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Emerging Perspectives on the Built Environment

Results of the 1st International
Conference of Dot.AT.i 2025 “Knowing
and Connecting”



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Preface

The Study Day “Knowing and Connecting” held in Catania on January 30, 2025, was organized by the Dot.AT.i group—PhD Candidates and Doctors of Research in Architectural Engineering—with the support of the Scientific Society of Technical Architecture Ar.Tec. The event aimed to provide a shared platform for discussion among doctoral students, early-career researchers, postdoctoral fellows, and scholarship holders within the CEAR/08 Italian Sector disciplinary field. This initiative is part of a broader effort to strengthen the scientific and disciplinary identity of emerging scholars and to build a national network capable of representing their interests, values, and contributions in both academic and professional contexts. The program seeks to foster an ongoing inter-generational dialogue, promoting the development of cohesive and innovation-oriented communities.

Dot.AT.i was established precisely to reinforce cohesion and interconnection among young scholars in the field, offering a space for aggregation and exchange in which experiences, methods, approaches, and scientific perspectives can be shared. The official foundation of the group, which took place in 2023 during the Colloqui.AT.e in Bari, marked the beginning of an inclusive and participatory journey aimed at enhancing the contributions of new generations of researchers in innovation, experimentation, and technology transfer, in alignment with the objectives of the University’s Third Mission. The Dot.AT.i network thus represents a horizontal support structure capable of fostering critical discussion and collaborative projects, strengthening the positioning of the discipline in addressing contemporary challenges.

The purpose of the Study Day, as well as of this volume “Emerging Perspectives on the Built Environment—Results of Dot.AT.i 2025 “Knowing and Connecting”, is to present a plural, dynamic, and structured narrative of ongoing research, organized around major thematic areas that reflect the primary fronts of scientific advancement within the discipline. The evolution of architecture, engineering, and design is increasingly characterized by multidisciplinary and integrated approaches capable of addressing the environmental, social, and technological challenges of the contemporary built environment. These approaches converge on the need for preservation, enhancement, and conservation of Cultural Heritage, alongside the adoption of new digital technologies and innovative building materials, balancing the safeguarding of historical and cultural identity with the promotion of new concepts of the built environment. **Cultural Heritage** thus occupies a central role in scientific discourse, as it embodies both tangible intrinsic values—related to history, technical knowledge, and architectural features—and intangible ones, serving as a repository of cultural and social legacy through which communities transmit collective memory. Heritage constitutes a complex system encompassing monuments, archaeological sites, artworks, artifacts, artisanal traditions, and rural and urban environments. Its conservation and enhancement require a rethinking of traditional operational strategies, which must now confront new methods and tools. Within the built heritage domain, **Digitalization** assumes an increasingly relevant role, serving as a strategic

direction of national and international interest. Digital technologies, such as Building Information Modeling (BIM), Geographic Information Systems (GIS), Digital Twins (DT), Artificial Intelligence (AI), and the Internet of Things (IoT), are significantly influencing processes across the entire life cycle of the built heritage: from documentation and knowledge acquisition to design, construction, management, and conservation. These technologies promote an integrated and interoperable approach among stakeholders, enabling greater efficiency, improved data accessibility, and optimized operational processes. Mapping, data access and integration, and operational efficiency become feasible through reliable digital support. In this context, the scientific community is called upon to contribute to the development of predictive models, automated processes, and increasingly accurate digital representations. Simultaneously, technological innovation is reflected in research on **Innovative Materials and the Building Envelope**, areas in which material science and architectural design converge. Integrating innovative materials and technologies into heritage contexts represents a crucial challenge for contemporary design, requiring a balance between innovation needs and compatibility with existing structures. Achieving this equilibrium is essential to ensure performance quality, energy efficiency, and durability of interventions. Material experimentation, envelope design adapted to climatic conditions, and the adoption of flexible and adaptive building components represent key directions for transitioning toward a resilient built environment. Equally significant is the theme of **Comfort and Design**, which prompts reflection on the contemporary built environment. Architecture is here interpreted as a space of interaction between individuals, communities, and the environment, where functional, psychological, and environmental needs intersect. Research increasingly moves beyond an anthropocentric project perspective toward systemic and holistic approaches, aiming to promote well-being, inclusion, and sustainability through innovative paradigms.

