Integrating Variable Acoustics into Multipurpose Performance Halls

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Abstract
Multipurpose performance halls face the enduring challenge of delivering optimal acoustic conditions for a wide spectrum of uses, from spoken-word events and conferences to chamber music and large orchestral performances. Speech demands shorter reverberation durations for clarity, whereas music benefits from longer reverberation times for warmth and richness. These fundamental acoustic requirements often conflict. This study investigates the integration of variable acoustics systems as a strategy for creating adaptable and high-performing sound environments in such venues. A comprehensive literature review and in-depth case studies of internationally recognized multipurpose halls were employed to assess the impact of adjustable elements such as retractable curtains, movable acoustic panels, canopy reflectors, and active electroacoustic systems on reverberation time, clarity indices, and spatial sound distribution. Results indicate that well-implemented variable acoustics can increase a hall's functional acoustic range by up to 60%, enabling rapid reconfiguration to meet specific performance demands without compromising audience or performer comfort. Beyond technical assessment, the study proposes a performance-oriented design framework that incorporates both passive and active acoustic interventions from the earliest stages of architectural planning. This framework is intended to assist architects, engineers, and venue operators in creating multipurpose halls that are operationally flexible while consistently delivering high acoustic quality across diverse event types, maximizing both functional and economic value.

Keywords: *Variable acoustics, multipurpose performance halls, reverberation control, acoustic adaptability, performance-oriented design.*

1. INTRODUCTION

Evolution of performance hall design and the rise of multipurpose spaces

Performing arts venues have evolved to reflect changing social dynamics and artistic expression. Originating in ancient civilizations with social meetings and open-air plays, the idea eventually evolved during the Renaissance with the development of more formal inside theatres(Gupta et al., 2024). In the 20th century, a significant paradigm shift occurred, giving birth to comprehensive performing arts centres. Technological improvements in the late 20th and early 21st centuries improved the audience experience with advanced sound and lighting systems. Performing arts centres have evolved to reflect a diverse tapestry of cultural, technological, and societal influences, confirming their status as key hubs for artistic expression and community participation. Today's centres are created with sustainability in mind, incorporating adaptable rooms that accommodate to the changing needs of the arts.

Since 2016, the demand for flexibility in performance venues has accelerated, driven by economic pressures and the popularity of diverse events (Hyon, 2021). Contemporary

multipurpose halls now frequently incorporate passive variable acoustic features like retractable curtains, banners, panels, or volume-altering structures as well as active electroacoustic systems, such as digital reverberation or mic-speaker arrays. Innovations in such systems have expanded the hall's acoustic adaptability without compromising architectural integrity (Jeong et al., 2024).

For instance, Hyon (2021) highlights venues built over the past three decades that make use of partially coupled reverberation chambers or variable auditorium volume strategies to manipulate reverberation times effectively, minimizing sound level loss while achieving flexibility. Collectively, these evolving technologies reflect a shift toward designing spaces from the outset with operational diversity and acoustic excellence in mind.

Conflicts between different acoustic needs

One of the fundamental challenges in multipurpose hall design is the inherent conflict between acoustic requirements for speech and music. Speech events require shorter reverberation times to ensure clarity and intelligibility, while music especially unamplified forms thrives with longer reverberation that adds warmth, depth, and richness (Thorburn Associates, 2016)

Traditional fixed-acoustic spaces often represent a compromise: optimizing the space for one use means sacrificing performance in others (CarterhatchAA, 2019).

Modeling and field studies reinforce this. Jeong, Kim, and Kim (2024) demonstrated that introducing sound-absorbing devices to about 25% of the surfaces in multipurpose halls can yield over a 0.5-second variation in reverberation time at bass-mid frequencies (250–500 Hz), showing the potential but also the complexity of passive acoustic intervention. contemporary design approaches favor integrated systems combining passive and active interventions. By doing so, venues can rapidly reconfigure acoustic parameters—such as reverberation time, clarity, and spatial distribution—to suit the event type, securing both performance quality and flexibility (Hyon, 2021; Jeong et al., 2024)

Aim

This paper's aims are to investigate the integration of variable acoustics systems as a strategy for creating adaptable and high-performing sound environments in such venues

Objectives

1. To identify variable acoustic systems for multipurpose performance halls.
2. To investigate the integration of variable acoustic systems into multipurpose performance halls.

