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Unconventional Materials and Techniques in Sustainable Architecture Education: A Literature Review

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Arquitetura e sustentabilidade: revisão sobre a abordagem de materiais e técnicas não convencionais nos cursos de Arquitetura e Urbanismo

RESUMO

Objetivo – Apresentar um aporte teórico sobre Arquitetura, Urbanismo e sustentabilidade, abordando materiais e técnicas não convencionais como alternativa para minimizar os impactos ambientais da Construção Civil, e, além disso, identificar como esses temas são tratados no processo formativo dos cursos de Arquitetura e Urbanismo.

Metodologia – Pesquisa bibliográfica com consulta a livros, dissertações, teses e artigos científicos, com abordagem teórica para fundamentar a discussão.

Originalidade/relevância – A pesquisa insere-se na lacuna teórica, relacionada à necessidade de incorporação de práticas e conceitos sustentáveis no ensino de Arquitetura e Urbanismo, considerando a perda de técnicas construtivas tradicionais e a necessidade de alternativas ecologicamente responsáveis. A temática é relevante por fomentar reflexões acadêmicas sobre a importância da formação profissional na consolidação de práticas alinhadas com a sustentabilidade.

Resultados – O estudo destaca a importância dos materiais não convencionais, caracterizados por serem naturais, renováveis e pouco poluentes, e evidencia a progressiva desvalorização de técnicas construtivas tradicionais não normatizadas. Além disso, aponta a necessidade urgente de ampliar e consolidar a abordagem da sustentabilidade na formação de arquitetos e urbanistas.

Contribuições teóricas/metodológicas – O trabalho contribui com discussões teóricas ao reforçar a importância da integração entre sustentabilidade, uso de materiais não convencionais e a formação acadêmica em Arquitetura e Urbanismo. No aspecto metodológico, a pesquisa bibliográfica oferece um referencial sólido que pode embasar futuras investigações práticas e aprofundamentos sobre o tema.

Contribuições sociais e ambientais – O artigo contribui socialmente e ambientalmente no incentivo de práticas construtivas que priorizem o uso de recursos renováveis e a preservação de técnicas tradicionais, promovendo uma atuação profissional comprometida com o meio ambiente e com a melhoria da qualidade de vida das gerações futuras.

PALAVRAS-CHAVE: Sustentabilidade. Educação. Materiais alternativos.

Unconventional Materials and Techniques in Sustainable Architecture Education: A Literature Review

ABSTRACT

Objective – This paper offers a theoretical contribution to the fields of Architecture, Urban Planning, and sustainability, focusing on the use of unconventional materials and techniques as alternatives to mitigate the environmental impact of the construction industry. It also seeks to examine how these topics are incorporated into the academic training of architecture and urban planning students.

Methodology – A literature review grounded in books, dissertations, theses, and peer-reviewed articles, with a theoretical lens supporting the analysis.

Originality/relevance – This research fills a theoretical gap related to the need to incorporate sustainable concepts and practices into Architecture and Urban Planning education, considering the loss of traditional building techniques and the growing demand for ecologically responsible alternatives. The topic is relevant as it encourages academic reflection on the role of professional training in shaping practices aligned with sustainability.

Results – The study highlights the importance of unconventional materials—defined as natural, renewable, and low-polluting—and reveals the ongoing devaluation of traditional, non-standardized construction techniques. It also emphasizes the urgent need to expand and strengthen sustainability approaches in the academic training of architects and urban planners.

Theoretical/methodological contributions – The research contributes to theoretical discussions by reinforcing the importance of integrating sustainability, unconventional materials, and academic training in Architecture and Urban Planning. Methodologically, the literature review provides a solid foundation for future empirical studies and further exploration of the topic.

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Social and environmental contributions – The article contributes to both social and environmental awareness by promoting construction practices that prioritize the use of renewable resources and the preservation of traditional techniques, fostering a professional approach committed to environmental responsibility and the well-being of future generations.

KEYWORDS: Sustainability. Education. Alternative materials.

Arquitectura y sostenibilidad: una revisión sobre el enfoque de materiales y técnicas no convencionales en los cursos de Arquitectura y Urbanismo

RESUMEN

Objetivo – Presentar un aporte teórico sobre Arquitectura, Urbanismo y sostenibilidad, abordando materiales y técnicas no convencionales como alternativa para minimizar los impactos ambientales de la Construcción Civil, y, además, identificar cómo se tratan estos temas en el proceso formativo de los cursos de Arquitectura y Urbanismo.

Metodología – Investigación bibliográfica con consulta de libros, disertaciones, tesis y artículos científicos, con un enfoque teórico para fundamentar la discusión.

Originalidad/Relevancia – La investigación se inserta en una laguna teórica relacionada con la necesidad de incorporar prácticas y conceptos sostenibles en la enseñanza de Arquitectura y Urbanismo, considerando la pérdida de técnicas constructivas tradicionales y la necesidad de alternativas ecológicamente responsables. La temática resulta relevante al fomentar reflexiones académicas sobre la importancia de la formación profesional en la consolidación de prácticas alineadas con la sostenibilidad.

Resultados – El estudio destaca la importancia de los materiales no convencionales, caracterizados por ser naturales, renovables y de bajo impacto contaminante, y evidencia la progresiva desvalorización de técnicas constructivas tradicionales no normatizadas. Asimismo, señala la necesidad urgente de ampliar y consolidar el enfoque de la sostenibilidad en la formación de arquitectos y urbanistas.

