

# The Role of Eco-Friendly Building Materials in Improving the Acoustic Condition in an art and Craft Center

\*Williams Gbenga O., Babamboni Adekunle S., Surprise Olaomo O. & Manuwa Solomon A.,

Department of Architecture, Caleb University, Imota, Lagos state, Nigeria

\*Corresponding Author

DOI: <https://dx.doi.org/10.47772/IJRISS.2026.10200552>

Received: 20 February 2026; Accepted: 02 March 2026; Published: 19 March 2026

## ABSTRACT

This study investigates how eco-friendly construction materials might enhance the acoustics of art and craft centers, where a variety of activities like workshops, exhibitions, performances, and group production produce intricate soundscapes. Even though conventional acoustic materials work well, their high embodied energy, restricted recyclability, and possible hazardous emissions might pose health and environmental risks. Sustainable substitutes made from natural fibers, recycled materials, and agricultural waste have gained popularity as a result. The study synthesizes information from academic papers, technical reports, and case studies on sustainable materials and architectural acoustics using a qualitative, literature-based technique. In addition to a few manufactured and waste-derived composites, the study assesses the environmental performance and acoustic behaviour of materials such wood-cement boards, hemp, bamboo, coir, timber panels, recycled PET felt, and bio-fiber composites. According to research, a lot of environmentally friendly materials support occupant health, sustainability objectives, and the ideas of the circular economy while also exhibiting good sound absorption, reverberation management, and noise reduction qualities. The analysis also identifies new digital technologies as complementing approaches for tracking and improving indoor acoustic performance, such as digital twin systems, BIM, and IoT. According to the study's findings, art and craft centers can greatly improve their functional, environmental, and experiential quality by combining eco-friendly materials with knowledgeable acoustic design and digital management frameworks. It also offers a comprehensive set of recommendations for architects and designers looking to implement sustainable acoustic solutions.

**Keywords:** Eco-friendly building materials, Architectural acoustics, Sustainable acoustic design, Art and craft centers, Sound absorption

## INTRODUCTION

The global built environment contributes nearly 40% of global greenhouse gas emissions and consumes an enormous share of the world's natural resources, prompting an urgent call for sustainable innovations within the construction industry. As climate change concerns intensify, the shift toward environmentally responsible architecture has become an integral part of global sustainability goals and the pursuit of the Sustainable Development Goals (SDGs) (Figueiredo, Vela, Ascens~ao, Vettorazzi, Vicente & Oliveira, 2025). At the forefront of eco-friendly building practices is the careful selection of green materials designed to minimize environmental impact across their life cycle. These often include natural fibers, recycled-content composites, and materials with low carbon footprints. Traditional acoustic and insulation materials, such as glass wool and polyester, pose well-documented challenges including difficulties in recycling, emissions of toxic gases during incineration, and high energy consumption during production (Saleh, Dawoud & Hassan, 2023). As the built environment evolves, there is a growing recognition that architectural sustainability extends beyond structural integrity; it also requires a nuanced understanding of acoustic performance. Acoustic quality shapes occupants' perception and experience of spaces and is particularly crucial in environments such as lecture rooms, theatres, and cultural facilities where clarity and sound control are essential. When acoustic performance is integrated with the use of energy-efficient, environmentally responsible materials, sustainable design becomes holistically achievable (Enwerem, Malomo, Jayeoba, Ibitoye & Olaoye, 2025). Cultural facilities such as art and craft centers serve as crucial spaces for

creative engagement, exhibitions, performances, and communal interaction. In such settings, acoustic comfort is fundamental: clear sound is needed for performances, workshops, and presentations, while staff and visitors depend on well-balanced acoustics for comfort, reduced stress, and improved focus. Poor acoustic conditions manifesting as excessive noise levels or long reverberation times affect user satisfaction, productivity, and the overall functionality of the environment (Okoro & Adeyemi, 2024). A major challenge lies in achieving effective acoustic treatment while adhering to eco-friendly standards. Many traditional acoustic materials rely on synthetic fibers, whose environmental and health impacts are increasingly scrutinized. This has led researchers to explore natural fiber composites and bio-based alternatives that provide both thermal and acoustic insulation (Bhoir, Patil, Joshi & Shinde, 2024). Promising examples include coir fiber composites, wood strand rock wool cement boards, recycled PET felt, and acoustic panels derived from various agricultural waste fibers. These materials offer multifunctional environmental benefits while addressing the acoustic needs of modern cultural spaces (Hemmati, Mirzaei, Soltani, Berardi, Mozafari, Edalat & Taban, 2024).

This study limits its focus to the analysis of global academic literature relating to the acoustic effectiveness of eco-friendly building materials within spaces comparable to Art and Craft Centers, including performance venues, museums, creative hubs, and workshop environments. The material scope is entered on sustainable indoor acoustic treatment materials that are either natural fiber-based such as coir, hemp, and wood or derived from post-consumer or industrial waste products like recycled plastics or textiles (Gabriel, Anthony, Tunji, Omolola, & Patience, 2023). Despite widespread recognition of the environmental advantages of green materials and the necessity of proper acoustic design for cultural facilities, there remains a lack of consolidated qualitative reviews examining how specific eco-friendly materials contribute to improved acoustic parameters such as sound clarity, and noise reduction. (Herman & Saragih, 2024). The study is justified by its contribution to merging environmental sustainability with functional performance within architectural design, this supports environmental responsibility by promoting the use of materials that reduce energy consumption, limit emissions, and minimize ecological footprints compared to conventional synthetic alternatives Lee, Sarkar, Guo, Zhou, Armstrong & Ren, (2023) also reinforces the importance of acoustic comfort in cultural centers, where the quality of sound greatly influences user experience, performance quality, and the effective functioning of the space, moreover, it encourages the adoption of multifunctional eco-friendly materials that often deliver both thermal and acoustic benefits, supporting broader energy-efficiency and sustainability goals in modern architecture (Almagro-pastor, García-Quesada, Vida-Manzano, & Ramos-Ridao, 2022). The primary aim of this study is to qualitatively synthesize the roles of eco-friendly building materials in enhancing the acoustic comfort and functionality of Art and Craft Centers through a systematic review of existing academic literature. The objectives guiding this research include identifying the primary eco-friendly materials emphasized in acoustic studies, exploring the commonly documented acoustic performance criteria, and examining the qualitative design strategies proposed by researchers for incorporating sustainable materials into acoustically sensitive cultural environments.

