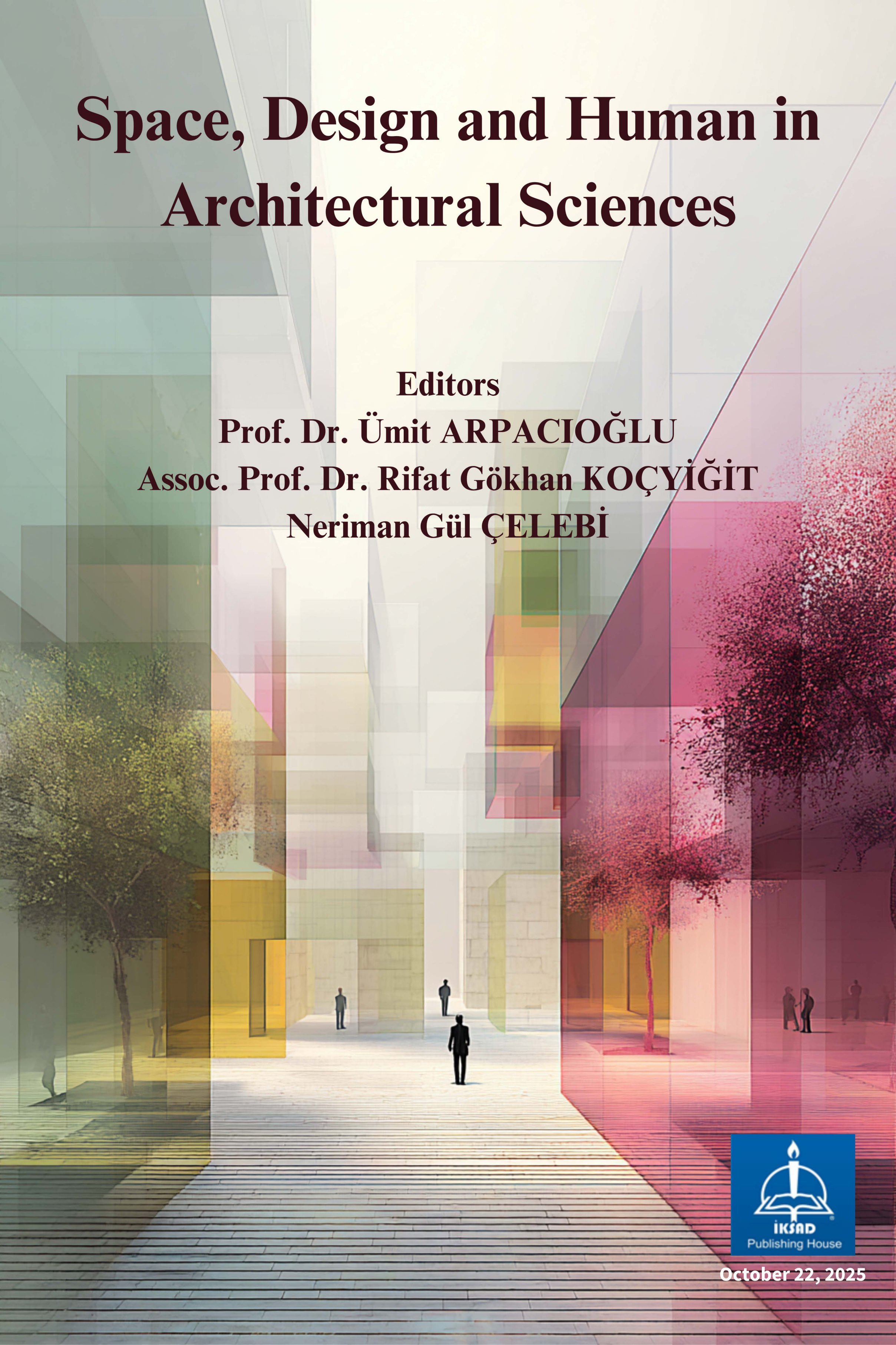

Space, Design and Human in Architectural Sciences

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PREFACE

Architecture has always been one of the most fundamental and dynamic dimensions of the human condition, shaping and reshaped by the ways in which societies live, produce, and imagine their worlds. It has never been a mere practice of building; rather, it has continuously unfolded as a complex field of thought and production that integrates cultural values, technological capacities, and ecological sensitivities. With this book, *Space, Design and Human in Architectural Sciences*, we invite readers to rethink the architectural discipline through a broad spectrum of theoretical and practical perspectives, each grounded in original scholarly contributions.

The primary aim of this volume is to address contemporary architectural questions not from a singular viewpoint, but through a multi-authored, multi-layered, and wide-ranging framework. Architecture, by its very nature, simultaneously touches upon human life, the environment, and technology. For this reason, it cannot be confined within the boundaries of a single field; rather, it emerges at the intersections of different disciplines. By gathering contributions from various scholars, this book highlights that pluralism and offers a comprehensive integration of philosophical, technological, social, pedagogical, and material-oriented discussions.

The human dimension of architecture is also inseparable from philosophical reflections on the human condition itself. The opening chapters of this book are therefore devoted to ontological and humanistic considerations. The first chapter, *From Humanimal to Humus: Rethinking Human and Architectural Ontologies*, critically reconsiders anthropocentric paradigms and proposes an expanded ontology of architecture in which humans, animals, and natural forces intersect in shared spaces of existence. The second chapter, *Humanoid Technologies in Architecture: Redefining the Boundaries of Spatial Experience*, examines the hybrid relationship between humans and emerging technologies, arguing that the boundaries of spatial experience are being radically redefined in the age of digital design and artificial intelligence. Together, these perspectives push us to understand architecture as more than a response to human need: it becomes a field of encounter between multiple forms of being.

The exploration of human–technology relations extends into critical readings of modern and experimental architectural movements. The third chapter, *Conceptual Transformation of Archigram Futurism and Its Reflections in Architecture*, revisits the radical visions of the 1960s Archigram group and interrogates their relevance for contemporary conditions. By doing so, it demonstrates how architecture continually negotiates its relation to technology, urbanity, and lifestyles. In parallel, the fourth chapter, *Architecture of Madness: R. D. Laing's Kingsley Hall vs. Jeremy Bentham's Panopticon*, develops an alternative discourse where architecture is discussed not only as a rational and ordering practice but also as a domain entangled with psychology, social control, and the quest for freedom.

Following this, the book turns toward the representational and expressive dimensions of architecture. The fifth chapter, *Hidden Supporters of Architects: Narrative Codes*, reveals how underlying narrative structures shape design processes, even when they remain unseen. The sixth chapter, *Tracing the Pre-Modern Representation in Contemporary Architectural Drawing*, argues for drawing as more than a technical tool: it is a form of pre-representation that grounds the very possibility of architectural thought. Complementing these, the seventh chapter, *Color in Function: The Perceptual Role of Chromatics in Spatial Experience*, highlights the perceptual and functional dimensions of color in shaping spatial experience, while the eighth chapter, *Representation of Materials and New Dimensions of Perception in Digital Spaces*, examines how digital technologies reconfigure the ways in which materials are perceived and represented. Collectively, these chapters underscore that architecture is as much about expression and perception as it is about construction.

The third thematic axis of the book concerns urban and institutional dynamics. The ninth chapter, *Exploring Methodologies on Housing Production: Open Building Approach in Habraken's Sar73*, investigates flexible and participatory approaches to urban infill, reconnecting historical methodologies with contemporary urban challenges. The tenth chapter, *Operational Dynamics and Challenges of Architectural Design Competitions in Türkiye: A Process-Oriented Analysis*, analyzes architectural competitions in Türkiye as complex processes shaped by both opportunities and constraints. The eleventh chapter, *Holistic Interpretations and*

Contemporary Critical Readings in the Context of Architectural Pedagogy, situates architectural pedagogy within broader interpretative frameworks, proposing a more holistic approach to teaching and learning. These three contributions make clear that architecture cannot be reduced to the scale of the building alone; it must also be understood in relation to cities, institutions, and systems of knowledge.

The fourth and final cluster of chapters is dedicated to sustainability and material research. The twelfth chapter, *Cross-Laminated Timber (CLT) for Sustainable Buildings: An Assessment for New Zealand and Türkiye*, evaluates cross-laminated timber (CLT) within both the New Zealand and Turkish contexts, situating timber construction within global discourses of sustainable building. The thirteenth chapter, *Investigation of Stabilization Using Mineral Binders for Earthen Materials under Varying Curing Conditions*, presents a scientific investigation into the strengthening of traditional earthen materials through mineral binders. The fourteenth chapter, *Application of Boron Compounds in Building Materials: A Review*, examines the innovative potential of boron in construction practices, reflecting the growing intersections between material science and architecture. The fifteenth chapter, *Quality Management Systems in Construction Projects: Reframing QMS Tools through Complexity Principles*, addresses management and organizational dimensions by exploring how complexity theory can illuminate the challenges of implementing quality systems in construction. Finally, the sixteenth chapter, *An Assessment of the Relationship Between*

Türkiye's Residential Stock and Environmental Impact in the Context of Structural Systems, presents the importance and analyzes the relationship between Türkiye's residential stock and life cycle environmental performance in the scope of load-bearing systems.

Taken together, these sixteen contributions guide the reader from ontological reconsiderations of the human condition, through debates on representation and perception, into urban and pedagogical processes, and finally into sustainability and material innovation. The deliberate sequencing of the chapters aims to create a coherent trajectory while preserving the richness of plurality.

What emerges is a portrait of architecture as a deeply interdisciplinary and multifaceted field. Human–environment relations, technological transformations, social complexities, and material experiments converge in ways that demand new forms of scholarly engagement. The multi-authored structure of this book is not only a methodological choice but also a necessity, given the complexity of the questions at stake. The diversity of perspectives and contexts represented here provides readers with a more nuanced and comprehensive understanding of architecture's current challenges.

Our aspiration for the future is that this book will serve not only as a scholarly reference but also as a catalyst for new debates and inquiries. To comprehend the ever-shifting relationships among space, design, and humanity is not simply an academic exercise; it is also an ethical and practical imperative for building a sustainable, equitable, and imaginative future. We hope the insights and discussions presented here will make lasting contributions to the architectural sciences and inspire future generations of scholars and practitioners.

Finally, we would like to extend our sincere gratitude to all the contributing authors, whose original and comprehensive works form the backbone of this volume. We are equally indebted to the reviewers, whose meticulous evaluations and constructive suggestions for revision have significantly enhanced the scholarly quality of the book. Our thanks also go to IKSAD Publishing House for providing the platform that made this collective endeavor possible, and Prof. Dr. Atila GÜL, who is the General Coordinator of the Architectural Sciences book series, for his invaluable support. Above all, we acknowledge the spirit of dialogue, intellectual curiosity, and commitment that has guided this project from its inception to completion.

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From Humanimal to Humus: Rethinking Human and Architectural Ontologies

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1. Introduction

The intellectual legacy that places the human at the center of the universe has left profound marks, particularly within the knowledge systems of the modern era. This legacy defines the human as a being who thinks, represents, and shapes the world through technology—positioning them as a transcendent and superior subject, separate from nature and all other entities. Grounded in humanism, this approach has evolved into an all-encompassing framework that not only shapes the human's understanding of being but also dictates how space is constructed, how values are distributed, and how the Other is represented.

However, the order established by this model of the subject has begun to unravel. The planetary crisis, climatic collapse, interspecies loss, and the complex entanglements between technology and matter have made it necessary to reconsider the human's central position. Today, intellectual responsibility is felt not only for the human, but also with the human—and at times, for those who exist beyond the human.

This transformation entails not only a philosophical search but also an ethical, aesthetic, and ontological reconfiguration across various fields—including architecture. From classical antiquity through the Renaissance and into the modern period, architecture has been shaped by an anthropocentric perspective that takes the human body as its measure, regards nature as a passive background, and centers representation. In antiquity, Vitruvius articulated three essential principles of architecture—*firmitas* (strength), *utilitas* (utility), and *venustas* (beauty)—which located the human body and its proportions at the core of architectural thought (Vitruvius, 2001). The Renaissance reinterpreted these principles through ideals of harmony, symmetry, and perspective, further consolidating the human as the central reference point in spatial order (Wittkower, 1949). Modernist discourse, in turn, often foregrounded notions of form and function—exemplified by Louis Sullivan's maxim "form follows function" (1896) and Le Corbusier's design principles (2000)—as dominant tendencies, even though architectural practice has always encompassed a broader range of concerns (Le Corbusier, 2000).

The research approach has three conceptual planes: *Humanimal*, *Human*, and *Humus*. These strategic planes propose not only a typology of being, but also a theoretical repositioning of architecture in relation to ethical and ontological transformation. This orientation necessitates the dissolution of anthropocentric frameworks, the expansion of the limits of representation, and the rethinking of the material, sensorial, and political conditions of co-existence.

2. Material and Method

This research adopts a theoretical and conceptual analysis in order to evaluate the historical development and dissolution of the anthropocentric model of subjectivity, along with the alternative ontological orientations that have emerged in its wake. The object of the research is not a physical structure or a specific architectural project, but rather the philosophical and ontological transformation of the human's relationship with nature, the body, and nonhuman entities. Within this framework, architecture is approached not merely as the production of physical space, but as a conceptual domain that shapes inter-relational dynamics, organizes systems of representation, and bears ethical responsibility.

The research is conducted through a theoretical analysis grounded in literature review, through which the transformation of the human conception is conceptualized across three main planes: Humanimal, Human, and Humus. These planes are not chronological categories confined to specific periods; rather, they are constructed as analytical frameworks aimed at comparatively understanding different regimes of being, modes of representation, and approaches to spatial organization. Each plane reveals the ruptures that have occurred both in the conception of subjectivity and within the discipline of architecture.

Methodologically, the research follows a multilayered analytical strategy that values conceptual permeability and brings together critical theory with new ontological approaches. Alongside the interpretation of the thinkers' arguments, it also constructs a strategy for how these theoretical approaches can be rearticulated within the field of architecture. The methodology is both analytical and speculative in character.

The strategic structure of the research is organized around three conceptual planes, and each section discusses the relationship between a corresponding ontological approach and architecture. The Humanimal plane explores alternative modes of thought in which the human is not separated from nature but conceived as a relational being. The notion of "Humanimal" a term employed in posthumanist literature to highlight the ontological continuities between humans and animals (Braidotti, 2013) is "extended to articulate the broader entanglements between humans, animals, and the natural environment, thereby challenging the boundaries that separate species. The Human plane examines how the dominant model of subjectivity, through structures of representation and domination, has shaped architectural discourse; and the Humus plane addresses posthumanist approaches that reimagine the human as an earth-bound, multispecies, and material being.

In this context, the methodological aim is to develop an interdisciplinary theoretical reading that is not reducible to any single idea. The objective is to deconstruct the prevailing anthropocentric framework in architecture and to propose a form of architectural thinking that embraces the principle of ontological pluralism, considers ethical responsibilities, and is grounded in relational reciprocity.

3. Findings and Discussion

The historical and theoretical transformations concerning the ontological position of the human are examined in this research through three primary planes: Humanimal, Human, and Humus. These planes are constructed as conceptual frameworks that enable a reconsideration of the nature of the human's relationship with nature and of architecture's place within this relational network. Each plane points to different conceptions of being, material encounters, and modes of ethical responsibility.

This analytical structure aims not only to reveal epistemic ruptures, but also to make visible how these ruptures affect architectural production, spatial organization, and an ethics grounded in reciprocity. The discussion is shaped by multiple perspectives drawn from theoretical orientations such as anthropological ontology (Descola, Viveiros de Castro) and posthumanist thought (Haraway, Barad), in pursuit of an architectural thinking that moves beyond representation.

3.1. Settled Ontology and Dwelling in the Humanimal Plane

In the history of Western thought, the figure of the "human" has long been defined as a subjectivized being that is separate from nature and ontologically privileged. However, this understanding of the subject does not merely indicate a historical definition of the human; it also produces a deeper ontological framework that determines the human's relationship with nature, animals, objects, and space. In contrast, peoples, cultures, and modes of thought that fall outside of this framework conceptualize the human as a species that is entangled with nature, co-existing and co-thinking with it (Descola, 2013).

In the Humanimal framework, the human does not occupy a central position but is rather situated within an ontological plane shaped by co-existential modalities. This perspective emphasizes not only the biological continuity between humans and animals but also their intertwined modes of being. Philippe Descola's typology of four ontological regimes provides a foundational theoretical background for understanding this framework (Descola, 2013).

Descola categorizes the ways in which human societies make sense of the world into four fundamental models, which he refers to as "ontological regimes": naturalism, animism, totemism, and analogism. Each regime defines the type of relationship established between beings in terms of interiority (such as feelings, consciousness, and will) and physical appearance (Figure 1) (Descola, 2013, p. 103–113).

Modern Western thought is grounded in naturalism, which assumes that nonhuman beings are physically similar to humans but differ in their interior states. As a result, humans are distinguished as conscious, subjective agents, while animals or objects are reduced to passive entities devoid of interiority (Descola, 2013, p. 121). In contrast, animism—common among many Indigenous communities—acknowledges that nonhuman beings also possess inner experiences (Descola, 2013, p. 129). The perception of a jaguar as a hunter or a tree as a sensing subject by Amazonian peoples are clear examples of an animist ontology (Descola, 2013, p. 130). In this view, bodies may differ, but internal qualities such as thinking, feeling, and intending are shared. Totemism, on the other hand, establishes collective affiliations based on both physical and interior similarities (Descola, 2013, p. 142). In analogism, every being is distinct, yet relations among them are constructed through symbolic correspondences and analogical reasoning (Descola, 2013, p. 154). The four ontological regimes are comparatively summarized in Figure 1, which illustrates how beings are related according to their interior qualities and physical attributes (Descola, 2013).

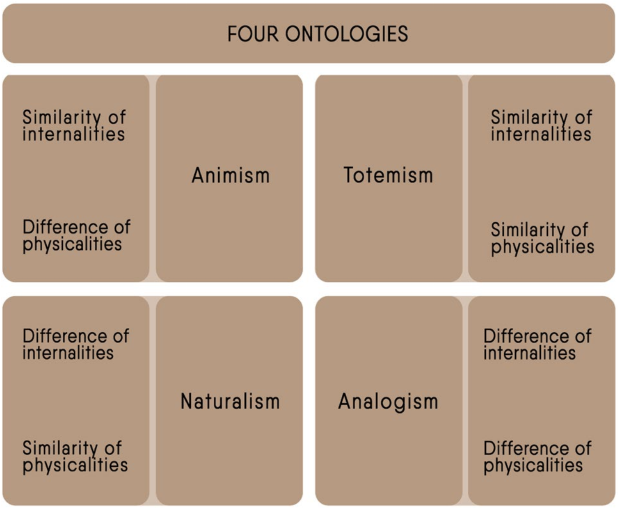

Figure 1. Philippe Descola's Four Ontological Regimes (Descola, 2013, p. 111)

The Humanimal plane closely parallels animistic ontology (Descola, 2013). In this framework, the human is not defined solely by internal consciousness, but rather envisioned as a living being who attains subjectivity through reciprocal relationships with animals, plants, and the surrounding environment. Here, subjectivity is not an individual privilege, but the outcome of a multispecies entanglement. The human exists not merely as a "self," but through encounters with others and through cultivating responsiveness toward them.

Within this understanding, "dwelling" is no longer merely a physical necessity or a technical process of building structures. Instead, it gains meaning through reciprocal relations woven between humans and animals, nature and material, memory and topography. At this point, Tim Ingold's concept of the dwelling perspective deepens the spatial articulation of the Humanimal plane. According to Ingold, space is not a pre-designed, static backdrop, but a dynamic process continuously shaped through the cohabitation and interweaving of humans, animals, soil, wind, and other beings (Ingold, 2000, p. 186). This conceptual framework resonates with Songline maps, which exemplify how certain Indigenous peoples relate to topography. For instance, the Songlines of Australian Aboriginal communities illustrate that the land is understood not simply as a geographical surface, but as a dynamic and layered landscape, animated by ancestral memories, navigational knowledge, and collective social ties (Figure 2) (Chatwin, 1988).

Figure 2. Seven Sisters Songline, Josephine Mick (1994), Ninuku Arts (National Museum of Australia, n.d.)

Ingold argues that modern thought conceives space as a static, empty, and pre-given stage upon which humans and buildings are subsequently positioned. In contrast, within the *dwelling perspective*, space is understood as a living process: it is continuously woven through the coexistence of beings such as humans, animals, soil, wind, material, and sound (Ingold, 2000, p. 153). In this sense, to dwell means to take part in a living fabric and to participate in its ongoing renewal.

Within this framework, architecture is not merely a discipline concerned with formal or functional arrangements. Rather, it becomes a relational field where different species encounter one another and develop shared modes of cohabitation. Structures are not solely designed to facilitate human life; they are conceived to enable the spatial conditions for sustaining mutual and continuous relations with nonhuman beings (Ingold, 2000, p. 186).

In this respect, the Humanimal plane redefines dwelling as a shared sphere of existence among multispecies beings. What matters here is not merely possessing a structure, but living, orienting, and sensing together with others within it. To dwell is to take part in a kind of collective fabric. Architecture, then, becomes a practice through which this fabric is woven, felt, and sustained.

One of the key thinkers who argues that the relationship between humans and nonhumans operates not only on a physical or symbolic level, but also on cognitive and meaning-generating dimensions, is Eduardo Kohn. In his work *How Forests Think*, Kohn (2013) investigates the world of the Runa people in the Amazon and argues that animals and plants are not merely reactive beings, but also subjects capable of thinking, producing signs, and interpreting. This approach removes meaning-making from being an exclusively human trait and instead conceptualizes thought as a process emerging from semiotic relations among all living beings, not limited to the mind alone. Kohn's concept of "thinking with life" intersects with Descola's animistic ontology, yet moves in a more radical direction by understanding thought as an immanent outcome of bodily, environmental, and multispecies entanglements (Kohn, 2013, p. 76).

According to Kohn, for a living being in the forest, to think is to sense the gaze of a jaguar, to associate the sound of a woodpecker with a potential predator—in other words, to exist within the world and to be affected by it. This approach offers a mode of existence that challenges the limits of representation. Instead of a human-centered epistemology, it posits a reciprocal process of meaning-making among beings that co-constitute the world. The philosophical foundation of the Humanimal plane is rooted in pluralism and a notion of multiple subjectivities. Within this framework, Kohn's work opens the door to an understanding that recognizes not only humans but all living beings as epistemological subjects. Dwelling, too, is conceived within this multispecies epistemological realm as a world jointly constituted by beings who engage in shared meaning-making.

The deeper philosophical roots of this ontological approach can be found in Spinoza, who defines nature as one of the infinite modes of a single substance (*substantia*) (Spinoza, 2004). According to him, the human being is not separate from nature but rather an immanent expression of it. This understanding displaces the human from a privileged position of agency and re-situates them within a continuum of beings.

Spinoza's notions of *conatus* and *potentia* are crucial in this regard: *conatus* refers to the intrinsic striving of each being to persevere in its own existence, while *potentia* denotes the capacity of a being to act and to enhance this capacity through its relations with other entities (Deleuze, 1988; Braidotti, 2013). From this perspective, the human is not positioned as a ruler over nature but as a participant that evolves and diversifies through mutual adaptation with it.

An immanent ontology envisions a realm shaped by mutual influence, emerging not from a transcendent source or from nature in isolation, but through the ongoing interrelations among diverse forms of existence.

Spinoza's framework thus grounds the Humanimal plane both ethically and ontologically. The human bears responsibility not only toward their own species but also toward the animals, the soil, the air, and the water with which they share existence. Such a sense of responsibility calls for an ethical approach based on reciprocity and interconnectedness, contrasting with the hierarchical and rule-based logic that typifies modern moral systems (Braidotti, 2013). Spinoza's philosophy of immanence further suggests that architecture is not merely a technical activity of form-making, but a practice of establishing zones of interaction among beings (Deleuze, 1988).

In this context, the Humanimal plane points to a deeper and more relational ontological ground that extends beyond the superficial biological similarities between humans and animals. This approach recognizes that human existence has historically unfolded not in isolation, but in constant interaction with animals, plants, and other living beings in the environment. The primary aim here is to reconceptualize the human not as a fixed, autonomous, and central subject, but as an entity constituted within a web of relations. Human existence takes shape not within individual boundaries alone, but through its entanglement with shared worlds.

Within this framework, the act of dwelling can be understood not merely as the construction of a physical shelter, but as a mode of being shaped by reciprocity, continuity, and the desire to co-inhabit with other living beings. Space is no longer a static and objective entity, but a dynamic and relational process that weaves together the fabric of coexistence. Architecture, then, becomes not simply an aesthetic or technical arrangement of forms, but the spatial expression of the intimacy and companionship humans cultivate with other sentient beings.

In Tim Ingold's *dwelling perspective*, space is not a predesigned and empty ground; rather, it is conceptualized as an ongoing process woven through lived experiences (Ingold, 2000, p. 186). According to him, dwelling is not merely about inhabiting a structure, but about participating in a meshwork of life formed in relation with other beings. When this approach converges with Eduardo Kohn’s (2013) semiotic account—asserting that nonhuman beings are capable of producing meaning and constructing cognitive worlds—dwelling ceases to be an activity exclusive to humans. Instead, it becomes a shared life practice among animals and other living entities. Spinoza’s ontology of immanence, which posits nature as a single substance, offers a deeper ontological grounding for this shared existence, arguing that it is not only perceptual but also existential in nature (Spinoza, 2004, p. 51). In this light, dwelling is redefined as a field of existence emerging from interspecies encounters.

The modern conception of the subject has positioned the human at the center by separating them from nature, animals, and the material environment—an ontological rupture that has profoundly shaped architectural thought. In contrast, the Humanimal plane recalls that throughout history, humans have lived not only among their own kind but also in continuous contact with other beings—contacts that have significantly shaped the human's ontological constitution. Within this framework, the human ceases to be an autonomous agent and instead becomes a being who co-exists and co-evolves with nature.

Accordingly, dwelling is not merely the act of producing physical structures but entails becoming part of an environment that is sensed, experienced, and shared with other life forms. Animals, plants, and material elements are not passive components of this environment; rather, they are active subjects that inhabit space through their sounds, movements, and presences. The Humanimal perspective thus defines space as the primary and foundational terrain of these encounters and positions architecture as one of the most refined sensory textiles that can be woven upon this terrain.

3.2. The Modern Subject and Architecture in Representation within the Human Plane

The foundations of the modern understanding of the subject are rooted in a framework that ontologically and intellectually separates the human from nature, bodily existence, and nonhuman entities—a framework shaped by centuries of Western metaphysical thought. This conception crystallized during the Scientific Revolution and the Enlightenment, when rationalist philosophy and mechanistic science (e.g., Descartes' mind–body dualism and Newton's laws of nature) established a dualistic separation between mind and matter, human and nature (Descartes, 2005; Toulmin, 1990). This perspective constructs the human as a privileged being, not only by virtue of reason and consciousness but also through the capacity to represent, transform, and regulate nature. Accordingly, the human has been positioned as a decisive agent not only over the natural world but also in the organization of space, the lives of other beings, and systems of meaning.

Over time, this model of *subjectivity* became normative not only in the production of knowledge but also in spatial practices such as architecture; the authority to organize and control space was assumed to belong to the human. It became dominant precisely because it aligned with the rise of political, scientific, and technological control mechanisms that reinforced human sovereignty over nature and institutionalized the authority of the modern subject (Foucault, 2001).

Especially from the Renaissance onward, modern architecture inscribed this *representational regime*—that is, the system through which spatial order reflects and reinforces human-centered authority—into the material world through form, scale, and symmetry. Nature, in turn, was reconstructed as a passive and controllable background.

The historical foundations of this process of *subjectification* can be traced back to the human–nature divide articulated in Ancient Greek philosophy. Plato's theory of ideas positioned the world perceived through the senses as a deficient and deceptive reflection of truth, while locating real knowledge within abstract forms accessible only through reason (Platon, 2006, 509d–511e). This approach relegated nature to a realm considered disordered, mutable, and materially inferior, while elevating the human—particularly the rational human—to a higher and more orderly ontological plane (Copleston, 1994). This ontological separation redefined not only the epistemological conception of knowledge, but also reconfigured the human's position in the cosmos through a hierarchical lens.

Aristotle, on the other hand, articulated this separation within a more systematic framework by formulating the concept of the *scala naturae*, or the "great chain of being" (Figure 3). According to him, beings must be understood through the unity of form and matter (hylomorphism), and all entities in nature are to be hierarchically arranged based on their functional and cognitive capacities. Inanimate matter possesses only the quality of existence; plants exhibit vitality; animals demonstrate faculties such as sensation and movement. Due to the unique human capacity for reason (*logos*), the human is positioned at the top of this hierarchy. This classification may also be read as a metaphysical structure that presumes a teleological order among beings. Thus, the human is situated not merely as one species among others but as a privileged and central subject over nature—defined as the regulator of the ontological hierarchy of beings (Aristoteles, 1996, s. 112).