Contribuciones Teóricas/Metodológicas – El trabajo aporta a las discusiones teóricas al reforzar la importancia de la integración entre sostenibilidad, uso de materiales no convencionales y formación académica en Arquitectura y Urbanismo. En cuanto al aspecto metodológico, la investigación bibliográfica ofrece un marco sólido que puede servir de base para futuras investigaciones prácticas y profundizaciones sobre el tema.

Contribuciones Sociales y Ambientales – El artículo contribuye social y ambientalmente al fomentar prácticas constructivas que prioricen el uso de recursos renovables y la preservación de técnicas tradicionales, promoviendo un desempeño profesional comprometido con el medio ambiente y con la mejora de la calidad de vida de las generaciones futuras.

PALABRAS CLAVE: Sostenibilidad. Educación. Materiales alternativos.

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1 INTRODUCTION

Throughout history, humanity has long been closely connected to the use of natural resources available in the environment to ensure its survival. Our ancestors mastered farming, hunting, and the extraction of essential resources for their livelihood. However, it is important to note that, compared to the challenges we face today, those resources were abundant and relatively balanced relative to the population size at the time.

As society evolved, the relationship between humans and nature underwent a significant shift. This break from ancestral harmony has manifested in multiple forms of environmental degradation. In today's context, we face alarming signs of this degradation, including uncontrolled deforestation, accelerated species extinction, soil depletion due to overexploitation, and irreversible damage to aquatic ecosystems caused by industrial pollution.

Although climate change has been studied for decades, globalization and the constant increase in the desires of a growing population have made public awareness about the need for environmental preservation more urgent. As a major agent of environmental transformation, with inseparable links to sustainability, the construction industry is strongly positioned within this context (Callefi; Miotto; Silva, 2020). This sector emerges as a key player, being identified as the largest consumer of natural resources and energy, with substantial environmental impacts (CBIC, 2017). Therefore, it is crucial to recognize that the conventional building materials industry is a significant source of waste, generating environmental impacts throughout the various stages of its life cycle.

Given this challenging context, it is imperative to rethink and redefine current practices—especially within the construction sector, which is one of the main contributors to today's environmental problems. The pursuit of sustainable solutions, including the use of unconventional materials and construction techniques, represents a promising pathway. Responsibility lies not only with the industrial sector but also with education and professional training. This highlights the need to revisit curricula and teaching practices in Architecture and Urbanism programs. Promoting awareness and implementing sustainable practices within these programs can help shape a generation of professionals committed to environmental preservation and to advancing more sustainable living standards.

Within this context, the concept of Sustainable Architecture emerges as an inspiring framework. This concept goes beyond simply constructing buildings; it proposes a holistic approach that values not only the aesthetic and functional quality of built spaces, but also the reduction of environmental impacts across the building's entire life cycle. The pursuit of environmental quality and improved living conditions for users thus becomes a lasting legacy—an adaptive response to the pressing need for a cleaner and more sustainable world for future generations.

However, when it comes to discussions on adaptation and Architecture, it is intriguing to note how few studies address vernacular architecture—an effective model of environmental adaptation rooted in the architectural practices of ancient peoples. Recent studies, however, highlight the importance of open and collaborative construction systems that combine traditional knowledge with digital technologies, fostering more sustainable building practices that are adaptable to local contexts (Priavolou *et al.*, 2021). This form of architecture is a product of traditional knowledge, particularly

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that of Indigenous communities who inhabited specific geographic regions prior to colonization. These skilled communities relied on locally available natural resources to construct dwellings that harmonized with their surrounding environment.

The disregard for these traditional architectural practices not only undermines a rich cultural heritage but also perpetuates a discriminatory bias that marginalizes more sustainable and environmentally responsive building solutions. As the demand for more ecological and culturally inclusive practices continues to grow, it is crucial to revisit and integrate vernacular techniques into contemporary architectural practice. Vernacular architecture, by reflecting community culture and local environmental characteristics, holds significant potential to promote sustainability and strengthen urban identity (Elahi, 2022). Only then can we truly embrace cultural diversity and promote more holistic and sustainable approaches to designing living environments for both current and future generations.

Given their role in shaping buildings and urban landscapes through the selection of materials and construction techniques, architects and urban planners play a central role in defining construction guidelines. This underscores the importance of integrating sustainability into Architecture and Urbanism education, fostering a professional training approach that prioritizes the quality of the built environment and public health. Educational programs should encourage the exploration of unconventional materials and construction techniques—especially given the predominance of industrialized materials in both academic and professional contexts.

Although the national curriculum guidelines for Architecture and Urbanism (Brazil, 2010b) regulate academic training through educational principles focused on quality of life, ecological balance, and the quality of the built environment, it is worth asking which parameters are necessary to develop a methodology that effectively promotes the integration of sustainable architectural practices as students transition into professional practice. According to Setyowati and Novitasari (2021), integrating vernacular knowledge into architectural education not only preserves traditional sustainable practices but also enhances students' creativity and their socio-environmental awareness.

In this sense, it is essential that students are exposed to a wide range of construction materials and techniques—both conventional and unconventional—so they can understand both their theoretical foundations and practical applications. This approach allows students to develop autonomy and confidence in their future design decisions. The absence of technical support for projects involving unconventional construction systems often leads new professionals to default to traditional solutions. While learning and improvement are lifelong endeavors for both students and professionals, the adoption of sustainable practices becomes significantly more effective when introduced and reinforced during academic training.

Therefore, this study aims to explore the following topics through a literature review: Sustainable Architecture, the use of unconventional materials and construction techniques, and the teaching of sustainability in Architecture and Urbanism. It seeks to offer insights into these subjects and their integration into architectural education. The methodology adopted is a bibliographic review based on the analysis of books, dissertations, theses, and scientific articles. The following sections are organized around each of the key themes examined in this study.