## LITERATURE REVIEW

A multipurpose social and creative establishment that fosters artistic creation, craft customs, education, and community engagement is commonly referred to as an art and craft center. These facilities serve as gathering places for artistic expression, practical creation, exhibitions, performances, and educational initiatives in a structured physical setting. Art and craft centers, in contrast to single-purpose spaces, usually combine galleries, display rooms, learning studios, production workshops, and gathering areas to support both audiences and creators at the same time. With a focus on material experimentation, technical skill training, and group creativity, art and craft centers are a specific subset of cultural centers. The variety of activities that take place in these areas creates several, occasionally contradictory environmental needs. Noisy production workshops, busy teaching studios, and collaborative creative spaces are frequently found next to quiet reflecting locations like galleries or exhibition rooms (Arenas & Sakagami, 2020). As a result, the success of an art and craft center is dependent on environmental performance, especially acoustic comfort, in addition to spatial planning and visual quality. In the absence of meticulous acoustic design, noise produced in one functional zone might interfere with operations in another, impacting user experience, learning, and productivity. An art and craft center must therefore be viewed as an acoustic environment that necessitates careful material and spatial management techniques in addition to being a social and creative area (Okoro et al., 2024). A space created with the intention of serving as a means for

the dissemination of different artistic, philosophical, educational, and cultural expressions, open to a community with the aim of representing and promoting artistic and craft values and interests within the territory of a community," is defined as an art and craft center (Ibitoye, Abiola, Babamboni, 2023). These facilities might be complexes, buildings, or organizations that actively support cultural heritage, arts, and crafts. They serve as a center for a range of artistic events, workshops, exhibitions, and programs aimed at promoting social interaction, cross-cultural understanding, and creative development. Local communities are built and maintained in large part by art and craft centers. The precise layout of these centers may differ based on their size, mission, and financial constraints, but the ultimate objective is to build a flexible space that supports a variety of artistic endeavours and offers a warm and stimulating environment for artists, students, and guests (Parekh & Smith, 2024). Through exhibitions, performances, and workshops, these centers serve as venues for artists, performers, craftspeople, and creators to share their work, exchange skills, and interact with the general public. By doing this, they raise public awareness, encourage critical thinking, and provide people from different backgrounds a chance to interact, exchange stories, and discover one another's customs. By drawing tourists and visitors seeking genuine creative experiences, art and craft institutions also support local economic development. By engaging in creative events, buying crafts, and engaging in cultural tourism, these tourists boost local economies. More generally, art and craft centers foster community growth, education, and social harmony; they go beyond cultural enrichment to have a positive influence on society's social, educational, and economic well-being (Almagro-pastor et al., 2022).

### **Eco-Friendly Building Materials**

Eco-friendly building materials are defined as materials that minimize environmental harm during extraction, production, use, and disposal. They often consist of renewable, reclaimed, or recycled resources such as timber, bamboo, hemp, agricultural residues, recycled metals, and bio-based composites. The adoption of such materials in architecture is not merely an environmental concern but a multifaceted design strategy that contributes to sustainability, occupant health, and long-term economic efficiency. Reclaimed wood, salvaged from old buildings or structures, is a notable example (Anthony, Olaoye, Tunji, Omolola, and Patience, 2023). Its use reduces the demand for virgin lumber, thus conserving forests and reducing carbon emissions. Because of its density and fibrous structure, which allow it to absorb and disperse sound energy, salvaged wood offers durability, aesthetic appeal, and acoustic benefits in addition to environmental advantages. Another environmentally friendly option is recycled metals, such as steel and aluminium, which may be used repeatedly without suffering appreciable structural degradation. Recycled metals support the structure's acoustic mass and sound insulation qualities while lowering the environmental effect of mining and manufacture when used for roofs, building frames, or ornamental features (Obafemi, 2025). An increasingly popular material in environmentally aware design is bamboo, which grows quickly. It can be used for partitioning, wall cladding, flooring, and even structural elements due to its great tensile strength, flexibility, and low weight. Because bamboo's fibrous structure absorbs sound and lessens reverberation in interior spaces, it also has intrinsic acoustic benefits. Depending on how it is processed, recycled glass can have reflecting or diffusive acoustic qualities and support circular economy initiatives when used as insulation, concrete aggregates, tiles, or countertops. Sustainability and practical performance are combined in rammed earth and hempcrete, two ancient and contemporary composite materials, respectively. While hempcrete is lightweight, porous, and good in absorbing sound because of its fiber structure, rammed earth offers high thermal mass and moderate acoustic dampening. By lowering operating energy requirements, carbon footprints, and maintenance expenses and promoting occupant comfort, productivity, and health, the use of these materials is consistent with green building principles. These materials provide art and craft centers the advantages of sustainability and acoustic performance, fostering an imaginative, secure, and ecologically conscious learning environment (Abera, 2024).

### **Sustainable Acoustic Material Considerations**

One of the most used materials for modern building construction is still concrete. However, choosing materials for architecture should take into account more than just structural performance; it also needs to take into account other important design factors including acoustic quality. Growing attempts have been made to create and use environmentally friendly construction materials that are also good at controlling heat and sound as environmental sustainability becomes more widely recognized. Sustainable materials made from vegetable, agricultural, and animal waste have been investigated more and more recently as potential substitutes for traditional acoustic

materials (Tolulope, Obafemi, Grace, and Gabriel, 2025). Reusing materials and managing garbage are especially important in developing countries because the constant increase in waste presents major environmental problems. Waste materials with high development potential must be carefully chosen and sorted in order to lessen this problem. Because of their fibrous and porous architectures, materials having a high cellulose content have been shown to be very good at absorbing sound. For instance, the cellulose-rich fibers found in pineapple leaves have a long lifespan and a soft surface texture, which makes them ideal for sound absorption applications. Straw fibers, banana stems, and sugarcane bagasse are other natural fiber materials that are both acoustically effective and environmentally friendly (Nuratirah & Mohd, 2023.). Although noise is frequently thought of as a source of annoyance, its wider effects on human health are frequently overlooked. Long-term exposure to undesirable noise can interfere with sleep and relaxation, particularly in crowded settings, and can progressively cause psychological and physical health problems like exhaustion, tension, and irritation. This emphasizes how crucial acoustic control is in both public and home settings. For this reason, knowledge of room acoustics is crucial to architectural design. Certain building types necessitate special acoustic treatment because of the sort of activities carried out within them (Ibitoye Alagbe, Dare-Abe, 2022).. According to Abera, (2024) acoustics of buildings, these include places that require a great degree of quiet, music halls, recording studios, auditoriums, and multipurpose performance spaces. However, it is incorrect to assume that acoustic design is solely necessary in specialist audio environments. Even basic spaces need to be acoustically designed, especially if they are close to sources of noise or are used for activities requiring communication and focus. Reverberation time is one of the most important metrics used to assess a space's acoustic quality. The amount of time needed for sound to diminish by 60 dB after the sound source has ceased is known as the reverberation time. Room volume, surface area, material absorption capacity, and sound frequency are some of the variables that affect it. Every room has an optimal reverberation duration that supports both functional performance and acoustic comfort, depending on its intended use Sound absorption is the main method used to control reverberation. Structures that enclose an area have the ability to both absorb and reflect sound waves. Effective sound absorption lowers excessive noise levels, enhances acoustic clarity, and dissipates sound energy inside a space. In order to control reverberation and improve overall acoustic comfort, this procedure is crucial (Ibitoye, Abiola, Babamboni, 2023)