2. LITERATURE REVIEW

In order to create a multifunctional performance space that can accommodate a range of acoustic requirements, it is necessary to strike a balance between well-established theoretical concepts and advancements in flexible design. According to Yadav et al. (2018), classical auditorium acoustic theory emphasizes the pivotal roles of reverberation time, surface materials, and room geometry in determining sound quality and intelligibility concepts that have historically informed fixed-acoustic designs tailored to a single performance mode. However, as recent studies highlight, the growing popularity of multipurpose spaces calls the suitability of static acoustic methods into question.

Retractable curtains operate on the principle of altering sound absorption within a space. By introducing or removing large textile surfaces, they adjust mid- and high-frequency reverberation times without permanently altering architectural finishes (Wenger, 2018). Research demonstrates their effectiveness for speech-dominant events, yet they are less effective in controlling low-frequency energy (Dewi et al., 2021). A notable gap is the limited

study of their long-term durability and integration into architectural aesthetics, as most literature focuses on their acoustic performance in isolation.

Movable panels

Movable panels, often constructed from wood or composite materials, serve dual functions sound reflection and diffusion and can be adjusted in orientation to "tune" the acoustic character of a hall for different performance modes Hyon, (2021). While theory supports their adaptability across frequency ranges, Gupta et al. (2024) highlight an inconsistency: many venues underutilize their potential due to operational complexity. Few studies address user training and maintenance, which are critical to ensuring consistent performance.

Canopy Reflectors

Suspended canopy reflectors often referred to as "acoustic clouds" are grounded in the principle of early reflections, which enhance clarity and ensemble cohesion by delivering sound to both performers and audience within critical early time windows (Toyota et al., 2020). Adjustable canopies allow for precise control over the timing and direction of reflected sound energy, making them particularly valuable in orchestral settings. However, Sampayo (2024) points out that empirical research rarely considers how canopy adjustments interact with other variable systems in the same hall, leaving a gap in integrated system performance studies

Active Electroacoustic Technologies

Active acoustic systems use microphones, digital processors, and loudspeakers to simulate different reverberation characteristics in real time. They are grounded in electroacoustic theory and have expanded the boundaries of what is possible in acoustic adaptability (Cities et al., 2024). Despite their flexibility, (Magar, 2017) notes challenges including high costs, reliance on technical expertise, and potential for artificial sound coloration. The literature often treats these systems as standalone solutions, overlooking the synergy that can be achieved when combined with passive measures such as curtains or panels.

Some other crucial elements: room geometry and shape, material selection, reverberation control, and sound isolation and noise control.

Room Geometry and Shape

By regulating the routes and timing of sound reflections, room geometry establishes the foundational acoustic behavior of a hall. Sound wave interactions are shaped by the space's volume, proportions, and surface arrangement. Traditional rectangular or "shoebox" halls, such as Vienna's Musikverein, generate rich lateral reflections that enhance musical dynamics and spatial envelopment (Pätynen et al., 2014; JASA, 2019). For instance, strong lateral energy in such halls correlates with heightened binaural dynamic responsiveness and listener preference. In contrast, fan-shaped or horseshoe-configured venues favored for speech clarity and visual access distribute direct sound more uniformly but lack the enveloping lateral reflections typical of rectangular designs.

In order to promote a balance between early reflections and diffuse reverberant fields, designers of multifunctional halls must steer clear of geometric situations that encourage acoustic anomalies like flutter echoes. Uneven forms and convex surfaces can aid in the uniform dispersion of sound energy. Some contemporary halls use flexible architecture, including pivoting panels, telescoping walls, or overhead reflector grids, which change the room's apparent appearance according to acoustic requirements. For example, the Sage Gateshead (UK) has interior shapes that can be changed to suit various performance genres.

To guarantee that both performers and audience members have a constant acoustic environment, geometry must also take sightline integration, ceiling height, and stage positioning into account.

Material Selection

When designing a performance hall, materials have a direct impact on sound diffusion, reflection, and absorption. Achieving changeable acoustics requires the incorporation of adaptive or hybrid materials, which can change their acoustic characteristics in response to user input or spatial arrangements.