This volume compiles the contributions presented during the Study Day and is organized into four thematic sections—Heritage, Digitalization, Material, Comfort and Design—that reflect the primary areas of reflection during the event. The contributions testify to the diversity and complexity of issues characterizing the built environment, understood as a dynamic system in constant transformation, strongly influenced by cultural, technological, environmental, and social factors. The volume also demonstrates the vitality of a young yet highly active community that, through dialogue, collaboration, and research, shares a vision of technical architecture that is open, responsive to global challenges, and capable of generating impact. It is hoped that “Knowing and Connecting” Study Day will mark the beginning of an ongoing path of exchange, innovation, and shared growth.

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Comfort and Design



Comfort and Design in the Built Environment: Multisensory, Participatory, and Adaptive Strategies

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Abstract. The concept of comfort in the built environment is undergoing a fundamental redefinition, increasingly framed as a multisensory, adaptive, and participatory phenomenon rather than a static outcome derived from prescriptive standards. This paper explores emerging research and methodological approaches that challenge technocratic and reductionist paradigms, proposing instead a human-centred perspective grounded in experiential quality, environmental responsiveness, and user engagement. Drawing upon recent literature and cross-disciplinary studies, the paper examines the integration of thermal, visual, acoustic, and air quality domains with subjective feedback mechanisms and real-time environmental sensing. These hybrid methodologies enable a more nuanced and responsive design process, addressing the complexity of individual and collective needs across diverse building types and climatic conditions. Smart technologies such as BIM, Digital Twins, IoT-based monitoring systems, and data-driven control strategies are presented as pivotal tools for achieving dynamic comfort regulation, energy optimisation, and behavioural alignment. The discussion extends to outdoor environments, where comfort is increasingly conceptualised through the integration of sensory stimuli, climate-resilient urban interventions, and participatory tools such as climate walks and co-design platforms. Case studies demonstrate how adaptive and inclusive design strategies contribute to improved environmental justice, social cohesion, and spatial well-being. Special attention is given to the role of doctoral research in advancing this paradigm shift. Recent investigations demonstrate how early-career contributions are catalysing new models of comfort design that are empirical, co-creative, and responsive to emerging societal and environmental challenges. The study concludes by advocating for a systemic and transdisciplinary approach to comfort that supports healthier, more inclusive, and emotionally resonant built environments.

Keywords: Comfort · Multisensory · Adaptive Strategies · Participatory Approach · Design

1 Introduction

The built environment is a dynamic interface between human needs and spatial, environmental, and technological transformations. In recent years, the notion of comfort has expanded far beyond the classic definitions of thermal regulation or indoor air quality, now encompassing a broad and integrative understanding of human well-being that spans psychological, social, sensorial, and cultural dimensions. As environmental and societal challenges become increasingly intertwined, the role of architectural design and environmental engineering needs to evolve accordingly, adopting strategies that are both adaptive and inclusive.

Within this broader context, the IV session “Comfort e Design” of the DotATi 2025 conference aims to reflect upon and advance the evolving discourse on comfort in the built environment. This session was conceived as a platform to explore human-centred strategies and methodological innovations, capable of bridging disciplinary boundaries, working at the intersection of environmental quality, design innovation, and participatory processes. Comfort and well-being in the built environment need to be understood through a multi-domain lens, embracing both objective measurements - such as thermal, visual, acoustic, and air quality parameters - and subjective ones—e.g. experiential feedback from occupants. This dual perspective opens up the need for multidisciplinary contributions and methodological cross-pollination.