## Sound and Acoustics

Sound is a physical movement of air as an object vibrates, sending particles of surrounding material out in waves of pressure to travel through the medium that surrounds it most commonly, air. Our human ear picks up these waves and our brains ascribe them meaning in our sensation of hearing. The science of acoustics concerns the production, transmission, manipulation and reception of sound. In the field of architectural acoustics, the most fundamental characterization of sound is what gives a listener the impression of being enveloped by sound in an environment. Architectural acoustics helps the interior of a building, or any room gets physically "sound right." How well does it supports what is happening? Good acoustical design isn't just about getting rid of sound, but controlling the way a sound space sound. The acoustic requirements for a lecture space are different to those of workshop and gallery environments, the former requiring clear speech, the latter noise control, or calm background conditions etc. In creative buildings like art and craft centers, communication, safety factor, productive working atmosphere and creative concentration are inseparably connected with the acoustic performance (Mu, Wang & Zhang, 2022). Thus, accentuated acoustics should be regarded as a fundamental design element and not as a secondary technical adaption. A sound's physical behavior and perceptual impact are determined by a number of quantifiable properties that define and are measured in Hertz, frequency indicates the speed at which a sound source vibrates and establishes whether a sound is heard as high-pitched or low-pitched. Amplitude, which is often measured in decibels, is a measure of perceived loudness and the magnitude of the vibration. The spatial separation between a sound wave's repeating points is known as its wavelength, and it has a significant impact on how sound interacts with edges, surfaces, and different material thicknesses. Sound velocity, which varies with temperature and density, is a measure of how fast sound moves through a particular medium. Even when pitch and loudness are comparable, listeners can differentiate between various sound sources thanks to timbre, which is the tonal quality or character of sound. Since various materials react differently throughout frequency ranges, these properties are extremely important when choosing materials. While thicker and denser assemblies are required to manage lower frequencies, porous materials typically absorb higher frequencies more effectively. Acoustic solutions must address a wide range of sound characteristics rather than

a limited band in art and craft facilities, where sound sources include tools, machines, voices, and movement (Algargoosh & Soleimani, 2023).

Architectural acoustics research has made great strides, but there are still obstacles to overcome, especially in comprehending how environmentally friendly construction materials affect not just the physical characteristics of sound but also the perceptual, emotional, and cultural aspects of acoustic environments. There is still a need to apply this knowledge to other building types, such as art and craft centers, where creative production, collaboration, and exhibition coexist. This is despite the fact that many studies have examined audience responses to acoustics in performance spaces, including the seminal work of Leo Beranek, who established key principles for evaluating perceptual qualities of acoustic environments. Acoustic comfort is crucial for focus, communication, and artistic expression in these settings, and the use of environmentally friendly building materials adds new factors that need further research. Researchers like Anthony, (2023), Tolulope et al., (2025) & Okoro & Adeyemi, (2024) have used subjective reactions and psychophysiological data to investigate the connection between human perception and acoustic surroundings. Their results show that architectural elements like room geometry and surface materials can greatly affect emotional reactions through attributes like lateral reflections. Applying this viewpoint to art and craft centers, the use of environmentally friendly materials like recycled acoustic panels, natural fibers, earth-based materials, and sustainably sourced timber not only alters reverberation time, sound absorption, and diffusion, but also influences how users feel about the area. These materials frequently have unique tactile, visual, and textural characteristics that enhance psychological comfort as well as acoustic performance. Furthermore, because the acoustic environment created by architectural design contributes to a space's intangible cultural character, academics advocate for adding cultural components to acoustic research. Eco-friendly materials can both improve acoustics and reinforce cultural narratives in art and craft centers, which often highlight sustainable techniques and local workmanship. Physical acoustic characteristics including sound amplification, filtering, diffusion, blending of sound sources, and spatial localization are all directly impacted by architectural features. These elements can improve clarity in workshops, lessen undesired noise transmission between studios, and produce balanced acoustic conditions in exhibition and performance spaces when they are created with sustainable materials that have good absorption and diffusion qualities. These enhancements could increase consumers' emotional fulfillment, lower stress levels, and encourage creativity (Atef Bassioni, Azab, & Abdellatif, 2022).

For instance, it has long been known that the resonance qualities of natural materials, such as wood, can affect physiological reactions like heart rate and breathing pattern as well as mood. Similar to this, the arrangement of surfaces in a room can result in echoes or excessive reflections that impair task performance and voice intelligibility. Poorly managed echoes can interfere with teaching, teamwork, and creative concentration in art and craft centers. On the other hand, environmentally responsible acoustic treatments like bamboo diffusers, cork panels, or recycled cellulose insulation might lessen these impacts. Many acoustic investigations depend exclusively on auditory simulations, despite earlier research showing the link between visual and auditory perception (Ouda, Sanad, Abdelaal, Krishna, Kandah, & Kurdi, 2025). But when sound interacts with architectural features that have distinct visual identities, acoustic environments are created. The visual manifestation of sustainable materials, such as natural finishes, green walls, and exposed timber structures, enhances the entire sensory experience in the context of eco-friendly design. The absence of material authenticity and audiovisual congruency will alter the occupant's experience in an art and craft center, even if artificial sound systems can reproduce specific acoustic parameters. Therefore, ignoring the material and visual aspects of eco-friendly design may restrict our comprehension of the true effects of acoustic circumstances on consumers. The main goal of this study is to show how acoustic settings created with environmentally friendly building materials can improve art and craft centers' emotional health, creative output, and environmental consciousness. The excessive use of mechanical sound reinforcement systems in some modern buildings to make up for subpar material performance can occasionally produce acoustic circumstances that are at odds with the space's intended architectural and environmental goals (Algargoosh & Soleimani, 2023).

## Theoretical Framework

Based on a collection of interrelated architectural and environmental theories, this study explains how environmentally friendly construction materials can enhance an art and craft center's acoustics while simultaneously promoting environmental responsibility and human well-being. Aural Architecture Theory,

Biophilic Design Theory, Circular Economy and Waste-to-Resource Theory, and the Sustainable Development Goals framework are all integrated into the theoretical framework. When taken as a whole, these theories demonstrate that human experience, material sustainability, and acoustic quality are not distinct but rather related aspects of architectural design. Aural Architecture Theory, which contends that buildings influence both visual and audio experiences, serves as the main theoretical basis for this study. This theory states that acoustic environments are actively created by architectural form, enclosure, surface texture, and material composition, which affect how people view and react to space on an emotional level (Almagro-pastor et al., 2022). Thus, sound behavior in buildings is a perceptual and cultural phenomenon in addition to a technical one that can be quantified using absorption coefficients and reverberation duration. The idea highlights how spatial character, reflection patterns, and material presence influence human auditory perception. The acoustic environment has a direct impact on focus, creativity, communication, and emotional comfort at an art and craft center, where creating, instructing, displaying, and interacting take place. According to the hypothesis, people have a natural affinity for nature and react favorably to organic materials, natural textures, and natural fibers like cork, bamboo, wood, and plant-based composites. This category includes a variety of environmentally friendly acoustic materials, such as composites made from agricultural leftovers and natural fiber panels. In addition to enhancing sound absorption, their use indoors can promote relaxation, lower stress levels, and enhanced cognitive function. Choosing suitable environmentally friendly materials is an experiential acoustic design approach as well as a sustainability choice. It describes how natural materials and components from nature have a good impact on people's psychological and physical well-being in constructed spaces, drawing on the philosophy of biophilic design. Because of our innate connection to nature, people choose natural textures, organic materials, and fibers like wood, bamboo, cork, and plant-based composites. Many of these materials, such as composites created from agricultural waste and panels made of natural fiber, are also efficient acoustic solutions. In addition to increasing sound absorption, their use in interior spaces can improve cognitive function, lower stress levels, and encourage relaxation, all of which improve acoustic quality and user well-being (Sofi, Sheikh, Wani, Manzoor, 2025).