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2 ARCHITECTURE AND SUSTAINABILITY

The urgency to address the large-scale depletion of natural resources, biodiversity loss, excessive waste generation, and the growing threat of climate disruption resonates at both local and global levels. In response to these challenges, action plans have been developed in collaboration with governments and organizations, aiming to meet current needs without compromising the needs of future generations (UN, 2016).

A significant milestone in this effort was marked by the United Nations General Assembly in 2015 through the launch of the 2030 Agenda. This agenda encompasses the 17 Sustainable Development Goals (SDGs), which outline a broad range of critical global priorities. These goals include eradicating poverty; achieving zero hunger and promoting sustainable agriculture; improving health and well-being; ensuring quality education; achieving gender equality; securing access to clean water and sanitation; promoting affordable and clean energy; fostering economic growth; advancing innovation and resilient infrastructure; reducing inequalities; building sustainable cities and communities; encouraging responsible consumption and production; taking action against global climate change; conserving life below water; protecting life on land; promoting justice and effective institutions; and strengthening partnerships and implementation mechanisms (UN, 2016).

These goals form a comprehensive set that reflects the need to address contemporary challenges in a holistic and globally coordinated manner. They not only guide the actions of governments and institutions but also serve as a collective call to action toward sustainable development that takes into account both present and future generations.

Architecture, as a discipline intrinsically linked to the configuration of the built environment, plays a crucial role in advancing sustainability—particularly in the context of smart cities and sustainable buildings. Achieving this goal requires a thorough examination of architectural practice, including the definition of clear guidelines, the structuring of ideas, and the establishment of values capable of guiding design decisions. In this context, the concept of sustainability—as described by Ching and Shapiro (2017)—"is about the promise of things that last—of buildings with long and useful lives, renewable energy sources, and enduring communities" (Ching & Shapiro, 2017, p. 1), aligning closely with the Sustainable Development Goals (SDGs) discussed earlier.

According to the same authors, the goals that guide the development of sustainable architecture and urban design projects—aligned with the regulatory frameworks for academic and professional training—are both diverse and comprehensive. These goals include preventing environmental degradation, enhancing user comfort and health, achieving economic efficiency, addressing political concerns, and fostering socially oriented outcomes (Ching & Shapiro, 2017).

According to Kowaltowski *et al.* (2020), education in Architecture and Urban Planning encompasses multidisciplinary aspects, especially in design development:

> A multidisciplinary background needed in architectural design ranges from site, urban and legal issues, to climate, environmental comfort, energy and water efficiency, resources, specification of materials, landscaping and interior design. Complex integration of aesthetic, ethical and technical aspects of sustainability demand compatible approaches. An integrated and collaborative design process therefore should be encouraged, not only to satisfy codes and certifications, but to create actual sustainable design thinking.

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(Kowaltowski et al., 2020, p. 817).

From an urban planning perspective, Gonçalves and Duarte (2006) outline several goals that contribute to the development of sustainable architectural projects. These include urban compactness, the socialization of public spaces, the reduction of transportation-related pollution, the enhancement of microclimates to improve the usability of urban spaces, environmentally conscious buildings, and responsible resource use—particularly through reuse and recycling. Sustainable Urbanism is also advocated by Farr (2013), who links the concept to an efficient public transportation system and the promotion of active mobility modes, such as walking, integrated within high-performance infrastructure.

Federal Law No. 12.378, enacted on December 31, 2010 (Brazil, 2010a), which regulates the professional practice of architects and urban planners in Brazil, identifies "the environment, environmental impact studies and assessments, environmental licensing, the rational use of available resources, and sustainable development" (Brazil, 2010a, n.p.) as key areas of professional activity, in alignment with sustainability principles. The national curriculum guidelines for Architecture and Urbanism programs (Brazil, 2010b) further emphasize that pedagogical strategies aimed at professional training should address the following:

> I – the quality of life of residents in human settlements, as well as the material quality and durability of the built environment; II – the use of technology that responds to the social, cultural, aesthetic, and economic needs of communities; III – the ecological balance and sustainable development of both natural and built environments; IV – the recognition and preservation of architecture, urbanism, and the landscape as collective heritage and shared responsibility (Brazil, 2010b, p. 2).

As highlighted by Kowaltowski (2011), urban morphology and the design decisions made in the early stages of a project play a critical role in shaping climate-related dynamics and the environmental conditions of a given location. The approach adopted at this stage is essential to achieving buildings that are both responsive to and integrated with their surrounding environment. The knowledge accumulated over centuries by ancient societies—through observation and practical experience—led to the development of vernacular dwellings, which serve as exemplary models of sustainable architecture based on the use of locally available natural resources. These vernacular structures not only provide shelter but also incorporate effective strategies to ensure thermal and daylight comfort (Eduardo *et al.*, n.d.).

Unconventional materials are understood as those employed by humans throughout their evolution, encompassing natural resources as well as materials that incorporate by-products or waste from human activity. Examples of such materials and associated technologies include earthen construction, plant fiber-reinforced composites, and bamboo structures (Ghavami, 2014). Unconventional construction techniques are intrinsically linked to these materials and stand in contrast to mainstream methods that are widely applied without consideration for environmental impact.

However, for an extended period, unconventional construction materials and techniques were neglected. In eras marked by the celebration of formal, iconic, and monumental architecture produced

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by colonial powers, vernacular architecture was often undervalued. As noted by Vellinga (2007), vernacular architecture is frequently regarded as the architecture of economically marginalized communities and is routinely overlooked in favor of its more ostentatious counterpart. This historical disregard has contributed to the gradual loss of valuable techniques and knowledge associated with these non-conventional building practices, which nonetheless prove essential in the pursuit of architecture that is both sustainable and environmentally responsive.