The core of the session lies in the ambition to challenge reductionist and technocratic paradigms of comfort, encouraging instead a holistic vision in which design, environmental psychology, digital innovation, and participatory co-creation converge. The contributions presented in the session exemplify this approach, highlighting the relevance of multisensory and adaptive strategies for improving Indoor Environmental Quality (IEQ), fostering social innovation, and supporting the regeneration of both urban and marginal areas.

There is a new paradigm shift expressed in the section call, changing the way we conceive and design living environments - transcending anthropocentric and deterministic models in favour of more inclusive, dynamic, and responsive approaches. Central to this vision is the idea that both indoor and outdoor built environments are not just physical infrastructures, but also cultural and emotional ecosystems, where comfort must be understood as an evolving and participatory condition. All these aspects converge in the integration of comfort-oriented design with broader strategies of urban regeneration, environmental management, and social participation.

To do this, tackling comfort in today's built environment demands a systemic and transdisciplinary effort, involving architects, engineers, environmental psychologists, planners, and end-users alike. Comfort in contemporary contexts is no longer a mere issue of individual thermal perception or spatial ergonomics, but rather a multidimensional phenomenon shaped by cultural habits, socio-economic conditions, and environmental justice concerns.

The session featured a diverse set of contributions, each illustrating a facet of this comprehensive and people-centred vision of comfort. Papers ranged from the evaluation of indoor air and thermal comfort in educational settings, as examined through children's perceptions and health implications, to the exploration of co-design practices in inner territories as enablers of social innovation. Furthermore, sensory environments were

examined through thematic reviews on smellscape and soundscape research, reflecting the growing interest in how olfactory and acoustic dimensions contribute to spatial experience and well-being.

The idea shared by all contributions is that comfort can no longer be reduced to normative parameters or mathematical metrics based on average user of the built environment (a definition that has opened a rather broad debate in scientific research in the last decade), but rather require adaptive and specific models for different types of users. It also needs to be co-produced, iteratively measured, and dynamically adapted to users' needs and changing environmental conditions. The integration of quantitative and qualitative methodologies, the use of real-time sensors and user profiling, and the adoption of participatory design processes emerged as critical tools for enhancing design quality and spatial responsiveness.

By addressing these themes, the session "Comfort e Design" aims to redefine comfort as a design challenge of contemporary architecture and building engineering. The call for holistic and multisensory approaches - capable of integrating performance-based metrics with human-centred values and participatory practices - marks a turning point in the way professionals and researchers engage with the physical and experiential quality of spaces.

This contribution reports on the events that occurred during the session, encompassing both the elaboration and revision of the papers and the live debate held during the conference. The contribution is structured in 2 main sections: analysis of the state of the art regarding the research on Comfort Design (Sect. 2), both for indoor environments (Subsec. 2.1) and for outdoor environments (Subsec. 2.2); a focus on the emerging lines of research in this field within the scientific community of ArTec, to deal with Architectural Engineering, Comfort and Design (Sect. 3), and the fundamental role of PhD students and DotATi format in these new challenges, analyzing in detail also the papers presented in the session.

2 Indoor and Outdoor Comfort Design

2.1 Indoor Environment and Comfort Design

Recent research in indoor environmental quality (IEQ) increasingly emphasizes multisensory, adaptive, and participatory strategies for enhancing occupant comfort and well-being across thermal, air, visual, and acoustic domains. A recurring theme is the interdependence among these factors and their joint influence on comfort, particularly in offices, schools, and residential buildings.

While thermal comfort is a significant and dominant focus in IEQ studies due to its direct link with user satisfaction and productivity, other factors such as air quality, acoustic, and visual comfort play crucial roles in overall occupant well-being. As Kaushik et al. report, thermal comfort consistently emerges as the primary comfort parameter in offices and classrooms [1]. Appau et al. further affirm its centrality in shaping occupant satisfaction [2], while Weerasinghe et al. stress the need for nuanced approaches to thermal behavior, especially in mixed-mode ventilation settings [3].