## LITERATURE GAP

Green construction techniques, sustainable building materials, and architectural acoustics are all covered in great detail in the literature currently in publication. While some studies concentrate on eco-friendly materials and their benefits for the environment and the environment, others explain acoustic concepts like reverberation control, sound absorption, and noise management in buildings. Additionally, a lot of research has been done on cultural centers and creative facilities, emphasizing both their practical and social value. There isn't any integrated research, meanwhile, that precisely links eco-friendly building materials and acoustic performance in art and craft centers. Green construction techniques, sustainable building materials, and architectural acoustics are all covered in great detail in the literature currently in publication. While some studies concentrate on eco-friendly materials and their benefits for the environment and the environment, others explain acoustic concepts like reverberation control, sound absorption, and noise management in buildings. Additionally, a lot of research has been done on cultural centers and creative facilities, emphasizing both their practical and social value. There isn't any integrated research, meanwhile, that precisely links eco-friendly building materials and acoustic performance in art and craft centers.

## METHODOLOGY

This study examines how eco-friendly building materials can improve the acoustics of an art and craft center using a qualitative, literature-based technique backed by analytical and comparative evaluation. The study makes use of secondary data from academic publications, technical reports, textbooks, sustainability guidelines, and case studies that have been published about architectural acoustics and green building materials. To find sustainable materials with sound-absorbing qualities and to comprehend their acoustic behavior and environmental performance, thorough research of pertinent literature is carried out.

The gathered data is arranged topically and subjected to comparison analysis utilizing well-established acoustic principles, including material porosity, reverberation control, and absorption. The study develops design-oriented insights without laboratory experiments or field measurements by connecting eco-friendly material features to acoustic performance results in creative environments through theory-guided interpretation and conceptual mapping.

---

## FINDINGS

### Insulation Materials and Acoustic Performance in Buildings

Insulation materials are essential for controlling noise and temperature in buildings, especially specialty spaces like art and craft centers. According to recent studies, insulation products fall into two main categories: natural and synthetic. Each of these types of products has a unique impact on sustainability, durability, sound absorption, and sound insulation. Because they are renewable, biodegradable, and safe for the environment, natural insulating materials are becoming more and more popular. In contrast, synthetic materials are used extensively due to their excellent performance, controlled production quality, and durability. Insulation materials reduce heat transfer and minimize undesired sound transmission and reverberation in acoustically sensitive buildings (Ouda et al., 2025). Mineral, plant, and animal sources are frequently used to create natural insulating materials, plant fibers with cellulose-based porous structures, such as hemp, jute, flax, cotton, and coir, trap air and release sound energy through internal friction. They can be used for partition infills, wall panels, and ceiling systems in creative areas because of their microstructure, which also promotes heat resistance and mid-to-high frequency sound absorption. Because they can absorb and release moisture without losing their insulating properties, animal-based fibers like wool and silk offer additional benefits through moisture buffering and improved indoor air quality. When greater safety margins are needed, mineral fibers like rock wool and basalt fibers are suitable because of their superior fire and heat resistance. Green acoustic design solutions are increasingly incorporating natural insulating materials due to their reduced embodied energy and renewable nature. Due to their mechanical resilience and consistency, synthetic and recycled insulating materials are very frequently utilized. In order to lessen the load on landfills and promote circular construction models, reprocessed waste streams like glass, ash, slag, ceramics, recycled polymers, and industrial sludge are being turned into acoustic panels and insulating boards. Fiberglass insulation, which has a lightweight structure and high thermal resistance, is frequently made from recycled glass, whereas polystyrene foams made from polymers offer steady insulating behavior and low thermal conductivity. Synthetic fibers can be inorganic (like silicon carbide and boron fibers) or organic (like polyester and nylon). While inorganic types are prized for their high-temperature stability and fire resistance, organic types are lightweight and flexible and are commonly utilized in acoustic linings. Notwithstanding their performance advantages, research into more environmentally friendly substitutes and enhanced recyclability is nevertheless motivated by worries about production energy and disposal (Omole, Olajiga2, & Olatunde, 2024).

### Sustainable Insulation Materials and the Sdgs

Sustainable insulating materials support global sustainability goals in addition to improving building performance. In the framework of the Sustainable Development Goals of the United Nations, the building industry is acknowledged as a crucial lever for social and environmental advancement. Strong thermal and acoustic performance is offered by conventional insulation materials such as expanded polystyrene, fiberglass, and polyurethane foams, but they are frequently petroleum-based, non-renewable, and challenging to recycle, which poses health and environmental risks. Insulation materials made from bio-based, recycled, and agricultural leftovers, on the other hand, typically have smaller environmental impacts and better meet sustainable development goals. Eco-friendly insulating materials help achieve several SDGs at once. By lowering harmful pollutants and enhancing indoor environmental quality, they promote health and wellbeing. By increasing thermal efficiency and reducing the demand for heating and cooling, they help achieve clean energy targets. By creating new green material technologies, they foster innovation and robust infrastructure. They encourage responsible consumption by repurposing waste and renewable resources, and they help sustainable cities by facilitating the construction of low-carbon buildings. By reducing lifecycle greenhouse gas emissions from material manufacture and building operation, they also directly support climate action. However, a large portion of the material now in publication still only considers initial cost comparisons, frequently ignoring durability, lifecycle emissions, and long-term sustainability value. Therefore, when choosing insulation materials for ecologically conscious and acoustically sensitive institutions like art and craft centers, thorough evaluation frameworks are required (Hemmati et al., 2024).

## Sound-Absorbing Materials and Acoustic Composites

Since poor acoustic circumstances can contribute to stress, diminished focus, and other non-hearing health impacts in addition to hearing risk, acoustic comfort is widely acknowledged as a fundamental element of sustainable built environments. Therefore, it is common practice to utilize sound-absorbing materials to lower overall sound levels and reverberation in enclosed environments. In order to improve overall performance, the majority of contemporary acoustic goods are composite materials, which are created by combining two or more parts with differing physical qualities. Materials can be designed to balance insulation, diffusion, absorption, and reflection by using this composite technique. Since poor acoustic circumstances can contribute to stress, diminished focus, and other non-hearing health impacts in addition to hearing risk, acoustic comfort is widely acknowledged as a fundamental element of sustainable built environments (Science et al., 2024). Therefore, it is common practice to utilize sound-absorbing materials to lower overall sound levels and reverberation in enclosed environments. In order to improve overall performance, the majority of contemporary acoustic goods are composite materials, which are created by combining two or more parts with differing physical qualities. Materials can be designed to balance insulation, diffusion, absorption, and reflection by using this composite technique. In the past, asbestos-based acoustic solutions were widely used, but due to health concerns, glass fiber and mineral systems have since replaced them. Despite their good acoustics, glass wool and rock wool require a lot of energy to make and are challenging to properly dispose of. Because of this, research toward safer, lighter, biodegradable, and lower embodied energy alternatives has increased. A lot of these alternatives are made from natural fibers, recycled textiles, and agricultural waste, which satisfies sustainability and acoustic performance criteria (Arenas, 2020). Due to health concerns, glass fiber and mineral systems have supplanted asbestos-based acoustic solutions, which were once widely used. Although glass wool and rock wool have good acoustics, they are difficult to properly dispose of and require a lot of energy to produce. Because of this, research toward safer, lighter, biodegradable, and lower embodied energy alternatives has increased (Boge, 2025). A lot of these alternatives are made from natural fibers, recycled textiles, and agricultural waste, which satisfies sustainability and acoustic performance criteria. Mineral-based natural fibers, such as rock wool and basalt fiber, exhibit strong thermal resistance and long-term durability, making them applicable in both light creative buildings and more demanding workshop zones. In acoustically sensitive creative centers, the growing interest in natural insulation materials is driven by their renewability, biodegradability, environmental compatibility, and long-term cost potential. Animal-derived fibers, such as wool and silk, are protein-based materials with keratin structures that provide effective insulation, moisture regulation, and indoor air quality improvement (Arenas, 2020).

