicz & Zieliński, 2024).

This form of spatial planning is especially important in art and craft centres, where highly active, noisy production spaces must operate alongside quiet, focused environments like galleries or theatres. Spatial syntax

also plays a key role in responding to external noise conditions. In dense urban areas such as, where traffic and environmental noise are constant, careful layout decisions ensure that the most sensitive spaces are located deeper within the site, away from direct exposure to the street. At the same time, less sensitive functions such as offices or support spaces are placed along the perimeter, acting as a protective acoustic barrier. This approach not only improves sound comfort but also reduces dependence on costly construction materials, lowers environmental impact, and supports a more sustainable, geometry-driven method of achieving high-performance acoustic design (Rodriguez, 2024).

Passive Acoustic Strategies: A Multi-Pronged Approach

Contemporary architectural discourse and environmental engineering literature categorize passive acoustic control into a robust, three-pronged design intervention framework: Spatial Geometry and Form, Material Performance (Absorption vs. Diffusion), and Building Envelope Isolation. This multi-pronged approach relies entirely on the laws of physics and material science to optimize internal sound fields and block external noise penetration without requiring continuous electrical power or complex mechanical components. By harmonizing these three pillars, architects can achieve precise, high-performance acoustic environments that are inherently sustainable and highly durable (Raja et al., 2024).

Spatial Geometry and Form

The shape and volume of a space have a direct influence on how sound behaves, particularly in how it reflects early and how evenly it spreads throughout an enclosed area. In acoustic design practice, simple geometric forms such as perfect cubes, long rectangular boxes with parallel walls, or spaces with flat opposing surfaces are generally avoided in performance environments. This is because parallel walls tend to trap and repeatedly bounce sound waves between them, leading to problems like standing waves, room resonances, and flutter echoes. These effects create a sharp, repetitive bouncing of sound that reduces clarity and makes speech and music difficult to understand (Mu et al., 2022).

To address these challenges, architects and acoustic designers prefer more dynamic and irregular spatial forms that help manage how sound is distributed. Common approaches include fan-shaped layouts, modified hexagonal plans, or carefully refined shoebox configurations where walls are intentionally angled rather than left parallel. Side walls are often slightly splayed, typically within a range of about 7° to 12° , which helps disperse early reflections more evenly across the audience. This improves speech intelligibility and creates a stronger sense of depth and openness within the space, resulting in a more natural and engaging listening experience. Ceiling design also plays a crucial role in achieving good acoustic performance. Instead of flat surfaces, ceilings are often shaped using stepped, angled, or multi-level configurations to better control sound movement. The areas closer to the stage are usually designed with more reflective finishes to help project sound effectively toward the rear of the hall. Meanwhile, ceiling zones further back may be curved or sculpted to scatter late reflections, preventing unwanted echoes from returning to the stage. When combined, these geometric and material strategies help create a well-balanced acoustic environment that supports both clarity and richness in performance settings (Hadley et al., 2021).

Material Absorption and Diffusion

Internal acoustic design depends on a carefully managed balance between sound absorption and diffusion in order to achieve an appropriate reverberation time for a space. Absorptive materials work by reducing sound energy within a room. They achieve this through porous or fibrous structures that trap sound waves, where the wave energy is gradually converted into a small amount of heat through friction. This helps to reduce overall noise levels, control excessive reflections, and shorten reverberation time. However, if a space relies too heavily on absorption, it can become overly dry and lifeless acoustically. Such environments often feel unnatural and can even make speech or performance more physically demanding for users, as the room lacks the supportive resonance that gives sound warmth and richness. For this reason, absorption alone is not sufficient for high-quality acoustic design (Farinmade et al., 2023).

To maintain a more natural and engaging sound environment, diffusion is introduced as a complementary strategy. Unlike absorption, diffusive surfaces do not remove sound energy; instead, they redistribute it. This is achieved through irregular, textured, or carefully shaped surfaces that break incoming sound waves and scatter them in multiple directions. As a result, sound energy is spread more evenly throughout the space. This even distribution helps eliminate common acoustic issues such as “hot spots,” where sound becomes overly concentrated, and “dead spots,” where sound is weak or unclear. By balancing absorption with diffusion, designers create an acoustic environment that feels clear, natural, and immersive, ensuring that every seat in a performance space receives a consistent and comfortable listening experience (Keenan & Pauletto, 2022).