Thermal comfort is also intricately tied to Indoor Air Quality (IAQ). Diaz et al. advocate for balanced consideration of both parameters, particularly in educational settings

[4]. Joint evaluations are essential, as emphasized by Jia et al., who recommend integrated strategies for stable, healthy indoor conditions [5, 6]. This is particularly relevant during the winter months, when closed windows limit ventilation, degrading both indoor air quality (IAQ) and thermal satisfaction [7]. Acoustic comfort is essential in learning and working contexts. Because noise levels significantly impair focus and mental well-being, design strategies like acoustic zoning and sound-absorbing materials are essential [8, 9]. Similarly, visual comfort plays a crucial role. The integration of daylighting and artificial lighting influences not only perception and comfort but also energy efficiency [10, 11]. Natural light, in particular, has been linked to improved mood and cognitive performance [12].

Participatory approaches, such as involving occupants in the design and operation of spaces through surveys and feedback mechanisms, have gained traction as well. These methods allow for environments that better align with user preferences and improve IEQ. Post-occupancy evaluations (POE) are effective in aligning building performance with user preferences [13, 14]. These methods, when supported by real-time feedback tools, foster environments that respond to occupant perceptions and promote a sense of agency [8].

Adaptability in IEQ design is increasingly incorporating smart technologies, such as IoT sensors and data-driven controls, to enhance real-time environmental adjustments and optimize comfort-energy tradeoffs. Fuzzy logic-based controllers are employed to manage thermal and air conditions efficiently [11], supporting real-time environmental adjustments and optimizing comfort-energy trade-offs [15]. Holistic models of IEQ - such as those developed by Bluysen and Fissore et al. - underscore that comfort arises from the interplay of sensory inputs rather than isolated variables [8, 16].

Digital tools - such as Digital Twins, BIM, IoT sensors, and data-driven controls - are transforming IEQ management. Digital twins enable real-time monitoring and simulation of indoor environments, supporting responsive design processes [17]. IoT sensors enhance awareness and facilitate user-driven behavioral adjustments, and they also feed into automated systems for improved environmental control [18, 19]. POE methodologies increasingly leverage digital platforms to integrate subjective feedback with objective metrics [13], enabling more accurate diagnoses of comfort issues. The use of machine learning adds a predictive layer, allowing systems to anticipate user needs and optimize settings accordingly [14].

Data analytics are fundamental to this shift. Kaushik et al. demonstrate how sensor data on environmental parameters correlate with productivity outcomes [1], and Fowler et al. highlight the value of cross-disciplinary simulations in validating air quality perceptions against real conditions [20]. These insights are vital for creating buildings that support both health and performance.

The traditional dichotomy between energy efficiency and occupant comfort is being addressed through integrated, adaptive systems that utilize real-time data and user feedback to balance energy use with comfort needs. Jain et al. call for performance models that reflect user behavior and sensory feedback [15], while Khorasgani et al. illustrate how smart technologies can deliver energy savings without compromising comfort [21].

Design considerations must also account for physical and material elements. Innovative furniture and passive thermal strategies are increasingly emphasized in future-ready environments, along with layout choices that align with multisensory comfort requirements [22]. These solutions contribute not only to comfort but also to long-term sustainability.

The convergence of participatory design, smart technologies, and a multisensory understanding of IEQ marks a paradigm shift in building design—from energy-centric approaches to human-centered strategies. This shift implies a greater focus on occupant well-being and the integration of user feedback in design processes, ultimately leading to more sustainable and adaptive environments. As digital tools evolve and interdisciplinary research expands, the capacity to create healthier, more adaptive, and productive spaces continues to grow [23]. A comprehensive, data-informed approach to IEQ will drive the achievement of sustainable development goals and promote occupant well-being.