The recognition of the critical role played by educational institutions in the construction sector—particularly Architecture and Urbanism programs—underscores the urgent need to prepare professionals with a strong sense of environmental and collective responsibility. These individuals must be aware of their role as local agents of transformation, capable of positively influencing the contexts in which they operate. However, to fully realize this objective, students must be exposed to a broad spectrum of design perspectives. This includes engagement with diverse geographic and climatic contexts, as well as the exploration of both conventional and alternative (unconventional) materials that have been employed throughout human history. Particular emphasis should be placed on vernacular architecture, which is defined by solutions that are intrinsically tied to the regional characteristics of each project.

This broad and diverse approach provides students with the opportunity to develop a more comprehensive and critical understanding of architecture. Exposure to diverse contexts, materials, and design strategies fosters greater autonomy in architectural practice. By incorporating elements of vernacular architecture, students are encouraged to explore context-sensitive and environmentally responsive solutions. This multifaceted perspective not only enhances the understanding of architectural diversity, but also reinforces the capacity of future professionals to devise innovative solutions aligned with the principles of bioclimatic architecture.

Thus, by offering a comprehensive and integrative education, academic institutions play a key role in shaping a new generation of Architecture and Urbanism professionals—equipped to address contemporary challenges with a sustainable perspective and a deep understanding of the interactions between the built environment and the surrounding natural context.

2.1 Sustainable Architecture

In the 1960s and 1970s, Sustainable Architecture was often associated with ecological, self-sufficient buildings inspired by a more primitive philosophy—typically adopted by individuals seeking to live in isolation from mainstream society. Over time, however, this interpretation gave way to approaches more aligned with contemporary demands: architecture that is integrated into its context, high-performing, and efficient (Keeler & Vaidya, 2018).

Ching and Shapiro (2017) define sustainable construction as “one that has a significantly reduced environmental impact and provides indoor environments that support human health” (Ching & Shapiro, 2017, p. 14). Concern for both environmental preservation and human health grew significantly toward the end of the 20th century, as the overexploitation of natural resources led to increasingly severe environmental consequences. These concerns culminated in the emergence of the first formal definition of “sustainable development,” which was popularized in 1987 with the

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publication of *Our Common Future*, also known as the Brundtland Report.

In the following decades, international protocols were consolidated to establish goals and guidelines for achieving sustainable development on a global scale. These efforts sought to address critical challenges such as reducing the ecological footprint, mitigating environmental impacts, and managing consumption levels worldwide. The scale and significance of these issues brought sustainability to the forefront of discourse in Architecture and Urbanism by the late 1980s and early 1990s (Gonçalve; Duarte, 2006).

The growing momentum toward Sustainable Architecture has been driven by a convergence of political, economic, and environmental factors. The oil crisis of the 1970s in the United States, for instance, sparked a shift in building practices toward energy conservation and indoor air quality. The incorporation of sustainability into architectural practice thus reflects not only a response to specific crises—such as the oil shortage—but also a broader awareness of the interdependence between architecture and the environment.

Recent literature highlights that climate resilience has become a new performance standard for sustainable buildings. Architects and engineers are increasingly challenged to design spaces that not only reduce environmental impacts but also adapt to extreme climate events, such as heatwaves and floods. These guidelines are becoming more prominent in international frameworks, such as the New European Bauhaus, which promotes resilient and regenerative solutions (Roggema, 2022).

By designing buildings sustainably, architects can create healthier and more pleasant environments for users while reducing the environmental impact of both construction and operation. In addition, sustainable buildings can contribute to lowering energy consumption and greenhouse gas emissions, thereby supporting efforts to combat climate change. An example of this type of architecture is the Robert Schuster Residence, designed by Brazilian architect Mario Severiano Porto. The architect employed bioclimatic strategies and the use of locally sourced materials to enhance energy efficiency and thermal comfort, aligning the project with the principles of vernacular and sustainable architecture (Pollo; Souto; Scherer, 2024).

At the same time, there has been growing interest in the concept of "zero carbon"—both operational and embodied—as a new frontier for sustainability in the construction industry. This shift requires a profound rethinking of material choices, logistics, and building operations. Studies indicate that decarbonizing the sector necessarily involves integrating architectural design with urban strategies such as active mobility and green infrastructure (Jafari *et al.*, 2021).

Taking a more technical and practical approach, Ching and Shapiro (2017) reflect on the core of sustainable design:

> In the design and construction of sustainable buildings, applying common sense is often beneficial. Many of the strategies and technologies that enable efficient use of water and energy, for instance, are readily measurable and can effectively guide decision-making. Harmful and toxic materials are generally well-known and identifiable, and thus can be avoided. Common sense also proves valuable in addressing more complex problems, assessing the feasibility and practicality of new technologies, and avoiding creative blocks that may arise when navigating the multiple choices and unexplored dimensions of sustainable architecture (Ching & Shapiro, 2017, p. 10).

To support designers in making sound decisions, academic training in Architecture and

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Urbanism plays a fundamental role. It acts as a bridge between innovation and professional practice, fostering student engagement with issues relevant to contemporary architecture. It is also crucial to promote awareness of each individual's responsibility in advancing sustainable development. As noted by Gonçalves and Duarte (2006) regarding the challenges of Sustainable Architecture:

> For these interrelations to succeed, it is essential that researchers and educators remain engaged with contemporary architectural issues, while design professionals are committed to applying project methodologies and informed by research findings (Gonçalves & Duarte, 2006, p. 64).