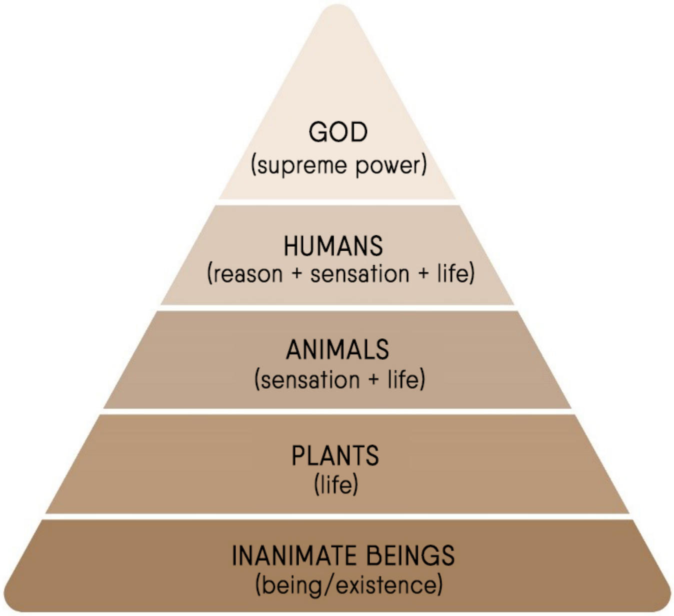

Figure 3. Aristotle's Hierarchical Order of Beings (scala naturae) (Created by the authors)

This metaphysical mode of thought also manifested itself strongly within the field of architecture. In Ancient Greece, architecture was conceived as a domain of knowledge that sought to tame the chaotic multiplicity of nature by reshaping it according to principles of order and harmony (*harmonia*, *symmetria*) (Vitruvius, 2001). Architecture aimed to reflect the rational order of the cosmos, becoming an expression of the human desire to impose form upon nature through concepts such as measurement, proportion, and geometry (Vitruvius, 2001). Within this framework, space is not merely understood as a physical setting for habitation, but as a *representation* of the form imposed by human reason upon nature. In this way, the human subject not only organizes nature through architecture, but also assumes the right to *represent* and interpret it.

The rationalist model of the subject was further consolidated throughout the Middle Ages through its fusion with Christian theology. As a being created in the image of God, the human was exalted both as sacred and as the ruler of all other beings on Earth. However, this theological centralization gave way in the modern period to a secular conception of subjectivity. The modern subject, formulated through René Descartes' famous proposition "Cogito ergo sum" ("I think, therefore I am"), is defined as a conscious being that thinks and represents (Descartes, 2005). Within this framework, the body is regarded merely as the vessel of thought, while nature becomes the object of that thought. His dualistic formulation of mind and body as two separate substances—*res cogitans* and *res extensa*—paves the way for an ontological rupture that isolates the subject from nature and bodily existence. In this division, the mind is elevated as the primary domain of reality, while the body and nature are reduced to mechanical, passive, and controllable systems (Descartes, 2005).One of the visual manifestations of this epistemic rupture became evident during the Renaissance with the emergence of one-point perspective. The fixed viewpoint placed at the center reinforced the position of the subject as a dominant, ordering, and *representational* force over the world. This gaze asserted its influence not only in painting and artistic production but also in architectural organization, where human-centered spatial constructs were transformed into instruments of visual authority. One of the early visual exemplars of this *representational regime* is the Renaissance fresco *The Holy Trinity* by Masaccio. In this work, the singular perspective system based on a fixed viewpoint powerfully illustrates the human subject's spatial centrality (Figure 4).

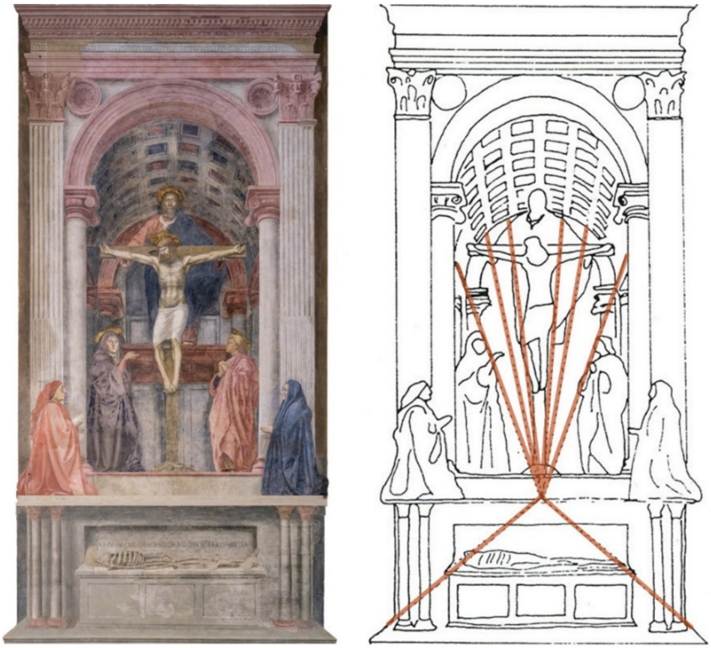

Figure 4. The Holy Trinity (Masaccio 1427) (Wikimedia Commons Contributors, 2023)

With the Renaissance, the subject centralized in visual *representation* evolved in the modern era into not only an aesthetic but also an epistemological foundation. The subject endowed with a fixed point of view no longer organized merely the visible image, but also knowledge and truth from a central position. This transformation became particularly pronounced in scientific thought, wherein nature was redefined as a system to be comprehended and governed through *representation*. Isaac Newton's approach, which conceptualized nature in terms of mathematical laws, framed the universe as a mechanical system functioning according to specific rules. The Newtonian view of nature presumes that physical phenomena can be explained through causal principles, and that these laws can be discovered and controlled by human reason. Thus, nature becomes an objectified system devoid of inherent meaning or *subjectivity*, while the human assumes the position of a privileged observer external to that system (Toulmin, 1990). This perspective contributed to the centralization of *representation* not only in the production of knowledge but also in the organization of space.

Within this framework, *representation* is no longer merely a tool for depiction; it becomes an epistemological medium for accessing and intervening in reality. The modern subject is thus transformed into an agent who not only observes the external world but also defines, interprets, and reconstructs it. This transformation becomes particularly concrete in spatial production domains such as architecture. In this context, architecture is not merely the organization of the physical environment; it is also a spatial articulation of an anthropocentric worldview. Representations created through plans, sections, models, and drawings place a particular body, gaze, and mode of life at the center. As such, architecture becomes not only a formal organization, but a *representational apparatus* that determines who is made visible and who is excluded.

The historical roots of this *representational regime* can be traced back to the Roman architect Vitruvius and his theory of proportion, which accepted the human body as the universal unit of measurement. According to Vitruvius, the architectural principles of firmness (*firmitas*), utility (*utilitas*), and beauty (*venustas*) are best expressed through the ideal proportions of the human body (Vitruvius, 2001). In the Renaissance, this approach gained symbolic visibility through Leonardo da Vinci's famous drawing of the *Vitruvian Man* (Figure 5).

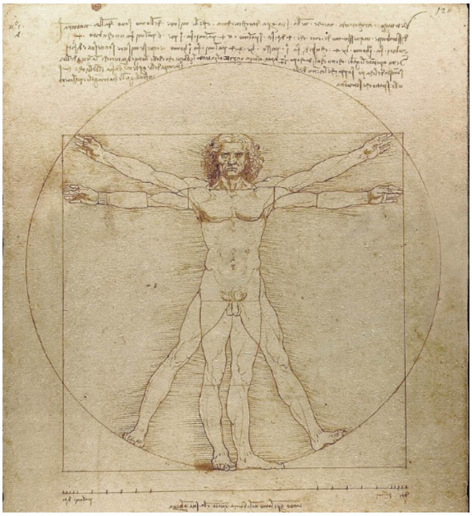

Figure 5. Vitruvian Man (Leonardo da Vinci, c. 1490) (Wikimedia Commons Contributors, 2019)

In the modern period, this understanding was revived in Le Corbusier's Modulor system, where the proportions of the human body were established as normative standards within the discipline of architecture (Le Corbusier, 2014, Vol. 1, p. 45). Although presented as a universal reference, the human figure employed in this system actually reflects a particular anthropometric standard—rooted in the body of a Western, white, and able-bodied male (Figure 5). By relying on the proportions of an idealized male body, the Modulor system informs spatial organization through a human-centered lens, thereby excluding bodies that fall outside its normative framework and reinforcing architectural bias (Le Corbusier, 2014, Vol. 2, p. 78). Within this framework, nature and nonhuman entities are rendered invisible, and diverse bodies, subjectivities, and species are excluded. Thus, architecture becomes not merely a matter of formal production but the spatial construction of a particular typology of being.

Within this framework, nature and nonhuman entities are rendered invisible, and diverse bodies, *subjectivities*, and species are excluded. Thus, architecture becomes not merely a matter of formal production but the spatial construction of a particular typology of being, exemplified in Le Corbusier's *Modulor Figure* (Figure 6).

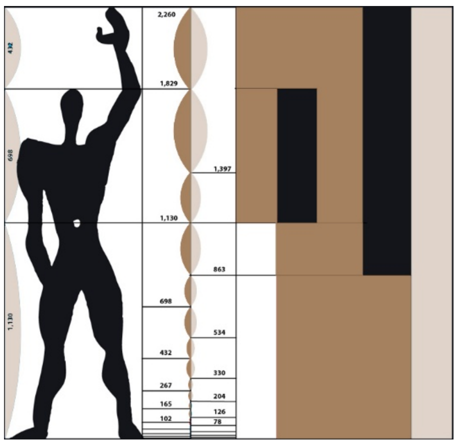

Figure 6. Modulor Figure (Le Corbusier, 2014; Adapted by the author from ArchDaily (2018))

The functioning of *representation* in this way leads to the organization of space not only as a physical entity, but also as an epistemological instrument. Space constructed through representation determines who will occupy the center, who will be excluded, which beings will be made visible, and which will be silenced. In this sense, modern architecture becomes not merely a formal aesthetic or functional system, but a representational structure that dictates visibility and marginalization.

Beginning in the second half of the 20th century, emerging currents of critical thought initiated a profound interrogation of the modern subject model. These critiques revealed that the *representational subject*—conceived as separate from nature, the body, and other beings—is not a universal figure but a historically, culturally, and politically constructed one. Within this framework, the "human" is reconsidered not as a purely biological or metaphysical category, but as a discursively produced figure embedded in structures of power.

Michel Foucault emphasized that the modern subject is produced by regimes of knowledge, and that this subject model becomes possible only under specific historical conditions. In *The Order of Things*, he defines the human as a "transcendental–empirical double" and demonstrates how it is positioned at the center within modern epistemic formations. According to Foucault, this subject model is the product of a provisional arrangement—one that will eventually disappear: "If those arrangements were to vanish, as they appeared in the first place, then one might indeed speak of the disappearance of man, like a face drawn in sand at the edge of the sea" (Foucault, 2001, p. 539).

Foucault's approach reveals that representation, too, is neither an absolute nor a neutral medium of knowledge. This extends into spatial practices such as architecture, where representational techniques—plans, perspectives, and visual regimes—function as mechanisms of power that define visibility and invisibility. It functions as a technique of power that determines what counts as knowledge and who is allowed to speak or be seen. This critical perspective is further deepened by Donna Haraway's concept of the *god trick*, developed within the framework of feminist epistemology. Haraway argues that scientific knowledge is often attributed to a neutral and universal subject, whereas such a gaze is always *situated*—emerging from a particular social, historical, and embodied position. According to her, knowledge is always *situated*, and every representation of reality is simultaneously an act of valuation and exclusion (Haraway, 1988). Haraway's notion of *situated knowledges* challenges not only epistemology but also the ethical and political dimensions of representation.

Bruno Latour extends these critiques into a broader ontological framework. According to Latour, the conceptual separation of nature and society as distinct domains is a modern illusion. The modern human objectifies nature, positioning it as a passive field within their own production of knowledge; and presents this hierarchical mode of relation as if it were a natural and inevitable reality (Latour, 1993, pp. 6–9).

Latour argues that this approach not only shapes the understanding of nature but also transforms knowledge production into a system governed by representation and control. Within the framework of *Actor-Network Theory* (*ANT*), he proposes a mode of thinking based on multi-actor networks shaped by both human and nonhuman entities, establishing an ontology grounded not in representation but in interaction and reciprocal relationality (Latour, 2004).

Rosi Braidotti defines the modern subject model as a reason-centered, self-sufficient, boundary-drawing structure of selfhood that excludes other beings. This conception of subjectivity not only hierarchically positions nature, but also women, animals, Indigenous peoples, and all marginalized identities. According to Braidotti, *representation* is not merely a reflection of reality; it is a normative tool that determines who can speak, who can be seen, and who is considered valuable (Braidotti, 2013, pp. 27–30).

Karen Barad, by contrast, offers a more radical critique of the concept of representation. According to Barad, *representation* assumes a fixed separation between subjects and objects, and this separation distorts the nature of reality itself. Therefore, what matters is not representation, but processes of mutual becoming. Through the concept of *intra-action*, Barad argues that entities do not preexist as separate and stable units, but emerge through relational interactions. Her approach, which she terms *ethico-onto-epistemology*, posits that knowledge, being, and ethical responsibility are inseparable (Barad, 2007). Within this framework, architecture, too, must be reconsidered not merely as a matter of form-making, but as a material-ontological apparatus that organizes representation.

The modern conception of the subject has enabled a worldview in which *representation* is equated with knowledge, and architecture with anthropocentric order. Within this framework, the subject positions nature as an external object and perceives space as a surface over which control can be exerted. However, as contemporary critical theories have shown, this subject model is neither universal nor inevitable. The exclusionary functioning of representation determines not only how space is organized, but also who becomes visible within that organization. Therefore, architecture should be recognized not merely as a technical or aesthetic practice, but as the material expression of historically constructed relations among subjectivity, knowledge, and ethics. The next section will explore alternative ontologies of being that might replace the representational subject model and will move toward a new conceptual ground—what this study refers to as the *Humus* plane.

3.3. Relational Ontology and Spatial Reciprocity within the Humus Plane

This section marks the transition to the *Humus* plane—an ontological level in which the modern conception of the subject begins to dissolve, and the human re-establishes connection with nature not only intellectually, but also materially, perceptually, and spatially. Within this plane, the human is no longer conceived as a central, ordering, and meaning-bearing subject, but as a being situated among soil, objects, other living entities, and material processes. Graham Harman's object-oriented ontology places the human on an ontologically equal footing with all other entities; no entity can ever be fully accessed or exhausted by another. This approach removes the human from the position of a privileged agent, rethinking it instead as merely another thing among things. Similarly, Karen Barad's principles of *entanglement* and *intra-action* propose that entities do not emerge from pre-existing essences but from ongoing processes of relational encounter. The human thus becomes a being that gains its form through entangled existence with nature, objects, and other entities—one that is constantly in formation and defined through material reciprocity (Harman, 2020; Barad, 2007).

Bruno Latour's concept of the terrestrials deepens this ontological shift through a spatial perspective. According to Latour, the human is no longer a transcendent agent ruling over nature from a celestial vantage point, but a relational subject embedded within the Earth—part of the soil itself. Indeed, the etymological root of the term *human* can be traced back to *humus* (soil, compost), revealing the human's existential embeddedness in nature, transformation, and mortality (Latour, 2018, pp. 31–34). In *A Cautious Prometheus? A Few Steps Toward a Philosophy of Design*, Latour further emphasizes the inadequacy of existing systems of representation, arguing that design must move beyond the depiction of static forms toward practices that register relations, processes, and responsibilities (Latour, 2008).

A similar etymological connection is emphasized by David Abram: "Just as the Hebrew term for human (*adam*) is directly related to the word for soil (*adamah*), so too is the English term *human* directly related to *humus*—that is, to soil. Thus both the Hebrew *adam* and the English *human* can be accurately translated as 'earthling' or 'earthborn'" (Abram, 1996, p. 143). Abram's emphasis on this linguistic and existential link invites us to consider the human's relation to place not as a mere etymological coincidence, but as a philosophical and ontological reorientation.

This ontological transformation calls into question not only the human relationship with nature, but also the humanist subject model constructed by modern philosophy. In this sense, the *Humus* plane represents a moment of ontological rupture—one that moves away from the modern subject model which placed the human outside of nature, and instead embeds the human within a network of multispecies, material, and transient relations. This rupture reconfigures not only our understanding of the human but also the conceptual foundations of architecture. Architecture is no longer seen as merely the sum of structures built for humans, but rather as material sites of encounter where different species, objects, and environmental processes interact, breathe together, and mutually transform one another. Within this framework, "space" becomes more than a formally organized physical domain; it emerges as a living milieu of transitions between beings, of traces left behind, and of shared transformations. Representation gives way to reciprocity, form to becoming, and the subject at the center of design to interactive agency.

At this point, it is crucial to note the insights of Mark Dorrian, who has extensively examined the limits of architectural representation. He emphasizes that traditional representational systems—such as plans, perspectives, and drawings—tend to reduce architecture to fixed and stable images, overlooking its relational, temporal, and material dimensions. The challenge for architecture today, in this view, lies in inventing new modes of representation capable of registering *surface effects*—the shifting appearances that arise in spatial experience—together with *temporal processes* and *situated encounters* that unfold in lived contexts (Dorrian, 2015). Within the context of the Humus plane, this perspective is particularly significant: as space is rethought as a field of reciprocity and becoming, representation itself must also be reconceived as a practice that traces relations and mediates shared conditions of existence.

Such an architectural paradigm generates a multisensory surface of encounter—one that includes tactile, auditory, olfactory, and affective experiences. Beyond human-centered visual codes, experiences such as bodily proximity, material porosity, and embeddedness in the soil come to the fore. Architecture becomes no longer an object-producing discipline, but a mode of action that organizes the material, sensory, and temporary conditions of living-together.

This mode of relating concerns not only how space is produced, but with whom it is produced.

Donna Haraway's concept of *sympoiesis* emphasizes that no entity exists on its own; everything takes shape in relation with others (Haraway, 2016, p. 61). This plural mode of existence suggests that in architecture, the design process is no longer guided solely by human will, but becomes a collective configuration involving material environments, nonhuman beings, climatic conditions, and even time itself. Karen Barad's approach of *intra-action* further deepens this perspective. According to Barad, entities do not possess pre-defined and stable identities; rather, they gain their existence through ongoing relational processes of becoming (Barad, 2007, p. 33). In this context, architecture no longer aims to produce finalized objects, but to generate arrangements that enable temporary and material encounters. Open systems, symbiotic surfaces, and ephemeral spatial forms are concrete expressions of this understanding. What matters here is not what the space looks like, but how it brings different beings together.

The *Humus* plane invites us to rethink architecture not merely as the production of form or the organization of function, but as a practice of interaction that senses the conditions of shared existence and remains open to shaping those conditions collectively. While reducing this orientation to mere architectural experimentation risks flattening its ethical and ontological depth, the *Humus* plane nonetheless offers a fertile conceptual ground for understanding the plural ontological regimes and relational responsibilities illuminated by posthumanist design approaches.

A relational mode of existence inevitably leads not only to mutual influence but also to the acknowledgment of an ethical obligation. Donna Haraway's concept of response-ability emphasizes that cohabitation is grounded not only in material entanglement but also in the capacity to respond. For Haraway, this term expresses not so much the ability to act, but rather the ability to sense the presence of others, to show sensitivity to their needs, and to participate in the conditions of living-together (Haraway, 2016, p. 105). While Haraway highlights the affective and relational capacity to respond to others, Karen Barad extends this orientation by developing a model of ethico-onto-epistemology, which asserts that ethics, ontology, and knowledge are inseparable. In this view, intervening in the world is not merely a physical act; it is also a decision about how the world will come into being, who will be included in this becoming, and who will be left out (Barad, 2007, p. 90).

Therefore, every architectural decision carries not only aesthetic or technical implications, but also an ethical orientation: Who is given space? Whose trace is made visible? Whose voice finds resonance in the environment? Posthumanist architecture poses these questions before considerations of form, function, or aesthetic quality—because shaping the conditions of co-existence is not merely an aesthetic concern, but an ontological and ethical one.

In conclusion, the Humus plane calls for a reconsideration not only of the concept of the human, but also of how space is designed, how entities come together, and what kinds of responsibilities architecture entails. Through the conceptual power of posthumanist thought, this plane enables architecture to be understood not merely as a material practice, but as an ethical and ontological mode of action.

This tripartite ontological model conceptualizes the human–nature relationship as a transformation that extends from immanence to entanglement, from *representation* to *reciprocity*. The following diagram summarizes the conceptual and philosophical structure of this transformation (Figure 7).

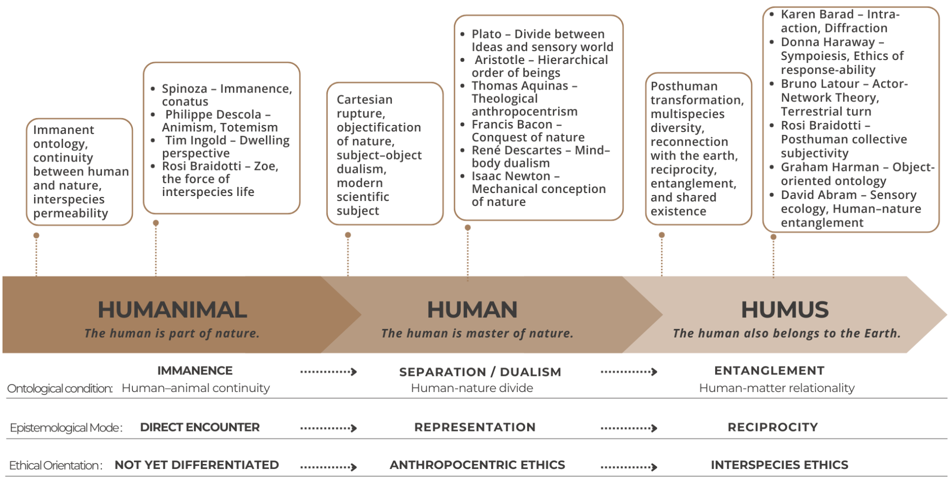

Figure 7. The Historical-Ontological Transformation of the Human: Epistemic Shifts and Relational Modes across the Humanimal, Human, and Humus Dimensions (Created by the authors)

4. Conclusion and Suggestions

This research has examined the historical roots, disintegration processes, and emerging alternatives to the anthropocentric subject model shaped within modern humanist thought through a tripartite conceptual framework: Humanimal, Human, and Humus. These three planes do not only trace ruptures in human self-conception but also offer a theoretical lens to understand how architecture's relation to nature, the body, and more-than-human entities can be reconfigured.

The Humanimal plane foregrounds a condition in which the human is not yet fixed as a separate and transcendent subject, but exists in relational continuity with nature, other species, and material environments. Dwelling is conceived less as technical construction than as a practice of living that enables sensory, bodily, and multispecies forms of being-in-space. This orientation resonates with the ontology of immanence (Spinoza, 2004), the dwelling perspective (Ingold, 2000), and approaches emphasizing nonhuman forms of thinking (Kohn, 2013). Cross-cultural ontological regimes—such as animism, totemism, and analogism—further show that the nature–culture divide is not universal but specific to Western modernity (Descola, 2013).

In architectural terms, the Humanimal plane suggests that design should not be reduced to form-giving but understood as enabling encounters, reciprocal flows, and shared sensory fields. Rather than an imposition of order, architecture becomes a milieu for multispecies cohabitation.

The Human plane represents the consolidation of the modern subject model, where the human is positioned as central, rational, and transcendent. Within this framework, nature was progressively reframed as an object of knowledge to be mastered and controlled, while all other beings were reduced to instruments at its disposal. This epistemological orientation was reinforced by early modern science and philosophy, which depicted nature through metaphors of domination and mechanistic order (Merchant, 1980; Descartes, 2005; Toulmin, 1990). Architecture, in turn, came to embody this anthropocentric regime: the body of the human male was elevated as the normative measure, most clearly exemplified in Le Corbusier’s Modulor system (Le Corbusier, 2014, Vol. 1).

Here, architecture functioned not only as a utilitarian discipline but as a representational system that projected the modern subject’s imagined superiority onto space. Nature became raw material to be classified, regulated, and shaped, while the human body became the normative unit of design. Yet ecological crises and posthumanist critiques have destabilized this anthropocentric regime, opening the way for alternative ontological orientations.

The Humus plane articulates this ontological rupture by repositioning the human within entangled relations of soil, matter, other beings, and environmental processes. In this perspective, the human is no longer a transcendent subject but one among many, continuously shaped through encounters and transformations. Humus thus conveys both a material rootedness in the Earth and an ontological orientation toward reciprocity, impermanence, and interdependence.

Within this orientation, philosophical approaches reveal distinct facets of relational existence. The idea that entities can never be fully exhausted by one another reflects the premise of *object-oriented ontology* (Harman, 2020). The insistence that ethics, knowledge, and being are inseparable echoes the framework of *ethico-onto-epistemology* (Barad, 2007). The emphasis on earthly embeddedness resonates with the concept of the *terrestrials* (Latour, 2018). Finally, the recognition that existence is always co-created with others finds expression in the notion of *sympoiesis* (Haraway, 2016).

Together, these perspectives allow architecture to be redefined not as a representational practice but as an existential and ethical one. Representation gives way to reciprocity; the centralized subject dissolves into distributed agencies; and space is reimagined as a porous, multisensory milieu in which the conditions of collective coexistence are cultivated.

Building on this orientation, emerging approaches in architectural thought emphasize:

- Developing participatory and pluralistic approaches to spatial production that acknowledge the agency of nonhuman entities and material processes;
- Moving beyond classical design frameworks based on representation, toward practices that enable sensory, temporary, permeable, and interaction-oriented forms of space;
- Approaching design not merely as a technical process but as an ethical and ontological act—placing the questions of “with whom,” “for whom,” and “how” at the center of design thinking;
- Reconceptualizing architecture as a domain that bears responsibility toward multispecies forms of life and opening possibilities for collective coexistence.

Ultimately, the trajectory that begins with Humanimal, becomes fixed in Human, and transforms through Humus invites a rethinking not only of the human but also of architecture, space, and modes of co-existence. This tripartite framework positions architecture within a new intellectual and practical horizon—one that is situated, relational, and ethically attuned to the plural conditions of life.

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Humanoid Technologies in Architecture: Redefining the Boundaries of Spatial Experience

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1. Introduction

Architecture is the art of shaping the human environment, and this gains meaning fundamentally through human experience. However, with the rapid advancement of technology, architecture has moved beyond the limits of merely designing physical structures. Especially, humanoid technologies are redefining the human-space relationship, profoundly transforming both the functional and aesthetic dimensions of architecture. As the boundaries between humans and technology become blurred, the fundamental parameters of architectural design are also undergoing a radical transformation. In this context, architecture in today's world is being redefined as a complex field of experience. This shift means that the processes by which architectural environments and spatial experiences are perceived, lived, and meaningfully interpreted by users are evolving alongside technological developments.

The digital transformation of architecture gains a new dimension with the integration of humanoid technologies into architectural practice. Something that is humanoid looks or acts like a human being, although it is not human (Collins Dictionary, n.d.). In terms of integrating humanoid technologies into design processes, the use of artificial intelligence, robotic structures, and algorithmic systems in architecture plays a critical role in the evolution of the relationship between space and humans.

The potential of humanoid technologies to transform spatial experience is becoming increasingly important in today's technology-driven social structure. While traditional architectural understanding treats space as a physical, fixed, and static entity, the transformation enabled by humanoid technologies turns space into a dynamic, multi-layered field of interaction involving emotional and cognitive processes. In architecture, these technologies go beyond building automation, allowing space to become a structure that responds to humans and actively interacts with them. Spatial experience is no longer limited to the direct relationship between the user and the space but extends into a context of data-based simulation and prediction.

Humanoid technologies, especially artificial intelligence-based systems and robotic tools, offer new possibilities in both the architectural design process and the stages of use and perception of the structure. AI architectural design tools, with their ability to "think and design like an architect," enable a dynamic, collaborative relationship with the architect during creative processes. They also allow design decisions to be tested with multiple scenarios, alternative solutions to be proposed, and aesthetic-spatial criteria to be optimized algorithmically. Therefore, changes in spatial experience encompass not only physical and visual perception but also information-based and cognitive dimensions.

The primary motivating force behind the use of humanoid technologies in architecture is to enable the “continual rediscovery” of the multilayered nature of space. In the architectural context, space is an existential field of experience; it represents a complex network of relationships shaped not only by the physical environment but also by human senses, mental perception, and technological interfaces. While traditional approaches have users experience space through vision, touch, movement, and other sensory inputs, humanoid technologies mediate these different dimensions of experience, creating a revolutionary change in how space is perceived and lived.