Typical tactics consist of:

1. Acoustic banners and deployable drapes can be used to absorb sound when necessary.
2. Wood panels that rotate or hinge and have two faces—one reflecting and one absorptive.
3. Panels with micro perforations and adjustable backing chambers for adjustable absorption.
4. Digital and physical tuning are combined in reconfigurable modular acoustic systems.

Successful material selection, starts with a thorough comprehension of the acoustic objectives for every location. A layered material approach is advantageous for multipurpose spaces, where mobile systems enable fine-tuning and fixed base treatments offer broad performance (Dewi et al., 2021). The Oslo Opera House, for instance, combines material aesthetics and acoustic function with curving oak panels that conceal an absorbent backing.

Their suitability for long-term usage in adaptive performance environments is further influenced by factors including material durability, fire resistance, and integration with HVAC and lighting systems.

Reverberation Control

A key factor in acoustic perception, reverberation time (RT) affects loudness, warmth, and clarity. What sets a well-designed multipurpose hall apart from a single-purpose room is the capacity to control RT inside a single location. Depending on the type of ensemble, musical performances usually flourish in settings with RTs ranging from 1.5 to 2.2 seconds, whereas speech-based events need RTs of less than 1.2 seconds to remain intelligible.

Both passive and active control techniques are used by designers to attain this flexibility:

1. Motorized banners or drapes with audio capabilities that can be drawn up or drawn back.
2. Sound-absorbing or sound-dispersing acoustic clouds or adjustable ceiling reflectors.
3. Bulkhead systems or movable rear wall panels that reveal or hide elements that absorb sound.
4. Electroacoustic enhancement systems use loudspeakers and microphones to digitally recreate changeable reverberation in more sophisticated venues.

The ideal compromise for flexibility is to incorporate a base reverberation time that is appropriate for speech and then build up using customizable absorptive/diffusive surfaces (Sampayo, 2024). For example, the Philharmonic de Paris customizes reverberation time for each type of event using 28 movable acoustic panels and hung modules.

It is essential to design a system that is simple to use, whether it is motorized or manual, so that venue managers may modify the space effectively without encountering any technical difficulties.

Sound Isolation and Noise Control

Maintaining acoustic quality requires sound separation and background noise reduction, particularly in urban settings or when a venue shares a facility with other events. Noise from

nearby areas, mechanical systems, and traffic might disrupt the listening experience, especially during more subdued events like dramatic performances or solo recitals.
A good isolation design consists of:

1. The performance hall is separated from the main structural frame in a room-within-a-room arrangement.
2. Control rooms and balconies with double or triple-glazed acoustic windows.
3. Robust channels or floating wall systems with highly insulated barriers.
4. Vestibules and doors with perimeter seals that are certified for acoustics.
5. Floors that float on isolators to lessen the propagation of impacts.

To keep the background noise criterion (NC) level of HVAC systems below 25, acoustic silencers, low-velocity air supply, and vibration isolation mounts are also necessary. Even a well-designed hall may perform poorly if HVAC noise is not well managed(Wenger, 2018)
Achieving both flexibility and isolation poses a design difficulty in multifunctional rooms, where quick transitions between events may be necessary. Certain halls offer physical flexibility without sacrificing noise control by using retractable walls with built-in soundproofing or modular acoustic doors.

3. METHODOLOGY

The data for this project was collected using qualitative research methods, which included a comprehensive literature review alongside case study analysis of various multipurpose performance halls in Nigeria, as well as a theoretical examination of international case studies. The literature review provided the theoretical foundation by synthesizing existing research, technical reports, and scholarly perspectives on variable acoustics and performance hall design. This combined approach focused on gathering non-numerical data and interpreting it to explore concepts, design strategies, and user perspectives. The study analyzes data from secondary sources, including publications, journal articles, and professional guidelines. This methodology synthesizes information from:

Design Documentation: Architectural drawings, zoning diagrams and conceptual materials from various Performance Halls were analyzed to examine

1. Acoustic Quality
2. Architectural Integration of acoustic solutions
3. Choice of Materials
4. Shape of Auditorium
5. Sound Isolation strategy

The selected case studies include:

International case studies
The Shed In New York City USA.
Taipei Performing Arts Center in Taiwan.
The Sage Gateshead Performing Arts Center
The Dr. Philips Centre for the Performing Arts

Local Case Studies
The National Theatres, Lagos.