Within this context, numerous definitions of sustainable construction have been proposed. Although these definitions vary across established approaches, each tends to address specific environmental challenges—yet it is rare for any single definition to encompass them all. As a result, a range of sustainability certifications and guidelines has been developed. While they may differ in scope, these frameworks consistently emphasize environmental stewardship, the reduction of ecological degradation, and the enhancement of indoor environmental quality, ultimately supporting occupant health.

The initial emphasis on energy consumption in the 1970s, as highlighted by Gonçalves and Duarte (2006), marked a critical starting point for the dissemination of sustainability discourse within the construction industry. Over time, however, this focus broadened substantially to encompass a range of concerns related to environmental degradation—particularly those linked to industrialized material production processes. This shift in focus underscores the complexity of the challenges faced by the construction sector and the pressing need for comprehensive strategies to foster more sustainable practices (Gonçalves & Duarte, 2006). Recent research also emphasizes the importance of integrating principles of environmental justice into sustainable architecture. Sustainability should not only meet technical efficiency criteria but also ensure equitable access to healthy and dignified housing. The approach known as 'Design Justice' has been gaining ground in academic curricula and community-based projects, particularly in Latin America and Africa (Schlosberg & Collins, 2021).

In addition to technological advancements, ancestral practices have been reappraised through the lens of sustainability. Vernacular solutions—such as green roofs, rammed earth walls, and natural cross ventilation—are now being reinterpreted using contemporary criteria for thermal performance and durability. This represents a convergence between traditional knowledge and environmental science (Boake *et al.*, 2020). The growing emphasis on alternative materials and construction techniques in Sustainable Architecture reflects not only a pursuit of energy efficiency, but also a broader awareness of the interconnection between building practices and the environment. By opting for alternative materials, the construction sector not only helps reduce its environmental footprint but also fosters a paradigm shift—promoting buildings that are more efficient, longer-lasting, and in harmony with sustainability principles.

It is essential to understand that the in-depth study of these topics extends beyond the academic sphere and carries significant implications for both the market and society as a whole. Identifying effective strategies for disseminating these practices can positively shape market trends and foster the widespread adoption of more sustainable construction methods. Moreover, the dissemination of knowledge about alternative materials and innovative construction techniques not

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only advances environmental preservation but also plays a pivotal role in shaping a more equitable and sustainable future. By embedding these principles into both academic training and professional practice, the construction sector can serve as a catalyst for positive transformation—contributing meaningfully to a more sustainable built environment.

2.2 Unconventional Materials and Techniques

Currently, two opposing perspectives can be observed among Architecture professionals with regard to sustainability.

On one hand, some experts view contemporary technology as a disruptive force to ecological balance, advocating exclusively for the use of vernacular techniques and materials—a philosophy referred to as "ecocentrism." This perspective places emphasis on harmony with nature, valuing traditional practices and sustainable materials as construction methods that minimize environmental impact (Castelnou, 2020).

On the other hand, there are those who, while equally concerned with environmental issues, view technology as the primary solution to ecological challenges—an approach referred to as "technocentrism." From this perspective, technological innovation is regarded as the key to developing effective and sustainable solutions that move beyond conventional practices. These professionals argue that the application of advanced technologies—such as next-generation building materials and smart systems—can support the pursuit of environmental sustainability without compromising progress (Castelnou, 2020).

Indeed, upon examining each of these approaches, it is possible to identify a range of strengths and limitations associated with both. Contemporary Sustainable Architecture must therefore adopt a holistic approach—one that integrates the most valuable aspects of each perspective. Striking a balance between ecocentrism and technocentrism is essential, as it not only supports environmental preservation but also aims to deliver tangible benefits to users of the built environment (Castelnou, 2020).

Given the increasing dominance of theoretical and practical instruction in industrialized materials in Architecture and Urbanism programs, it is essential to further explore the realm of unconventional materials and construction techniques. This approach aims to equip students and future professionals with comprehensive knowledge and skills to apply a wide range of materials and techniques—whether industrial or unconventional—ensuring the autonomy needed for architectural design and execution.

In this context, it is evident that public policies and local regulations can play a decisive role in legitimizing and promoting the use of alternative materials. Gatti *et al.* (2022) highlight that legislation encouraging the use of locally sourced and low-impact materials has driven sustainable practices, particularly in regions where vernacular architecture already holds strong cultural significance.

Unconventional materials are characterized by their origin in environmental resources—whether sourced directly from nature or derived from recycled products and repurposed objects that were initially intended for other uses before being adapted for construction (Brosler, 2011). This broad definition encompasses a diverse range of elements, highlighting the importance of adopting an

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inclusive and comprehensive approach to studying these materials in order to advance sustainable architectural practice.

Moreover, Hu (2023) argues that the adoption of unconventional materials can generate positive economic impacts, as it stimulates local production chains, reduces logistical costs, and increases community resilience in the face of supply crises. These aspects are particularly relevant in post-disaster reconstruction scenarios or in regions with limited infrastructure.

The use of unconventional materials is largely grounded in traditional, community-based knowledge passed down through generations—particularly within Brazilian vernacular architecture, which is deeply rooted in rural contexts. Various communities and Indigenous groups have contributed their expertise and construction techniques, leaving a lasting imprint on local building practices (Brosler, 2011). These materials are predominantly sourced locally, as described by Lima (2021):

> Materials are sourced from the land or the surrounding region, usually agricultural by-products such as clay, straw, palm leaves, stones, tree branches, and similar elements. Construction techniques are developed based on the available technology, which is often local. Finally, these structures tend to remain in a continuous and recurring process of construction, aligned with annual cycles of planting, harvesting, religious celebrations, and other community events (Lima, 2021, p. 39).