Technologies such as virtual reality, augmented reality, and mixed reality expand the boundaries of experience by transporting users beyond the physical space into digital realms, while robotic systems establish interactive and organic connections between the user and the space. In this sense, spatial experience and perception become deeply intertwined with humanoid technologies, undergoing a multidimensional transformation. Unlike previous architectural understandings, space is no longer defined solely by physical boundaries; through artificial intelligence and robotic systems, new forms of experience emerge that align with social, cultural, and cognitive contexts. These new types of experience break the static and inert nature of space in architectural practice, facilitating the emergence of more dynamic, flexible, and customizable environments.

Spatial experience is a fundamental dimension of the relationship between architecture and its users, encompassing how people perceive, live in, and make sense of space. Machine learning, artificial intelligence, and robotic systems are revealing transformative effects on spatial perception and experience. Within this context, the aim of the study is to examine the impacts of humanoid Technologies on spatial experience. The study seeks to reveal the ways humanoid technologies alter spatial perception and experience while also questioning their effects on the architectural production process, design decisions, and user-space interaction.

The study will analyze how advanced technologies defined as humanoid technologies—such as artificial intelligence, Generative Adversarial Networks (GAN), parametric design tools, robotic architectural elements, augmented reality (AR), and virtual reality (VR)—radically transform not only creative design processes but also users' spatial perception and experience. Specifically, it will examine the role of AI in the architectural design process and its interaction with architects; the integration of AI-based systems like GAN into design decisions; the use of robotic technologies in structural and spatial transformations in architecture; the impact of algorithmic design and parametric tools on spatial forms and arrangements; spatial experience simulation through virtual and augmented reality technologies; and the contributions of haptic robotic systems to multisensory spatial experience.

The methodological approach of the study aims to achieve new levels of knowledge and insight at the intersection of architecture and technology through a multidisciplinary perspective and a holistic view. Qualitative analysis techniques are used as the primary tools in the study. Data obtained from literature review and case studies are thematically classified through content analysis and phenomenological reading. Within the scope of qualitative analysis, the experiential components of architecture are evaluated to describe transformations in spatial perception and experience. Case analyses involve examining technology-based architectural products in terms of their visual, auditory, tactile, and cognitive dimensions of spatial experience. In this context, the study aims to contribute both theoretically and practically to the field by exploring how the interaction between architecture and humanoid technologies transforms architectural production and spatial experience.

2. Theoretical Framework of Spatial Experience and Perception

Architectural design is not only the construction of physical structures but also the process of creating spaces experienced within and around these structures. Space goes beyond being merely a physical place; as a multilayered system where social relationships, cultural values, and individual experiences interact, it holds psychological and social meanings as the stage for human connections with both the external world and their inner selves.

The sense of self, strengthened by art and architecture, allows us to engage fully in the mental dimensions of dream, imagination and desire. Buildings and cities provide the horizon for the understanding and confronting of the human existential condition. Instead of creating mere objects of visual seduction, architecture relates, mediates and projects meanings. The ultimate meaning of any building is beyond architecture; it directs our consciousness back to the world and towards our own sense of self and being. Significant architecture makes us experience ourselves as complete embodied and spiritual beings. In fact, this is the great function of all meaningful art (Pallasmaa, 2024). In this context, spatial experience and perception refer to the sensory, emotional, and cognitive relationships users establish with space, playing a central role in the meaning-making process of architecture.

2.1. Spatial Perception and Cognitive Processes: How Do We Understand Space?

Perception is not a science of the world, nor even an act or a deliberate taking of a stand; it is the back ground against which all acts stand out and is thus presupposed by them (Marleu-Ponty, 2012). Within this framework, spatial perception is the result of a person's sensory and cognitive interaction with their environment and is not limited to the physical characteristics of the space. Instead, it is interpreted through the individual's senses, memories, cultural codes, and psychological state.

Spatial perception, as a comprehensive part of sensory perception, shapes the relationship between a person and their environment.

Spatial perception generally arises from physical activities beginning in the brain, resulting from a person's interaction with the space through multiple sensory channels. The use of a space can be observed behind the unconscious actions in a person's mental perception and bodily understanding of that space. The way a person perceives their location is linked to the interactions formed by accumulated knowledge in memory based on visual and intuitive perception. This interaction occurs through both experiences and bodily actions rooted in intuition (Erap et al., 2021). One’s perception of its environment, including objects, is in direct relation with its kinesthetic dimensions; the perception and the kinesthetic dimensions together create the meaning for the said environment or objects for the individual (Husserl, 1970; Gallagher & Zahavi, 2012). Spatial perception is the sum of cognitive activities that begin the moment an individual encounters a space and are continuously updated. When encountering a space, the mind first recognizes and organizes the physical structures of the space, then makes sense of this information by relating it to past experiences.

Spatial perception is multimodal and fundamentally bound to the body that is not a mere receptor of sensory stimuli but an active agent engaged with the perceivable environment. The body apprehends the experience in which one’s kinesthetic engagement and knowledge play an essential role (Kwon & Iedema, 2022). The integration of the senses enables space to be experienced as a multidimensional phenomenon. This process leads to the formation of both the physical and symbolic meanings of space. At the core of this process is the individual's creation of mental maps and the attribution of meaning to the space. Thus, space transcends being merely a physical structure and becomes a place within the individual's subjective world of meaning.

Sensory experiences become integrated through the body, or rather, in the very constitution of the body and the human mode of being. Psychoanalytic theory has introduced the notion of body image or body schema as the centre of integration. Our bodies and movements are in constant interaction with the environment; the world and the self inform and redefine each other constantly. The percept of the body and the image of the world turn into one single continuous existential experience; there is no body separate from its domicile in space, and there is no space unrelated to the unconscious image of the perceiving self (Pallasmaa, 2024).

Spatial perception is a complex cognitive process that occurs through the brain's processing of sensory inputs, involving a holistic interaction of the sensory organs, emotions, memory, and mental processes beyond mere visual perception. Humans understand space not only in terms of measurements and forms but also based on meaning, functionality, and social context, with these comprehension processes deeply intertwined with cognitive and psychological experiences. The sensory responses of the human body to space affect the spatial experience on both physical and emotional levels.

When interpreting space, the human brain takes into account past experiences, cultural codes, and emotional states, which leads to variations in spatial experience. Therefore, spatial perception is not merely a simple reaction to external stimuli but the creation of a cognitive map shaped by individual experiences. As a result, spatial perception is not a passive data-gathering process; it is an active interpretive process involving the formation of mental maps, categorization of space, and shaping by expectations. The relationship between perception and space is critically important for understanding how space is represented and experienced in the human mind. In this context, perceiving and "understanding" space is part of a dynamic process of experience that continuously interacts with the environment.

2.2. The Multilayered Structure of Spatial Experience: Sensory and Mental Reflections

Relph (1976) defines spatial experience as the continuity between direct experience and abstract thought. Furthermore, he posits that space and society are inherently interlinked, as space is both socially constructed and shaped by the relationship between the experiencer and the experienced. This perspective integrates mental conceptions of existence with the physical dimensions of defined boundaries (Taşdemir & Öztürk, 2024).

Spatial experience, as one of the most fundamental elements of architecture, is not merely about an individual's presence in a physical space; it is a holistic integration of sensory, mental, and cultural interactions with the environment. Humans begin to relate to space through their senses; perception channels such as vision, hearing, touch, smell, and taste gather information about the space’s light, color, texture, sounds, and atmosphere.

Since an architectural space is not an independent entity from its environment; separations and integrations between the space and its environment shape experiences. It is known that the essence of the spatial experience based on the relationship between subject and object, is revealed by our reactions to space; in this sense, our body and somatic experience play a major role in the formation of spatial image (Soltani & Kırcı, 2019).

Sensory experience forms the foundation of the initial contact with space, and in this process, the function of the senses is extremely important. Experience begins with visual perception; the eyes are the organic prototype of philosophy. Their enigma is that they not only can see but are also able to see themselves seeing. This gives them a prominence among the body's cognitive organs. A good part of philosophical thinking is actually only eye reflex, eye dialectic, seeing-oneself-see (Sloterdijk, 2001). Our eyes stroke distant surfaces, contours and edges, and the unconscious tactile sensation determines the agreeableness or unpleasantness of the experience. The distant and the near are experienced with the same intensity (Pallasmaa, 2024). Vision enables the initial contact with space, while the other senses contribute to perceiving the space as a whole, determining how the space is physically experienced. However, sensory experience is only the surface of spatial perception. The mental dimension of this process involves the brain coding and interpreting sensory information to give meaning to the space. The human mind blends incoming sensory data with past experiences, memories, and expectations, reshaping space not merely as a physical entity but as an meaningful environment. In this context, when sensory perception combines with the mental processes that help the individual make sense of space, the spatial experience becomes far richer and multilayered.

The information received from the senses of the individual experiencing the space is combined with mental processes to gain meaning. The sensory perception of space is organized and interpreted by cognitive processes. This allows the individual to synthesize the space with their own experiences and knowledge, creating new meanings. Spatial perception is intertwined with human memory and cultural codes. At the cognitive level, spatial experience is shaped by navigation within the space, understanding the functional relationships between different areas, and grasping spatial organization. The meaning attributed to space is strengthened not only by individual experiences but also through social and cultural contexts.

Space is not merely a sensory object but becomes a structure woven with meanings, impressions, and emotions. This nature of spatial experience reflects a fundamental reality emerging from the intertwining of sensory and mental layers and is closely connected to the dimension of time. Space changes over time; people have different experiences within it, and these experiences form the temporal context of the space. While space physically transforms over time, individuals' perceptions and meanings associated with it also evolve. In this context, space is in a continuous process of formation and reinterpretation.

This multidimensional interaction process allows the meaning that the user attributes to space to deepen, enabling space to transcend its physical boundaries. In this context, spatial perception cannot be limited solely to structural and geometric features; rather, it also encompasses the emotional, mental, and cultural dimensions arising from the interactions between the user and the space. Space becomes a multilayered meaningful environment, enriched by the individual's sensory experiences, memories, perceptions, and social relationships. From this perspective, space emerges as a dynamic “field of experience” shaped by the user's perceptual and meaning-making processes.

3. Humanoid Technologies: Limits and Possibilities in Architecture

Humanoid technologies are systems that mimic or complement human behavior and cognitive processes both physically and mentally. These technologies encompass a wide spectrum, including robotics, artificial intelligence, learning algorithms, and human-like interaction forms. In the context of architecture, humanoid technologies have evolved beyond being mere tools for shaping, modeling, or optimizing space; they have become active agents that influence how space is experienced and how spatial perception is organized.

The development of technology in contemporary architectural practice, especially with the emergence of humanoid technologies, is reshaping the boundaries of architectural design. In architecture, humanoid technologies—from AI systems that think, perceive, and decide like architects to robotic architectural applications—are redefining spatial experience and perception. These technologies play a transformative role at multiple points, from the architect's creative process to the way space is experienced. Their use in architecture represents not merely a technical innovation but a paradigm shift that fundamentally transforms design, construction processes, and spatial experience and perception. While creating a new ground for interaction and communication between architect, user, and architectural product, these technologies also redefine the nature and limits of human-machine collaboration in the design process.

3.1. The Scope of Humanoid Technologies and Applications in Architecture

In architecture, humanoid technologies go beyond being mere tools for production; they become multilayered entities that transform how space is experienced, perceived, and how the design process itself unfolds. These technologies expand the boundaries of spatial experience while developing new paradigms based on the shared creativity between humans and machines.

Humanoid technologies are not merely robots or artificial intelligence software that imitate humans, but systems operating at physical and cognitive capacity levels that are human-like or compatible with humans. This scope represents the shift of space from being a static, passive structure to becoming a living or "quasi-living" entity that is shaped, transformed, and developed within historical, cultural, technological, and algorithmic contexts. The scope of such technologies in architecture can be examined in three main dimensions:

3.1.1. Physical humanoid entities (robotic systems)

Robots with human-like mobility, autonomous machines, and manipulative devices fall into this category. These entities create versatile applications ranging from building production and spatial transformation to maintenance, repair processes, and artistic or aesthetic interventions.

Robotics in architecture refers to the integration and application of automated machines - or robots - into architectural design processes and construction, fundamentally transforming how architects create and execute their projects. Robotics in architecture is a growing field. It uses machines to design, build, and research. These robots can bring new ideas to how we make buildings. With computer logic and digital skills, they're changing the game for architects (Cvetkovic, 2024).

In architecture, robotic science encompasses a wide range of applications—from material transport and 3D printing to the assembly of an entire building. This integration streamlines construction processes, enhancing both productivity and efficiency in the workflow. It also opens new possibilities for design exploration. The machines used are highly equipped and integrated with advanced sensors to make the entire process automated and precise (Çamuşoğlu, 2024).

Robotic technologies, with their movement capabilities beyond human physical and spatial limits and autonomous control, introduce new dimensions to architectural production and spatial experience. In architecture, these technologies play critical roles not only in material and structure production but also in reconfiguring spatial experience. Humanoid robots or robotic systems are considered not only for their mechanical functionality in design and construction processes but also as spatial entities. This technology enables robotic design elements that move within space, interact, and dynamically relate to their environment.

3.1.2. Cognitive humanoid systems (artificial intelligence and machine learning)

Algorithmic systems that support spatial decisions, learn from experience, and play roles in creative production and analysis processes belong to this category. Artificial intelligence (AI) in architecture stands out not only as an automation tool but also as a thinking and decision-making mechanism that mimics human cognitive processes. Defined as a technology that automates data analysis, learning, and decision-making, AI introduces new perspectives in spatial production (Pekince, 2024). AI, encountered in almost every area of life, has begun to be used in architecture alongside rapidly advancing technological developments. Initially focused on imitating human thinking and learning processes, AI later also addressed forms of human interaction, bringing new descriptors to architecture such as "interactive, informational, intelligent." Today, with the increasing use of information technology in architecture, the widespread understanding of smart building/space design is a result of AI application in the field (Taşçı & Aktaş, 2016). This technology holds significant potential in analyzing complex architectural decisions, producing alternative design solutions, and personalizing spatial experience.

Advances in artificial intelligence (AI) and machine learning (ML) present an opportunity to advance architectural spatial layout planning (SLP) and resolve limitations in previous work. Spatial layout planning in architecture requires a deep understanding of topological spatial relationships, yet the process remains repetitive and laborious for designers. However, advancements in artificial intelligence (AI) offer new perspectives through automated spatial layout planning (ASLP), diverging from traditional human-centered approaches (Ko et al., 2023).

Humanoid artificial intelligence systems learn the architect's way of thinking, offer aesthetic and functional suggestions, and act as active collaborators in the design process. AI's direct impact on architectural design decisions goes beyond processing numerical data, becoming an integral part of creativity. Generative models like GANs add originality and diversity to the design process while facilitating the architect's ability to transcend cognitive boundaries.

3.1.3. Interactive humanoid interfaces

Sensors that establish emotional and cognitive dialogue between space and user, responsive interface systems, smart technologies, and adaptive, dynamic structures fall into this category. These technologies give space personalized, adaptable, and dynamic behaviors. Humanoid interfaces that respond to human movements, voices, or emotional expressions transform spaces into more dynamic and personalized experience zones. Dynamic and adaptive interactive humanoid technologies add multilayered perceptual and functional qualities to architecture. Space is no longer solely visual but enriched with tactile, auditory, and kinetic interactions.

Dynamically controlled adaptable building facades refer to façades that can adjust to changing environmental conditions. Terms like "smart," "kinetic," "intelligent," and "active" are various variants of "dynamic" and "adaptable," often used interchangeably despite having different specific meanings (Kara, 2025). Dynamic building envelopes can be designed with mechanical systems that are movable, rotatable, expandable, or contractible through different operation methods. Research continues on "zero-energy" dynamic façade designs based on materials. These systems, which provide shading effects at micro and macro scales, aim to optimize energy performance to the highest possible level (Yaman & Arpacıoğlu, 2021).

3.2. The Evolution of Human-Machine Collaboration: New Roles and Responsibilities in Architecture

In architecture, human-machine collaboration represents a more complex and layered process than unilateral human control. New humanoid technologies become active and creative partners in architecture.

Integrating these technologies into architectural design processes necessitates a new collaboration model that blends human creativity and intuition with technology's technical power and processing capacity. This collaboration requires the architect to be not only a designer but also a technology user, decision-maker, and technology-focused thinker.

As humanoid technologies become integrated into architectural practice, the concept of space extends beyond traditional boundaries. Space transforms from a static structure or environment into a dynamic, multilayered, and interactive experiential field. This transformation requires architects to adopt innovative methods supported by algorithmic thinking, data analysis, and simulation capabilities alongside classical architectural approaches when making design decisions. Thus, the design process evolves beyond manual aesthetic and functional evaluations into a collaborative intelligence enriched by machine learning and generative adversarial networks (GAN)–based suggestions and optimizations.

Thus, architecture has entered a phase of transformation into a new discipline where human-machine interaction is elevated, and human perception and experience boundaries are extended through technology. This change redefines the limits of spatial experience, opening new horizons in both the theoretical and practical perspectives of architecture. In this context, collaboration with humanoid technologies can be examined in the following dimensions:

Shared Decision-Making Processes: Artificial intelligence and robotic systems provide decision proposals through big data analysis, rapid calculations, and simulations. In architecture, this requires a balanced synthesis of the architect's intuition and creativity with the algorithmic power of technology at different stages of design. The multiple and complex decisions arising during the design process are effectively distributed between technology and humans. For example, while AI offers alternative solutions based on big data and simulations, the architect makes the final decision considering aesthetic, historical, and cultural contexts.

Adaptation and Learning: The interaction between humans and machines is a continuously evolving dynamic process. Algorithmic systems learn the architect's design preferences while the architect experiences new methods, databases, and analytical approaches offered by the technology. Machine learning algorithms, by understanding the architect's preferences and the project-specific context, produce more competent and adaptable designs. This accelerates the design process and enables innovative solutions.

Integrated Creativity: Human-machine collaboration offers a dual yet integrated mode of production in the creative process. While the architect develops abstract concepts, artificial intelligence models quickly test and optimize these ideas, enhancing both the speed and depth of creative experimentation. Humanoid technologies expand the architect's exploratory scope by rapidly generating and testing different design scenarios. This enables the optimization of spatial programs according to diverse user needs and environmental conditions.

Phenomenology of Interaction: The dialogue established between humans and humanoid technologies synthesizes the architect's intuitive approach with algorithmic suggestions, supporting the emergence of innovative and context-sensitive design forms. Within this framework, human-machine collaboration is not only a technical process but also a phenomenological experience. The dialogue itself in the design process enables the redefinition of spatial perception and phenomenological experience. The capacity of humanoid technologies to respond to human emotion and spatial perception enriches user experience, deepening architecture's phenomenological dimension, multiplying the ways of relating to space, and expanding the boundaries of spatial experience.

4. Paradigm Shift in Architecture: The Effects of Humanoid Technologies on Spatial Experience

The discipline of architecture, shaped throughout history by social, cultural, and technological changes, is now undergoing a profound paradigm shift influenced by humanoid technologies such as artificial intelligence, robotic systems, and interactive interfaces. This transformation reshapes the foundations of spatial experience, alters the architect's role in their relationship with space, and adds a new dimension to the way experience is lived.

One of the most tangible reflections of the paradigm shift caused by humanoid technologies in architecture is the change in the perception and experience of space. In this new paradigm, the concept of space moves beyond being fixed, static, and one-dimensional to being defined as a temporal and experiential "plurality." Space continuously evolves through users' perception, sensory responses, technological interactions, and socio-cultural contexts. Humanoid technologies play a role in this process by both intervening in the physical characteristics of space and expanding its experiential dimension.

The paradigm shift brought by humanoid technologies in architecture causes radical transformations in both the design and perception dimensions of spatial experience. These technologies analyze micro-spatial experience patterns and continuously adapt to users' needs, enabling space to acquire a flexible and pluralistic structure. Space no longer remains a fixed and static entity but transforms into a dynamic, responsive, and relational process supported by digital and artificial sensory systems.

The user-space relationship is the dimension that most directly reflects the impact of humanoid technologies in architecture. Traditional architecture bases the experience of space on certain universal patterns and views this experience as static. However, today, the user's individual experience of space becomes dynamic with the involvement of sensors, artificial intelligence algorithms, and robotic systems. These systems make responsive adjustments based on the user's presence and conditions in the space. In this way, space transforms from a passive environment into an active entity interacting with the user.

This type of spatial flexibility allows for personalized experiences, multiple user scenarios, and contextual adaptability. AI-based systems can provide continuous, real-time feedback on the expected architectural experience, even in the early stages of design. This approach allows students and young architects to refine their proposals based on informed predictions, without the need for direct interaction with real users (Fischer & Schmid, 2025).

AI is transforming design, shifting designers from hands-on creators to curators focused on strategy. As design becomes more about shaping experiences than creating from scratch, this shift is setting the stage for a new era of design practices. AI models can recognise and emulate patterns in design. This enables people who may lack technical training to turn a conceptual idea into a visual draft, essentially bypassing the need for extensive design skills. For designers, this automation can accelerate the process of prototyping or wireframing, allowing more time to focus on the creative aspects of a project (Budd, 2024).

The integration of robotic technologies into the construction process transforms the mode of spatial production, increasing flexibility and customization in the design and assembly stages of building components. Robot-assisted structures accelerate the architect's process of bringing imagination into the physical world, offering new form possibilities and, accordingly, new experiential opportunities.

Humanoid technologies expand not only the technical aspects of architectural design but also the ways space is experienced, making spatial perception more multilayered, interactive, and dynamic. While traditional architecture relies on physical senses for spatial experience, today this is broadened and deepened through sensors, augmented reality (AR), virtual reality (VR), and sensory shaping technologies offered by humanoid technologies. Space now becomes an environment intertwined with digital layers, shaped by the user's time spent within it, responsive to them, and even reprogrammable. This requires space to be designed not merely as a physical structure but as a comprehensive system of interactive technologies. Within this context, the paradigm shift in architecture leads to an evolving, technology-integrated, and user-centered spatial experience.

When spatial experience is defined as the entirety of human sensory and cognitive processes, the impact of humanoid technologies enables the emergence of a multilayered and enriched experiential network. In scenarios where space interacts with its user in a "multisensory" manner, AI-based systems become tools that differentiate, measure, and guide every dimension of experience. The way these technologies transform spatial experience involves the continuous restructuring of the subject's knowledge and perceptions. By creating a new ecosystem between the user and space, humanoid technologies turn space from merely a place to live into an experience zone constantly explored by the user.

Technological advancements also pave the way for diversified forms of experience within space. Through the manipulation of robotic systems, users can physically reshape the space or interact with smart elements that move within it, differentiating spatial functions. In this context, new scenarios emerge at the intersection of space, user and technology. Smart systems can respond instantly to users' needs, thereby enhancing both the functionality and tangibility of the environment. This demonstrates that spatial experience is shaped not only by the space itself but also by technological entities within it and the interactions established with them.

Another important dimension of the paradigm shift involves ethical and philosophical questions arising during the design process. The use of humanoid technologies that expand spatial experience raises new responsibilities regarding privacy, user autonomy, and transparency in AI decision-making processes. Designers must be sensitive to the potential risks of these technologies and act consciously from an ethical standpoint while enhancing spatial experience. Moreover, establishing ethical and creative balances between technology and humans in design has become a fundamental topic of debate in architectural practice.

In summary, the paradigm shift in architecture is manifested through humanoid technologies as space has become a multilayered, dynamic, and interactive environment shaped by human perception, AI predictions and interventions, and robotic system manipulations. This transformation fundamentally alters the epistemology of the architectural discipline, design processes, and understanding of spatial experience, while creating new opportunities and responsibilities. By embracing these humanoid technological tools, architecture expands the boundaries of spatial experience and compels a renewed reflection on the space of the future.

5. New Forms of Experience in Spatial Interaction: Examples from Static Architecture to Dynamic and Responsive Systems

Architecture has historically been shaped by modes of perceiving space and spatial experiences. Traditional architectural approaches are largely based on static structures and fixed forms, relying on the user's physical and visual relationship with space while remaining as fixed environments without interactive or variable dynamic systems. Today, with the integration of humanoid technologies into architecture, spatial experience gains new dimensions, replacing the static architectural understanding with dynamic, responsive, and adaptable building systems.

5.1. The Biomimetic Transformation of Experience and Perception: The BIQ House

BIQ House (Figure 1) is a significant milestone in the innovative use of robotic systems. The BIQ House in Hamburg, became the first building worldwide to feature a full-scale bioreactive façade system covered with microalgae. This façade goes beyond the static architectural approach, offering a dynamic and responsive building envelope experience.

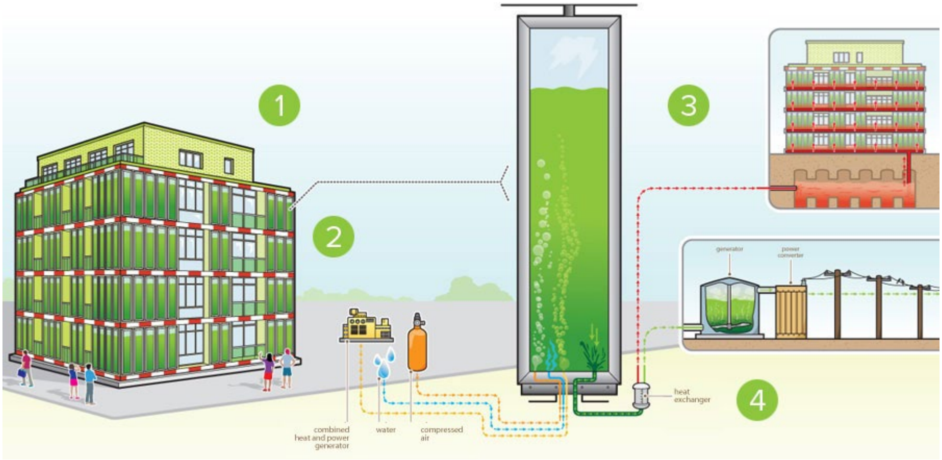

Figure 1. BIQ House Working Concept (Rethinking the Future, n.d.)

Built as part of International Building Exhibition 2013 in Hamburg, the BIQ house features 200 square metre of integrated photo-bioreactors (Figure 2). The innovative passive-energy BIQ house generates microalgae biomass and heat as renewable energy resources. Highlighting the full potential of the technology, the system integrates additional functionalities such as dynamic shading, thermal insulation and noise abatement (FX Design, n.d.).

The building's form is a straightforward cuboid with a total built-up area of approximately 1,350 sq.m. Its design is intentionally functional, prioritising performance over elaborate aesthetics. The north-east and north-west facades feature basic fenestration, while the south-east and south-west sides are clad in bio-adaptive panels, or bioreactors, that house algae cultivations. These bioreactors, which are seamlessly integrated into the façade and form its outer shell, are strategically positioned to harness the abundant sunlight available on these sun-facing sides of the building, using it to fuel the algae's photosynthesis and generate bio-energy. The minimalist approach reinforces the building's emphasis on practicality and environmental innovation (Rethinking the Future, n.d.).

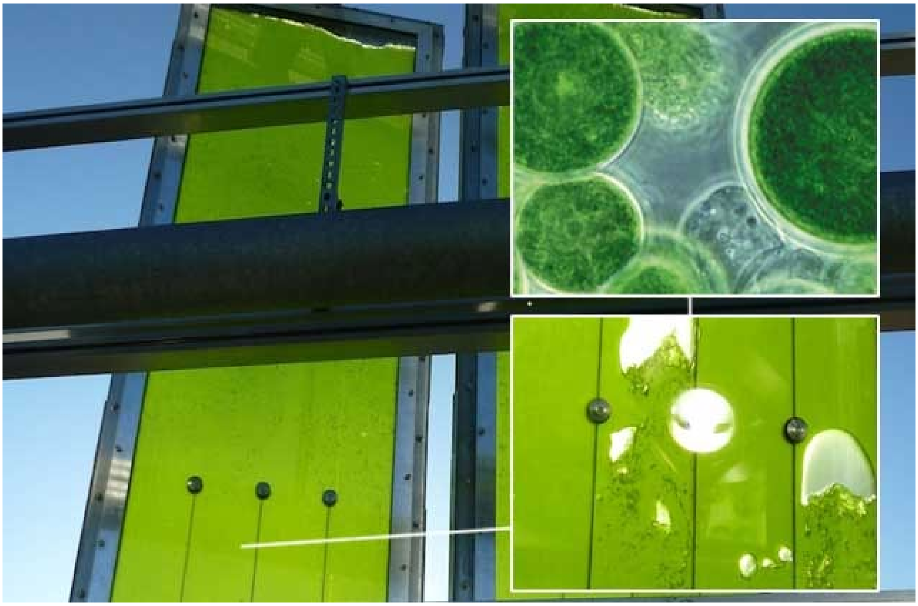

Figure 2. Bioreactive Façade with Algae Filled Panels (Beciri, 2013)

Robotic systems control the air bubbles inside the bioreactor containers filled with microalgae in the façade panels of the BIQ House. These bubbles promote the photosynthesis of the algae, optimizing the biochemical processes. Since the system automatically regulates the growth of algae based on the intensity of sunlight, the façade gains varying colors and transparency under different lighting conditions.