### Coconut Fiber (Coir) Used as Ecofriendly Acoustic Material

The outer husk of coconut fruits is used to make coconut fiber, also referred to as coir, a significant environmentally friendly acoustic material. Harvesting and the hand removal of the husk are the first steps in the extraction process, which is customarily completed by local producers. After that, the husks go through a three- to six-month retting process, frequently in saltwater. Microbial activity during this time facilitates the easier separation of fibers by breaking down binding molecules. Following retting, the fibers are extracted from the husks by beating them manually or mechanically the fibers are subsequently cleaned and dried using mechanical drying systems or exposure to the sun. The dried coir fibers are frequently subjected to an alkaline mercerization process using sodium hydroxide solutions in order to increase mechanical strength and compatibility with composite binders (Hemmati et al., 2024). This process improves bonding with polymer matrices, increases surface roughness, reveals crystalline cellulose structures, and eliminates lignin, waxes, and hemicellulose. Additionally, it improves stiffness and tensile performance while decreasing water absorption. Process management is crucial because high chemical concentrations or extended exposure might harm the fibers and lower performance. For composite acoustic panels and boards used in creative centers, properly treated coir fibers which are normally 10 to 30 cm long which also show better compatibility (Saleh, Dawoud, & Hassan, 2023). One noteworthy environmentally friendly material that comes from agricultural sources and is being used more and more in composite and acoustic goods is coconut coir fiber. A series of conventional and partially automated procedures are used to extract the fiber from the outer husk of mature coconuts. Coconuts are manually dehusked after harvesting in order to remove the inner shell from the fibrous outer covering. After that, the husks go through a several-month-long retting process, which is often carried out in saltwater, where natural microbial activity breaks down binding chemicals and facilitates easier fiber separation. After retting, the fibers are extracted from the husks by beating them manually or mechanically. The fibers are then cleaned to get rid

of contaminants and dried by either mechanical drying or sun exposure to reach useable moisture levels. One noteworthy environmentally friendly material that comes from agricultural sources and is being used more and more in composite and acoustic goods is coconut coir fiber. A series of conventional and partially automated procedures are used to extract the fiber from the outer husk of mature coconuts. Coconuts are manually dehusked after harvesting in order to remove the inner shell from the fibrous outer covering. After that, the husks go through a several-month-long retting process, which is often carried out in saltwater, where natural microbial activity breaks down binding chemicals and facilitates easier fiber separation. After retting, the fibers are extracted from the husks by beating them manually or mechanically. The fibers are then cleaned to get rid of contaminants and dried by either mechanical drying or sun exposure to reach useable moisture levels (Bravomoncayo, Puyana-Romero, Chávez, & Ciaburro., 2025).

### **Synthetic And Waste-Derived Composites for Acoustic Control**

Research has concentrated on enhancing synthetic and waste-derived composites for sound suppression in addition to bio-based materials. Increased layer count and acoustic impedance contrast have been shown to improve sound transmission loss in polyvinyl chloride multilayer composites with alternating foam and film layers. Modular sandwich wall panels with polystyrene cores and gypsum or magnesium oxide boards demonstrate how careful material selection may greatly enhance the acoustic performance of wall systems. Significant acoustic improvements have resulted from the integration of industrial waste. For sound suppression, research has focused on improving waste-derived and synthetic composites in addition to bio-based materials. In polyvinyl chloride multilayer composites with alternating foam and film layers, it has been demonstrated that sound transmission loss can be improved by increasing the number of layers and the acoustic impedance contrast. The acoustic performance of wall systems can be significantly improved by carefully choosing materials, as shown by modular sandwich wall panels with polystyrene cores and gypsum or magnesium oxide boards (Korjakins Sahmenko & Lapkovskis, 2025). The incorporation of industrial waste has produced notable acoustic enhancements. Plastics that have been recycled have also shown promise. Panels made from PET felt and recycled plastic bottles have encouraging acoustic properties. They are tested for biocompatibility, VOCs, and antifungals to ensure their safety, particularly in sensitive situations. Fly ash and recycled PET fibers combine to create lightweight aerogels with low density, high porosity, and good thermal and acoustic insulation. At specific thicknesses, adding rubber particles to concrete can increase absorption while preserving a respectable compressive strength. Further research shows promising outcomes with recycled textiles, leather waste, cork, sawdust, sand, wool waste, recycled denim, cotton fabric composites with PLA, ABS chip waste, plastic caps with natural fillers, cardboard packaging, egg boxes, and textile waste with natural rubber. These methods show that a variety of waste streams can be converted into valuable acoustic building materials. Another significant material family is represented by composites made of wood and biofiber that employ mineral binders. This field of study assesses the effects of vegetable fibers on mechanical and acoustic qualities when coupled with binders such Portland cement, lime, clay, gypsum, magnesium oxychloride cement, and magnesium phosphate cement (Bravo-moncayo, Puyana-Romero, Chávez, & Ciaburro., 2025).

These mineral-organic composites are prized for their mechanical stability, fire resistance, environmental friendliness, and high sound absorption. They also often have lower lifespan energy requirements and carbon emissions than many synthetic substitutes. In the past, clay and straw mixtures were utilized as early composite wall materials. Despite clay's sensitivity to moisture, straw served as reinforcement and enhanced thermal and acoustic characteristics. These days, sustainability objectives and carbon reduction targets rather than material scarcity which are what motivate interest in such composites (Korjakins & Sahmenko, 2025). Wood-cement boards, especially wood-wool cement boards, are good for both thermal insulation and sound absorption because they combine rigidity with high porosity levels, which are typically between 70% and 80%. Because of the cement component, these boards have more structural strength and better fire and biological resistance than simply fibrous porous composites. In order to lower experimental costs and improve the prediction of frequency-dependent performance, recent research have also used optimization and acoustic modelling techniques, such as theoretical and empirical prediction models. Therefore, these bio-fiber and wood-mineral binder composites provide an appealing mix of mechanical performance, acoustic efficiency, and environmental sustainability, which makes them ideal for use in multifunctional and performance-focused areas like art and craft centers (Bhoir, Patil, Joshi & Shinde, 2024). Green walls and porous absorbers, which lessen reverberation and enhance speech intelligibility, are examples of barriers and absorptive systems that are necessary for effective