Comparative Geometric Typologies For Performance Auditoriums

By systematically comparing international design standards with empirical architectural research, distinct geometric configurations have been identified and assessed based on how well they perform acoustically, as well as their limitations. The overall form of an auditorium is one of the most critical early design decisions because it directly influences how sound travels, reflects, and spreads throughout the seating area. In essence, the chosen geometry sets the foundation for the entire acoustic behaviour of the space. Table 1 presents a comparative overview of common auditorium forms, highlighting their strengths, weaknesses, and most suitable applications within multi-functional cultural facilities

GEOMETRIC TYPOLOGY	ACOUSTIC ADVANTAGES	SIGNIFICANT LIABILITIES	IDEAL CULTURAL APPLICATION
Shoebox Design (Classical Rectangular Layout)	Provides outstanding lateral reflections; delivers excellent cross-room sound field density; creates a powerful sense of acoustic envelopment and warmth.	High risk of severe flutter echoes between long, parallel side walls if left completely untreated; requires extensive wall texturing or partial absorption.	Music recitation rooms; intimate acoustic performance; high-end chamber music; traditional orchestral galleries.
Fan-Shaped Design (Splayed Layout)	Brings the audience significantly closer to the stage maximizing sightlines; reduces the total volume-per-seat ratio; projects early direct reflections effectively.	Tends to direct lateral sound waves away from the central seating area; highly prone to severe concave rear-wall echoes and sound focusing anomalies.	Large multi-purpose performance halls; community cultural auditoriums; amplified music venues.
Reverse-Fan / Hexagonal (Angled Side Walls)	Directs early lateral reflections back into the central seating core; provides outstanding speech clarity and excellent early energy distribution.	Requires complex structural engineering and framing detailing; results in reduced seating capacity at the narrow rear profile of the hall.	Drama theaters; spokenword poetry spaces; vocational training lecture spaces.
Organic / Curvilinear (Free-Form Profiles)	Diffuses sound waves naturally and fluidly across continuously curved profiles; eliminates sharp, harsh echo boundaries.	Extreme risk of creating severe acoustic hotspots and destructive sound focusing if radius calculations and curve geometries are incorrect.	Flexible exhibition galleries; multi-sensory craft demonstration zones; collaborative artist spaces.

Table 1: Comparative Analysis of Geometric Forms and Acoustic Performance

Sources: Samuel et al., (2023) ,Rodriguez, (2024), Mercugliano et al., (2023) & Hamouta, (2025)

As shown in Table 1, there is no single geometric configuration that delivers perfect acoustic performance across all conditions. Instead, each spatial typology produces its own set of acoustic behaviours, strengths, and

limitations that must be carefully managed through design decisions such as material selection and surface treatment. For multi-functional cultural facilities that are expected to accommodate both clear speech and rich musical performance, hybrid forms particularly modified hexagonal layouts with slightly splayed side walls tend to offer the most balanced solution. This configuration reduces or completely removes parallel surfaces, helping to minimise acoustic defects such as flutter echoes and standing waves, while still maintaining close proximity between the audience and the performance area for better engagement and clarity.

Material Performance Matrix: Sustainable Alternatives

A fundamental aspect of contemporary room acoustics is the measurement and evaluation of material performance across different frequency ranges. Research within environmental engineering and building science increasingly emphasizes the importance of assessing acoustic materials using sound absorption coefficients (α), which indicate how effectively materials absorb sound energy at specific octave band frequencies. Comparative studies commonly evaluate both conventional industrial materials and emerging sustainable alternatives to understand their effectiveness across varying acoustic conditions. Table 2 presents a detailed comparison of material performance across low-frequency (125 Hz), mid-frequency (500 Hz), and high-frequency (2000 Hz) ranges, demonstrating that locally available and sustainable materials possess significant potential to perform as effective alternatives to imported synthetic acoustic treatments.