This design decision goes beyond the traditional boundaries of static architecture. The façade is no longer just the outer shell of the building; it functions as a system responsible for energy production and environmental control. Components such as thermal comfort, light quality, and sound insulation are directly influenced by the performance of the robotically operated bioreactors. The architect transforms the façade into not only a visual or mass element but also a design tool focused on environmental and technological interactions. Users cease to be passive occupants of the space; instead, they encounter an environment that interacts with the façade and changes accordingly.

The façade of the BIQ House, integrating robotic and biological systems, expands the boundaries of spatial experience. It symbolizes the transition from a static façade concept to a dynamic and sustainable system model that is responsive to the presence of users and external environmental conditions over time. This system allows us to perceive architectural space as a "living" organism and serves as a significant example of how spatial experience in architecture can be transformed through human-centered technologies. This transformation in spatial experience makes the user-building relationship dynamic, extending beyond the physical limits of architecture. The microalgae interaction in the façade shapes the visual, thermal, and ecological qualities of the space, providing users with a continuously changing experience and enhancing the temporal and sensory dimensions of the environment.

5.2. New Horizons in Spatial Perception: AI-Based Generative Design and Zaha Hadid Architects

Zaha Hadid Architects uses AI text-to-image generators like DALL-E 2 and Midjourney to come up with design ideas for projects, studio principal Patrik Schumacher has revealed (Figure 3). At a recent roundtable discussion on how artificial intelligence (AI) could change design, Schumacher delivered a presentation about Zaha Hadid Architects' use of image-generating technology (Barker, 2023). Zaha Hadid Architects is one of the pioneering architectural firms that brings a new dimension to the design paradigm by using artificial intelligence in architecture. By especially integrating generative design methods, they have not only accelerated spatial design processes but also expanded the boundaries of design, enabling the emergence of organic and complex forms that were previously difficult to achieve (Figure 4 & Figure 5). Projects carried out with ZHA's Generative AI tools have transformed the traditional decision-making mechanism of the architect, creating a revolutionary impact on the perception of space.

Figure 3. ZHA Images Produced by Stable Diffusion (Barker, 2023)

Designs obtained through generative design enable the emergence of complex, fluid, and organic forms from the early draft stages of the space. The combination of Zaha Hadid’s aesthetic approach with the computational power of artificial intelligence offers an unconventional sensory richness in spatial experience. The user not only utilizes the space shaped by AI’s suggestions but also gains a new spatial awareness by perceiving the depth, flow, and continuity of the form.

Figure 4. ZHA Images Produced by DALL-E 2 (Barker, 2023)

Figure 5. ZHA Images Produced by Midjourney (Barker, 2023)

AI-based designs emerging in ZHA projects enhance the continuity and fluidity of space, enriching the relationship between the user and the environment. The space transforms not only through its physical boundaries but also into a sensory and perceptual experience field shaped by AI-generated formal and spatial decisions. AI-assisted designs can propose different spatial solutions based on user movements, lighting conditions, and functional needs. Thus, the spatial experience becomes a dynamic process that evolves over time according to the interaction between the space and the user. This transformation in architectural design makes the space more customizable and user-centered.

Zaha Hadid Architects' AI-supported generative design applications open new paradigms in redefining spatial experience in architecture. Space is not merely the sum of physical forms; thanks to AI's innovative algorithms, it becomes a continuously evolving environment that interacts with users and offers a multi-layered sensory experience. These systems expand the boundaries of spatial perception by enabling the creation of dynamic, adaptive forms that were previously impossible, moving architectural practice beyond static codes.

5.3. The Evolution of Perception in Spatial Experience: Humanoid Social Robots and Superflux's Drone Aviary Project

Superflux's "Drone Aviary" Project (Figure 6) constitutes an important example of how humanoid social robots introduce new forms of experience in the context of spatial experience. Superflux co-founder Anab Jain explains "Drone Aviary is a research and development project, which explores the social, political and cultural implications of drone technology as it enters civil space." (Hobson, 2015). The project examines the social, political, and cultural impacts arising from the presence of autonomous drones with human-like characteristics in the urban environment. Space becomes not only the sum of physical structures but a multi-layered and dynamic experience shaped by the symbiotic and interactive relationships established with robotic entities.

Drone Aviary depicts swarms of drones that move and make decisions autonomously in the city, exhibiting human-like behavior. These humanoid robots gain a significant presence not only in the physical space but also in the social space. The user's experience of the environment is shaped by the mobility and behaviors of these robotic entities, replacing the static and inert urban experience with dynamic, interactive, and emotionally rich mechanical organizations.

Figure 6. Drone Aviary Installation at the Victoria and Albert Museum (Hobson, 2015)

Architectural design mandates that robotic systems be considered not only as technological components but also as social agents. Drone swarms redefine the physical and social structure of urban space. The spatial experience is shaped by the continuous flow, visibility, and surveillance dynamics created by these drone movements (Figure 7). People's sense of safety, expectations of privacy, and modes of social interaction in the urban environment vary depending on the behavior of the drones.

Figure 7. Madison Advertising Drone & Nightwatch (Hobson, 2015)

Space is no longer just a functional platform for human experience but also for the actions, perceptions, and decision-making processes of robotic agents. This shared living environment is a complex hybrid space requiring both physical and social regulations. When users encounter these robotic swarms in the city, their spatial perception is continuously redefined, and with mechanisms such as movement, surveillance, and social control, the spatial experience becomes more layered and complex. Human-robot interaction provides a dynamic that affects space emotionally and cognitively, opening the door to new forms of sensory and social experiences in the urban environment.

5.4. AI and Robotics Integration: MIT Senseable City Lab's Responsive City Pavilion

MIT Senseable City Lab is one of the pioneering projects on how artificial intelligence and robotic technologies can be integrated into architecture. The Responsive City Pavilion (Figure 8 & Figure 9) demonstrates how AI-supported robotic systems transform spatial experience. This pavilion is a structure that can dynamically change its form and function in response to environmental data and in accordance with the movements of users. Thus, the space goes beyond fixed forms and becomes a responsive and adaptive organism that is in consant harmony with the user.

Figure 8. Data Points to Create Virtual Environments (Tesler, 2022)

The functionality of AI and robotic integration enables new approaches in the design process. Space now adapts to the expectations and behaviors of the user, guides them, and simultaneously creates new experiential situations. Since the user's movements and environmental variables determine the form and function of the space, the static boundaries of the space disappear, leading to a continuously reshaping form.

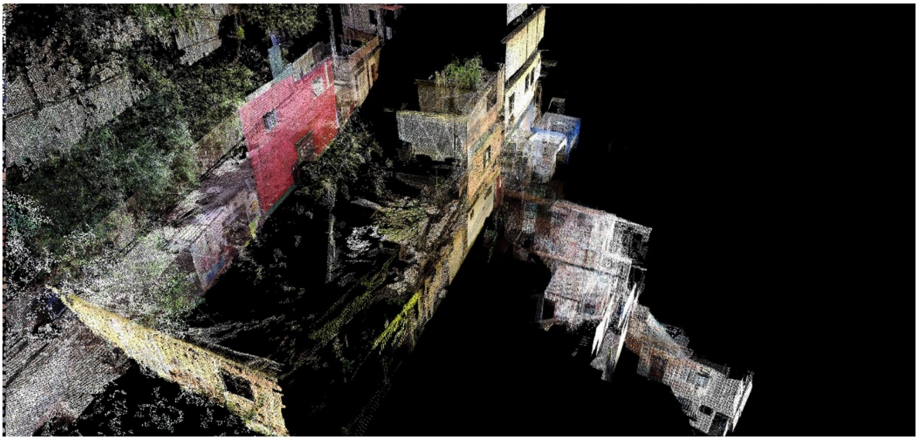

Figure 9. Data Points to Create Virtual Environments (Tesler, 2022)

In the case of the Responsive City Pavilion, space is not just a physical area occupied; it is a living experiential field shaped by the presence and movement of users, environmental conditions, and data flows. AI algorithms and robotic systems continuously alter the pavilion's form based on external stimuli such as temperature, light, and wind, as well as the movements of users inside. This offers users a spatial experience that changes over time, adapts, and remains open to interaction.

Consequently, the perception of space is enriched with temporal and sensory layers. The user engages with the space not merely passively but through a form of mutual communication and interaction. This constant change in spatial experience transcends the static boundaries of architecture, enabling the space to be experienced as a living, responsive, and dynamic organism.

The Responsive City Pavilion stands out as an architectural example where the spatial experience adapts to the presence and interaction of the user. Users engage with the space by directly experiencing the movement and shape-shifting of the pavilion's components. This interaction blurs the boundaries between space and user, while also redefining spatial perception on both collective and individual levels. With this model, AI and robotic technologies enable the creation of new responsive systems and forms of experience in architecture, extending spatial experience beyond the purely visual or functional. The space, with its variable and adaptive qualities, responds to users' mental, physical, and emotional states, bringing a fresh perspective to the ideal of human-centered design.

6. Conclusion and Suggestions

The rise of humanoid technologies in architecture is leading to profound changes in spatial experience and perception. Artificial intelligence and robotic systems, which go beyond traditional architectural approaches, not only transform design processes but also enrich and redefine how users interact with space. Spatial experience, influenced by humanoid technologies, transcends limited sensory and cognitive dimensions to become a form capable of interactivity and adaptation. This shift represents the user's move from a passive observer of space to an active and interactive participant. Thanks to the possibilities offered by humanoid technologies, spatial experience reaches multidimensional and dynamic levels, and the architectural discipline evolves from human-centered design toward a human-technology hybrid approach (Table 1).

Table 1. Role of Humanoid Technologies on Spatial Experience & Perception and Collaboration in Architecture (Developed by the author)

Technology	Impact on Spatial Experience	Impact of Spatial Perception	Role and Collaboration in Architecture	Example of Use/ Contribution
Virtual Reality (VR)	Experiencing space through movement, time, and bodily interaction	Enhancing the visual and physical dimensions of space	Realistic spatial simulation in the design process	Deepening the experiential and emotional perception of spaces
Artificial Intelligence (GAN)	Producing new spatial solutions in the design process	Expanding perception by synthesizing alternative spatial formations	Support during analysis, synthesis, and evaluation stages	Creating rapid and diverse design alternatives
Robotic Technologies	Adding new dimensions to the physical interaction with space	Increasing interaction between humans, machines, and space	Automatic production and spatial adjustments in collaboration with architects	Automated building systems, moving elements
Augmented Reality (AR)	Expanding experience by adding digital layers to real space	Increasing real-digital interaction within the space	Enhancing user-based experiences and providing design feedbacks	Interactive solutions for the use of space

One of the most fundamental impacts of technologies transforming spatial experience is making spatial qualities customizable and universally accessible. Advanced systems analyze users' needs, habits, and emotional states to optimize the form and function of the space. This challenges the generalized approaches, leading to unique and accessible designs for everyone in terms of spatial experience. Thus, architecture can take on an inclusive, responsive, and flexible form within social and cultural contexts. The integration of humanoid technologies in architecture brings a radical transformation to the process of meaning-making in space. Space is no longer just a physical entity; it emerges as a phenomenon that interacts with, learns from, and evolves through artificial intelligence and robotic systems. This reconfigures the temporal dynamics of spatial experience, allowing the relationship between space and its past, present, and future to be continuously updated through technological infrastructures.

The new understanding of spatial experience developed alongside humanoid technologies is expected to become increasingly personalized and integrated in the future, thanks to artificial intelligence's growing learning ability and adaptation capacity. The combination of AI with technologies like augmented reality and virtual reality will create hybrid spaces that establish a strong connection between real and virtual worlds, featuring multiple sensory and symbolic layers. The design process will be able to more consciously and comprehensively guide spatial solutions by perceiving users' behaviors, preferences, and emotional states, enabling more effective and flexible implementation.

In light of these developments, transformation is required in many areas, from architectural education to practical applications. Increasing knowledge and skills in artificial intelligence and robotic technologies and encouraging interdisciplinary approaches should be prioritized. However, the ethical, social, and cultural questions brought about by these advancements must not be overlooked. The power of technology to reconfigure spatial experience should be considered for its significant impacts on fundamental elements such as the public nature of space, privacy, and cultural identity. The evolution of architecture with humanoid technologies necessitates rethinking the human mode of existence in space and reflecting this reconsideration in design practice. Within this framework, a sustainable collaboration model between architects and artificial intelligence should be developed not only on a technical level but also ethically and aesthetically.

In conclusion, humanoid technologies in architecture are redefining the boundaries of spatial experience while also transforming the epistemological and ontological foundations of architecture. Space is shaped as a living and dynamic experiential field, a collaborative product of human and machine intelligence. This evolution signifies a lasting transformation in the nature of architectural design, calling for a reinterpretation of spatial perception within the framework of user-machine interaction and the development of design approaches accordingly. In this context, technology in architecture ceases to be merely a tool and becomes a creative and active component of spatial experience. The deeper integration of humanoid technologies in architecture in the future will enhance the personalization, adaptation, and sustainability of spatial experience, elevating architecture's function and meaning in human life to new levels.

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Conceptual Transformation of Archigram Futurism and Its Reflections in Architecture

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1. Introduction

This study aims to analyze the works of the Archigram group, one of the prominent representatives of the futurist avant-garde movement that emerged within the architectural atmosphere of the 1960s modern period. Rather than approaching Archigram as a singular and fixed phenomenon, the study focuses on its multifaceted character and the conceptual diversity that resulted from its internal critiques and transformations over time. The rich and experimental vocabulary developed by Archigram has continued to resonate in the architectural productions that followed, leaving conceptual traces in contemporary design thinking.

According to Alan Colquhoun, modern architecture derives its value from being part of a historical continuum. Its true meaning is not found solely within the lineage of architectural history, but rather in its ability to reflect the collective values of its own time. Architecture must be new in a way that evokes the spirit of its age (Colquhoun, 1990). Within modern architecture, futurist tendencies have also evolved through shifting approaches across different periods. When Archigram emerged in the 1960s, the intellectual discourse around futurist architecture had already shifted significantly from its early twentieth-century roots. Antonio Sant'Elia's Città Nuova, with its aesthetics that merged machinery and architecture, became emblematic of the early modern style later criticized as soulless and emotionally detached.

By the 1960s, the cumulative effects of two world wars, along with sweeping technological and sociological transformations, had reshaped everyday life and acted as a driving force behind new architectural paradigms. Established norms and traditions were increasingly being challenged and replaced by new ways of thinking.

The architectural thinkers of the time who intellectually nourished the formation of Archigram are also embedded within this historical cycle. Although collective formations such as CIAM, Bauhaus, and Team 10, as well as architectural pioneers like Buckminster Fuller, Constant Nieuwenhuys, Bruno Taut, Cedric Price, and Yona Friedman, each represent different architectural approaches, various conceptual ties can be drawn between them and Archigram. These connections suggest that the designs produced by each architect or collective are not only the result of their own internal critiques, but also reflections of shared ideas and ways of seeing shaped by the broader modernist process (Conrads & Yavuz, 1991).

According to Sadler, despite these affiliations, the ideas that inspired Archigram went beyond merely looking back at academic precedents. While they respected earlier avant-garde approaches, they shared modernism's foundational notion of constantly seeking out what is new and potentially pioneering (Sadler, 2005). This orientation reveals their distanced perspective toward site-specific design and traditional architectural methods.

Why did Archigram emerge? According to Peter Cook, the origins of Archigram lie in the spontaneous architectural conversations he had with David Greene and Michael Webb. Their shared sense of suffocation within the existing architectural environment of the 1960s, and their desire to influence the dominant discourse through their own publications, became the driving force behind their work (Cook, 1994).

The term Archigram was coined by combining the words Architecture and Telegram. While it was initially used as the name of the group’s first self-published magazine, it eventually came to represent the entire collective, their architectural philosophy, and their expressive style in the architectural discourse. The first issue of the magazine that only two pages long was published in 1961 by newly graduated architects Peter Cook, Michael Webb, and David Greene. It aimed to provide a rapid means of communication for the rising wave of architectural avant-garde thinking among students and young architects, and to establish a common platform for like-minded individuals. In the following issues, Ron Herron, Dennis Crompton, and Warren Chalk joined the team, forming the group’s well-known core of six members. Archigram’s work continued through nine issues published until 1970, with a final publication, titled 9½, released in 1974, marking the end of their active collaborative period (Cook, 1999).

Archigram’s unique style of expression was one of the key factors in its recognition within architectural circles. Their stylistic approach that formed through a combination of collage, comic strips, posters, and slogans set them apart from the mainstream architectural discourse and shaped their international public identity. Beneath their bold visual language, their published works reveal clear and at times subtle ideas that critically reflect on social, economic, and architectural issues. The emergence of Archigram as a futuristic avant-garde movement within modern architecture, as well as the scope of its activities, reveals a notable diversity. Though the six founding members produced under a collective identity, their differences in age, geography, and areas of interest fostered the development of innovative perspectives within the group and enabled a continual process of renewal driven by this internal variety (Kardaş, 2024).

2. Material and Method

Archigram's evolving mode of production can be observed through the publications they produced over the years. The varying themes, design trajectories, and architectural positions they explored in each irregularly issued magazine provide insights into the group's shifting focuses. Nevertheless, overarching principles that span across all their publications are also present. These core principles, articulated in their manifestos and expanded over time, are evident in their architectural outputs.

For this reason, a comprehensive examination of all of Archigram's output forms the structure of this study. The nature of their work is evaluated along several axes, including function, scale, user, form, and spatial organization. As a group that emerged within the modernist architectural environment, their work cannot be considered separate from the social, temporal, and spatial context that shaped their era. A deeper understanding of this modernist context is crucial for interpreting the dynamic and reciprocal relationship between architecture and the human condition. Accordingly, both individual and collective contributions to modern architecture have been explored through the writings of architectural historians, critics, and sociologists. This approach has enabled a detailed reading of Archigram's formation, transformation, and lasting impact.

3. Findings and Discussion

Based on an evaluation of Archigram's written and oral publications, the group's evolving design paradigm over the years has been examined in three phases. These can also be interpreted as an introduction, development, and conclusion. Although the chronological progression of their work does not present rigid breaks, it aligns with the principles outlined in their manifestos. Still, the direction in which their ideas and forms evolved reveals a clear intellectual transformation.

The conceptual diversity brought about by this transformation has left discernible traces in various fields of architecture in the following decades. In tracing these influences, this study aims to reflect on theoretical frameworks, architectural practices, and the diverse realities of existence that shaped the era in which these ideas emerged.

3.1. The Expressionist Phase 1961-1964

The first issue of Archigram was published in 1961 as a two-page leaflet. Edited by Peter Cook, David Greene, and Michael Webb, the issue compiled selected student projects alongside slogans that reflected the themes they wished to explore. It also featured a poem by David Greene that could be considered a kind of manifesto for the group. In his poem, Greene highlighted the significance of the new phenomena emerging in contemporary life and spoke of novel possibilities. In his view, architecture should align itself with the realities of its time like the countdown to a rocket launch, the helmet of an astronaut, or new mechanical and technological equipment capable of carrying the human body. Using the example of the brick, he argued that traditional methods of construction and standardized angular forms were no longer adequate to express the complexities of the human mind. This conventional approach had reduced architectural thought to façades and a surface-level artistic language. According to Greene, it was this condition that had caused the "love" for architecture to die. A new generation of architects had to emerge one that rejected the increasingly rigid principles of modernism in order to truly capture its original spirit (Cook, 1999).

In his poem, Greene also spoke of the new materials made possible by the era and how their forms could be shaped in countless ways. Steel could be bent to any desired curve, plastics could assume infinite shapes through their molds, string could be woven into any network, and paper tubes could be manufactured at any length (Cook, 1999). For Greene, discovering and continually seeking out this latent potential within everyday life would be the path to rediscovering the lost "love" for architecture. Additionally, the first issue of the magazine featured a series of slogans that outlined the group's emerging design direction *form*, *futurism*, *expressionism*, *flow*, *skin*, *plastics*, *mechanics*…

The special project selection featured in the first issue included works that Archigram members had recently developed or drawings by architects whose design sensibilities resonated with the group's vision. Movement, vitality, and shell-like forms were recurring themes among the chosen works. One of the most significant examples supporting this narrative was Michael Webb's 1958 project *Furniture Manufacturers Association Building*, featured in the issue. The structure, composed of rounded units joined together, reflected Archigram's desire to break away from the right-angled rigidity of conventional modernist architecture. According to Webb, the project that is presented during his fourth-year jury was harshly criticized by James Stirling, one of Britain's leading architects of the time, who likened it to a "prehistorical monster" attempting to shed its outdated exoskeleton (Chalk & Crompton 2018). The project is also considered the first example of the "*Bowellism*" movement. It became one of the most celebrated student projects in the avant-garde scene of the late 1950s (Sadler, 2005).

Another drawing featured in the first issue was David Greene's *Baghdad Mosque*, designed as his diploma project in 1958. The structure resembles a flower on the verge of blooming. The slogan "the inner void pushes the skin" was inscribed around the visuals of the project. (Chalk & Crompton, 2018). This phrase offers insight into Archigram's expressionist ambitions. The building's boundaries, the voids created to let in light, the pressure exerted outward by the interior, and the enclosing skin together formed an organic shell where each element balanced and constrained the others. As a building type, the mosque had minimal functional requirements, offering flexibility in shaping the form. This allowed Greene to prioritize form, structure, and surface. With a conceptual structure in mind, he meticulously focused on technical, technological, and material aspects. According to Greene, the structure resembled a hyper-baroque object formed by carefully rotating a Gothic section around itself, where vaults, walls, floors, and ceilings merged to blur their distinctions (Chalk & Crompton, 2018).

In the early part of the century, modern architectural practice was largely guided by functional control. However, the ensuing dissolution of this approach began to manifest in student projects and avant-garde thinking. Within Archigram's design trajectory, the form of the architectural structure and its constituent elements began to merge, creating organic shapes in which the boundary between interior and exterior gradually dissolved. The principle of form follows function held little appeal for

Archigram; for them, form should instead follow the idea that makes architecture delightful (Chalk & Crompton, 2018).

Archigram's second issue was published in May 1962, continuing the group's experimental approach to architectural projects. In this issue, other members of the group Dennis Crompton, Warren Chalk, and Ron Herron appeared for the first time with their projects, introduced as employees of the London County Council (L.C.C). Unlike the earlier student-driven projects, these members represented a bridge to the architectural profession, actively participating in built architecture at the time (Sadler, 2005). The projects in the first issue were associated by architectural circles with the aesthetics of Gaudi and Erich Mendelsohn. However, the group members regarded this comparison as an incomplete assessment. While they acknowledged partial similarities with Art Nouveau and Mendelsohn's expressionism, they emphasized that the inevitable changes brought by the passage of time played a crucial role in shaping their own distinct style (Chalk & Crompton, 2018).

The *Living City* installation, prepared in 1963, marked the first collaborative work involving all members of Archigram The Living City exhibition, organized by the Institute of Contemporary Arts (ICA), invited Archigram members to reflect on the current state of architecture and the city under the conditions of modernity (Cook, 1999). In the editorial section of Archigram's second issue, Peter Cook published a statement explaining the contributors' roles. According to this statement, each individual who influenced the formation of the group had their own trajectory, with varying interests and commitments, and it was intended to remain that way. Yet, these diverging views also had the capacity to overlap. Cook emphasized that those who would become architects and practice architecture should carve their own paths (Chalk & Crompton, 2018). In this sense, Living City holds a significant place within Archigram's body of work. The members of the group interpreted the complex structure of urban architecture through the diversity generated by their individual differences.

According to Sadler, before their breakthrough projects in 1964, Archigram's stance in Living City was tentative, evolving, and poetic in tone (Sadler, 2005). Living City represented the group's first collective stance against the architectural status quo. Although minimal in structural scale, their ideas found expression through the installation realized within the exhibition space. (Steiner, 2013).

Archigram's Living City was conceived around the essence of lived experience. The group expressed the underlying idea of the project as follows: *"Our belief in the city as a unique organism underlies the whole project"* (Chalk & Crompton, 2018, p.42). The fixity of the elements that compose the environment stood helpless against the vitality of the city. As urban relationships were constantly being formed and reformed, architecture's static form became the manifestation of an incompatible relationship.

The analogy between architecture and rain on Oxford Street, one of the slogans of the exhibition, reflected the group's intentions. "*When it rains on Oxford Street, architecture is no longer as important as the rain*." Later on, David Greene pushed this idea further: "*If buildings are no more important than rain when it rains on Oxford Street, then why draw buildings instead of rain?*" (Steiner, 2013, p.33).

The idea that the city is a living organism, shaped by the interaction of all the entities that compose it, was a central view within Archigram. The different rooms, referred to as "gloops," were assembled side by side in a way that resembled the organization of cellular units or the walls of an organic tissue under a microscope. The main concepts chosen for Living City and names of gloops were: man, survival, crowd, movement, communication, place, and situation. Those were believed to shape the city through their effects.

Although the initial sketches of Living City envisioned balloon-like, transparent, amorphous plastic domes, the actual construction used tense triangular structures made of thin rods, as they were more practical. The design, which evokes Buckminster Fuller's geodesic structures, also reveals Archigram's struggle at the time between design and realization.

Archigram's Living City suggested that the force animating urban life should also shape its form. The city was not a rigid built entity but a dynamic organism that existed simultaneously in the past, present, and future. Efforts to create spatial comfort tend to encourage suburbanization, and this in turn may lead to homogeneous and low-quality environments that lack the natural evolution of urban life. In contrast, Archigram argued that urban life is shaped by cross-stimulation, multiple layers, and unexpected encounters. What keeps the city alive is not the orderly or planned, but rather a pluralistic structure made up of diverse individuals, varied experiences, and mental worlds that cannot be easily classified as good or bad. Therefore, defending the value of what is difficult to define is a critical approach for ensuring the continuity of urban existence. For Archigram, the city is a collective space of ongoing creation shaped by personal and collective memories, enriched by emotions, and constantly evolving. In their own words: "*The image is a total image of it all like a film*" (Chalk & Crompton, 2018, p.42).

The fourth issue of the Archigram magazine, published in 1964, marked the beginning of a period in which the group attracted increasing attention. The issue's theme, "Zoom" represented one of the turning points in the direction of Archigram's futurism. A space-themed comic was designed with the aim of merging the futuristic architecture of that imagined world with everyday reality. This design approach reflected Archigram's focus on technology and mechanics, while also expressing their role as mediators between fantasy and reality. According to the group, the new vernacular would be shaped by space capsules, expendable systems, and the atomic-electronic age.

The post-World War II expansion of mass production networks and the cultural dominance of the United States also shaped the characteristics of the production tools chosen by Archigram. In a sense, this can be interpreted as a desire to integrate contemporary technological advances into the more archaic practices of architectural production. At this stage, Archigram presented a new architectural vocabulary to the professional community, such as systems, balloons, domes, satellites, rockets, and expandable, mobile cities. Their formerly expressionist language began to shift toward an industrial framework.

3.2. Departure from the Megastructure and the Turn Toward Individual Solutions

The fourth issue of Archigram, published in 1964, and the fifth issue with the Metropolis theme, released in the autumn of the same year, presented some of the group’s most striking projects to date. Among these, Peter Cook’s *Plug-In City* stands out prominently (Figure 1, Figure 2). With Plug-In City, Cook aimed to create a city composed of an expandable and reconfigurable system. Units with various functions such as offices, educational facilities, housing, accommodations, and commercial spaces would be designed to be replaceable based on their lifespan and necessity, thereby allowing the city to be continuously reprogrammed. Warren Chalk and Dennis Crompton contributed by designing the infrastructural and superstructural elements required to support this city (Cook, 1999).