2.2 Outdoor Environment and Comfort Design

The outdoor environment has a significant influence on human comfort, behavior, and well-being, playing a pivotal role in shaping the quality of urban life. Practical outdoor comfort design addresses multiple environmental stimuli—thermal, visual, acoustic, olfactory—while actively engaging users and integrating adaptive strategies. Recent research highlights the importance of a holistic approach to outdoor comfort that can dynamically respond to diverse and changing climatic conditions, user expectations, and sensory experiences. Acoustic stimuli, for example, play a crucial role; natural sounds, such as rustling leaves, flowing water, or bird songs, can mask undesirable urban noises, reduce perceived stress, and foster psychological restoration. Olfactory experiences are similarly influential: aromatic vegetation such as lavender, rosemary, or jasmine enriches sensory perception, creating positive emotional responses and a relaxing atmosphere. Tactile stimuli provided by diverse surface materials, such as textured paving, smooth wooden benches, or interactive water features, can enhance sensory engagement and accessibility. Implementing multisensory elements, such as sensory gardens or integrated natural sound installations, not only boosts environmental comfort but also promotes inclusivity and enriches the public space experience for diverse user groups.

Integrating user feedback into urban design processes is essential for creating environments that are responsive to actual comfort perceptions and behavioral patterns. Participatory approaches, such as surveys, questionnaires, and “urban climate walks”, enable the capture of subjective experiences linked to thermal and spatial conditions. Such methodologies, as elaborated by [24], provide nuanced insights into how individuals perceive thermal comfort, influenced by spatial context, memory, and expectations. Empirical studies have successfully combined objective micrometeorological data with subjective questionnaires, refining outdoor thermal comfort models to align with local user expectations [25, 26]. For example, defining acceptable PET (Physiological Equivalent Temperature) ranges through community feedback has directly informed urban interventions, such as shading strategies and vegetation placement, in hot climates.

Adaptive strategies leverage real-time adjustments and dynamic interventions to address variable climate conditions in urban environments. Unlike traditional static

approaches, adaptive solutions incorporate responsive technologies, such as deployable shading devices, misting systems activated under specific heat thresholds, and thermochromic materials that modify their reflectivity based on ambient temperature. Simulation tools are essential in predicting the effectiveness of these interventions and optimizing their configurations. Infrared thermography has also emerged as a valuable method for identifying urban hotspots and quantifying pedestrians' radiative heat exposure, facilitating targeted and practical design solutions [27]. Urban design strategies are increasingly focusing on integrating Internet of Things (IoT) sensors and data analytics, enabling the automated and responsive management of microclimates. This approach significantly enhances pedestrian comfort in real-time and improves urban resilience to climatic extremes.

3 Architectural Engineering, Comfort and Design

In recent years, Architectural Engineering has shown increasing scientific interest in multisensory, participatory, and adaptive strategies, particularly focused on occupant comfort and environmental sustainability. The latest edition of the international conference Colloqui.AT.e 2024 clearly demonstrated this trend, featuring several contributions adopting interdisciplinary, innovative, and user-centered approaches.

Numerous studies emphasized the relevance of participatory and user-centric methods in spatial design, investigating how indoor environmental quality parameters significantly affect occupant perception and well-being, especially in educational and residential contexts [28, 29]. Further contributions explored adaptive and responsive design approaches, proposing innovative textile components that can dynamically respond to environmental stimuli, thereby enhancing sensory comfort and energy efficiency [30].

Research has also examined how multisensory perception affects user responses to complex scenarios involving combined risks, such as heatwaves, air pollution, or emergency conditions in historic urban contexts [31, 32]. Additionally, recent contributions have explored the integration of biophilic principles in architectural design, highlighting how auditory, olfactory, tactile, and gustatory sensory stimuli significantly enhance occupants' psychological and physiological comfort, promoting environments supportive of well-being [33]. Moreover, innovative virtual reality approaches have been employed to assess the multisensory effects of biophilic strategies on user perception, cognitive performance, and comfort within office spaces [34]. The digitization of cultural heritage has also been addressed from a user-centered design perspective, underscoring the importance of participatory methodologies and user journeys as critical components in developing inclusive and responsive architectural solutions [35].