Adaptability is one of the most distinctive features of this type of construction. Indigenous peoples, Africans, and immigrant communities—such as Italians, Germans, Portuguese, and Japanese—have creatively adapted their construction techniques to local conditions using the materials available in each context (Weimer, 2012). Despite the capitalist and market-oriented view that associates unconventional materials with "a step backward or even a complete disqualification of modern construction technologies" (Brosler, 2011, p. 22), various populations have used the resources provided by their environment to develop remarkable solutions. "Even in the most inhospitable places—where human survival seems impossible—there are communities that have adapted to highly diverse conditions and, at times, manage to maintain admirable levels of quality of life" (Weimer, 2012, p. 1). Zuo *et al*. (2021) also note that traditional practices of reusing organic and agricultural waste in construction materials—such as the use of rice husk ash or natural fibers—have the potential to significantly reduce the carbon footprint of the construction industry, while also contributing to the conservation of natural resources.

Oliver (2006) emphasizes that, despite the various cultural nuances that characterize different regions of the world, there are numerous commonalities in buildings—one of which is the use of specific materials such as cane or bamboo, granite, or adobe. These materials are typically chosen based on the specific physical conditions of the local landscape.

An example of this integration can be seen in studies that assess the energy efficiency and thermal comfort of buildings inspired by vernacular solutions. Liang *et al*. (2023) demonstrated that traditional techniques—such as rammed earth walls combined with natural shading—can be optimized with smart sensors for environmental monitoring, significantly enhancing thermal performance without the need for mechanical cooling systems.

Given the breadth of constructive diversity observed in architectural practices, it is important

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to highlight applications that stand out for their relevance, warranting deeper reflection and broader review. Notably, many of these practices are moving toward formalization through standards and legislation, which could significantly contribute to their wider adoption and integration in contemporary construction. This trend not only enriches global architectural discourse but also promotes the consolidation of sustainable and culturally responsive construction practices on an international scale.

2.3 Teaching Sustainability in Architecture and Urbanism

In the 1940s, a new curricular model was introduced at the National School of Architecture (FNA) in Rio de Janeiro, incorporating subjects that combined artistic studies with technical content rooted in Engineering. This multidisciplinary approach aimed to provide students with a broad and well-rounded education, equipping them to address the challenges of the Architecture and Urbanism field. In the 1960s, the core curriculum was revised to include not only these foundational disciplines but also additional key areas of knowledge, such as Urbanism, Construction Materials and Techniques, Urban Sanitation, Mathematics, Physics, and Housing Hygiene (Machado, Melo & Oliveira, 2021).

The creation of the Brazilian Association for Architectural and Urbanism Education (ABEA) in 1973 marked a significant milestone in the history of architectural education in Brazil. The institution was established with the aim of promoting the quality of education and the professional training of future architects and urban planners. An analysis of the discussions led by ABEA between 1973 and 1985, as documented in the Association's journals, shows that the main concerns were centered on the teaching of Structural Systems, with little to no reference to construction technology. The primary topics of discussion included the core curriculum, contact hours, design studios, professional responsibilities, and the introduction of new subjects such as Landscape Architecture, Environmental Comfort, and Information Technology (Laverde & Oliveira, 2020).

These developments reflect the ongoing evolution and adaptation of architectural and urban planning education in Brazil, as professionals seek to refine and expand the curriculum to meet the field's ever-changing demands. ABEA plays a vital role in this process, fostering dialogue and the exchange of ideas among educators, practitioners, and students, with the aim of strengthening and enriching the education of future Brazilian architects and urban planners.

Starting in 1994, with the implementation of the National Curriculum Guidelines, architecture and urban planning education in Brazil underwent a significant reorganization. As part of this reform, the subject of Housing Hygiene was replaced by Environmental Comfort, reflecting a shift in focus toward broader and more contemporary concerns related to occupant well-being and quality of life within built environments (Machado; Melo; Oliveira, 2021)..

Regarding the teaching of technology in Architecture, earlier discussions promoted by ABEA revealed a scenario in which the topic was frequently debated—often through a critical lens—but without a full acknowledgment of the responsibility of Architecture programs in promoting the necessary advancements in this area (Laverde; Oliveira, 2020). While these debates were relevant, they seldom translated into concrete measures to integrate construction technology into academic curricula, resulting in gaps in the training of future architects to address the technological demands of

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the field.

According to Schiano-Phan, Gonçalves, and Vallejo (2022), the traditional architecture curriculum lacks approaches that enable a training process truly committed to the environmental challenges of the 21st century:

> There is a genuine concern that the current level of sustainability education provided in the mainstream architectural curricula is no longer sufficient to combat urgent climate challenges, and that a stronger interdisciplinary approach needs to be followed where architectural students are formed and empowered with a different pedagogical paradigm, better tools, and diverse sets of skills (Schiano-Phan, Gonçalves & Vallejo, 2022, p. 1).

In light of this context, it becomes evident that a joint effort is needed among educational institutions, professionals, and regulatory bodies to rethink and strengthen the role of technology education in training future architects. This includes revising and updating academic curricula to more fully incorporate technological advancements and innovative practices in the construction field, thus ensuring that future professionals are adequately prepared to meet the demands and challenges of the contemporary job market.

In recent years, this transformation has been accompanied by international discussions pointing to a paradigmatic shift in architectural curricula. A study by Salama and MacLean (2020) argues that architectural education must move away from its traditional structure and evolve into a more integrative model, in which students engage with real-world problems through project- and community-based learning methods. This approach aims to foster not only technical competencies but also critical and ethical capabilities in students.