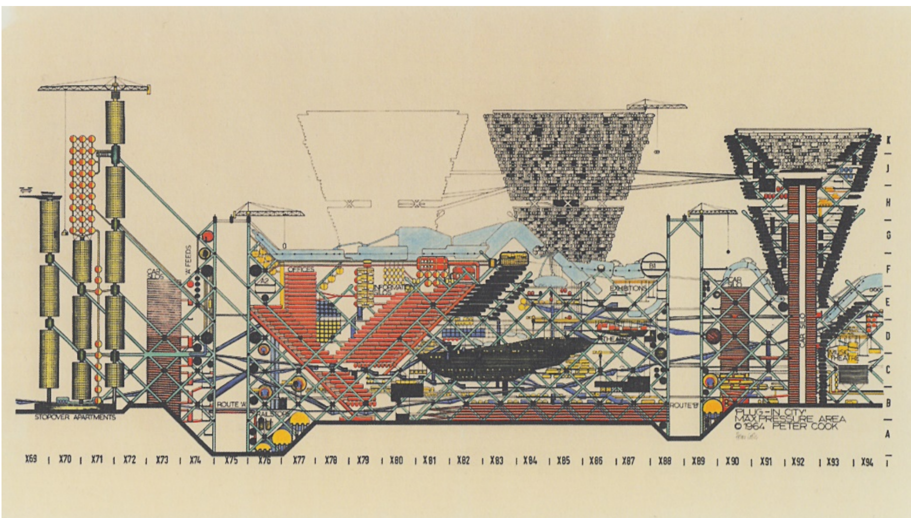

Figure 1. Peter Cook, Plug-In City Max Pressure Area 1964 (IV Toran, 2016b)

Archigram’s new technological approach presented a dynamic and flexible urban vision on a large scale; however, it also displayed certain shortcomings in terms of detailing. While the overall image portrayed a seamlessly functioning, modular city system, a closer examination reveals minor ambiguities. For instance, it is unclear what an individual entering the structure through its front door would actually encounter. The complex accumulation of spatial components such as staircases, elevators, and corridors seems to envelop the entire structure (Chapman, 1965).

Figure 2. Peter Cook presents Plug-in City (Lindberg, 2008)

Archigram's new technological approach presented a dynamic and flexible urban vision on a large scale; however, it also displayed certain shortcomings in terms of detailing. While the overall image portrayed a seamlessly functioning, modular city system, a closer examination reveals minor ambiguities. For instance, it is unclear what an individual entering the structure through its front door would actually encounter. The complex accumulation of spatial components such as staircases, elevators, and corridors seems to envelop the entire structure (Chapman, 1965).

At this point, it can be argued that what Archigram intended to convey was not an emphasis on architectural detailing, but rather a vision at the scale of systems. Plug-In City heralded a megastructure that could expand infinitely through aggregation and a dynamic, constantly renewing urban organization. Reyner Banham interpreted Archigram's attitude as a helping hand extended to the imagination-starved field of architecture. Through architectural components placed on racks and cranes standing above the resulting stacks, the project aimed to reflect the notions of incompleteness and motion. With the idea of continuous organization, the city could remain adaptive. Banham deemed their position valid, as they sought to answer the question everyone was wondering: "*What the city of the future is going to look like"* (Banham, 1965, p.30). The Plug-In concept also expressed a desire related to life itself. The ability of space to adapt made its sustainability possible, while offering a framework that questioned the rigidity of architecture. This approach paved the way for a structure to be both short-lived and immortal at the same time.

Another significant project published in the same year was *Walking City* by Ron Herron which is one of Archigram's most well-known works. The project appeared in Archigram No. 5 under the theme Metropolis. Described by Herron as "*a city that was nowhere and everywhere*" Walking City contributed to the architectural debates of the 1960s concerning the relationship between architecture and its environment. Within their own search, the group asked a fundamental question: "*What was architecture about?"* (Misterbigtown, 2010).

Herron defined this mobile city as a "*friendly-looking machine*," expressing a vision of architecture unbound from fixed location (Chalk &

Crompton, 2018). Among Archigram members, the idea that architecture could change and adapt was a shared understanding. Herron advanced this notion further, asking, *Why shouldn't it move?* (Misterbigtown, 2010).

After 1965, Archigram began moving toward a more independent direction in terms of architectural thought. They no longer prioritized fulfilling the moral responsibilities traditionally associated with architecture. Gradually, this also led to a departure from mainstream architectural forms. Although projects such as *Plug-In City*, *Capsule Homes*, and *Walking City* presented unconventional visuals, they still retained ties to traditional architectural organization. At this point, Peter Cook argued that architecture's inward-looking nature and its constant reference to previous projects had caused it to lose touch with industry, environment, and human life. He claimed, architectural style and fixed discourses, had become a form of escape (Cook, 1999) However, this continuity of spatial and formal organization would be disrupted by mechanical, biological, and individually autonomous systems, as seen in projects such as *Living Pod*, *Auto-Environment*, *Suitaloon,* and *Cushicle* (Figure 3, Figure 4) (Cook, 1999).

Michael Webb's Auto-Environment concept, developed during this period, aligns closely with this line of thinking. It was based on the principle that folded, leaf-like plastic panels could automatically unfold and form the floor and walls of a building. The aim was to enable prefabricated units to be organized and planned in an adaptive manner. On the floor composed of modular plates, the walls would be able to move and accommodate spontaneously emerging functions. Webb suggested that such a mobile system could offer the comfort of a conventional home in locations like caravan parks, which provide a minimal infrastructure.

Webb’s response to the question “Why?” reflects Archigram’s critique of urban organization. While Europe stood on the edge of the space age, its built environment remained inefficient. For a working individual or family, it was practically impossible to transport their architectural setting when seeking to spend the weekend in a rural area or by the sea (Chalk & Crompton, 2018). Webb’s 1966 projects Cushicle and Suitaloon also aimed to address this issue. As he wrote: “*Clothing for living in or if it wasn’t for my Suitaloon I would have to buy a house*” (Cook, 1999, p.80).

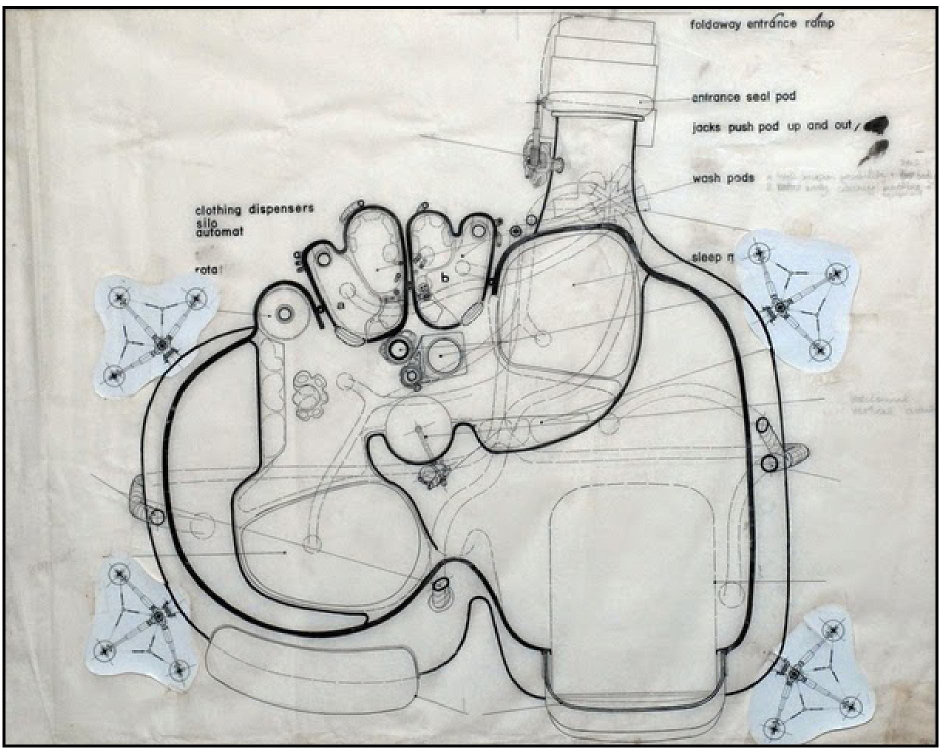

Figure 3. David Greene, Living Pod 1966 (IV Toran, 2016a)

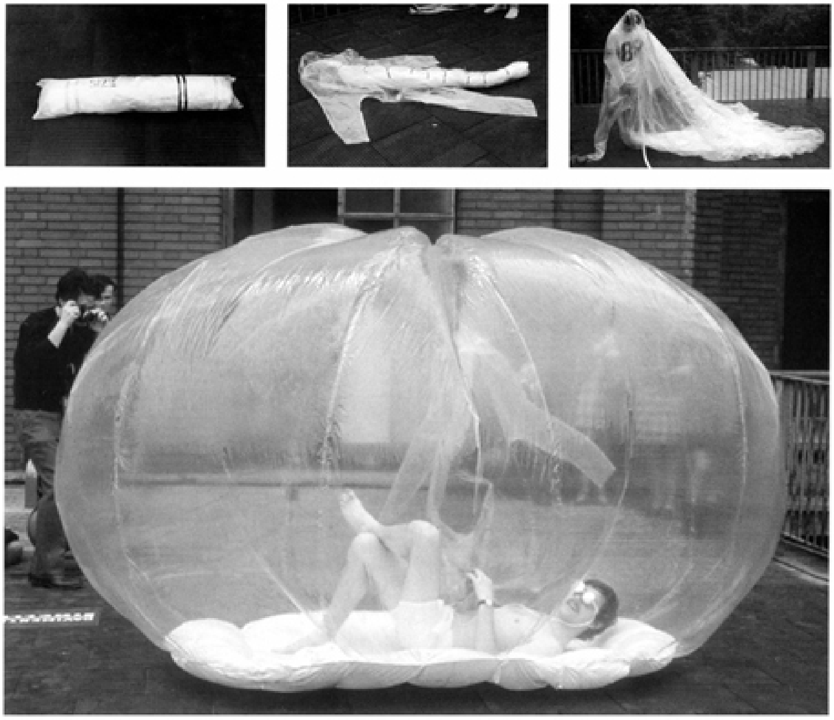

Figure 4. Michael Webb, Suitaloon in Milan Triennale 1968 (Wikimedia Commons, 2024)

Cushicle was conceived as a neurally-mechanized extension of the human body, a mobile system that could carry space with the individual, supplying food and water as needed. This wearable architecture eliminated the necessity of remaining in a fixed location to meet basic needs. Suitaloon, on the other hand, was a wearable architectural product that could expand to create a space for rest when necessary and incorporated the services provided by Cushicle. The combination of Cushicle and Suitaloon offered mobility, a functional protective shell, food and water storage for survival, and multimedia interfaces such as radio and television screens all within a single unit (Cook, 1999).

Archigram first blurred architecture's boundaries with *Plug-In City* and *Capsule Homes*, then rendered it mobile and ephemeral through *Walking City*, and later fragmented this organization into individual components in *Living Pod*. The user, liberated from place by mechanical-architectural solutions, became autonomous. After 1966, with Webb's *Auto-Environment* project, Archigram began developing non-building solutions. Through *Cushicle and Suitaloon*, the user's connection to place was severed once again. Nomadic, bio-mechanical systems transformed the architectural form. Archigram argued that architecture could be more than a building sometimes a machine, an electric circuit, a semi-organic form, a mathematical system, or sometimes randomness (Cook, 1999).

3.3. From Machine Aesthetics to the Aesthetics of Invisibility and Lightness

The endless search for the form of the home and the city echoes Martin Heidegger's reflections on dwelling: "*The real dwelling plight lies in this, that mortals ever search anew for the nature of dwelling, that they must ever learn to dwell*." (Heidegger, 1971, s.159)

Archigram's relationship with architecture and their constant pursuit aligns with Heidegger's notion. Dwelling is not merely the construction of a building; it is a process in which life is continuously reconstituted.

The seventh issue of Archigram magazine, published in 1967, hinted that future works might no longer involve buildings. In the editorial section of this issue, Peter Cook suggested that the group was embarking on a new journey. Since the first issue, Archigram had emphasized that life, technology, and architecture had not been adequately integrated and by the time they reached this issue, not much had changed in the architectural scene. The two questions posed by Cook in the magazine: "*Does architecture have anything to do with life anymore? Are there any abstract values worth waiting around for whilst we fall further and further behind reality?"* express their disconnection from traditional architectural values, and perhaps also a sense of disappointment (Chalk & Crompton, 2018, p.147).

In the eighth issue, published in 1968, the idea of "architecture without buildings" began to manifest in Archigram's output. Webb's Cushicle and Suitaloon projects appeared in this issue, presenting a more explicit interpretation of reducing the concept of architecture to the scale of the individual. In the editorial, Cook summarized the transformation of their practice, claiming that the entire discourse had shifted over the course of seven years. According to him, Archigram initially sought new forms. Then, it began to question the lifespan of architecture, introducing concepts such as "expendability" and "throwaway architecture" into the core of their design thinking. From there, they moved toward the idea of a city in constant flux with unlimited possibilities, inevitably leading them to contemplate the future of the building itself. Ultimately, the architectural object they once pursued began to loosen, blur, and lose its boundaries. At this point, architecture had evolved into a form that aimed to ensure comfort and personal satisfaction, shaped by individual needs and desires.

Cook described the point they had reached as bringing an immense sense of relief. For him, the absence of buildings in this issue signified the collapse of boundaries. He expressed happiness at embarking on a new exploration once again (Chalk & Crompton, 2018). According to Steiner, with the eighth issue, for the first time, the textual content of the magazine outweighed its visual elements and drawings. This may be seen as a result of the disappearance of form itself. There were fewer things left that could be expressed through drawing (Steiner, 2013)

The first *Instant City* project, published in 1968, emerged as a consequence of the logical formlessness of Archigram's architectural thinking (Sadler, 2005).

In Instant City, the architectural connection to place is no longer present. Architecture becomes fragmented, blurred, and lighter, ultimately reaching a point where it is capable of flight through a kind of "*urban emergency service*." Designed by Cook, Herron, and Crompton, the project aimed to create an environment for urban inhabitants that was engaging but not permanent. The nature of this environment that entering through infiltration, articulation, and appearance was reminiscent of a traveling circus that would disappear once its function had been fulfilled. Instant City was not so much an architectural object as an event, a festival, a form of temporary intervention.

Several collage works were produced for Instant City, but among them, the image of the zeppelin gained particular importance. The zeppelin represented Archigram's architecture of infiltration, suspension and flow as a technological image that could gently fade from the scene. In one of Ron Herron's collages, the zeppelin is shown disassembling as it arrives at its target location. The dispersed components from the massive body spread out to form Instant City. This visual narrative serves as a summary of Archigram's own evolution: the megastructure has been reduced to the human scale. Instant City marks the point at which no single element is dominant and architectural aesthetics have been fragmented. At this stage, the most important aspect of the city is no longer its form, but rather the human interaction it enables. Architecture assumes the role of a mediator merely a tool to facilitate engagement.

From the beginning, Archigram had emphasized the role of the human as a key element in the urban equation. In Living City, they had proposed that the city should merely serve as a backdrop in the film of the urban dweller's life. In this sense, Instant City becomes the set that completes the scene. Architecture transforms into a service that responds to temporary needs of individuals or society, capable of constant reinvention.

The ninth issue of Archigram magazine was published in 1970 and is considered the group's final issue in the conventional sense, both in terms of visuals and written content. Its cover resembles that of a gardening magazine, signaling a clear shift toward the natural environment and systems associated with it.

By 1970, however, the systems they proposed began to turn toward a more intuitive relationship with nature and its forms. Peter Cook invited readers to explore this desirable return to nature. Concepts such as birth, death, and rebirth indicated not only a dramatic but also a rhythmic condition. Their self-constructed technological order was now envisioned as integrated with nature, producing responsive environments attuned to the individual. Along with this, the interaction between environment and mind became another topic of discussion. At the point when Archigram's architecture began to vanish and conceal itself, attention turned to the possibility of mentally transcending the physical world with the help of technology. The idea of going beyond physical limits gave way to mental architectures constructed within the imagination, supported by responsive technological environments (Chalk & Crompton, 2018)

An example of these nature-related systems is David Greene's L.A.W.U.N. concept (Locally Available World Unseen Networks), which was introduced in this issue. Greene summarized the system as follows: "*L.A.W.U.N. means doing your own thing in a way that is invisible because it does not formally declare itself and does not disrupt the happenings on the current scene. It may or may not be there at any moment, because it is concerned with time*" (Cook, 1999, p.115).

When a person leaves the scene, no trace should remain. Greene's story of the fisherman encapsulates this idea. The old man sits with his portable television and cooler. His car, which brought him there, stands in the background. He has temporarily customized his surroundings. After creating his portable environment and fulfilling his needs, the user departs, leaving behind nothing more than some flattened grass and fading impressions. What has been created is an architectural setting unique to that moment in time. Portable devices and the invisible networks that support them have the capacity to render fixed architecture obsolete. The presence of the structure is no more legitimate than its absence, as human needs are subject to temporal change. Greene regards architecture's historical insensitivity to the concept of time as somewhat absurd.

Greene also designed two "invisible" service units within the L.A.W.U.N. system: *Logplug* and *Rokplug*. These would form concealed service nodes in natural environments, replacing traditional roadside rest stops. Without disturbing the landscape, they would provide equivalent services. From the outside, the system might appear to be just a log or a rock, but it would contain everything needed for a caravan journey. As hardware, software, and organic forms merge within the design, Greene presents a peak of group's technological idealism (Cook, 1999).

Peter Cook offered a different perspective on dissolving architecture form ın the *Cheek by Jowl* project featured in Archigram’s 9th issue.

Cook had already explored the future of housing in his 1968 drawings under the title *Metamorphosis*. These drawings, featuring deconstructivist, autonomous, electro-mechanical systems based on personal preference, reflected the group’s general outlook at the time. However, his 1970 piece The Metamorphosis Of Our Town Cheek by Jowl suggests a shift in the narrative. A classic urban façade slowly becomes overtaken by trees, hills, and earth until the architectural structures appear to dissolve into the landscape. Cook asks: “*Where might it lead? Which is building and which is growth?*” (Chalk & Crompton, 2018, p.227). This design recalls scenes from science fiction films where an abandoned city is revisited decades later, but for Cook, it symbolizes a perfect fusion between nature and architecture. A new form is envisioned that is outside the bounds of classical order, composed of chaotic yet controllable elements.

Another approach in Archigram’s 9th issue becomes evident in Peter Cook’s *Room of 1000 Delights*, Ron Herron’s *Enviro Pill*, *Holographic Scene Setter*, and Mike Webb’s *Dreams Come True*. These drawings share a common purpose: rather than producing physical space, they aim to construct a mental realm of perception.

Cook’s design explores the idea of a sensory-stimulating room, aiming to transcend environmental limits within the mind. It envisions an oscillation between reality and the unreal, aspiring to bring dreams closer to tangible experience. Herron's work shares a similar ambition. He describes a device that, once activated, could transport you to Hollywood Boulevard, bring Laurel and Hardy to your side, and change your surroundings and the entire scene as the film shifts. Merely switching it on would be enough to initiate the transformation (Cook, 1999). Webb's project, Dreams Come True, presents a fictional company that provides life scenarios. To escape an unsatisfying life, one simply selects a new life plan from a broad range of options. Dreams Come True Inc. will then provide the chosen life (Chalk & Crompton, 2018).

Across these projects, a kind of psychedelic therapy can be discerned. Perhaps it is more accurate to relate these efforts to the condition of human existence itself. The solution to a depressive state, a design of consciousness, is proposed to emerge through dreaming. These works envision a means of escaping dystopian reality by crafting a new one. The form and organization of the home, neighborhood, or city are pushed into the background, framed as grander, perhaps unsolvable issues. Instead, a deeper focus is placed on the individual's mind and emotions, constructing a world of pleasure and comfort. These visions articulate the indifference of existing systems and institutions toward the human self. It is a striking approach to what it means to be human and to the modern condition of helplessness.

Published in September 1974, the issue titled Archigram 9 ½ compiled the group's activities in the intervening years. However, it lacked the visual and theoretical depth of the earlier issues. As its title suggests, the group itself did not consider it a full issue. Though Archigram's publications and projects continued in various forms afterward, the creative intensity of the 1961–1970 period was never quite matched again.

Archigram believed that architectural structures should be temporal, allowing them to better adapt to life. In this sense, it would not be incorrect to view the avant-garde structure they built as one that had fulfilled its purpose, realized its ambitions, and thereby completed its life cycle.

One of the most frequently raised criticisms against the group was the impractical nature of their ideas and the fact that none of them were ever built. Yet this very condition allowed them to remain flexible, to operate freely, and to produce ideas across a wide spectrum. The only principle to which they consistently adhered throughout their productive years was a desire to explore. When considered from a broader perspective, Archigram's avant-garde style and futuristic vision emerged through a wide range of very different forms over time.

3.4. Traces of Archigram

Throughout its existence, Archigram created its own sphere of influence through its publications, academic involvement, conferences, symposiums, and on-air appearances. The abundance of conceptual material they produced gave rise to an avant-garde existence of its own, precisely in response to the absence of realized physical structures.

One of the main criticisms directed at Archigram's projects is their alleged unbuildability and their tendency to prioritize iconic imagery (Venturi et al., 1993). However, this notion was firmly rejected by the group themselves (Moore, 2018). In fact, it is possible to acknowledge both positions without declaring one absolutely right or wrong. On the one hand, the lack of realization may support the criticisms; on the other hand, the recurrence of their ideas in various forms over time suggests that the real issue may have been organizational constraints. According to Tanyeli, this reflects a problem of temporality. He argues that the values Archigram introduced would be better understood with the lapse of time (Tanyeli, 1998).

Peter Cook regarded Archigram's architectural experience as a practice rooted in discovery which is closer to that of a scientist or a technical specialist. The prevailing academic and artistic doctrines of architecture held little appeal for them. At this point, the relationship between the architect and their product diverges from the traditional design process. The architectural role, according to Cook, should reflect the methodical and sometimes incidental nature of invention, where the "scientist-designer" reveals what is necessary and latent. Though this fragmented approach may at times overlook the bigger picture, Cook argued that it would still achieve its intended goal. Fundamentally, this is because, in his view, intellect itself emerges from problem-solving, innovation, and invention (Cook, 1970).

In the post-Archigram period, it is possible to observe numerous designers, architects, and engineers who embody this outlook. Indeed, architectural movements that later gained popularity such as High-Tech, Bowelism, and Blob Architecture can be traced back to Archigram's approach. The terms and behavioral concepts that formed Archigram's unique architectural vocabulary appear again in a variety of subsequent works. Their insistence on ideas such as plug-in, clip-on, industrial aesthetics, expendability, adaptability, indeterminacy, nomadism, temporality, lightness, expandability, systemic logic, hardware and software, responsiveness, and many others, reflects their pursuit of uncovering and extending the potential of architecture.

The diverse forms of production in which these recurring concepts appear have been analyzed through concrete examples. These investigations take into account the different requirements of remaining within the theoretical realm versus applying architectural ideas in practice. Thus the selected topics propose a comprehensive framework. The examined examples reflect Archigram's concepts reinterpreted in practical terms, adapted to the specific time and space in which they were realized.

3.4.1. Modular, reconfigurable, and open-ended architecture

Archigram's Plug-In concept was driven by the ambition to create a form that could expand endlessly through modular addition. The goal was to address contemporary needs through an embedded sense of systematization. *The Igus Plastic Factory and Headquarters* built in Cologne by Nicholas Grimshaw Architects (Figure 5) stands as a realized embodiment of this idea.

Nicholas Grimshaw's connection with Archigram dates back to his student years, as an alumnus of the Architectural Association School of Architecture (AA). His thesis project at the AA was featured in the sixth issue of Archigram in 1965 (Chalk & Crompton, 2018). Peter Cook praised Grimshaw for successfully translating avant-garde ideas into built architectural practice (Grimshaw, 2019).

The architectural challenge in the Igus project was to meet the evolving demands of a rapidly growing company. The building was designed with a flexible plan capable of accommodating a variety of production scenarios. This was achieved through a wide-span, unobstructed layout enabled by a roof suspended on steel pylons. Modular façade and ceiling components allow for the seamless addition of new units. Within the factory, administrative spaces and technical volumes are housed in custom-designed metal pods, elevated from the ground to maintain the continuity of operations. These service and office capsules bear a clear resemblance to David Greene's Living Pod concept. Due to their autonomous structure and compatibility with the factory's modular infrastructure, they can be positioned both indoors and outdoors. In this way, the building maintains adaptability to new layouts (Moore, 1993).

Over the twenty years following its construction, the Igus building underwent seven expansions in response to changing needs. This outcome can be seen as a testament to the success of the designed system (Grimshaw Architects, 2016a).

Figure 5. Nicholas Grimshaw, Igus Factory 2000 (Wikimedia Commons, 2013)

3.4.2. Industrial and technological language–driven design

Robert Maxwell describes the foundations of the industrial language and the fascination it evokes as rooted in a unique sense of beauty, which is derived from the logic and engineering embedded in its components, and the visible presence of calculated necessity. According to Maxwell, the architect creates aesthetic harmony by assembling these objects with deliberate intent and order (Sennott, 2004).

Archigram's fascination with the industrial domain can be traced in the poetic tone of their manifestos. They declared the end of the brick era and envisioned a new age shaped by space capsules, orbital helmets, and mechanical body transport systems. Their designs frequently drew inspiration from forms emerging in the industrial and technological fields, incorporating them into architectural expression.

Peter Cook relates the idea of assembling a whole from small components to a tradition deeply rooted in British culture. He also connects the emergence of High-Tech architecture to this tradition (Grimshaw, 2019). He further notes that this architectural movement gained momentum through the collaborative synergy between prominent British engineers and architects, including Peter Rice, Frank Newby, Tony Hunt, and Ted Happold. (Cook, 2016). Frampton suggests that Archigram's technological aesthetic reflects Fuller's Dymaxion ideals, a lineage that can be traced in the subsequent works of architects like Richard Rogers and Renzo Piano (Frampton, 2020)

One of the most iconic buildings to emerge from this movement is the *Lloyd's of London* project by the Richard Rogers Partnership (Figure 6). Though it serves a conventional function as an insurance market, the building's striking use of industrial forms recalls the imagery of oil refineries. Despite the fragmented and seemingly chaotic exterior, the interior offers a stark contrast with its open and minimal office layout (Ingersoll, 2018).

Figure 6. Richard Rogers Partnership, Lloyd's of London 1984 (Iliff, 2007)

The placement of circulation, service, and mechanical infrastructure on the exterior, wrapping the building like an exposed skeleton, is characteristic of Bowellist architecture. In this regard, the building shares conceptual similarities with Michael Webb's Furniture Manufacturers Association Building. The glass atrium roof evokes memories of the Crystal Palace, while the metallic pods and cranes positioned along the façade and rooftops clearly echo the adaptable modules of Plug-In City. The sophisticated assembly and expressive nature of these components blurs the boundaries between machine and architecture, offering a new aesthetic that bridges the two.

3.4.3. Lightweight structures and ephemeral architecture

Interest in lightweight structures frequently appears in Archigram's later projects. Their explorations into the disappearance of architecture and nomadism redefined the relationship between structure and site. Projects like Instant City, L.A.W.U.N., and Cushicle-Suitaloon questioned the permanence of architecture, its footprint, and its dependence on a fixed location. These projects proposed ephemeral spatial alternatives tailored to specific moments. Through lightweight and nomadic design, they aimed for a minimalist yet refined form of building. Form of lightweight structure and its relationship with the ground demand unique and qualified solutions.

One such project that embodies this meticulous integration is *The Eden Project*, designed by Nicholas Grimshaw Architects (Figure 7). Functioning as a large-scale botanical garden and visitor center, the project consists of eight geodesic domes of varying sizes. These domes adapt to the site's natural contours, defining their boundaries accordingly. Located within a former clay pit, the structure required minimal intervention in the topography (Larsen, 2016). The lightness of the structure and its relationship to the site embody Archigram's idea that a building should feel like a natural intervention.

Figure 7. Nicholas Grimshaw, Eden Project Cornwall 2001 (O'Sullivan, 2007)

The design process unfolded during a period when the site remained under the commercial control of a quarry operator. Faced with constantly changing topography data each week, Grimshaw’s team identified the geodesic dome as the most adaptable form. Thanks to the modular nature of the structure, the domes could be trimmed precisely where they met the ground. The standardized units also contributed to reduced construction costs. The dome’s membrane is composed of semi-transparent, lightweight, inflatable ETFE (Ethylene Tetrafluoroethylene) pillows, which are easily replaceable and facilitate assembly and maintenance (Larsen, 2016). Grimshaw envisioned the modular units as a means to accommodate future material advancements that could make Eden even more efficient. Perhaps, new technological materials could one day enable the structure to generate its own outer skin (Grimshaw Architects, 2016b). Similar ideas can be seen in Peter Cook's Cheek by Jowl drawings. The concept of a system that balances organic growth with human intervention, forming a controlled chaos, became one of Cook's favored visions for the ideal urban environment.

3.4.4. Organic form and vitality in architectural expression

The idea of organic form and the potential for architectural structures to move has been one of the key conceptual themes explored in Archigram's work. Ron Herron's Walking City envisions a machine that carries the city on itself, thereby creating a unique aesthetic. The structure that described by Herron as a "friendly-looking machine" seeks to become a responsive shell, one that interacts through its movement, adaptability, and outward appearance.

Another project reflecting this notion is Living City. In 1963, Archigram proposed the city as a unique organism, bringing forward the idea that the gap between architectural design and the dynamic, ever-changing nature of life should be bridged.