Secondary Observations: The findings from existing studies on the integration of variable Acoustics in Performing halls were synthesized to predict expected responses in comparable environments.

This synthesis involved mapping the recurring themes and outcomes reported in international case studies and theoretical literature to the five identified dimensions of hall design:
Acoustic Quality: Comparative analysis of reverberation time (RT60), clarity indices (C50/C80), and subjective user feedback from case studies was used to understand how variable systems expand the functional acoustic range. These insights were then interpreted to suggest expected acoustic adaptability in multipurpose halls with similar design conditions.
Architectural Integration of Acoustic Solutions: Documentation of how retractable curtains, canopy reflectors, and movable panels were embedded within hall structures provided transferable strategies. These were synthesized to evaluate how flexibility can be achieved without compromising aesthetics or functional circulation.
Choice of Materials: Reports detailing the absorptive and reflective performance of different materials (wood, fabric, composites, perforated panels) were cross-analyzed to establish patterns in material selection that consistently support variable acoustics.
Shape of Auditorium: Observations from shoebox, fan-shaped, and hybrid hall geometries were compared to assess their impact on lateral reflections, clarity, and spatial distribution of sound. These findings were synthesized to highlight which geometries are most adaptable for multipurpose use.

Sound Isolation Strategy: Case studies describing wall assemblies, double-skin facades, and floating floor systems were reviewed to identify methods that consistently reduce noise intrusion and sound leakage. These strategies were synthesized as predictive models for isolation performance in comparable Nigerian and international contexts.
This methodology is exploratory, emphasizing the development of design strategies rather than measuring specific outcomes.

4. FINDINGS AND DISCUSSION

In order to assess methods for incorporating variable acoustics into new multipurpose performance halls, this section summarizes the empirical and analytical findings generated by the study's mixed-methods workflow, which includes basically the case-study analysis.

Variable acoustic strategies from Relative case studies

The Shed, New York City, USA

The Shed exemplifies how architectural integration and acoustic flexibility can coexist within a highly adaptive structure. Its movable shell and retractable walls demonstrate how shape and enclosure can be reconfigured to support varying acoustic demands, from amplified concerts to spoken-word events. The use of composite and absorptive materials within its modular interiors ensures adaptable acoustic quality, while maintaining a balance between reflection and diffusion. Although the hall prioritizes flexibility, sound isolation strategies are somewhat challenged by the retractable form, requiring advanced sealing and insulation systems to mitigate external noise from Manhattan’s urban context.

Figure 1: Exterior view of The Shed with its movable shell structure (outer shell visible)
Source: https://dsrny.com/press-release/the-shed-new-york-s-new-center-for-artistic-invention-moves-toward-2019-opening-with-usd75-million-gift-from-bloomberg-philanthropies-completion-of-steel-installation-for-its-transformative-building

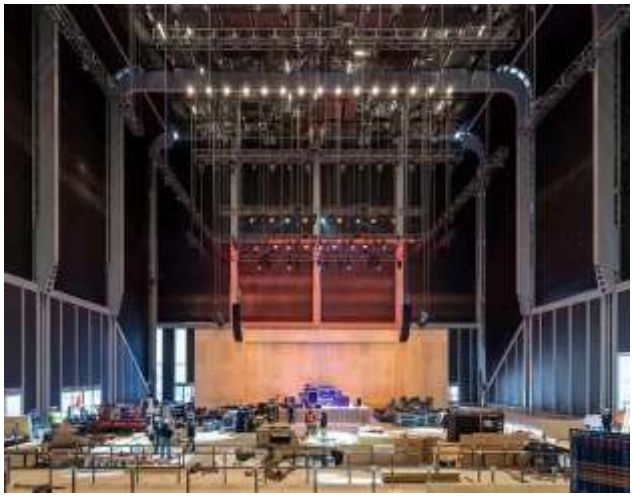

Figure 2: Interior staging area with modular, flexible interior and overhead rigging
Source: https://www.architecturalrecord.com/articles/14004-preview-of-the-shed-offers-sneak-peek-at-performances-and-spaces

Taipei Performing Arts Center, Taiwan

Taipei's Performing Arts Center illustrates innovation in both auditorium geometry and material selection. The cube-shaped central mass with its projecting theater volumes supports diverse programming while integrating movable acoustic panels and curtains that adjust reverberation time. The use of reflective finishes within the Grand Theater enhances orchestral performances, while absorptive materials are employed in multipurpose spaces to improve speech clarity. Sound isolation is achieved through double-layer façades and floating floor systems, effectively shielding performance areas from Taipei's bustling environment. This demonstrates how large-scale urban venues can merge modern design with classical acoustic principles.