Collectively, these studies highlight the growing emphasis on multisensory design, user perception, and participatory methodologies within Architectural Engineering, underscoring the necessity for increasingly responsive, integrated, and human-centered approaches to contemporary sustainability and comfort challenges.

The recent doctoral research contributions presented at the DOTATI conference highlight the emerging yet still limited engagement of Ph.D. candidates in integrating multisensory, participatory, and adaptive approaches within Architectural Engineering. While the number of contributions remains relatively small, the studies presented demonstrate a

high level of methodological innovation and a strong interdisciplinary orientation, underscoring the potential of doctoral research to act as a catalyst for thematic convergence and scientific advancement.

Crespino et al. (this proceeding) focused on children's perception of indoor air quality and thermal comfort in school environments, revealing critical mismatches between standard comfort models and the actual needs of younger occupants. The work highlights the importance of tailoring environmental quality criteria to the physiological and cognitive needs of children, advocating for evidence-based design strategies that promote health and learning outcomes..

Morvillo (this proceeding) explored the use of co-design and hackathons as participatory tools for sustainable territorial development in the inner Sicani area. By engaging diverse actors—residents, students, and professionals—in collaborative design processes, the research demonstrates how doctoral projects can bridge the gap between academic frameworks and community-led innovation, providing scalable models for rural regeneration.

Finally, Torriani et al. (this proceeding) conducted a thematic analysis of recent literature on soundscape and smellscape research, highlighting both the growing interest and the methodological gaps in this field. Their work advocates for a broader integration of sensory dimensions into urban and architectural design, calling for the development of standardized frameworks that enhance environmental comfort and urban liveability.

Despite their limited number, these contributions reveal the significant potential of doctoral research to advance a more integrated and human-centered approach to the built environment. They demonstrate how Ph.D. students can play a strategic role in bridging disciplines, translating emerging societal needs into innovative research directions, and enriching the scientific debate on comfort, perception, and participation in architectural design.

4 Conclusion

Contemporary approaches to comfort in the built environment are increasingly moving beyond conventional, metric-driven models towards integrative, human-centred frameworks. The review of recent research and emerging practices demonstrates a clear paradigm shift: comfort is no longer considered a static or universal condition, but rather a dynamic and situated construct shaped by sensory perception, behavioural feedback, and socio-cultural expectations.

This transformation calls for the adoption of multisensory, adaptive, and participatory strategies in both indoor and outdoor environments. Evidence highlights the importance of integrating thermal, visual, acoustic, and air quality parameters with real-time sensing, user profiling, and subjective evaluation tools. Such methodologies enable a more granular and responsive design process, improving not only environmental performance but also user satisfaction and well-being.

Outdoor comfort design similarly benefits from the incorporation of user-centred and climate-responsive solutions, such as deployable shading, misting systems, and tactile or olfactory interventions that enhance experiential quality and urban inclusiveness. The intersection between environmental stimuli and user perception is increasingly recognised as a crucial vector for resilient and emotionally engaging public spaces.

Doctoral and early-stage research, and in particular in Architectural Engineering sector, are contributing significantly to this evolving field, offering innovative perspectives on comfort as a multiscalar and interdisciplinary challenge. The studies examined illustrate how methodological innovation and cross-sectoral collaboration can support more inclusive and sustainable built environments.

In conclusion, comfort must be redefined as a co-produced and evolving condition—measurable but also lived, regulated yet inherently subjective. A systemic and transdisciplinary commitment is required to address it, bridging environmental engineering, architectural design, digital innovation, and social participation. Only through such integrative efforts we can design environments that are not only efficient and healthy, but also equitable, adaptable, and attuned to human experience.

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