Peter Cook and Colin Fournier's *Kunsthaus Graz* is one of the most notable buildings to carry Archigram's conceptual legacy into the 21st century (Figure 8). Cook recalls that during its construction, polls revealed that 70% of Graz residents disliked the project. However, ten years later, this percentage had completely reversed. He interprets this shift as follows: perhaps people came to recognize that the building rather than being a threat had become part of the city's collective and complex cultural stage. (Cook, 2016).

Often referred to as the “Friendly Alien,” the building expresses vitality through its inflated amorphous form, glossy surfaces, eye-like protrusions, and interactive façade. Hundreds of programmable light rings embedded beneath the shell enable dynamic visual displays and establish a communicative relationship with the urban space. The building aims to assert its vitality not only through its shape but also through its behavior.

In the early stages of the project, one of Cook’s main goals was to design a more meaningful interface between interior and exterior through semi-transparent surfaces, LED screens, and sophisticated digital systems. However, constraints related to budget and timeline ultimately shaped the project’s final outcome (Cook, 2016). This also underscores how the various filters inherent in architectural practice can significantly impact the end result.

Figure 8. Peter Cook, Colin Fournier, Kunsthaus Graz 2003 (Schneider & Aistleitner, 2006)

3.4.5. Virtual space and transformation through software

In its later phase, Archigram adopted an approach that deliberately avoided rigid interventions in the built environment. The rapid transformation of contemporary values and needs cast doubt on the permanence of architecture. While the Instant City concept aimed to create an urban image through lightweight solutions, customizable displays, and portable units, it sought to do so with minimal physical traces.

Pushing this idea further, Archigram's final experiments ventured into creating virtual realities enabled by hardware and software systems. Projects such as Holographic Scene Setter, Info Gonks, Dreams Come True, and Rooms of 1000 Delights reflect a shared premise: the physical environment is no longer sufficient, and users must be offered personal virtual realities drawn from their own imaginations. With the right technology, infinite spatial alternatives can be created within the mind, giving rise to an immaterial subject-object relationship that defines an individual's informational space.

Today, individuals can create their own micro-environments using personalized audiovisual devices. Lightweight, low-energy portable systems allow these environments to be carried and experienced anywhere. If we consider the 1970s as the foundational era of the digital age, it is fair to say we are now several steps beyond. Although the comprehensive infrastructure needed to fully realize Archigram's vision is still emerging, that vision seems less speculative and more imminent with each passing year.

When we look at the example of *Times Square*, we can identify two distinct aspects in relation to Archigram: it could be considered both as a source of inspiration and as a projection of the spatial conditions they envisioned (Figure 9).

The area's development spans over a century. Once a mixed-use residential and commercial district in the 19th century, Times Square became a cultural hub of theaters in the early 20th century. New York's rise as a commercial epicenter in the U.S., coupled with Times Square's function as a major subway hub, significantly increased its urban value. By the 1920s, it had become the epicenter of America's emerging advertising culture (Taylor, 1991).

Figure 9. Times Square in 2014 (Created by the second author)

The square's influence shaped consumer behavior and trends. Late-20th-century investments enhanced its visibility, and new legislation even required building tenants to display illuminated signs. In this way, Times Square became the spatial manifestation of modern consumer culture, a phenomenon that radiated from America to the rest of the Western world

(Wallenfeldt, 2024). The urban image of the modern metropolis entered the collective consciousness largely through Times Square, and that image directly inspired several of Archigram's collages. Ron Herron's *Urban Action Tune Up* from 1969, for instance, features enormous display screens clearly informed by high-density visual environments like Times Square and Piccadilly Circus (Sadler, 2005).

For Archigram, the city must offer more than static plans and fixed functions; it should be sensitive to the evolving needs of individuals in a rapidly changing world. In Instant City, a flexible arrangement of mobile units and information surfaces aims to provide highly personalized experiences rather than uniform structures. Similarly, in Living City, the suggestion that the city should serve merely as a backdrop in the citizen's personal "film" underscores this perspective. Even in Times Square where the buildings themselves remain static, the space is endlessly redefined through the dynamic content of digital screens. With today's technological capabilities, it seems increasingly feasible to scale this condition down to the individual level.

Georg Simmel once observed that the overwhelming display of countless commodities at world fairs dulled perception, paralyzing attention with sensory overload and leaving the individual with nothing but the imperative to be entertained (Simmel, 2006). The same kind of cognitive and visual intensity is now found perhaps even more intensely in Times Square. In this sense, Archigram's vision of the city resonates strongly with this "space of stimuli," which acts as a kind of neuropsychological pomade for the challenges of urban modernity.

4. Conclusion and Suggestions

"Beauty consists of an eternal, immutable element whose quantity is very difficult to determine, and a relative element that changes according to circumstances. This element may be the era in which one lives, the fashions of that era, moral values, emotions, or perhaps all of these." Charles Baudelaire 1863 (Baudelaire, 2003, p.92).

The conceptual framework Baudelaire constructs in defining aesthetics points toward uncertainty. The chaotic harmony of ever-changing and uncontrollable values generates the visible image of beauty. This dynamic is driven by critical thinking, which surrounds the modern condition. In an era of uncertainties, perhaps the only certainty is that every principle can and must be questioned.

Poggioli describes four stages of the avant-garde: activism, antagonism, nihilism, and agonism (Heynen, 2011). Disappearance is as ordinary a condition for the avant-garde as its birth, following these stages one by one. When the futurist avant-garde in architecture is evaluated through Archigram's production, we observe a conceptual transformation that leads to formal dissolution, fragmentation, adaptation, and ultimately, a merging with the absolute order of nature an act of self-erasure. This process is enabled by a secondary nature: technology.

Considering that all values of modernity are transient, to exist and then to disappear might be the only enduring value. From this perspective, Archigram's architectural practice and its unbuilt condition can also be interpreted accordingly. If today's values are doomed to vanish, if all that is solid eventually melts into air, then not building may become a conscious choice. And contrary to some criticisms, this may even be considered a moral responsibility.

Archigram has created a small representation of the constant questioning at the heart of modernism and the change that comes with it, across all issues of the magazine, spanning years, it has explored diverse topics such as organic forms, lightweight structures, modular buildings with adaptable boundaries, architecture connected to nature, industrial language, disappearing architecture, service networks, hardware and software, nomadism, the lifespan of architectural structures, and temporariness. The diverse range of topics covered has created a rich “vocabulary” whose elements can be seen in the works of subsequent architects. The use of these elements may be accompanied by other shaping factors in architecture, such as location, time, cost, and users. Of course, the vital values inherent in these factors shape the architectural product.

From this perspective, the limited resemblance between Archigram’s designs and the physical examples in which their traces can be identified is to be expected. However, the truly significant connection lies in the desire for exploration, renewal, and inquiry. The images that seek to establish a sense of affinity would remain incomplete without the founding ideas that shape them. Yet, innovative attempts that pose a problem and explore the boundaries of its solution will sustain Archigram’s legacy as progressive steps that keep the architectural debate alive.

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Architecture of Madness: R. D. Laing's Kingsley Hall vs. Jeremy Bentham's Panopticon

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1. Introduction

This study aims to analyze the evolving role of architecture in power distribution and segregating practices among society by comparing Panopticon, Jeremy Bentham's renowned prison and asylum model, with Ronald David Laing's Kingsley Hall Experiment, an iconic communal example of the Anti-Psychiatry movement, that gained momentum in late 1960s.

Madness has evoked almost always same response from the community across time: spatial segregation or isolation. The predominant Western reaction towards those seen as psychologically imbalanced has been about creating designated facilities, be it for mending, confining or managing purposes. The relationship between architecture and psychiatric illnesses has long remained as a discussion reduced to medicinal purposes. The design of built space has been considered as one of the most vital forces forming differing methods of care for the mad. A closer study of these spaces would reflect important insights about the transforming perception of madness in society across time. Moreover, it would reveal important truths about how these transformations have been driven by the ruling authority and its desire to control power distribution in society. Therefore, the reciprocal relationship between insanity and asylum spaces cannot be reduced to the realm of medicine alone.

In this regard, Scottish psychiatrist Ronald David Laing and English entrepreneur/lawyer Jeremy Bentham represent two very contradicting figures. While the former advocated an inclusive open-community model, it wouldn't be an exaggeration to define the latter as the forefather of modern incarceration facilities with increased surveillance and control mechanisms. The division between control and freedom as two rivaling factors in determining the design of psychiatric spaces, contains valuable insights not about psychiatry alone, but also about architecture and its formative role in representing the power of governing institutions of the society. A comparison between Laing's famous Kingsley Hall, an experimental residence where the psychiatric patients (mostly schizophrenic) lived without any limitations together with doctors in an open-community and Jeremy Bentham's Panopticon; a schema designed specifically for surveillance and control, which was suggested as a model not just for asylums but also for schools, prisons, workshops; would provide significant reflections about the underlying context of the implicit relationship between architecture, psychiatry and social structures.

2. Material and Method

Since it's beyond the scope of this work to include a comprehensive historical background of psychiatric treatment and its designated spaces, the study will mainly focus on a comparative analysis between R. D. Laing and Jeremy Bentham's models. The comparison method is based on architectural scheme, spatial relationships, socio-cultural context and psycho-spatial setting. A brief overview to the historiographical relationship between architectural theory and the institutional care of insanity would provide the relevant initiation point for the discussion. A sole spatial comparison of two contradicting models would not be sufficient to understand the intricate relationship between psychiatric institutions, society and the ever-transforming power mechanisms that is reflected through the spatial organization of these facilities. When evaluated as a formative force, "asylum" can be explored as an emerging tool with a crucial role in social engineering. Hence a discourse analysis of its cultural and historical context will accompany the examination of case studies; one representing the open-community and the other the absolute rule of surveillance.

It is impossible to understand the history of madness; it's architectural reflections and the underlying social mechanisms or governmental structures without consulting Foucault's extensive work about this subject. Philo insightfully asserts that Foucault's main contribution to this field was the establishment of the vital relationship between psychiatric care and its spatial organization (Philo, 2014, p. 8). Moreover, Foucault deciphered the spatial symbolism of incarceration and its underlying metaphorical meanings with a strong relationship to history and sociology. Prior to his account, any history of psychiatric spaces was constructed as a linear progression diagram, each new spatial organization being presented as a major improvement, portraying the previous methods as unrefined and disconcerted. Through his "archeological and genealogical surveys", the theory of insanity underwent a comprehensive and sophisticated reconstruction process. Henceforth Foucault's extensive account on this subject matter constitutes an important trajectory for the discussion.

R.D. Laing's emancipatory anti-psychiatric approach and Bentham's surveillance-oriented Panopticon model represent two systems of knowledge, which can be described in Foucault's terminology as two contradicting *epistemes* or discursive formations. Foucault initially formulated his "archeological" approach to examine discursive formations; a method, which engages epistemic organizations as multiplicities determined by rules, which transcend any logical syntax and perform subconsciously within individual subjects. This set of rules define a system of theoretical potentialities, which demarcate the confines of *epistemes* or discursive formations in a specific context and temporality. The archeological method constitutes a vertical excavation, transecting through discursive formations that govern the oral, written or any other intellectual narratives (discourses) of a specific period. This approach allowed Foucault to transcend the restraints of conventional historiography, which is generally distorted through the subjectivity (or consciousness) of the historiographer. The archeological method constituted an important tool to construct comparative studies on different discursive formations of different periods, but when it came to decipher the transitions from one epistemic position to another, this critical methodology displayed a significant deficiency. To overcome this barrier, Foucault formulated what he called "the genealogical analysis" which was inspired largely from Nietzsche's genealogy of ethics. This approach aims to unravel the genesis of discursive formations and the transformative forces behind them, which, due to their ambiguous nature, are always determined through an arbitrary flow of complex historical events (Gutting, 2022).

This comparative study will employ both genealogical and archeological approaches, as it targets two rivaling discursive formations. The analysis of cultural and historical context of both models will follow a genealogical methodology for understanding the transformations of what Foucault characterized as "Psy-function"; a term for describing the unending power struggle between madness and psychiatric discipline (Foucault, 2006). Accordingly, the survey of psycho-spatial settings of Panopticon and

Kingsley Hall will adopt an archeological methodology, as it constitutes the comparative part between two distinct discursive formations.

3. Architecture of Compos-Mentis/Madness

3.1. The Genealogy of Psy-Function and Its Psycho-Spatial Setting

Architecture of mental institutions, as well as their organization and methodological approach have been the most discussed topics since their first establishment in Europe (Denny, 2014). Michel Foucault argues that the hitherto historiographical accounts regarding psychiatric spaces have been strategically over-simplifying the history of psychiatric spaces (Foucault, 1961/2009, p. 462). They claim that this tendency dates to eighteenth century France and Britain, accompanied by the initial attempts to reform and rationalize the management of the mentally challenged by introducing public asylum services (Moran et al., 2007, p. 8).

On the other hand, up until the foundation of institutionalized asylums, the confinement of the "lunatic" in designated buildings remained a rather seldom practice. The Ancient Greek and Roman law required them to be prevented from harming life or property, but this was considered as a domestic responsibility assigned to their family members as guardians. Same practice was common in Christian Europe. Here too, the lunatic remained as a neglected crowd among family, sometimes even subject to cruelty, constrained at domestic cellars or pigpens, on many occasions they were sent away to wander on roads for preventing further public disgrace (Porter, 2002, pp. 89-90).

The official isolation of mental patients from society began towards the end of Middle Ages, mostly in religious institutions as a reflection of Christian virtue. An institutionalized concept of "madness" first established itself in France and England in 17^{th} and 18^{th} Centuries. This rapidly spread across the rest of the Europe in close connection to a series of economic, political, ideological and socio-cultural transformations in whole continent. In London, the religious House of St. Mary of Bethelem (1247) became a care center for lunatics by the late 14^{th} Century (Andrews et al., 1997). Healing institutions at Flemish village Gheel or Spanish Valencia, Zaragoza, Seville, Valladolid, Toledo and Barcelona, for which the Andalusian Islamic hospitals may have served as a model, could be listed among similar examples. Foundation of later establishments has followed similar religious motivations, including asylums in Liverpool, New Castle and York dating back to 18^{th} Century. Although, the Spanish institutions were renowned with their humane conditions, focusing on well-being, activities, nutrition and hygiene of their patients, and in this regard, they were different than their British counterparts. At these establishments, the devotees of faith have served as staff, offering care to the insane as charity (Porter, 2002, pp. 90-91).

Around 1800, the conditions in asylums were often subject to heated debates. Instead of mere confinement and control, questions regarding treatment of the patients arose. Those advocated a moral reform, saw insanity as a disorder of inner/mental mechanisms which had to be retuned through "moral therapy" (Porter, 2002, p. 106). The merchant Tuke was among them, who favored a behavioral approach instead of medical and established a local community retreat at York in 1796, where any kind of physical restriction was minimized. Similar developments followed in different locations. In Florence, Chiarugi pioneered the replacement of restraint and medication with mental therapy forms, which treated the insane individuals as a person instead of wild animals or degenerates. Inspired by the ideals of revolution, Dr. Philippe Pinel initiated similar reforms in France at the end of 18th Century. Guided by the Enlightenment principles, he saw any possible catharsis for mental disorders in mental methodologies, in his case, through moral treatment. These developments led to the reformation and eventual institutionalization of psychiatric retreats. They were no longer considered as spaces of mere isolation (Porter, 2002, pp. 106-108).

3.2. Reform and Transitions

In 19th Century, psychiatric institutions saw a parabolic growth both in sheer size and number. This increase had its reasons of course. The positivistic Zeitgeist demanded from everyone to put their faith in bureaucratic mechanism; approaching any problem with correct tool set; in this case with designated buildings for incarceration. Urbanization and industrialization brought demographic transformations with themselves, which initiated the increasing demand for specialized buildings. Psychiatry as a scientific methodology for handling mental disorders was first conceptualized by Johan Christian Reil in 1808 and from then onwards it entered the medical discipline as a phenomenon (Chase, 2018). Pinel's *A Treatise on Insanity* (1801) and Daniel Hack Tuke's *Moral Management of the Insane* (1854) exerted great influence on the transformation of the institutes and on emergence of new treatment methods, which paved the way for development of psychoanalytic method throughout the 19th Century, that culminated in Freud's approach (Oakes, 2021, pp. 53-55).

Regardless of location, architecture always played a vital role in treatment of insanity. Specialized design methodology had to provide optimum sanitary conditions (ventilation, sewage etc.) and above all maximum security. The development phase of mental institutions reflects foremost the ever-transforming architecture to meet these criteria. From late 18th century onwards, design of psychiatric space has been under a constant reform process. Each improvement attempt was seen as the ultimate solution, whilst the narrative about the previous episodes were painted as unrefined failures (Moran et al., 2007, p. 9). In this regard, it is important to mark important turning points.

The reformation attempts of mental facilities underline the increasing reciprocity between architecture and psychiatry. The ideals of Enlightenment played an important role in this, by raising an awareness about social wellbeing and individual rights, both phenomena being based on the philosophies of John Locke and Baruch Spinoza. Then there was the transcendent thought of German philosopher Immanual Kant, who in 1850's called for "emancipation of human consciousness from an immature state of ignorance" (Kant, 1784/1991).

Tuke's Quaker retreat was an inflection point on this matter, emphasizing positive, humane treatment and a constant regular condition for patient's (Carlson, 1974). He contracted London-based architect John Bevans to design him a house, which wouldn't reflect any characteristics of an asylum on its appearance (Topp, 2005). Unlike its counterparts, which were initially built as something else and repurposed as a mental facility, Tuke's retreat would constitute the first example, that is designed and constructed as a psychiatric institute from scratch. Francesca Denny argues that Bevans composed the building as a physical metaphor for Descartes' Cartesian Dualism. The building itself would constitute a guide for the body and eventually affect the mind, as both being entities of same unity (Denny, 2014, p. 10). The principles of this moral approach were carefully engraved into the design of the building (Figure 1). As an example, peripheric walls and fences were hidden by virtue of embedding them into the lower sides of the slope, preventing them from signifying captivity for the inhabitants (Donnelly, 1983, pp. 52-55). Instead of control and surveillance, the influence of design on the inhabitants' mental state was prioritized. In this regard, Tuke's Retreat did represent the emancipation of insanity from the punishment system of prisons and workhouses but at the same time it was a sincere attempt to design for wellbeing of mental patients instead of captivity. Bevans successfully transformed the form of control to produce an environment that would allow the mental patient to live a normal life, since sane and insane were now considered to possess same awareness and needs (Edginton, 2007).

Figure 1. A view of the North Front of the Retreat near York (Tuke, 1813)

The York Retreat represents an important turning point for marking the relationship between asylum design and its influence on treatment. Edginton accurately points out that many asylum architects of 19th century paid visits to the facility and made remarks about the significant attention paid to the details that would affect patients' mood (Edginton, 2007). The insane individual was now considered as suffering under a mental illness, instead of being a disorder to public space, but in the end all similar institutions preserved their inherent role in being instruments to the power of gaze or surveillance of the rulers.

3.3. Jeremy Bentham and the Panopticon Model

A building circular... The prisoners in their cells, occupying the circumference—The officers in the centre. By blinds and other contrivances, the Inspectors concealed... from the observation of the prisoners: hence the sentiment of a sort of omnipresence—The whole circuit reviewable with little, or... without any, change of place. One station in the inspection part affording the most perfect view of every cell (Bentham, 1798, p. 195).

It is interesting that the opening of William Tuke's York Retreat virtually coincides with the emergence of a complete contradicting idea. This was the renowned Panopticon model, an imaginary facility with improved surveillance proposed by Jeremy Bentham (Semple, 1993). The term is derived from Greek words *παν/pan*- ("all") and -*οπτικος/optiki* ("seeing") (University College London Bentham Project, n.d.). It is based on Argus Panoptes, a mythological giant with hundred eyes (OVID, 2004; as cited in Denny, 2014).

Panopticon was originally designed by Samuel Bentham, Jeremy's older brother in Russia, where he was working as advisor for Prince Grigory Aleksandrovich Potemkin, Catherine II's most influential and favorite military leader (Werret, 1999, p. 3). Samuel, a naval engineer, was tasked with overseeing Potemkin's manufacturing facilities in Krichev (Cricheff) and constructing new transport vessels to transfer goods over Dnepr to Black Sea (Bentham, 1856). For this task, he was provided with necessary workforce, unlimited funds to expand Potemkin's estate, experiment on new inventions, a house and servants. However, his workforce was consisted of serfs and supervising this unskilled labor force was an almost impossible task. This immediate need to discipline his employees motivated him to devise a circular schema with a surveillance tower in the middle, to be constructed on the principle of central inspection, allowing the supervisor to oversee large number of workers at once. The Krichev Panopticon would transform horticultural, carpentry and other industrial facilities in the estate into one structural unity and provide full control over the production. It is important to understand the background of this original idea, since it has strong affinities with Russian tendence towards theatricality. Bentham's initial attempt to achieve would eventually be transformed into a European production utopia and an architectural stage, one which materialized many Imperial metaphors of Russia. Envious of the Western ideals, the inspection lodge in the middle would provide the omnipotent throne for Empress Catherine, allowing her to place her enlightened, watchful gaze on her peasants and represent them her great achievements (Werret, 1999, p. 13).

In 1786, Jeremy Bentham had an extended visiting stay in Cricheff and became fascinated with the Panopticon idea. This coincides with British government's plan to construct a new correction facility in Middlesex. Jeremy saw his brother's invention as an excellent model for the planned penitentiary and decided to propose it to the officials. He explained his idea in detail through a series of letters that he first sent to his father and his friend George Wilson. For reasons unknown the letters remained unpublished until Chancellor of Irish Exchequer Sir John Pannell showed interest in them during 1790's. He took initiative to have Bentham's letters published in Dublin (Bentham, 1988, p. 373). Bentham revised and extended his original letters and complemented them with three illustrations (Figure 2), explaining the building in plan, section and elevation, all of which was published in 1791 as a book (Bentham, 1791/1993).

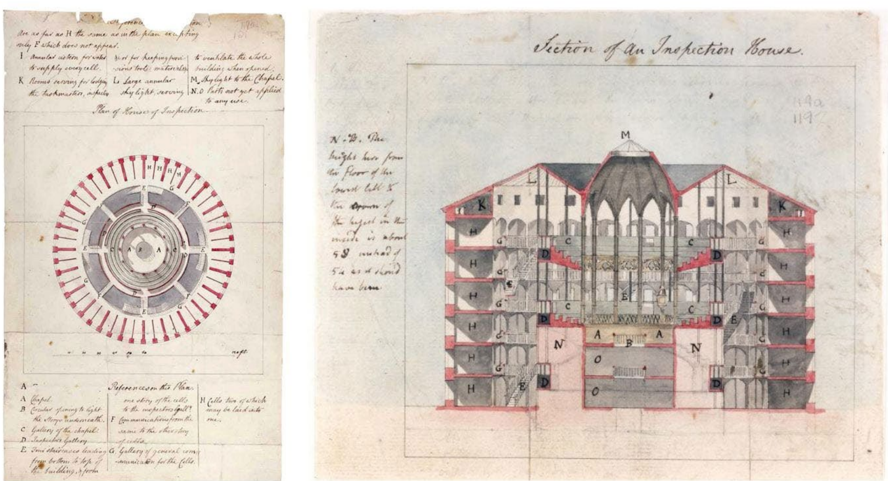

Figure 2. Jeremy Bentham's Panopticon Illustrations (Bentham, 1791/1993)

Bentham’s Panopticon was a circular structure consisting of radially placed cell units around an observation tower in the middle. This watch tower would allow the warden to hold all inmates under observation without himself being seen. The central inspection point would be separated from the cells around the circumference via multi-story galleries. The only connection points between the watch tower and the cell area would be the stairways and the whole building would be lit through central skylights and peripheral windows on the outer cell walls (Semple, 1993). The inspection principle would be applicable to the warden as well, when the public authorities were to visit and observe his activities. This was a clear indication of Bentham’s characteristic principle of transparency. The window openings of this tower would be veiled through blinds or other means, masking the observing-gaze of the warden from inmates, preventing them from knowing if they are observed or not (Pease-Watkin, 2003). Simultaneously the communication between cell inhabitants was to be blocked through side walls and Bentham suggested to connect all cells to the central tower via conversation tubes, a system reminiscent of today’s modern listening devices (Semple, 1993). The arrangement of this scheme was carefully devised to keep all inmates under constant potential observation, forcing them to behave obedient.

3.3.1. The Panopticon as a discourse

Panopticon became popularized through Foucault’s famous works Discipline and Punish (1975/1985) and History of Madness (2009/1961). Bentham Brothers never saw their proposal materialized, but the principles of this diagram are embedded in almost all modern incarceration facilities. Foucault describes how plagues forced societies to apply spatial restrictions (discipline) and quarantine (segregation) during Middle Ages, which later gave rise to what he calls Great Confinement of 17th Century or Age of Reason (Khalfa, 2009). Those authorized to exert power, apply constant divisions between insane/sane, dangerous/harmless, normal/abnormal, and make decisions regarding how they are defined and where they are to remain (or kept). For Foucault, this differential evaluation and resulting disciplinary/isolating actions represented the operating core of psychiatric institutes, prisons, schools and in some ways to hospitals.

Foucault considered Bentham's Panopticon as the architectural figure of this power distribution system, to keep the abnormal in isolation and transform him according to what is considered as "normal" by the ruling power (Foucault, 1985/1975, pp. 199-200). The trap of "visibility" and lateral invisibility between cells would prevent any reciprocal bad influence and violence upon one another. In this spatial unity the encapsulated "abnormal" is under perpetual surveillance. This way, the Panopticon becomes the ultimate device for ensuring automatic exertion of power. Foucault defines Bentham's diagram as "*a machine for dissociating the see/being seen dyad*" (Foucault, 1985/1975, p. 202). By the virtue of panoptic mechanism there won't be any need for power display, since the control is engraved into the surfaces, lights, gaze and compartmentalized distribution of inmates.

Foucault saw Panopticon as an authority device, but he also acknowledged its function as a laboratory, a machine to alter behavior, train or conduct medical experiments, with provision to observe their effects. However, in his theoretical position, the Panopticon represented foremost a turning point from an era of exceptional (and mostly cruel) discipline actions to a period in which surveillance became a general apparatus to exert power (Foucault, 1985/1975, p. 209). This paradigmatic change reflects the structural transformations that marks the transition from Age of Reason to Modern Era.

3.4. A Counter-Asylum: Kingsley Hall

3.4.1 Ronald David Laing: An anti-psychiatric maverick

The initial way we see a thing determines all our subsequent dealings with it (Laing, 1960/1966).

As the second part of the comparative study, this section will explore Kingsley Hall, an experimental community established by the Scottish psychiatrist R. D. Laing in London. Laing was a radical figure, like his contemporary Foucault, he too had ambivalent views towards psychiatric institutions. He criticized the common madness rhetoric of capitalist society with a virtually anarchic method. Laing saw no significant difference between sanity and madness, for him they were just different dialects of human language, desperately seeking to be heard. In this belief he sought transition and connection points between these two conditions and developed a radicalized view towards the normative discourse of psychiatric discipline (Kotowicz, 1997, s.2).

Before specializing in neurology and psychiatry, Laing studied medicine. He became Karl Jasper's apprentice until the break of Korean War where he served in the psychiatric unit. Upon return, he first took a position in Glasgow University and later at Tavistock Clinic, where his initiation to psychoanalytic method began. In his younger years he very much admired the European existentialist theory such as Sartre and Heidegger. During

Tavistock years he adopted the American research tradition and focused on intra-family interactions. Maturity period of his career was heavily influenced by counter-cultural streams, which formed his iconoclastic attitude towards the interactions between contemporary capitalist society and psychiatric practice (Mullan, 1995).

Laing had a prolific career; although some as co-author, he published fourteen books, of which eight were written between 1960-70. His oeuvre contains many journal articles and book chapters. He was also one of the active authors in New Leftist Review (Oakes, 2021). 1960s mark a period of change in political and medical scene. Post-war atmosphere was echoing with equality protests. The beat generation was in full swing and its most important members like Yeats were close affiliates of Laing's close circle. Laing advocated the ideas of the counterculture. Crossley argues that his views on psychiatry were major concerns inspired from this political context (Crossley, 1998, p. 885). In the same year Laing published The Politics of Experience (1967), he participated on Dialectics of Liberation Conference (DLC). A wide array of politico-cultural thinkers like Herbert Marcuse, Stokely Carmichael, Allen Ginsberg or Francis Huxley were among the attendants, contributing to anthropology, critical theory, poetry and civil rights (Kotowicz, 1997). Laing is often displayed as a representative of avant-garde and The New Left group, but his critics were never about mere everyday politics. In this regard the Dialectics of Liberation conference exemplify a case where his political activism came close to its full extent. His critical stance was generally directed towards inner life, intra-family and inter-personal relationships/experiences in their social context (Clay, 1996, p. 102).