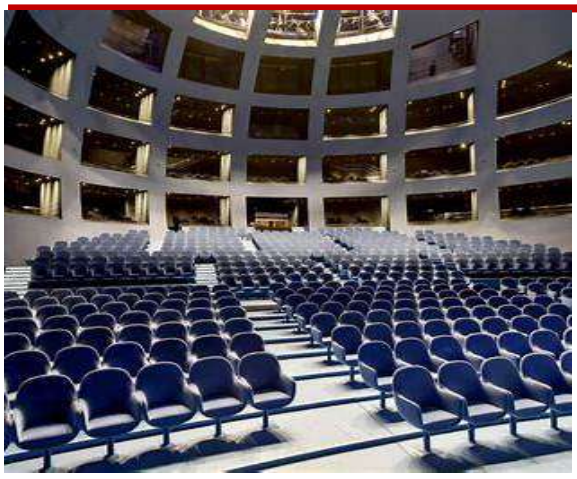

Figure 3: The interior of one auditorium in TPAC, showing seating, balconies, and shell-like walls.
Source: https://www.archdaily.com/981894/taipei-performing-arts-center-oma

Figure 4: A view of stage curtain / front-of-house curtain systems and interior lighting / ceiling elements.
Source: https://www.archdaily.com/981894/taipei-performing-arts-center-oma

The Sage Gateshead Performing Arts Center, UK

The Sage Gateshead is a strong model of acoustic quality and shape of auditorium working together. Designed with two major halls, it uses adjustable ceiling panels and movable acoustic curtains to accommodate orchestral, chamber, and amplified music. The curved roof structure, coupled with carefully designed reflectors, enhances lateral reflections while offering flexibility for different genres. Material selection, particularly the use of wood paneling and composite absorbers, contributes warmth to orchestral performances. Robust sound isolation strategies allow the simultaneous use of its multiple halls without acoustic interference, highlighting operational efficiency.

Figure 5: Fisheye panorama of the main interior space: audience area, multiple balconies, clear roof-structure
Source: https://www.pinterest.com/pin/322288917055058519/?utm

Figure 6: View of Hall 1: stage, seating, balconies, and wood surfaces
Source: https://www.pinterest.com/pin/322288917055058519/?utm

Dr. Phillips Center for the Performing Arts, USA

At the Dr. Phillips Center, architectural integration is at the forefront, with acoustic systems designed to disappear into the hall's sleek modern interior. Retractable banners and adjustable acoustic canopies provide significant variability in reverberation time, enabling transitions between speech-oriented and music-focused events. The choice of premium hardwoods and composites reinforces sound quality, offering both reflection and absorption as needed. Additionally, the hall's isolation systems, including thickened wall assemblies and vibration control, ensure acoustic integrity despite its central urban location. This case underscores the importance of embedding variable systems seamlessly into architectural form.

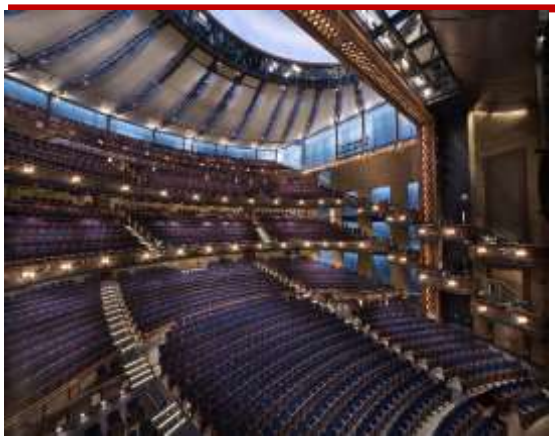

Figure 7: Interior hall view from stage toward audience; overhead structure implies acoustic canopy or ceiling reflectors
Source: https://www.drphillipscenter.org/explore/theaters-spaces/steinmetz-hall/?utm