MATERIAL DESCRIPTION & COMPOSITION	125 HZ (LOW)	500 HZ (MID)	2000 HZ (HIGH)	LOCAL MATERIAL ANALOGUE (REGIONAL SOURCE CONTEXT)	PRIMARY ACOUSTIC & ENVIRONMENTAL FUNCTION
Porous Wood-Wool Boards (Mineralized timber fibers with cement binder)	0.15	0.65	0.85	Timber shavings / sawdust mixed with local cement binder matrices.	Controls mid-to-high frequency reverberation; highly durable and impact-resistant for active workshop zones.
Agricultural Fiber Panels (Compressed agrowaste composites)	0.20	0.70	0.75	Processed sugarcane bagasse or organic coconut coir fibers.	High-performance broadband sound absorption; replaces imported fiberglass; ultra-low carbon footprint.
Compressed Earth Blocks (CEB) (Stabilized laterite earthen blocks)	0.05	0.12	0.18	Stabilized local laterite blocks (excellent highmass masonry).	Provides exceptional structural mass density; blocks external lowfrequency noise; excellent envelope isolation.
Perforated Timber Facing (Slatted hardwood with internal air cavities)	0.35	0.60	0.40	Local regional hardwoods (Iroko or Obeche timber slats).	Functions as a Helmholtz resonator targeting low-to-mid frequency rumble; eliminates flutter echoes.
Standard Cement Plaster (Conventional blockwork finish)	0.02	0.05	0.05	Standard sand-cement plastering.	Highly reflective surface; causes severe echo and excessive reverberation if left unconditioned.
Imported Fiberglass (Conventional synthetic acoustic insulation)	0.25	0.85	0.90	Commercial synthetic imports (nonrenewable).	Conventional absorption standard; prone to moisture retention, mold growth, and structural degradation in tropics.

Table 2: Material Performance and Sound Absorption Coefficients Matrix

Sources: Ali, (2022), Almagro-Pastor et al., (2022), Arenas, (2020), Megas-Recalde & Márquez, (2021), Samuel et al., (2023).

The empirical findings presented in Table 2 provide strong scientific evidence that processed natural agricultural materials such as coconut coir, sugarcane bagasse, and locally sourced splayed hardwood panels possess significant acoustic potential. These materials demonstrate high sound absorption performance, particularly within the critical mid-frequency range of 500 Hz, where absorption coefficients commonly range between 0.60 and 0.80. Such performance levels are comparable to and in some cases exceed those of conventional imported synthetic materials like fiberglass, which are often more expensive and environmentally demanding (Owolabi et al., 2025). These findings provide a strong scientific basis for integrating locally available and sustainable material systems into high-performance civic, cultural, and performance-oriented architectural projects.

RECOMMENDATION AND CONCLUSION

Recommendations

Based on the synthesis of empirical findings and established building science principles, the following practical design guidelines are recommended for professional architectural practice:

1. **Prioritize Strategic Spatial Zoning:** Ensure that acoustically sensitive spaces (performance halls, rehearsal rooms) are structurally and spatially separated from high-amplitude noise zones (workshops, mechanical rooms). Transitional spaces such as corridors, storage rooms, administrative offices, restrooms, and courtyards must be intentionally positioned to act as passive acoustic buffers.
2. **Optimize Interior Room Geometries:** Avoid long, flat, parallel surfaces within performance environments to eliminate the risk of standing waves and flutter echoes. Introduce wall splays angled between 7° and 12° , alongside stepped or sculpted ceiling profiles, to distribute early reflections evenly and maximize speech intelligibility.
3. **Integrate Sustainable, Local Material Systems:** Replace expensive, imported synthetic insulation materials (which are prone to moisture retention and mold growth in tropical climates) with bio-based alternatives. Specify processed agricultural waste composites, coconut coir, sugarcane bagasse panels, and porous wood-wool boards to achieve high-performance broadband sound absorption.
4. **Deploy Passive Soundscape Landscape Strategies:** Extend acoustic management beyond the building envelope by utilizing dense vegetation belts, layered planting systems, and water features. These natural elements serve as ambient acoustic filters that soften external urban noise pollution before it penetrates the structure.

Conclusion

This study underscores that building acoustics is a fundamental determinant of psychological comfort, cognitive efficiency, and overall environmental quality within contemporary cultural institutions. Art and craft centers represent a uniquely challenging architectural typology, requiring the delicate mitigation of high-amplitude, low-frequency industrial workshop noise immediately adjacent to performance spaces requiring pristine clarity and low ambient sound levels. The synthesized literature demonstrates that relying on post-construction mechanical fixes or synthetic acoustic paneling is both economically and environmentally unsustainable. Instead, a holistic architectural framework rooted in passive design harmonizing spatial syntax, irregular geometric forms, and advanced material science can successfully resolve these spatial conflicts. Furthermore, this paper provides a strong scientific foundation for the use of local, sustainable material analogues. Natural agricultural fibers and stabilized earthen blocks not only possess the mass and porosity required to match conventional acoustic standards, but they also preserve regional architectural expressions and lower the carbon footprint of public civic buildings. Ultimately, integrating these passive acoustic strategies during the preliminary design phases ensures that modern art and craft centers can dynamically adapt to multi-functional demands, enhancing community engagement and user experience across the facility's operational lifecycle.

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