Laing directed fierce critics towards the established position of psychiatry in capitalist society. These political attacks transformed him into a maverick in public eyes. His rigorous work was laser focused on reinstating madness into its former position before asylums, before incarceration or exile: back into public realm, where it once existed as a natural member (Kotowicz, 1997, pp. 2-8). For Laing, the difference between being mad or normal was a mere matter of the interpretation of the attending psychiatrist. However, he did never underestimate the pain in psychotic episodes or schizophrenic attacks, he saw them as transition phases, communication attempts and foremost cathartic events that would allow one to align himself with his true feelings. In this regard his critic was more about the authority that was granted to psychiatry by the society and its governing structures. Laing described the schizophrenia diagnosis as a "political event". An article that he wrote for New Left Review displays his stance on this matter crystal clear:

"I do not myself believe that there is any such 'condition' as 'schizophrenia'. Yet the label is a social fact. Indeed, this label as social fact, is a political event. This political event, occurring in the civic order of society, imposes definitions and consequences on the labelled person. It is a social prescription that rationalizes a set of social actions whereby the labelled person is annexed by others, who are legally sanctioned, medically empowered, and morally obliged, to become responsible for the person labelled. The person labelled is inaugurated not only into a role, but into a career of patient, by the concerted actions of numerous others who for some considerable time become the only ones with whom a sustained relationship is permitted. The 'committed' person labelled as

patient, and specifically as 'schizophrenic', is degraded from full existential status as human agent and responsible person, no longer in possession of his own definition of himself. [...] His time is no longer his own and the space he occupies is no longer of his choosing. After being subjected to a degradation ceremonial known as a psychiatric examination, he is bereft of his civic liberties in being imprisoned in a total institution known as a 'mental' hospital. [...] In the mental hospital he must remain, until the label is rescinded or qualified by such terms as 'remitted', or socially readjusted." (Laing, 1964).

Laing had worked in Gartnavel Royal Mental Hospital in Glasgow during his psychiatric training after his army years. This 19th Century Victorian building was initially constructed as an asylum. The psychiatric wards were divided among fee-paying and non-fee patients. Some patients in the free ward had been staying there for many decades. Laing proposed to establish an experimental ward based on a research protocol. This special unit was to be a separate area from other wings, and the treatment would be based on inter-personal relationship with the psychiatrist. The committee granted Laing permission and so was the "Rumpus Room" established. He chose 12 patients which were considered as most challenging cases among those in hospital. They were presented with a well-lit, comfortably decorated room, equipped with various hobby opportunities such as knitting, magazines, drawing and so on. The patients and staff were to spend the daytime in this activity room, and everyone was allowed to wear everyday clothes instead of uniforms. The reaction was very positive; every morning the patients couldn't wait to get back into the room; they were gathering, laughing, talking in joy. The negative behavior significantly diminished, and in eighteen months all patients were released from the hospital (Clay, 1996, p. 55). Although they all returned within a year, the Rumpus Room experiment remained a very influential experience in Laing's career, and paved the way for Kingsley Hall community, which he would establish some years later.

3.4.2. The Kingsley Hall experiment

The Kingsley Hall experiment was the grand project of Laing, which granted him simultaneously vast critic and fame. Since his experimental Rumpus Room at Gartnavel he wanted to explore this subject more and has been searching for ways to establish something similar. In 1963, he started to organize round table discussions on this matter with his colleagues Esterson, Sigal, Cooper, Briskin, Cunnold and Wilkinson A similar experiment had been conducted by Maxwell Jones; he had been running a therapeutic community at Mill Hill Hospital for some time. Another example was David Cooper's experimental psychiatric ward at Shenley Hospital, which went by the name Villa 21. But these projects were run within psychiatric institutions, they were not independent communities (Clay, 1996, p. 121). They were aiming an independent establishment, with his own set of rules and psycho-spatial setting. In 1965, Laing and his colleagues collaborated in establishment of The Philadelphia Association, which would provide the Kingsley Hall community its needed legal basis (Kotowicz, 1997, pp. 76-77). The code of the Association stated that its main goal was to emancipate mental illness (schizophrenia in particular) from all formal descriptions, explore its possible causes, diagnosis methodologies, preventive means and treatment forms (Clay, 1996, p. 120).

A suitable building for the community was found in the East End of London. Kingsley Hall, designed by C. C. Voysey, was built originally as an orphanage in 1923 by philanthropist sisters Muriel and Doris Lester. This large building had been now deprived of its initial function and remained unoccupied amidst Victorian terraces and high-rise blocks. The Association signed a five-year lease and started the community in June 1965. With its arched windows and brick facade, this Art-Deco building had a rather austere appearance (Figure 3).

Figure 3. Kingsley Hall, London East End (Joly, 2005)

The ground floor contained a spacious common room, and first floor had two large rooms with vaulted ceilings. One of these was equipped with a billiard table while the other one served as dining area with its long, majestic table for 24 people. Second floor had a series of modest bedrooms (Figure 4-5). The building was crowned with a roof terrace, which contained additional four cell-like rooms (Clay, 1996, p. 122). In 1931, when he visited England for the Roundtable Conference on the

Independence of India, Gandhi stayed in one of these rooms with his goat for several months (Chapman, 2021, p. 478).

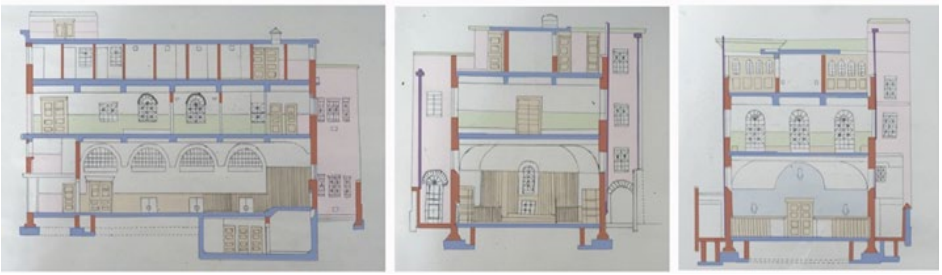

Figure 4. Self-drawn image based on architectural sections of *Kingsley Hall, Powis Road, Bow, London* (Cowles-Voysey, 1927)

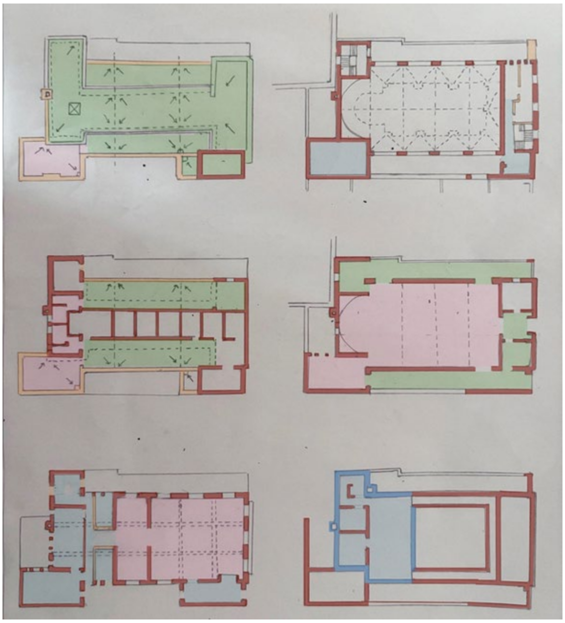

Figure 5. Self-drawn image based on architectural plans of *Kingsley Hall, Powis Road, Bow, London* (Cowles-Voysey, 1927)

Laing's experimental community was an attempt to combine his theoretical work with practice. His goal was to facilitate madness as a self-healing process (Laing, 1967, p. 110). Psychotic or schizophrenic episodes were seen as an inherent part of this process. For some time, Laing had considered regression as an illuminating experience and saw the disintegration-reintegration phases in a way very similar to death and re-birth, granting the psychotic events an almost metaphysical character. Majority of the inhabitants of the community consisted of schizophrenic individuals, who under different circumstances would've been placed in psychiatric institutions. Ultimately, this was not foreseen as an asylum per se but rather somewhere to relieve the schizophrenic from their state of distress by allowing them to experience their psychosis without being confined or sedated. The inhabitants were free (even encouraged) to express or act out they feelings; allowing them to explore and experience each other's true selves without having to display a semi-fake persona like in outside world for being tolerated by the society. Here they would be able to live through their psychotic episodes without any intervention. In Laing's view, vital knowledge is encrypted into schizophrenic's speech, listening and encrypting these so-called delirious talks was of key importance in understanding their world. In this regard, "madness" remained as a core element of Kingsley Hall (Clay, 1996, pp. 125-127).

Few months after the opening, Laing and his family moved to a compact room at ground floor. Other therapists including David Cooper, Aaron Esterson, Sid Briskin as well as four young American psychiatrists; Leon Redler, Joseph Berke, Morton Schatzman and Jerome Liss lived among the patients as a part of the commune, adopting equal roles. The dissolvement of traditional psychiatrist role lifted the barrier between patients and staff. Days would begin past midday with house chores like cleaning or shopping; distributed equally among those who were able and volunteered. Those who didn't want to participate or were buried into their inner journey were left alone reading, listening to music, sitting silently in common room or in their own rooms. The most colorful part of the day was the communal dinner at late evening around the long table in dining room, with Laing sitting at the head (Clay, 1996, p. 126).

Anyone was free to apply to stay here. Many sought out the community by their acquaintance with Laing's books. Some were in a disintegrated state or about to have an episode, desperately looking for somewhere to be taken care of or trying to prevent incarceration in an institute. Acceptance was voted equally, prioritizing those in most dire condition. Laing never enforced any decision on these matters. Each inhabitant paid around three pounds weekly for common budget. Many of them received social support from the government (Clay, 1996, p. 128).

Mary Barnes, a former certified nurse with schizophrenia, was the first resident in Kingsley Hall. She co-authored in following years *Two Accounts of a Journey Through Madness* with her therapist Joseph Berke, in which they provided vital information about the domestic life of the Hall (Barnes & Berke, 1971). During her stay, Barnes was able to experience her insanity to its full extent, regressing back to her childhood. This inner journey was marked with extreme distress and pain, from whence she emerged through her painting activity and community life in the Hall, eventually becoming a self-made artist. A similar example was Jesse Watkins, a sculptor who immersed into a psychotic episode for over a week by regressing back in time and recovered into everyday life. Watkins' story was told in Francis Horn Williams' testimony (Williams, 1970), who had a similar experience like Barnes (Chapman, 2021). She describes her regression as a rediscovery of her infancy and adulthood.

With her experience, she could be called as “a cosmonaut of interior space”, a phrase borrowed from Scottish Beat writer and Laing’s friend Alexander Trocchi (Bartie & Bell, 2012). Laing saw it crucial to explore uncharted intra-psychic waters, which was restricted in traditional society. Anyone entering this forbidden zone would have been expelled from normality. The ego, which mediates the social norms must be eliminated and replaced with a more liquid state of mind. He contented this experience with “metanoia”, a term borrowed from Jung’s terminology to define a change in mindset (Laing, 1972). The counter-cultural expression of this expression would be “expanding own consciousness” (Chapman, 2021, p. 476). Kingsley Hall had a strong spiritual association among its residents’ eyes. This view was endorsed by Laing’s opinions about post-war Western culture, which in his eyes lost authenticity through being deprived of any experience of sensuality, spirituality and fantasy (Laing, 1967).

Throughout its five-year life span, Kingsley Hall became a pilgrimage for American hippies, students from recently established Anti-University, members of counter-culture movement, Left-wing activists, Beat poets, writers, journalists, painters, sculptors and various other artists. It was launched to enable people live their state of distress freely without being marginalized by psychiatric diagnosis. They were hoped to overcome their disorientation through participation in this innovative community. Chapman defines the Hall project as “*a therapeutic art colony, which posed an aesthetic challenge to ‘one-dimensional’ subject of post-war affluent capitalism*” (Chapman, 2021, p. 485). He borrows these terms from Herbert Marcuse, the popular philosopher of 1960s counterculture, who saw redemption in marginalized groups (Marcuse, 1964). Chapman compares the Hall's performative character and its challenge to conventional boundaries with London Drury Lane Art Labs (1967-68), which Laing and his community members frequently visited and participated on performative arts. The Lab, which was a multimedia center that included a theatre, cinema, gallery, a restaurant and accommodation units, focused mainly on experimental arts. Its main goal was to establish a reciprocal relationship between everyday life and arts, with experimental culture and dwelling, deconstructing and reconstructing each other endlessly (Chapman, 2021).

After its first year, Kingsley Hall started to evoke negative reactions from its surroundings. Residents from neighboring housing blocks and other middle-class locals started to become hostile. Unusual visitors, long drinking sessions, noise was not always easy to tolerate. Class difference was one of the most contributing factors to this matter. The avant-garde population inside the Hall displayed profound differences from the inhabitants of East End London living few blocks away. By that time much of the London's underground culture posed same contrast in comparison to the rest of the population, of which majority was low-income middle-class citizens. In his interview with Mullan, Laing explained the hidden reason for this situation with ideological view about mental institutions among society members. The neighbors saw the residents of the Hall as poor souls, who deserved a better treatment in "designated facility". In defense of the community, he commented that in those five years, the Hall harbored many people who didn't have any place to stay. He stated that, despite occasional guidance, there wasn't any restrictions for the inhabitants and yet, in this period no single case of suicide, murder or death happened in the building. Laing describes his experimental community as "*beacon of light in the mental health field at the time, a place that held out hope in an era when the sane/made divide was first being questioned*." (Mullan, 1995, pp. 181-198)

Kingsley Hall was shut down in 1970, when the lease ran out. According to community statistics it hosted 113 people between 1965-69. The most veteran resident stayed about four and half years. None of the community members had to be hospitalized during or after their stay in any mental institution (Clay, 1996, p. 137). The Kingsley Hall was a bald materialization of the radical 1960s counterculture in mental health discipline, the crown jewel of the movement that was named by David Cooper as "Anti-Psychiatry". The psycho-spatial setting was nothing like any of its contemporaries or its predecessors. Its architectural setup promoted unity and interaction, where conventional class roles and definitions would be dissolved and reintegration of one's own inner world would constitute the singular concern. It represented an utopian optimism, an alternative community, the vision for a new world. Chapman accurately summarizes its diverse roles as "*an inner spaceship, a location for exploring the psychic interior; an embattled middle-class countercultural plantation in a working-class locale; a site of spiritual renewal and development; a single-building art colony; and a countercultural experiment with the accent on therapy as attention to the practice of everyday life*."

As a concluding remark, citing an analogy from Keith Musgrove's writings on Laing's experimental community appears strikingly adequate. In his essay, Musgrove characterized Kingsley Hall as a theatre, an experimental live stage which defamiliarizes social roles and theatricality in everyday life. His definition borrows heavily from Antonin Artaud. This is no coincidence, because one of the inspiration sources of Ronald David Laing's anti-psychiatric views was Antonin Artaud, a prominent avant-garde figure in Paris in the 1930s, who experienced a mental breakdown prior to his literary and acting career and had to stay for an extended period in an asylum. Artaud's disenchantment with psychiatry is most notable in his essay "Van Gogh, The Man Suicided by Society". Laing never referred to him directly, but the resemblance is still uncanny (Kotowicz, 1997, pp. 60-63). Musgrove compares the theatrical character of Kingsley Hall with Artaud's *Théâtre de la Cruauté* (Theatre of Cruelty). There is no border between illusion and reality but just an appeal to antagonism, an elaborate mixture of magic and danger. He describes the whole setting as "*an arena in which pervasive self-consciousness blurred the customary distinctions between actor and audience, the player and his parts*" (Laing, n.d.).

As a totality, The Kingsley Hall constitutes an important inflection point in the history of asylum. This experimental residence represents the culmination of a critical discursive formation towards established position of psychiatric authority regime in Western society. The most common discipline tools of this mechanism have long been disguised under normative standards imposed by the authority structures, and they are sole materializations of their contemporary epistemological systems. The extensive Foucauldian analysis of these potentialities in previous sections made this relationship more apparent. In this regard, the theatre metaphor not only underlines the role of Laing's experiment in disrupting the conventional operations of psychiatric authority, but also the obvious affinity between visual regime, social seclusion/inclusion mechanisms and psycho-spatial settings of mental institutions. As a discursive formation, Kingsley Hall experiment can be described as a strong criticism towards the established methodologies and practices of traditional psychiatric treatment. It represents an "anti-psychiatric spatiality", which eventually became a materialized form of resistance towards psychiatric discipline mechanisms.

4. Conclusion

In this comparative study, asylum represents a conceptual container for various potentialities, which define the relationship between insanity, subject and power in accordance with the epistemological position in a specific temporal and cultural context. Bentham's Panopticon and Laing's Kingsley Hall experiment constitute two radically different discursive formations, with each establishing this relationship in unique psycho-spatial organizations. Previous chapters attempted to engage these differences in two parallel trajectories. The genealogical examination targeted the transitions between corresponding epistemological positions and the transformative forces in play. On the other hand, the archeological evaluation of two typologies revealed how governing power structures materialize in discipline institutions, what tools they employ and how are these disguised in plain sight.

The theatrical character of Kingsley Hall, conveyed from Keith Musgrove in previous section will constitute a significant connection point in this duality. This metaphor becomes very interesting, when it's applied simultaneously to the definitive character of the Panopticon, which was explored previously. After all, neither experimental art nor experimental living as its counterpart is about norms, codes and definitions. It is always incomplete, challenges established canons, displays its authors iterative trial, it is nearly impossible to categorize, it addresses a limited, specific group and it is never mainstream (Attridge, 2018). In this regard, Kingsley Hall could never be more than a sketch, which would require each time an interpretation in accordance with differing local and social contexts. Panopticon on the other hand, was devised as a universal model for any future incarceration facility.

Chapman and Ostwald apply Nietzsche's Apollyonic/Dionysian dichotomy to this paradigmatic change to explain the relationship between visual demarcation and social structure (Chapman & Ostwald, 2006). In *Birth of Tragedy*, Nietzsche underlines two rivaling currents in Greek culture; Apollo the god of light versus Dionysus the god of wine, fertility and drama (Nietzsche, 1872/1993). Apollo represents in Nietzsche's thought the forces of individuation. These forces materialize in sculpture, the architectural manifestation of form, such as the austere monumental temples in Acropolis. The inner sanctum of a Greek temple commands both his immediate surroundings and the broader environment through its location. With its dimmed center, this extroverted buildings visual command penetrates all its surrounding territory. Its envelope on the other hand, gathers gaze on itself, while keeping its core and the statue veiled from vision. Chapman and Ostwald see strong affinities between this mode of thinking and the visual setting of the Panopticon. The Dionysian thought on the other hand, is more about unity between individuals than their contained, atomic existence. In this regard, they regard theatre as the most accurate archetypal model for representing the Dionysian mode of vision.

During the venue, the individual sphere dissolves and every single person immerse himself in collective unity. Both archetypal structures materialize different correlation between personal sphere and the world through differing operandi of vision (Chapman & Ostwald, 2006).

If applied to psycho-spatial settings, this dichotomy could prove useful to understand the distinction between asylums that employ a patient-oriented setting and those who adopt an Apolline correlation between vision, power and the inmate. Foucault's distinction between two images of discipline could be positioned accordingly:

"*There are two images, then, of discipline. At one extreme, the discipline-blockade, the enclosed institution, established on the edges of society, turned inwards towards negative functions: arresting evil, breaking communications, suspending time. At the other extreme, with panopticism, is the discipline-mechanism: a functional mechanism that must improve the exercise of power by making it lighter, more rapid, more effective, a design of subtle coercion for a society to come. The movement from one project to the other, from a schema of exceptional discipline to one of a generalized surveillance, rests on a historical transformation: the gradual extension of the mechanisms of discipline throughout the seventeenth and eighteenth centuries, their spread throughout the whole social body, the formation of what might be called in general the disciplinary society.*" (Foucault, 1975/1985, p. 209)

In this discussion, any comparison between Panopticon and Kingsley Hall would find its logical ground in their respective function as dividing and unifying mechanisms. When evaluated in Foucauldian terms, the differing typologies of psychiatric institutions interconnect architecture with exercises of spatial power, representing broader philosophical transformations than mere construction ingenuities. Henceforth, in their own contexts, both Panopticon and Kingsley Hall should be considered as an apparatus or what Foucault defined as "*dispositif*".

Foucault explains the term "*dispositif*" for the first time in 1977 during an interview with Agamben. His conceptualization of the term transcends the sole vocabular meaning of apparatus, as he sees this term as an overarching concept of "d*iscourses, institutions, architectural forms, regulatory decisions, laws, administrative measures, scientific statements, philosophical, moral and philanthropic propositions…mainly a system of relations that can be established between these elements"* (Foucault & Agamben, 1980). In this context, Kingsley Hall and Panopticon constitute architectural forms which represent elements of the *dispositif*. In his essay "Can a Building Be an Apparatus?", Neil Leach underlines the problem regarding the use of the term diagram in Foucault's writings and in architectural design. For Foucault the building itself doesn't exercise power, it is rather "a diagram to exercise power", he considers the building a diagram of potentiality in as much as it becomes an apparatus/*dispositif* for power (Leach, 2019, p.4).

What kind of role would Panopticon and Kingsley Hall play then, when considered as diagrams of potential power exercise, elements that would possess a certain capacity to influence and transform social settings? Foucault disqualifies architects from their position as "masters of space", claiming that architecture alone is incapable of inducing any social change; liberty or oppression as singular practices cannot be exercised by a diagram or project alone (Foucault, 1997).

When considered as elements within Foucault's over-arching *dispositif* concept; neither Panopticon nor Kingsley Hall or any other architectural form can be the sole determinant of social behavior. On the other hand, this does not mean that their role and meaning is to be ignored. Both structures, although in different ways and contexts, serve as the necessary nexus for a political current, as sub-parts within a system of relations. Following same line of thought, it would be impossible to achieve any social and political change by just transforming any building. On the other hand, considering them in their own dispositive system of relations, hidden meanings that they materialize can be deciphered.

If we go back to the Apolline/Dionysian comparison, the theatrical Kingsley Hall, constructed temporarily a symbiotic relationship between individual and its community. In its setting, the metaphorical vision trans-connects center to periphery and vice versa; namely madness to community and community to madness. This temporal contract is made valid through being resident and contributing to community through being present. However, the success of this operation is not dependent on the architectural form, it is rather a result of politico-cultural setting, that finds its translation in a specific architectural context: in this case the Kingsley Hall. On the other hand, Panopticon, as an Apolline mode of thought, represents a structure which is solely based on the vision of individuals. Here the connection operates only one-way, from center to periphery. The periphery is suppressed through perpetual potential surveillance. Bentham devised the ultimate materialized metaphor for individuation, abstinent towards any form of social collectivity and threatened by any possible association or unity. However, the structure is not the driving force of this power exercise. Anthony Vidler defines Panopticon as the dominant typology of machine culture (Vidler, 1977) henceforth the mechanic precision of Panopticon should be considered as a physical translation of Enlightenment into politico-cultural and social sphere.

Can architecture apply positive forces on a politico-social setting? From the perspective of this study, no *dispositif* can play the role of an agency. It constitutes a vital element of discursive formations, a thing or a sub-system within a system of things, which can host certain actions, but transcending given associations is on most occasions out of its range. The politico-spatial setting of any given discursive formation is a result of complex flow of events operating in subconsciousness of individual subjects, which is inscribed in a specific language on the fabric of architecture.

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The article complies with national and international research and publication ethics.

Ethics Committee approval was not required for the study.

Author Contribution and Conflict of Interest Declaration Information

The article was written by a single author. There is no conflict of interest.

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Hidden Supporters of Architects: Narrative Codes

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1. Introduction

Architects' major representation techniques like orthogonal drawings, perspective presentations, models, 3D models, etc. are visual, while texts are also one of the preferable techniques which they use for expressing the design ideas. Although there is a dominant bias supports that "an architect should draw rather than write", there is a notable quantity among the architects who write about their designs. Text is a way for the architects that they can express the product's spatiality, specific features, context, design approach, design process, building process or the spatial experience.

This study begins with a broad question: "How do architects explain their ideas of the tangible object itself?" and continues with another question: "Do/can architects represent intangible aspects of their designs?" If a quick skip is done through commonly preferred digital architectural media which are preferred by lots of architects, it can obviously be observed that the photographs of the buildings are the dominant representation techniques. The photographs are usually captured as long exposures that are freed from the user and the life within the space. However, if the texts are studied, then the central issue changes; the connotative content spread through the whole text becomes an issue for the debate. This enhancing attitude of the texts could support the architectural design's specific features rather than merely the visual ones.

With this role of text in mind, another question arises: "Do architects express the relational knowledge rather than the architectural object merely?" with another question: "Do they have the eagerness to represent the multi-layered features of their designs?" In this paper, a case study, which is a part of a larger research[i], to argue that architects try to represent the relational knowledge and the intangible features of their designs with the help of connotation in the texts is presented. With this case study, it is argued that representing the intangible aspects of the architectural project and positioning the design idea among all the other architectures is possible via the connotative approach in text.

2. Methodology: Sample Set Construction and Narrative Codes

The methodology of the research starts with the establishment of the media sample, identifying the project typology, and selection of the projects to be analysed. The next step of the research is applying Roland Barthes' *narrative codes* approach to the texts published of those projects. In the following section, methodology criteria are explained in detail because this study's importance lies in the sample selection criteria and the method applied to the sample set.

2.1. Sample Construction: Decision of the Media, Project Typology and Projects to be Analysed:

First, for making the comparison possible, the media sample is constructed according to the criteria that the texts were prepared by different sources. Thus, two sample groups were decided; one group of texts was prepared by the editors, the other group of texts was prepared by the architects of the buildings. The visitor quantity of the platforms was the second selection criteria so that they could be mainstream media.

The first platform is the digital publication of the Architectural Record Journal (AR). It is an architecture and design magazine that published its first issue in 1891 and has been published monthly in the United States since 1902 (Architectural Record, 2015). The magazine, which has special sections on various building types, publishes titles such as homes, schools, universities, healthcare buildings, and interiors. The second platform is *ArchDaily* (AD), the world's most visited architecture website in 2015, which describes itself as "a continuous online source where thousands of architects can access information about the latest architectural news, such as projects, products, events, interviews, and competitions." (ArchDaily, 2015).

In the first one (AR), the textual material is created by editorial board members. They were written by the journal's writers after the interviews with both the architect and the users, sometimes after a visit to the projects and research. Texts may include information about the place of the project, the approach of the architect, materials, user experience, etc. In the second one (AD), the texts of the projects are supplied by the designers themselves. In both platforms, the visual material's source was various; architectural drawings were created by the designer or by the firm employees, and photographs were captured by either an architectural photographer or the architect/firm.

Secondly, each project was determined to be found in both environments for providing a comparison between the two media. Apart from this, a single house/villa typology was determined. In this selection, it was aimed to make the typology easily understandable in terms of the scale of the building. The villa projects published between 2011-2016 in the "Record Houses" section of the AR platform were scanned, and attention was paid to ensure that these projects were also found in the AD platform. Since there was confusion in the content of the AR publications before 2011, the sample was limited at this stage. A total of 20 villa projects located in different geographies were determined. The designers and locations of the villas in the sample are different.

2.2. Barthes' Narrative Codes

At the very beginning of the research, a content analysis was applied to the texts, and some keywords were detected. However, while reading the texts, there was something different that needed more concentration, which cannot be distinguished via the content analysis technique. At first, it was observed that authors have an attempt to transmit the architectural design approach, design process and spatial experience through the connotation via signifiers. Then, the aim basically became to unveil the signs, which is an approach that helps the reader follow the reasoning, the process, and the associational knowledge. To unveil the signs, which is an approach that has roots in semiotics, Roland Barthes's (2002) approach of *narrative codes*, which he uses to analyse texts as plural structures, was applied to the texts.

According to Roland Barthes (2002) "..text is a galaxy of signifiers, not a structure of signifiers; it has no beginning; it is reversable; we gain access to it by several entrances, none of which can be authoritatively declared to be the main one; the codes it mobilizes extend *as far as the eye can reach*, they are indeterminable (meaning here is never subject to a principle of determination, unless by throwing dice); the systems of meaning can take over this absolutely plural text, but their number is never closed, based as it is on the infinity of language." In other words, this point of view is for understanding the text not as an hierarchical structure but as a "galaxy" of signifiers, without a single beginning or definitive meaning. The networks within the text are interrelated but non-hierarchical, allowing for multiple entry points and an unresolvable proliferation of codes.

Barthes (2002) explains narrative codes as: “The five codes create a kind of network, a *topos* through which the entire text passes (or rather, in passing, becomes text). Thus, if we make no effort to structure each code, or the five codes among themselves, we do so deliberately, to assume the multivalence of the text, its partial reversibility. We are, in fact, concerned not to manifest a structure but to produce a structuration… Code here not in the sense of a list, a paradigm that must be reconstituted.” This method, originally developed for consistent literary texts, has since been widely applied in visual arts, especially in cinema. In this direction, narrative codes definition helped to understand the attempt of the texts in terms of project’s intangible aspects.