management of sound throughout its transmission channel. Compared to resonant systems, porous absorbers are typically easier to manufacture and more affordable. They work especially well at mid- and high frequencies. Synthetic or mineral fibers like fiberglass and polypropylene are frequently used in conventional porous absorbers; however, these materials pose health and environmental risks due to their high embodied energy, potential for skin and eye irritation, toxic emissions during burning, landfill persistence, and difficulties with recycling (Vela & Ascens, 2025). A considerable portion of the world's energy consumption and greenhouse gas emissions come from buildings, and insulation is essential for lowering the demand for heating and cooling, particularly in tropical regions where peak demand and yearly cooling energy can be greatly decreased. However, the majority of insulating materials on the market today are still made from fossil fuels or minerals, which raises environmental issues comparable to those with synthetic acoustic absorbers. Bhoir, Patil, Joshi & Shinde, (2024) research into natural porous materials, which are less expensive, more accessible, non-toxic, biodegradable, lightweight, and electrically resistant, has increased as a result of these worries. Cellular, fibrous, and granular are the structural categories for porous materials; fibrous systems make up the biggest group. Vegetable, animal, and mineral fibers are examples of natural fibrous materials that have shown excellent dual performance in thermal insulation and sound absorption. Despite its great potential, wood is nevertheless susceptible to biological attack, fire, humidity, and temperature fluctuations. For this reason, hybridization with cement and other stabilizing binders is encouraged in order to increase durability and safety. Reusing household and industrial waste materials offers acoustic benefits, lowers embodied carbon, and promotes the circular economy. Recycled PET and felt panels exceed sustainability certification standards and offer robust mid- and high-frequency absorption. Composites made from leftover rubber and paper pulp reduce the loss of sound, while sophisticated fabrication techniques like additive manufacturing allow for the low-waste creation of intricate acoustic shapes. Psychological comfort and well-being are equally important aspects of healthy creative environments (Bhoir et al., 2024). Natural and biophilic materials help create peaceful indoor environments and typically release fewer toxic compounds. Art and craft centers benefit from improved indoor microclimates because to materials like bamboo and rammed earth that help control temperature and humidity. Integrating spatial planning and zoning to control movement and acoustic interaction between loud workshops, educational studios, cultural display spaces, and leisure zones is necessary for effective implementation. In order to track and modify acoustic response in real time, contemporary management techniques are progressively integrating digital twins connected to BIM and Internet of Things sensor systems. With the help of these systems, adjustable acoustic elements may be controlled automatically, and without constant manual adjustment, the ideal reverberation time targets can be maintained for various activities. The analysed findings collectively show that the use of bio-based, recycled, and environmentally friendly materials can improve acoustic performance and further sustainability objectives in the design and operation of art and craft facilities (Saleh et al., 2023).

### **Timber and Wood Panels Used Acoustic Design**

In addition to being environmentally friendly acoustic materials, timber and engineered wood panels also offer controlled reflection, diffusion, and absorption. The surface roughness and cellular microstructure of wood assist control reverberation and enhance sound quality in areas. Timber enhances the overall occupant experience in creative spaces by buffering dampness and providing thermal comfort in addition to its acoustic advantages. When compared to untreated hard surfaces, timber wall panels can significantly shorten reverberation times and attain mid-frequency absorption levels that are noticeably higher than those of bare masonry or plaster. In addition to reducing transmitted noise across areas, well-designed timber panel systems can diffuse reflected sound to prevent harsh echoes. Benefits to aesthetics and culture are especially noteworthy since natural wood finishes can convey regional identity and workmanship while also creating cozy spaces (Okoro & Adeyemi, 2024). Perforation, slotting, layered backing absorbers, and the application of sophisticated technologies like cross-laminated wood for better low-frequency management can all further increase performance. To effectively shape the acoustic environment spanning workshops, studios, galleries, and performance zones inside an art and craft center, strategic placement is prioritized over ornamental application. The effectiveness and safety of natural fibers and biocomposites as substitutes for manufactured acoustic materials are becoming more widely acknowledged. By combining absorption, diffusion, and regulated resonance, timber and timber composites also improve acoustic quality. In multipurpose halls, timber wall panels promote craftsmanship and cultural expression while reducing resonance. Panels constructed from wood waste species have thermal and acoustic behaviour equivalent to commercial synthetic materials, providing lower-carbon options, while wood-cement

composites, such as wood strands, rock, wool-cement boards, give balanced performance in speech frequency ranges (Oladunni, Daramola, & Ajayi, 2025).

### Comparative Acoustic Performance of Eco-Friendly Materials

Material	Type	NRC / Absorption (α)	Frequency Effectiveness	Sustainability Benefit
Hemp Fiber Panels	Natural	0.60 – 0.85	Mid–High (500–2000 Hz)	Renewable, low embodied carbon
Coir Composite	Agricultural waste	0.45 – 0.80	Mid frequency	Biodegradable, waste reuse
Bamboo Panels	Rapid renewable	0.50 – 0.75	Speech range	Fast-growing resource
Recycled PET Felt	Post-consumer plastic	0.65 – 0.90	Broad range	Diverts plastic waste
Wood-Cement Boards	Bio-mineral composite	0.55 – 0.85	Balanced	Fire-resistant, durable
Rock Wool	Mineral	0.80 – 0.95	Broad	High energy production

Source: (Yan & Tronchin, 2025)

### Digital Twins, Bim, and Iot for Indoor Sound Quality Management

How indoor sound quality is tracked and managed is changing more and more due to digital technologies, particularly in performance and multipurpose spaces like art and craft centers. The monitoring and management of interior sound quality is changing as a result of emerging digital technologies like the Internet of Things (IoT) and Building Information modelling (BIM). In addition to providing extensive interconnection between sensors, devices, and control systems, Internet of Things (IoT) systems enable dense networks of sensors and connected devices that gather operational and environmental data in real-time, enabling buildings to react intelligently to changing conditions. In performance and multipurpose spaces, sensor networks and control software can monitor occupancy, layout changes, and environmental parameters like indoor environmental quality and energy use. These systems also support autonomous decision-making, predictive alerts, and responsive control of building subsystems. IoT devices can track occupancy levels, equipment conditions, layout configurations, and ambient factors that affect sound behaviour in acoustically sensitive buildings. Three-dimensional building models are extended by Digital Twin (DT) systems, which connect them to real-time IoT data streams to provide dynamic virtual representations of physical environments. BIM models are also extended by DT systems, which include real-time sensor data to model and forecast building behaviour. Acoustic parameters like reverberation time can be estimated and adjusted in real time based on occupancy percentage and hall configuration when digital twins are integrated with Building Information modelling (BIM). In acoustic applications, DT platforms can estimate reverberation time based on occupancy levels and spatial configuration, using stagecraft and variable acoustic element sensors to detect layout conditions. Without the need for repeated manual measurements, sensor networks linked to stage equipment and variable acoustic elements can automatically detect spatial configurations and initiate adjustments, eliminating the need for experts to manually tune acoustics. This enables real-time acoustic panel and movable element adjustments to maintain ideal sound conditions (Cairolì & Tagliabue, 2023).

When digital twins are combined with Building Information Modelling (BIM), acoustic parameters, such as reverberation duration, can be evaluated and modified in real time based on occupancy percentage and hall

arrangement. By employing stagecraft and changeable acoustic element sensors to identify layout conditions, DT platforms can predict reverberation time in acoustic applications based on occupancy levels and spatial configuration. Sensor networks connected to stage equipment and variable acoustic elements may automatically recognize spatial configurations and initiate modifications without the need for repeated manual measurements. This eliminates the requirement for specialists to manually tune acoustics which makes it possible to alter the movable elements and acoustic panel in real time to maintain optimal sound conditions. This enables a quicker reaction to shifting space use conditions and lessens the need for recurrent manual acoustic adjustment by experts. By integrating digital twins with BIM systems, facility management, documentation quality, and predictive scheduling are all improved by the increased interchange between architectural models and operational performance data (Saleh et al., 2023). Digital building systems are widely used in design stages, but their use in facility management is still limited due to issues like static data models, unclear responsibility frameworks, lack of interoperability standards, and inadequate as-built data updating. Similarly, while BIM is widely used during design and construction, its application in facility management has historically been limited by static data structures, lack of interoperability with FM tools, and insufficient lifecycle updates. Current research focuses on connecting IoT databases with BIM platforms to improve acoustic management in operational buildings, such as theatres and multipurpose art facilities, and on integrating IoT databases with BIM platforms so that as-built acoustic data and operational measurements continuously update the model. In multipurpose halls and cultural venues where acoustic circumstances fluctuate regularly, this kind of integration is especially beneficial. However, there are more opportunities for real-time acoustic monitoring and optimization due to the expanding presence of sensors and Industry 4.0 technologies. DT-BIM-IoT integration facilitates adaptive acoustic control and enhanced user experience for art and craft centers that host exhibitions, workshops, lectures, and performances. These digital frameworks also support safer operations, adaptive acoustic management, and enhanced user experience through responsive environmental control in art and craft centers and multipurpose creative facilities (Cairolì & Tagliabue, 2023).