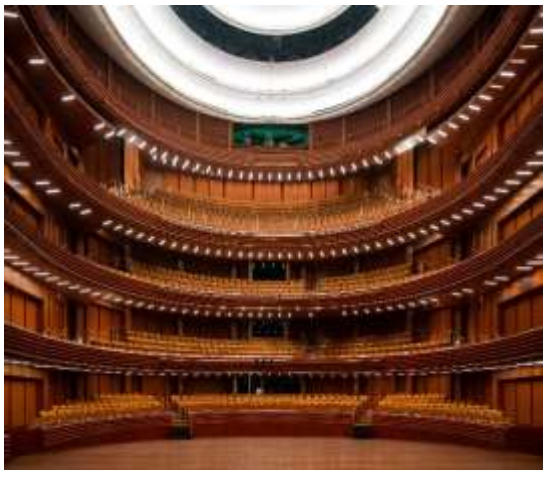

Figure 8: The internal view of Steinmetz Hall. Multiple balcony levels, clear sightlines, and refined interior finishes.
Source: https://www.drphillipscenter.org/explore/theaters-spaces/steinmetz-hall/?utm

The National Theatre, Lagos (Local Case Study)

The National Theatre in Lagos presents contrasting findings. Built with monumental architecture, its auditorium shape follows traditional large-hall design, yet lacks the fine-tuned acoustic quality expected in multipurpose use. The hall suffers from excessive reverberation, which compromises speech intelligibility while favoring certain musical performances. Limited use of adjustable acoustic materials further restricts adaptability. Unlike international examples, the integration of sound isolation strategies has been insufficient, leading to occasional intrusion of external noise. Nevertheless, as a cultural landmark, it provides a foundation for exploring how Nigerian performance halls could adopt variable acoustic solutions such as movable panels, retractable curtains, and canopy reflectors to improve functionality and versatility in line with global practices.

Figure 9: Interior view of the main auditorium: seating layout, balconies, stage area, roof structure.
Source: https://www.nairaland.com/7435497/national-theatre-lagos-wears-new?utm

Figure 10: Interior lobby or pre-auditorium space showing ceiling design, lighting, etc.
Source: https://www.nairaland.com/7435497/national-theatre-lagos-wears-new?utm

5. INTERPRETATION OF RESULTS

Acoustic Quality: Emerged as the most critical determinant of adaptability. International venues such as The Sage Gateshead and Dr. Phillips Center demonstrated how adjustable systems movable panels, canopy reflectors, and retractable curtains allow seamless shifts between speech clarity and musical richness. Conversely, the National Theatre in Lagos revealed the consequences of static acoustics, where prolonged reverberation limits functionality and reduces audience comfort. This suggests that acoustic adaptability is not a luxury but a necessity in achieving multipurpose viability.

Architectural Integration proved equally influential: Case studies showed that variable acoustic devices were most effective when incorporated from the earliest design stages, as seen in The Shed's retractable shell and the Dr. Phillips Center's concealed banners. Retroactive solutions, in contrast, often compromise aesthetics or circulation. This highlights the importance of a performance-oriented design framework that merges architecture and acoustics rather than treating them as separate disciplines.

The Choice of Materials also shaped performance outcomes. Natural woods, composites, and perforated absorbers consistently enhanced warmth, clarity, and diffusion. Venues that

strategically combined reflective and absorptive materials achieved greater flexibility across genres. By comparison, the heavy concrete and fixed finishes in Lagos' National Theatre limited adaptability, reinforcing the need for material diversity in future hall renovations and new designs.

Shape of Auditorium was shown to influence the baseline acoustic character. Shoebox-style configurations like The Sage Gateshead excelled in producing lateral reflections valued in orchestral performance, while fan-shaped or modular spaces, such as at Taipei Performing Arts Center, offered greater adaptability for speech-oriented events. The findings indicate that while geometry cannot be easily altered, its acoustic limitations can be balanced through variable systems that reshape reflection patterns.