Furthermore, international teaching guidelines have increasingly emphasized the importance of developing the social and environmental awareness of future architects. According to research by Stevens and Imrie (2021), architecture schools must reconsider their curricula to integrate, in a cross-cutting manner, themes such as accessibility, spatial justice, and the right to the city—topics often neglected in overly technical approaches.

Federal Law No. 12.378, enacted on December 31, 2010 (Brazil, 2010a), regulates the professional practice of Architecture and Urbanism in Brazil and also established the national Council of Architecture and Urbanism (CAU). The law outlines the professional's areas of activity, which, in the context of sustainability, include the ability to assess "the environment, conduct environmental impact studies and evaluations, obtain environmental licenses, use resources rationally, and promote sustainable development" (Brazil, 2010a, n.p.). To support this, the National Curriculum Guidelines define the pedagogical framework for professional training, which must include "[...] the conservation and enhancement of built heritage, the protection of ecological balance, and the rational use of available resources" (Brazil, 2010b, p. 1).

To achieve a sustainable architectural project, Dourado (2015) outlines the following requirements:

> [...] from the early design stages, it is necessary to adopt architectural strategies that are rational and adapted to the local climate—such as appropriate building siting and orientation, as well as ventilation, solar shading, and natural lighting solutions suited to the site's topography and climate conditions; to use locally sourced building materials that contribute to thermal comfort, are less harmful to the environment, and offer high durability; to

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> encourage the use of low-impact technologies that enhance indoor comfort; to ensure energy efficiency, and promote the conservation and reuse of water and materials; and to incorporate waste recycling practices—among other actions that support the sustainability of buildings and their surroundings (Dourado, 2015, p. 64).

As Dourado (2015) observes, a review of the curricula in Brazilian Architecture schools reveals that Environmental Comfort courses are the primary carriers of sustainability-related content, yet there is limited integration with other subjects. This fragmentation undermines students' holistic understanding of sustainable principles, creating a significant gap in their academic development. Moreover, there is a notable deficiency in the incorporation of these themes into practical coursework—an essential component for deepening understanding and enabling the effective application of sustainability concepts in architectural design projects (Dourado, 2015).

Researchers such as Lu *et al*. (2022) emphasize that the most effective curricula are those that integrate energy simulations and environmental performance analysis into design courses, allowing students to practically understand how design decisions impact energy consumption and thermal comfort. Although still uncommon in Brazil, this practice is already being implemented in European and Asian universities with positive outcomes.

Along the same lines, Taylor and Harrison (2023) stress that the pedagogical approach to Architecture must undergo a structural redesign, prioritizing interdisciplinary collaboration, systems thinking, and ecological literacy as core foundations. In their view, training 21st-century architects requires a break from fragmented teaching models and an explicit commitment to the principles of climate justice.

Oliver (2006), on the other hand, argues that the development of Architecture should move beyond merely reproducing the symbols and status of the society in which it is embedded. Factors such as location, orientation, and spatial relationships—both within and around buildings—play a fundamental role. The customs and rituals of local communities likewise exert a significant influence on the formation of architectural spaces.

Thus, the study of Vernacular Architecture not only offers valuable insights into construction techniques and materials, but also fosters a deeper understanding of the cultural and social dimensions embedded in architectural practice. Although vernacular architecture is intrinsically linked to the use of locally sourced materials, this topic remains insufficiently addressed in Architecture schools (Dourado, 2015). The "desire to build with conventional materials results in a loss of autonomy in the construction process, leading to dependence on external materials and funding" (Brosler, 2011, p. 9).

According to Weimer (2012), Architecture schools still tend to focus on the traditional foundations of the profession, maintaining an outdated perspective that heavily emphasizes monumentality as a defining characteristic of Architecture. Although such rigid views are gradually being left behind, a considerable gap remains in academic training with regard to vernacular architecture.

Vernacular Architecture, present in diverse regions across the globe in a multitude of forms, incorporates a wide range of materials and techniques that reflect local cultures and traditions. Nevertheless, it continues to receive limited attention in Architecture schools (Lima, 2021). In an effort to reverse this trend, Asquith and Vellinga (2006) published *Vernacular Architecture in the Twenty-*

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first Century: Theory, Education, and Practice, a book with the aim of broadening the discourse on the relevance of vernacular research in contemporary practice and throughout the 21st century. Their approach extends beyond the analysis of historical traditions, seeking instead to contribute to the development of new methods, solutions, and innovations for the future of the built environment (Asquith; Vellinga, 2006).

According to Vellinga (2017), vernacular architecture is defined as a "heterogeneous, adaptive, and active cultural process" (Vellinga, 2017, p. 166). This defining feature enables it not only to respond to contemporary environmental challenges but also to engage with pressing social issues. Vernacular architecture, therefore, holds the potential to play a significant and transformative role in both urban and rural spaces, while also preserving cultural and local traditions. By incorporating traditional materials, techniques, and building practices, it offers context-specific and sustainable solutions to meet community needs, thereby promoting sustainable development and socio-environmental resilience.

This initiative represents a significant effort to value and integrate vernacular architecture within both architectural education and professional practice, recognizing its potential to inspire and inform contemporary and future design. By emphasizing the value of this architectural approach, Asquith and Vellinga (2006) aim to challenge established paradigms and promote a more inclusive and diversified approach to architectural teaching and practice.

The study and exploration of alternative materials began in the 1980s, representing a response to the growing interest in more sustainable and innovative approaches within the construction industry. However, even today, these materials have not achieved widespread acceptance or adoption. This is largely attributed to the predominance of conventional materials in the market, which continue to be widely used due to their familiarity, availability, and support from established industry interests. In addition, the absence of specific technical guidelines for the use of alternative materials contributes to a degree of skepticism among professionals, who are often not fully informed about their properties and practical applications (Barbosa, 2005).