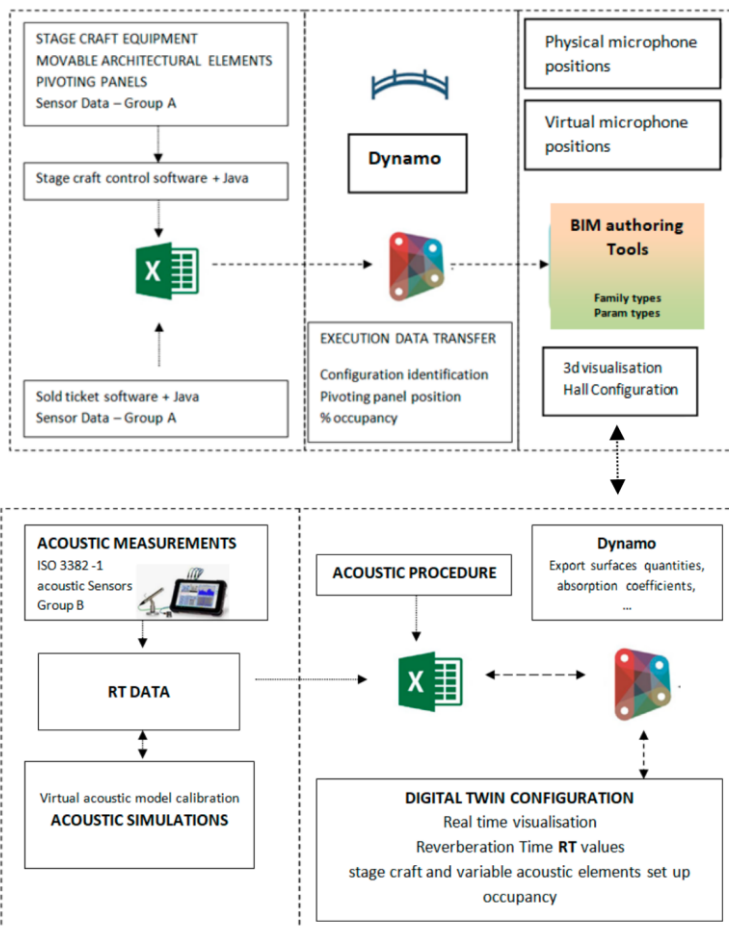


Fig 1: The workflow of the BIM and IoT integration approach

Source: (Cairolì & Tagliabue, 2023)

---

## Implementation Challenges of Eco-Friendly Acoustic Materials in Art and Craft Centers

Eco-friendly acoustic materials show promise in the lab, but there are a number of practical issues with their use in Art and Craft Centers. Under normal conditions, laboratory testing frequently yield favourable Noise Reduction Coefficients (NRC 0.60–0.90); however, when materials are implemented in multifunctional contexts that include studios, galleries, workshops, and performance areas, these values may fluctuate dramatically (Bhoir et al., 2024). Such facilities' acoustic complexity needs careful customization beyond theoretical absorption statistics. Durability and moisture sensitivity are still major issues. Many natural fiber materials, such as hemp, coir, bamboo, and cellulose composites, are hygroscopic and can absorb moisture in humid climates, which can eventually cause dimensional instability, mold growth, or decreased acoustic efficiency. This problem is especially pertinent in art and craft centers where wet processes, like the production of ceramics and textiles, raise indoor humidity levels. To sustain long-term performance, protective treatments and hybrid mineral binders are frequently needed. Direct application is also restricted by fire safety regulations. Because bio-based fibers are naturally flammable, public assembly buildings must adhere to fire-resistance regulations. Chemical treatments or composite stabilization are frequently needed to achieve acceptable fire classes, which may raise prices and perhaps negate environmental benefits. Another implementation challenge is mechanical durability (Lee et al., 2023). Workshops expose soft bio-based panels to wear and impact damage due to tool use, equipment vibration, and frequent physical contact. In high-activity areas, material lifespan may be shortened in the absence of intentional zoning or reinforcing. Furthermore, even though a lot of environmentally friendly materials work well at mid-to-high speech frequencies (500–2000 Hz), they might not provide much low-frequency control unless they are paired with mass-based devices. Cost perception and procurement hurdles further influence acceptance (Saleh et al., 2023). Although lifecycle studies suggest reduced embodied carbon, initial procurement prices and limited availability in some places may prevent widespread deployment. Facility managers must also be technically aware of maintenance issues such surface treatment renewal, moisture monitoring, and routine inspections. Performance predictability issues arise when digital acoustic systems like BIM, IoT sensors, and digital twins are integrated (Cairolì & Tagliabue, 2023). While eco-friendly acoustic materials offer significant theoretical sustainability and absorption benefits, successful implementation in Art and Craft Centers requires addressing durability, fire compliance, humidity control, installation quality, cost structures, and digital integration constraints. Natural materials may exhibit variability in density and moisture content, which complicates real-time modelling and adaptive acoustic management. Therefore, environmental responsibility must be balanced with operational, climatic, and regulatory realities in sustainable acoustic design.

## CONCLUSION

This study has shown that environmentally friendly construction materials are important and multifaceted in enhancing Art and Craft Centers' acoustics and promoting environmental sustainability objectives at the same time. The research demonstrated that sustainable materials, such as natural fibers, recycled composites, timber-based panels, mineral–biofiber composites, and agricultural waste derivatives, have quantifiable sound absorption, reverberation control, and noise reduction capabilities appropriate for acoustically sensitive creative environments through a qualitative review and comparative analysis of the body of existing literature. The results demonstrate that a variety of bio-based and recycled materials, including wood-cement boards, hemp, bamboo, coir fiber, recycled PET panels, and natural fiber composites, can attain acoustic performance that is on par with or, in some frequency ranges, superior to that of traditional synthetic materials. In addition to improving acoustic performance, these materials' biophilic and natural material expression lowers embodied energy, lowers carbon emissions, improves indoor air quality, and increases psychological comfort. This brings the profession of acoustic design into line with more general sustainability and wellness ideas. Additionally, the study demonstrates that rather than being a post-construction adjustment, acoustic quality in Art and Craft Centers should be seen as an integrated design component. These facilities demand careful coordination of material selection, spatial zoning, and surface treatment since they incorporate workshops, studios, galleries, instructional zones, and performance sections with varying acoustic requirements. Digital tools like BIM, IoT sensors, and Digital Twin systems, along with eco-friendly acoustic materials, offer new possibilities for performance-driven and adaptive acoustic management. All things considered, the study closes a significant knowledge gap by directly connecting environmentally friendly material choices with acoustic performance in creative cultural

institutions and demonstrates that sustainable acoustic design is both ecologically conscious and technically feasible.