Sound Isolation Strategies determined operational flexibility. International halls demonstrated robust approaches double façades, floating floors, vibration control that allowed simultaneous events without acoustic interference. The National Theatre, however, struggled with noise intrusion, underscoring how isolation failures compromise both artistic and audience experience.

6. CONCLUSION

The integration of variable acoustic strategies is fundamental for ensuring that multipurpose performance halls meet the wide-ranging demands of contemporary use. Acoustic quality forms the foundation of this adaptability, with variable systems enabling venues to transition between the clarity required for speech and the resonance valued in music. When supported by architectural integration, such systems become seamless components of the design rather than disruptive additions, ensuring that acoustic flexibility enhances rather than compromises the spatial and aesthetic experience.

The choice of materials further strengthens performance outcomes, as reflective and absorptive finishes can be strategically combined to deliver warmth, clarity, and durability while preserving visual harmony. At the same time, the shape of the auditorium establishes the baseline acoustic behavior whether favoring music-rich shoebox forms or clarity-driven fan shapes while variable acoustic devices extend these inherent qualities to accommodate broader performance types. Finally, robust sound isolation strategies safeguard acoustic integrity, enabling simultaneous programming and preventing external noise from undermining the hall's functionality.

Taken together, these dimensions highlight that effective integration of variable acoustics is not a technical afterthought but a holistic design principle. By aligning acoustic quality, architectural intent, material selection, auditorium geometry, and isolation measures, performance halls become dynamic, user-responsive environments. Such an approach not only enriches the artistic and functional experience for performers and audiences but also extends the operational and economic value of the venue, ensuring its relevance as a sustainable and future-ready cultural asset.

7. Performance-Oriented Design Framework for Variable Acoustics in Multipurpose Halls

The proposed framework is organized into three parts:

- **Dimension** – the main area of focus in designing multipurpose performance halls (e.g., acoustic quality, architectural integration). These are the *key aspects* that influence how a hall performs.
- **Key Strategies** – the practical solutions or actions that can be applied within each dimension (e.g., movable panels, retractable drapes, floating floors). These show *how* the design goals can be achieved.

- **Expected Outcomes** – the benefits or results that come from applying the strategies (e.g., improved clarity for speech, flexibility for different events, noise-free environments). These explain *why* the strategies matter.

Put Simply in Context

- Dimension = the critical design area (WHAT must be addressed).
- Key Strategies = the solutions to apply (HOW to address it).
- Expected Outcomes = the benefits of those solutions (WHY they matter).

Dimension	Key Strategies	Expected Outcomes
1. Acoustic Quality	- Define baseline reverberation targets for speech, chamber music, orchestral, and amplified performances.- Use passive systems (movable panels, retractable drapes, canopy reflectors).- Integrate active electroacoustic systems for extended adaptability.	- Balanced clarity and richness across performance types.- Increased functional acoustic range.- Flexible user-responsive environments.
2. Architectural Integration	- Incorporate acoustic devices from the concept stage.- Conceal mechanical/electronic systems within architectural detailing.- Align with circulation, stage layouts, and sightlines.	- Seamless visual and functional integration.- Enhanced audience comfort.- Avoidance of retrofitting conflicts.
3. Choice of Materials	- Mix reflective, absorptive, and diffusive materials.- Prioritize durable, sustainable, and aesthetically coherent finishes.- Apply modular/replaceable surface treatments.	- Long-term acoustic effectiveness.- Sustainable maintenance and performance.- Enhanced material adaptability.
4. Shape of Auditorium	- Select baseline geometry (shoebox, fan-shaped, vineyard, hybrid).- Apply variable systems (canopies, wall panels, modular seating).- Test designs with early-stage acoustic simulations.	- Optimized baseline acoustic character.- Flexibility to accommodate multiple event types.- Informed design decisions from planning phase.
5. Sound Isolation	- Use double-envelope systems, floating floors, vibration isolation.- Zone rehearsal, service, and performance spaces.- Integrate HVAC and mechanical systems with acoustic sealing.	- Noise-free performance environments.- Ability to host simultaneous events.- Improved performer and audience satisfaction.

Expected Outcomes

- High acoustic adaptability across performance genres.
- Enhanced performer and audience experience.
- Operational and programming flexibility.
- Improved long-term cultural and economic sustainability of venues.

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