Although the landscape continues to evolve, it is important to note that some progress has been made in recent years with the implementation of regulations and standards aimed at supporting the use of alternative materials in construction. However, much still needs to be done to encourage their broader and more informed adoption. It is essential to invest in research and education to expand understanding and trust in these materials, and to encourage collaboration among professionals, academics, and the construction industry in developing innovative and sustainable solutions for the sector's current challenges.

Another major barrier is the lack of support from government authorities, which significantly hinders the adoption of unconventional materials in the construction industry. The absence of incentive policies, clear regulations, and financial backing presents substantial challenges to the integration of these innovative materials into the market. As a result, many construction companies tend to follow the more familiar and less risky route, continuing to rely on widely used conventional materials rather than investing in more sustainable and underutilized alternatives (Barbosa, 2005).

Moreover, education plays a crucial role in overcoming this barrier. Many Architecture and Engineering programs still fall short in properly integrating the study and application of alternative

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materials into their curricula. With few exceptions, students do not receive comprehensive training on these materials during their academic education—resulting in graduates who enter the workforce with limited knowledge on how to evaluate, specify, and effectively apply unconventional materials in construction projects (Machado; Melo; Oliveira, 2021).

Therefore, the limited adoption of alternative materials in construction is closely linked to several factors: the prevalence of conventional materials, the absence of technical standards, the lack of government incentives, and educational gaps. Overcoming these challenges is essential to facilitate the broader application and acceptance of unconventional materials within the construction sector.

In light of this scenario, it is evident that a more comprehensive and inclusive approach is required in Architecture and Engineering education—one that emphasizes the integration of sustainability and innovation in the selection and application of construction materials. Such an approach would not only better equip future professionals to address the challenges of the modern construction industry but would also support the wider adoption of unconventional materials and the advancement of more sustainable practices across the built environment.

However, a significant shift has begun to emerge. A publication by the Brazilian Association for Architectural and Urbanism Education (ABEA) introduced a timely and thought-provoking theme: *"Inclusion, Materiality, and Physical Presence: What Did We (Un)learn from the Pandemic?"* This topic was explored during a 2022 roundtable discussion, where participants shared studies, research findings, and personal experiences. At the heart of the debate was a critical reflection on the essential role of social inclusion and gender equity, as well as the exploration of experience and experimentation with materiality—both intrinsic to the practice and education of Architecture and Urbanism (ABEA, 2022).

During the event, key issues were examined concerning how the pandemic influenced both the teaching and practice of Architecture and Urbanism. Topics included the role of technology, the adaptation of physical spaces to ensure accessibility and safety, and the impact of mobility restrictions on the design and use of urban environments. The discussion also placed strong emphasis on the need to rethink pedagogical approaches in order to foster a more inclusive and responsive educational experience that addresses the diverse needs of students.

This multidisciplinary and reflective approach reinforces a positive shift in thinking and practice within the academic community of Architecture and Urbanism. As we adapt to a post-pandemic world, such discussions and reflections are essential for shaping future education and professional practice, ensuring a more inclusive, responsive, and sustainable approach to planning and constructing the built environment.

3 CONCLUSION

This study aimed to conduct a literature review on Sustainable Architecture, the use of unconventional materials and techniques as strategies to advance this architectural approach, and the treatment of these themes in Architecture and Urbanism degree programs. A broad range of sources was consulted, including books, dissertations, theses, academic journals, websites, and scientific events. The research process enabled the development of a solid theoretical foundation, providing a

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comprehensive understanding of the topic and its implications in both professional practice and educational contexts. Viewed through this theoretical lens, it becomes clear that human activity continues to drive environmental degradation—highlighting the urgent need to adopt sustainable practices that enhance quality of life and societal well-being, and also have the potential for innovation, practical application, and preservation which is made possible through the use of unconventional materials and techniques that could potentially contribute to contemporary architectural practice.

Although more and more architects and urban planners are drawing inspiration from local traditions, history, and the specific cultural context of each region—something reflected in the growing revival of unconventional construction materials and techniques, as well as in academia, where new studies and research are emerging—much remains to be encouraged within the academic sphere. Academia plays a crucial role in exploring and promoting the integration of these elements, fostering a deeper understanding of traditional building methods, natural materials, and vernacular techniques. However, for this to be effective, changes may need to occur even within the national curricular guidelines that shape Architecture and Urbanism programs in Brazil, given that courses across the country tend to follow a very similar structure.

A broad and inclusive approach within the construction sector—particularly relevant to Architecture and Urbanism education—should prioritize the integration of sustainability and innovation principles in the selection and application of building materials. This approach would not only enhance the training of future professionals to meet the demands of the contemporary construction industry but also play a key role in advancing the adoption of unconventional materials and promoting more sustainable practices. Considering that the construction sector is one of the leading sources of pollution and a major consumer of natural resources and energy, it is imperative to implement measures now to mitigate long-term environmental consequences for future generations. Embedding these principles into academic curricula would not only equip graduates with the skills required to address current industry challenges, but also empower them to become agents of change—leading the shift toward a more sustainable and accountable construction industry.

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CONFLICT OF INTEREST-STATEMENT

The authors, **Raíza de Oliveira Machado Borges, Yasmin Camilato Cabral, and Sergio Rafael Cortes de Oliveira,** declare that the manuscript entitled "**Unconventional Materials and Techniques in Sustainable Architecture Education: A Literature Review"** includes the following disclosures:

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