## REFERENCES

1. Abera, Y. A. (2024). Sustainable building materials : A comprehensive study on eco-friendly alternatives for construction. 33, 1–17. <https://doi.org/10.1177/26349833241255957>
2. Algargoosh, A., & Soleimani, B. (2023). The impact of the acoustic environment on human emotion and experience : A case study of worship spaces. December. <https://doi.org/10.1177/1351010X211068850>
3. Almagro-pastor, J. A., Garc, R., Vida-manzano, J., Mart, F. J., & Ramos-ridao, Á. F. (2022). The Acoustics of the Palace of Charles V as a Cultural Heritage Concert Hall. 800–820.
4. Anthony, I. (2023). SYMBOLIC FORMS IN CHURCH ARCHITECTURE : A CASE STUDY OF SAINT AUGUSTINE CATHOLIC CHURCH IKORODU , LAGOS STATE . 6(1), 161–179.
5. Arenas, J. P. (2020). Sustainable Acoustic Materials. 10–14.
6. Atef, M., Bassioni, G., Azab, N., Abdellatif, M. H., & Division, C. (n.d.). On the Acoustical Performance of Eco-Friendly Cementitious Composite with Recycled Fine Rubber Particles. 1–14.
7. Bhoir, J. H., Rajan, J., Patil, S. R., Joshi, A. R., & Shinde, A. A. (2024). Design and manufacturing of eco-friendly acoustic panels Design and manufacturing of eco-friendly acoustic panels. May. <https://doi.org/10.30574/gjeta.2024.19.2.0075>
8. Bravo-moncayo, L., Puyana-romero, V., Chávez, M., & Ciaburro, G. (2025). Improving Building Acoustics with Coir Fiber Composites : Towards Sustainable Construction Systems. 1–24.
9. Caioli, M., & Tagliabue, L. C. (2023). Digital Twin for Acoustics and Stage Craft Facility Management in a Multipurpose Hall. 909–927.
10. Enwerem, M., Malomo, G. E., Ibitoye, O., & Ogunyemi, G. (2025). The Role of Eco-Friendly Materials in Enhancing Comfort and Aesthetics in Hotel Design. 08(2), 129–145.
11. Hemmati, N., Mirzaei, R., Soltani, P., Berardi, U., Javad, M., Mozafari, S., Edalat, H., Rezaieyan, E., & Taban, E. (2024). Acoustic and thermal performance of wood strands-rock wool-cement composite boards as eco-friendly construction materials. 445(May).
12. I, O. J. O. O., A, P. D. S., & Ajayi, O. O. (2025). The Acoustic Benefits of Timber Wall Panels Towards Enhancing Sound Quality and Comfort in Musical Theatres : A Case Study of Terra Culture Arena , Lagos . 8(12), 1276–1284.
13. Ibitoye, O. A., Alagbe, P. O., & Dare-abel, P. O. (2022). Comparative Cost Advantages of Interlocking Stabilized Soil Block and Sandcrete Block for Building Construction in South-West. 5(5), 549–558.
14. Journal, C. (2025). IKORODU: THE EVOLUTION AND DEVELOPMENT OF A CITY Faruq Idowu Boge, Ph.D Department of History and International Studies Lagos State University, Ojo, Lagos. 2(1), 52–67.
15. Korjajins, A., & Sahmenko, G. (2025). A Short Review of Recent Innovations in Acoustic Materials and Panel Design : Emphasizing Wood Composites for Enhanced Performance and Sustainability.
16. Lee, M., Sarkar, A., Guo, Z., Zhou, C., Armstrong, J. N., & Ren, S. (2023). Nanoscale Advances insulation materials by recycling pulp and paper †. <https://doi.org/10.1039/d3na00036b>
17. Obafemi A. Ibitoye, Oyewole A. Abiola, & Adekunle S. Babamboni (2023) DEMOGRAPHIC CHARACTERISTICS OF HOUSING ESTATES DEVELOPED WITH ISSB TECHNOLOGY IN SELECTED SOUTHWESTERN NIGERIAN (SWN) CITIES. 7(2), 275–283.
18. Nuratirah, S., & Mohd, C. (n.d.). Pragmatic Consideration on Eco-Friendly Building Materials for Healthy Homes. 319–338. <https://doi.org/10.4018/978-1-6684-8253-7.ch017>
19. Oa, I. (2025). A Critical Analysis of Interlocking Stabilized Soil Blocks ( ISSB ) in Residential Architecture : A Case Study of Obayemi House , Redemption Camp , Ogun State. 562–569.
20. Okoro, N. A., & Adeyemi, T. O. (2024). THE IMPACT OF ACOUSTICS ON THE DESIGN OF A VIBRANT CULTURAL CENTRE IN YENAGOA , BAYELSA STATE . 12(2), 1–15.
21. Ouda, M., Sanad, A. A. A., Abdelaal, A., Krishna, A., Kandah, M., & Kurdi, J. (2025). A Comprehensive Review of Sustainable Thermal and Acoustic Insulation Materials from Various Waste Sources. 1–38.
22. Parekh, R., & Smith, C. (2024). Eco-friendly urban design : An analysis of sustainable building practices and their community impact.
23. Review, A. S. (2022). Research on the Acoustic Environment of Heritage Buildings :

24. Saleh, H. M., Dawoud, M. M., & Hassan, A. I. (2023). Editorial : Sustainable and eco-friendly building materials. February, 1–3. <https://doi.org/10.3390/SU12187427>
25. Science, E., Journal, T., Publishers, F. E., Omole, F. O., Olajiga, O. K., Olatunde, T. M., Infrastructure, E., & Researcher, I. (2024). SUSTAINABLE URBAN DESIGN : A REVIEW OF ECO- FRIENDLY BUILDING PRACTICES AND COMMUNITY. 5(3), 1020–1030. <https://doi.org/10.51594/estj/v5i3.955>
26. Sofi, A. A., Sheikh, T. A., Wani, R. A., & Manzoor, A. (2025). Cement stabilized earth blocks ( CSEB ): An economic and eco- friendly building material Cement stabilized earth blocks ( CSEB ): An economic and eco- friendly building material . September, 5–11. <https://doi.org/10.9790/1684-1306050611>
27. Song, Z. (n.d.). Spatial Acoustic Approach : Sustainable Design Methods in Creative Centre Building Spatial Acoustic Approach: Sustainable Design Methods in Creative Centre Building. 0–9. <https://doi.org/10.1088/1755-1315/1324/1/012048>
28. Tolulope, A., Obafemi, A., Grace, C., & Gabriel, O. (2025). Afropolitan Journals Green Facade Systems as a Sustainable Solution f or Urban Heat Island Mitigation i n Lagos State. 19(1), 61–75.
29. Vela, G., & Ascens, G. (2025). Development of an innovative biocomposite using coconut fibres and bio-based binder for thermal and acoustic applications in buildings. 491(January). <https://doi.org/10.1016/j.jclepro.2025.144834>
30. Yan, R., & Tronchin, L. (2025). Acoustic characteristics and objective evaluation of acoustic quality in historical Italian theaters. Applied Acoustics, 233(November 2024), 110483. <https://doi.org/10.1016/j.apacoust.2024.110483>