Five narration codes Hermeneutic Codes (HER), Semantic Codes (SEM), Symbolic Area Codes (SYM), *Proairetic* Codes (ACT) and Referential/Cultural Codes (REF) that help to unveil the signifiers in the text are defined by Roland Barthes. In the book S/Z, which was first published in 1970s, he applies narrative codes on the short story *Sarrasine* of Balzac which is the book published in 1830.

The hermeneutic code (Barthes, 2002) refers to the mysterious elements in a story and how they get resolved. This code examines how an enigma (or mystery) is presented, how it makes its presence felt, how it develops, how its solution is delayed, and how it's eventually solved (Barthes, 2002). Barthes (2002) calls this "the voice of truth," and breaks it down into three main parts: the presentation, the prolongation, and the conclusion.

The semantic code refers to elements within a text that act as "signs" (Barthes, 2002). These are migrating elements that combine with others of their kind to create characters, atmospheres, figures, or symbols. Barthes (2002) calls this code, as "the voice of the person" which is a "signified" or even a "seme" (which in semantics is a unit related to the signified). It is defined as simply "by means of a word (approximately representing it) which at each point designates the connotative signified to which the lexia refers" (Barthes, 2002).

The symbolic area code (Barthes, 2002) is where a text's "multiplicity and reversibility" truly reside. When identifying codes, the goal is simply to show that "it is always entered by many equal entrances, which problematizes its depth and secret" (Barthes, 2002). This area is often established in texts through a series of opposing elements, much like the well-known rhetorical figure of antithesis (Barthes, 2002). Barthes (2002) calls this "the voice of the symbol", where the signified element is emphasized through these oppositions.

The *proairetic* code (Barthes, 2002) links actions and behaviours to Aristotle's concept of *proairesis*—the ability to deliberate where an action is referred to as "the voice of experience," this code's segments explain human actions (Barthes, 2002). It is stated that the code has an "empirical rather than logical basis," with no logic beyond what's "already done or already read," which accounts for the variety of segments and elements.

Referential codes are the many bits of knowledge or wisdom that a text often refers to (Barthes, 2002). Barthes (2002) refers to this code as "the voice of science" and calls these "cultural codes" (since all codes are cultural), or "referential codes" because they allow the text to draw on scientific or moral authority. It is just pointed out to the type of knowledge involved (like physical, medical, psychological, literary, historical, etc.) (Barthes, 2002). Table 1 presents the comparative summary of the narrative codes.

Table 1. Narrative codes of Roland Barthes (It is produced by the author from the book S/Z (Barthes, 2002)

Name & Abbreviation	Short explanation	Barthes'(2002) terminology for the codes
Hermeneutic Codes (HER)	deals with enigmas, questions, and their resolutions or delays within the text's plot	"voice of truth"
Semantic Codes (SEM)	Refers to migratory signifiers throughout the text, forming personalities, atmospheres, and symbols	"voice of the person" "practices of meaning"
Symbolic Area Codes (SYM)	The text's multiplicity and reversibility, often structured by antitheses	"voice of the symbol"
***Proairetic* Codes (ACT)**	Relates to actions and behaviours, connecting *praxis* with *proairesis* of Aristotle	"voice of experience"
Referential Codes/Cultural Codes (REF)	Numerous codes of knowledge or wisdom frequently referenced in the text, acting as cultural codes	"voice of the science"

3. Case Study: A Section of Narrative Codes that Architects Use in Commonly Visited Digital Media

A total of 20 villas' texts (names of the 20 villas are presented in Table 2), amounting to approximately 26,250 English language words across both environments, were analysed individually in each platform. The findings were then grouped, and percentage graphs were prepared. In this section, a detailed example of the analysis drawn from the large sample set is provided, followed by an explanation of the findings.

Table 2. The information of the 20 villas in the sample set

Name	Architect	Place
Lightbox	Bohlin Cywinski Jackson	USA
Mirror Houses	Peter Pichler Arch.	Italy
Balint House	Fran Silvestre Arch.	Valencia, Spain
Los Limoneros	Gus Wüstemann	Malaga, Spain
Villa Kogelhof	Paul de Ruiter Arch.	Netherlands
#house#1.130	Estuido.	Madrid, Spain
The P House	Studio MK27-Marcio Kogan	Brazil
The Tower House	Gluck+	NY, USA
Atrium House	Fran Silvestre Arch.	Spain
BB House	BAK Architects	Argentina
2Verandas	Gus Wüstemann	Zurich, Switzerland
Two Hulls House	Mackay-Lyons Sweetapple Arch.	Canada
Twin Houses Kastanienbaum	Lussi+Halter	Sweeden
Naka House	XTEN Architecture	LA, USA
Hose Roces	Govaert&Vanhoutte Arch.	Bruges, Belgium
747 Wing House	David Hertz Architects	CA, USA
Genius Loci	Bates Masi Architects	NY, USA
Montecito Residence	Barton Myers Assoc.	CA, USA
Bahia House	Marcio Kogan	Brazil
In Between House	Koji Tsutsui Arch.&Assoc.	Japan

3.1. The Narrative Codes Analysis

As Barthes (2002) proposes segmentation, a process of dividing the text into small, arbitrary "lexical units" without imposing a predefined structure or deep meaning, each text in the sample group was divided into pieces to follow the signifiers properly. This breaking down text procedure is done like Barthes (2002) practiced; the pieces do not have any meaningful order; each division has two to four codes. The spatial and stylistic features of the texts in the Internet pages such as interrupted texts with figures, boldfaces, italics were ignored, and they all arranged in plain-text documents to concentrate on just narrative codes.

Below is a short explanation from the wide text folders in terms of assigning the codes to the text. Figure 1 presents an example of how the analysis is done with one of the texts. First the text is prepared as plain text. Then it is separated into short segments (lexical units) which are numbered in square brackets.

> [1] **#house#1.130** *[title of the text]*
>
> [2] Down the Garden Path (HER): A house on a tight suburban site (SEM) provides a series of choreographed views through landscaped spaces and pavilion-like rooms. *[subtitle of the text]*
>
> [3] So the house turns inward (SEM), its principal spaces and circulation paths looking back and forth among themselves (SYM). The project's odd name is a code the architect uses to maintain the client's anonymity (HER).
>
> ...
>
> [6] The architect divided (ACT) the upper floor into two zones, with the main entry in between. The living room overlooks the trees at the back of the parcel. At the front, (SYM) the dining room—an almost independent pavilion of floor-to- ceiling glass— (REF) is set in a handsome court with a covered terrace and pool presided over by one of the site's original holm oak trees. *[quotation from the text to explain how the codes are defined]*

Figure 1. A short example presents the lexical units and detects the narrative code types. (The text is a part of the text written by David Cohn, a writer of the journal, in 2017)

When Figure 1 is considered which is one of the quotations from one of the texts (Cohn, 2017) analysed; the project's name is "#house#1.130". The first segment *([1]#house#1.130)* is the title of the text which is also the name of the project. It is not obvious that this is a name, or that this kind of term has a meaning at the beginning. Thus, it creates an enigma which corresponds to hermeneutic codes (HER) and makes the reader continue with a curiosity. Later, at the end of the third segment *([3] So the house turns inward, its principal spaces and circulation paths looking back and forth among themselves. The project's odd name is a code the architect uses to maintain the client's anonymity.)* the reader understands that this is a code defined for the anonymity of the client, and the enigma has been solved. The semantic code "SEM: *privacy"* in the second *([2] Down the Garden Path: A house on a tight suburban site provides a series of choreographed views through landscaped spaces and pavilion-like rooms.)* and third segment work together, first it is declared that the site is a *tight suburban*, and the solution comes after a while: *the house turns inward*. Thus, the reader understands that the spatial arrangement is decided to supply *privacy*. In the sixth segment *([6] The architect divided the upper floor into two zones, with the main entry in between. The living room overlooks the trees at the back of the parcel. At the front, the dining room -an almost independed pavilion of floor-t-ceiling glass is set in a handsome court with a covered terrace and pool presided over by one of the site's original holm oak trees.)* the text mentions physical features and spatial organisation of the project via the codes *proairetic* (ACT), symbolic area (SYM), and referential (REF). This time architect is the real actor that divides the mass "into two zones" which is a code to connote that the building is fragmented into pieces. This is the *proairetic* code (ACT). Next the writer tries to emphasize that the living room and the dining room are situated in controversial places which have different views. This is the symbolic area code (SYM) which is done to create and emphasize a clear imagery via contrasts. The term “glass from floor to ceiling” is a referential code that is the knowledge of the material and space perception which is the specific knowledge of the architecture. This is the specific profession’s knowledge that corresponds to the referential/cultural code (REF).

Consequently, each segment was assigned several codes, with the corresponding words or phrases in the text being marked. The abbreviation for each relevant code was placed next to the marked expression. Explanations were provided before moving to the next segment, including information such as code names, referenced concepts, and code numbers where necessary. Finally, the codes derived from these analyses were used to create code tables for each example (Table 3). Data from these tables was then graphically reorganized to identify concentrations in AR and AD environments, and these graphical data were subsequently evaluated.

Table 3. Narrative codes list from the analysis of #house#1.130 (Özgür, 2019)

AR (Architectural Record)		**AD (ArchDaily)**
HER: Enigma-1: the code hides the real name of the user (presentation)	ACT-2: connect	HER: Enigma-1: the code hides the real name of the user (presentation)
HER: Enigma-2: the settlement of the slope (presentation)	ACT-1: divide	SYM: Antithesis-single/wide
SEM: near environment	SYM: Antithesis: front/back	SEM: coherent design with the slope
SYM: Antithesis: interior/exterior	SYM: Antithesis: interior/exterior	SEM: coherent design with the slope
SEM: total space	SYM: Antithesis: interior/exterior	SEM: usage in different times of the day
REF: knowledge about architect	SEM: Modernist approach	SEM: total space
REF: knowledge of the architecture	SEM: coherence with the near environment	REF: the knowledge of architecture
REF: knowledge of the geography	HER: Enigma-2: the settlement of the slope (short explanation)	SEM: total space
SEM: privacy	REF: chronological code	SYM: Antithesis: interior/exterior
SYM: Antithesis: front/back	SEM: total splace	SEM: fragmented mass
HER: Enigma-1: the code hides the real name of the user (result)	SYM: Antithesis: interior/exterior	SEM: fragmented mass
REF: chronological knowledge	REF: chronological code	SEM: spatial richness
SEM: coherence with the nature	REF: the knowledge of the maths	SEM: spatial richness
REF: the knowledge of the history of architecture	ACT-4: hesitate	SEM: building process witness
REF: knowledge about architect	ACT-5: eliminate	
SEM: free façade		

3.3. Findings

The results were fascinating: the writers usually connote to something else rather than the object itself. These connotations sometimes become a cinematographic space design approach or sustainable design principles, while sometimes it becomes the attempt to position the object into some common sense like "the visual relation between inner space and outside is a requirement". Else, Modernist traces could be followed, for example, "making the mass as simple as possible and leaving the corners transparent" sometimes could be a great design issue. The spectrum was quite wide. Nevertheless, there are five groups of findings can be determined in terms of Barthes' narrative codes.

The first finding is that *the semantic codes are the most used ones in both platforms*. *There are referential and symbolic codes, respectively following the semantic codes. The proportions of proairetic and hermeneutic codes are quite low* (Figure 2). Since semantic codes function as codes, connecting the knowledge at various points throughout the text, they thereby assist in the holistic comprehension of knowledge areas and ensure the continuity of meaning. Regardless of whether the authors are architects or editors, texts are structured with signs revolving around one or more specific themes. This enables the readers to form a general image in their minds related to the signified that the semantic code points to. For instance, frequent referencing to "spatial coherence" throughout a text causes the reader to construct the knowledge area of the relevant architectural project through the concept of "spatial coherence."

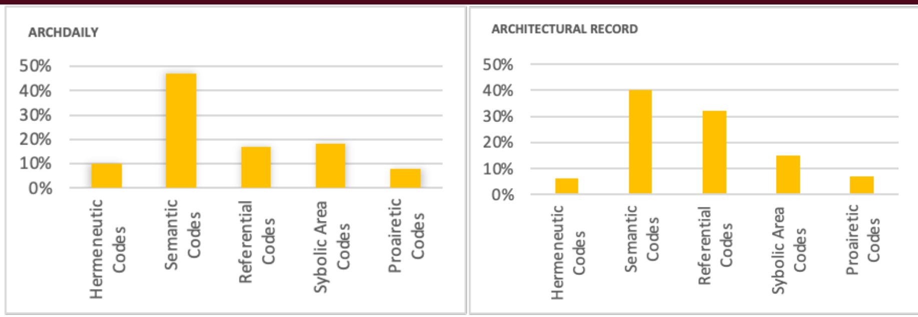


Figure 2. The proportions of the code types in two platforms (Özgür, 2019)

The second finding is that *the semantic codes exhibit considerable variety; however, concentrations are observed within certain codes* (Figure 3). To illustrate, the Modernist approach, social belonging, spatial integrity, distinguishable forms, sustainable design, spatial coherence, and harmony with the natural environment are the most frequent codes throughout the texts analysed. Moreover, the considerable variety observed in semantic codes is because of the unique knowledge embedded within every architectural product. Each product is characterized by distinctive design decisions, specific design requirements, and particular resulting elements. Therefore, it is a natural and expected outcome that the structure facilitating the holistic apprehension of knowledge areas will also exhibit diversity when transmitting the knowledge associated with each individual product.

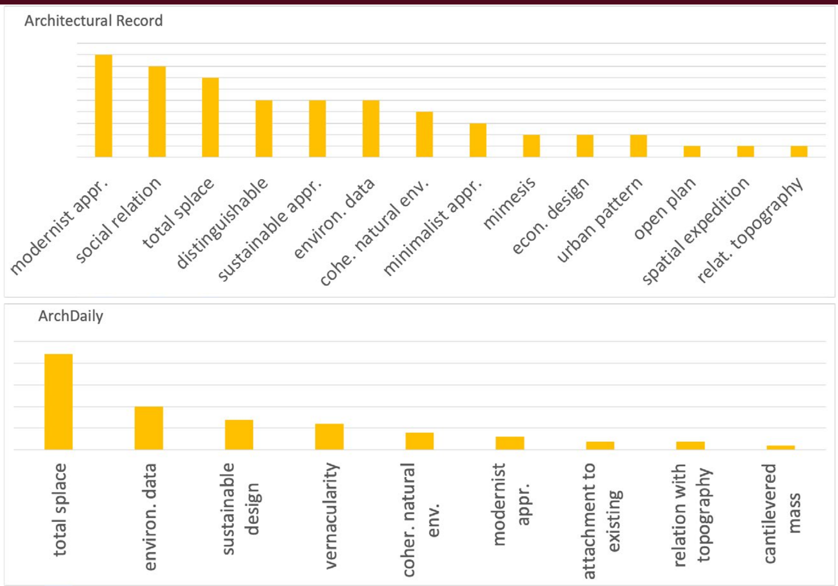
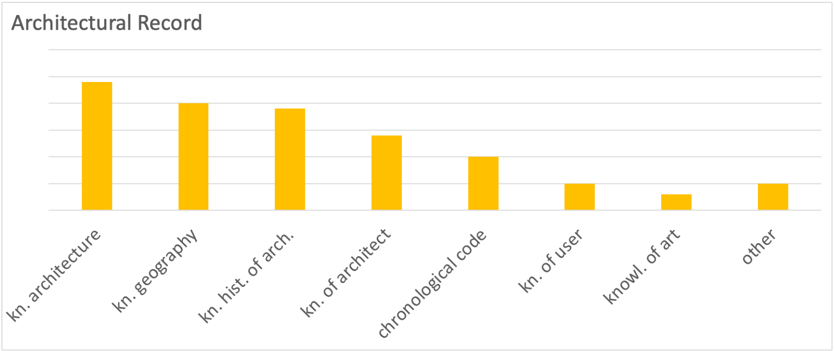


Figure 3. The variety of the semantic codes in two platforms (Özgür, 2019)

As the third finding it is possible to declare that *referential codes belonging to specific information about architecture, geography, history of architecture and information about the designer have been densely identified in both environments while in both environments, information about the user is at a very low level* (Figure 4). This situation primarily indicates that writers assume the reader already possesses knowledge of the scientific field being referenced. For instance, in an architectural product discussed in relation to a design by Le Corbusier, it is assumed that the reader is familiar with this name, his context in architectural history, his sphere of influence, design approaches, and architectural works. If the reader lacks this background knowledge, the reference will not be sufficiently meaningful. On the other hand, knowledge provided about the building's location and immediate surroundings, its users, and its designer suggests that the building is related to more comprehensive knowledge than just its physical or spatial qualities. Usually, the writer's effort to position themselves within a specific historical design approach is much less, indicating a reluctance to self-position. Instead, the writer points to specialized knowledge within the field of architecture, such as materials and structural capacity, as well as knowledge regarding the product's location.



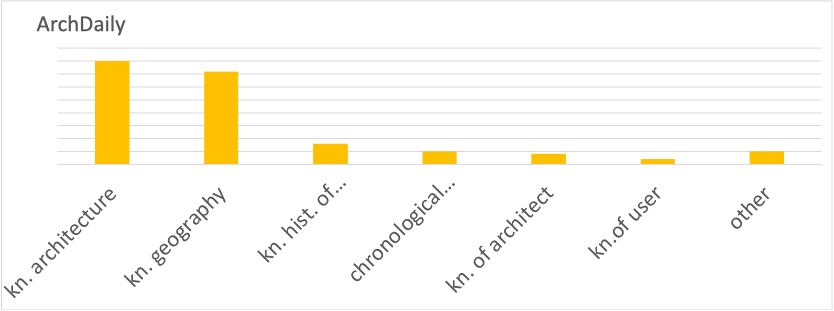


Figure 4. The variety of the referential codes in two platforms (Özgür, 2019)

The next finding is that *symbolic area codes are quite diverse in both environments and the concentrated contrasts of "interior space-exterior space" and "public space-private space" are noteworthy in both environments* (Figure 5). The diversity in symbolic area codes in both environments reflects the unique structure of each architectural project.

The observed concentration in the antitheses of interior/exterior and public/private within symbolic area codes indicates that both the architect and the editor point to conventional and accepted dichotomies in the field of architecture. Fundamentally, the establishment of relationships between contrasts, which serve as a rationale in design decisions, is generally accepted and legitimate approach in architectural design. It's noteworthy that these contrasts are not explicitly stated and thus cannot be detected during content analysis, with the texts merely indicating these rationales through signs.

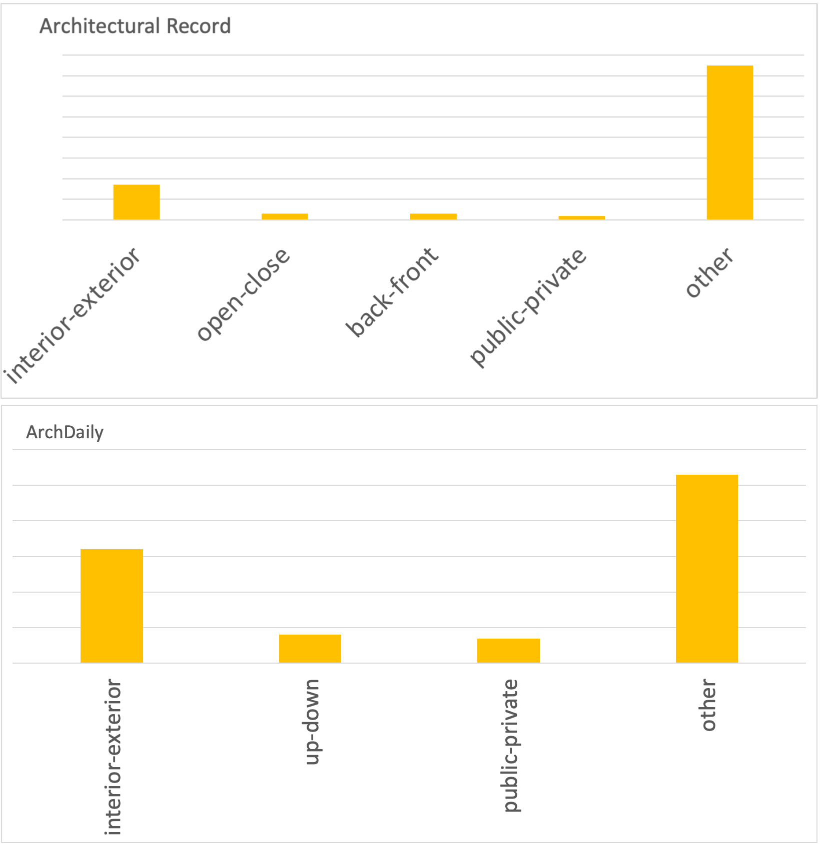


Figure 5. The proportions of the most used symbolic area codes as antitheses in two platforms (Özgür, 2019)

The last finding of the analysis is *in some of the texts written by the architects, a remarkable concentration in the proportions of symbolic area codes and semantic codes is observed in the statements of some architects while in the texts prepared by the editors were quite close to each other, showing a balanced distribution*. This situation, observed in the texts of architects, indicates that the architects' desire to create an original imagery in their narrative for their unique designs might also lead to original semantic constructions. In contrast, such a situation is not present in the other sample set due to the necessity of maintaining consistency in the journal's publication philosophy.

To sum up the findings; it was obvious that the knowledge areas created via narrative codes in the analysed texts were quite varied. There were many different knowledge layers like context and design solution relationship, environment-climate-topography relationships, place's specific features, spatial relations, site plan decisions, body movements that could be derived by spatial features, sensory effects like light/sound/scent/texture, the movements backward and forward during the design process and their reasons, user and designer information, the meaning that was designated by the author, the relationship with the prior designs or comparisons with them, etc. The more the signifiers were unveiled, the deeper knowledge could be gathered, and the satisfaction degree could get higher, and the joy gathered became quite exciting in terms of intangible features of the architectural project. This process also contributes to the formation of an imagery related to the product. The proportions of the narrative codes determine the framework of this imagery and its structure, which is composed of layers of knowledge.

The knowledge structured via narrative codes resides within a network, following a specific theme or many themes. Furthermore, by emphasizing various focal points through contrasts, certain characteristics of the product are made more visible. The analysis is done in detail and the qualitative approach is dominant with the researcher's point of view. As the nature of qualitative research, the results may change with another researcher's point of view. At this point, it is important to keep in mind that the possibility of unveiling the signifiers depends on the reader's/viewer's encyclopaedical capacity as Eco (2003) remarks. In other words, if the reader/viewer has the faculty or experience of textual expressions multi-faceted nature, then it is possible to travel among the multi-layered knowledge.

4. Conclusion

As hidden supporters of architects, narrative codes do not exist properly in the text; rather they are diffused through signifier systems for connoting to different knowledge areas. In other words, they are not just pure information pieces; they are an inference of a field, an emphasized concept or phenomenon, and they have the impact of reasoning and association. Accordingly, the signifiers make the reader contemplate among different knowledge areas of an architectural project.

The signifiers observed during the analysis, create an imagination of the architectural products by the associational knowledge like the design process, design methodology, approach, the paradigm it refers to, spatial experience, users, context of the product, etc. in terms of intangible knowledge layers of architectural product.

In other words, textual material, with the help of signifiers, the project's intangible properties had the opportunity to be represented. Within this study, it can be assumed that both architectural media and the architects themselves benefit text's connotative nature to place their designs among others. The intricate knowledge layers are transmitted with the help of narrative codes, they are the hidden pillars of architects for their both explanation and legitimization of the design ideas.

To sum up, when we take a quick look at the very preferred digital architectural media, it is obvious that the represented is still widely the visual features with visual techniques especially the photographs. However, an architectural project has much more intangible features than the visual or aesthetic form combinations, material, or colour harmony. It is possible to indicate that architects benefit the narrative codes in texts either consciously or not, yet the narrative codes are quite common in almost every textual expression. It may be remarked that being aware of the narrative codes, as the hidden supporters of the architects, in texts is important for contemplating among the intangible characteristics of the designed object.

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Tracing the Pre-Modern Representation in Contemporary Architectural Drawing

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1. Introduction

This paper aims to explore the underlying motivation of pre-representational traces in works observed in contemporary architectural representations that differ from conventional technics of architectural drawings. It proposes a general overview of the literature by arguing that memory can be both preserved and recalled through those specific approaches. The research establishes a structure for illuminating the underlying motivation for postmodern architectural drawing practice via positioning them in a trilogy of axes consisting of semantics, syntactics, and pragmatics. This three-axial framework has been established to demonstrate that representations can interact with other domains in different ways. The aim is to achieve a holistic perspective for the analysis of artistic and architectural works. In other words, drawings may propose an alternative mode of thought not only through their visual expression but also through the semantic value they signify symbolically. As a representative instance of this condition, within the scope of this study, such a construction has been adopted in order to make visible the connection between the theme of “memory” and its representations. The interpretation of the drawing through this trilogy can be read in relation to Rosalind Krauss’s concept of ‘expansion, expanded field’ for inter-art relations, considering its connections with other disciplines."

The study also seeks to develop alternative meanings through the functional possibilities of the representations differ from conventional representational methods, and focusing on parallels between current styles and pre-representational methods. The essay presents within a framework for investigating contemporary architectural representation methods, establishing a parallel with the “iconoclastic” operation which refers to the conventional icon as practiced during the Middle Ages.

In this regard, the article discusses the transfer of deformations in pre-representational representations to postmodern architectural drawing as an iconoclastic operation, occurring either unconsciously or being consciously constructed, and articulates this rupture through the dialectical tension between remembering and forgetting. As a result of the study, a new way of thinking about architectural representation is presented, thus differentiation from orthodox representation techniques can be conceived as a search for an alternative architectural representational language, thereby presenting a new perspective to the academic discourse.

The crisis of representation, the emergence of paper architecture, and the use of diagrammatic representation methods alongside critiques of modernism constitute a central discussion within postmodern architectural theory. In this context, a differentation from conventional/orthodox representational techniques and tools become a primary concern in architectural theory of the 1970s, especially through diagrammatic explorations. However, according to Robert Somol (2007), the crucial method and process of architectural knowledge appears to have transitioned, throughout the latter half of the twentieth century, from drawing to diagram. The architectural production of the past more than forty years can be characterized by the desire to create an architecture that is both autonomous and heterogeneous, in opposition to the anonymous and homogeneous buildings associated with the post-war discourse and postwar realities of the modern movement.

After the modernist period, architectural representation has come to be discussed not only as a means for the materialization of buildings but also as an instrument for intellectual examination that expands interdisciplinary perspectives and redefines the scope of architecture during the early design process. In this sense architectural representation has become to be discussed within an intellectual domain characterized by an experimental approach involving speculation, criticism, imagining, examining, interpreting, and thinking. Although post-war interest in the topic increased, speculative representations have long been prevalent, and during this period, engagement with them intensified.

Regarding this, Alberto Pérez-Gómez (2005, p.164) posits that since the Renaissance, the correlation between the intentions of architectural design and the built object they describe, the purpose of the representation and the building has changed. As indicated above it can be argued that the architectural medium, wherein the drawing itself become an object of research, have evolved. Therefore, in parallel with the debates of the period, the architectural medium in which drawing itself became an object of research, makes the correlation of architectural representation with various disciplines visible through its intersection with art, by taking the 'drawing of the drawing' as a primary concern so seeking to differentiate from orthodox styles of drawing. In parallel with this development the ability of drawing to challenge conventional methods of representation and to open them up to critical inquiry has endowed contemporary drawing practices with a distinctly speculative and experimental character.

The act of drawing itself has been considered directly becoming a research object by a various viewpoint in theoretical field, opening up to critical engagement within architectural debates of the postmodern period.

Pre-representational representations signify the period before the Renaissance Period when drawing had not yet become institutionalised with architectural qualities. The essay assumes that drawings which related to pre-representational representations also question the “drawing of drawing” thus, the study focuses on theories that emphasize memory by revealing the connection between architectural representation and both the past and the arts, with a particular emphasis on pre-representational representation techniques. According to Avci (2022, p.145), in architectural education one of the most usual and universal representation techniques is 'central perspective', which was discovered during the Renaissance. The rational worldview of the Renaissance helped create a universal language in architecture and enabled us to express our ideas about space, facilitating dialogue between ourselves and others. However, other techniques, such as iconography or miniature painting, reflect a different understanding of the world and space, and could offer a new approach to representation in our era.

Evans states (1989, p.21) that in terms of art, the fact that all significant decisions are normally taken before the construction of an architectural object even begins is peculiar to architecture. However, it makes a great deal of sense to describe the process of its conception as abstract. Architects do not make buildings; they draw them on paper. Other things are conceived in a similar way, such as engineering and legislation, but they are not usually considered art.

Gómez (2005) states that the space 'between dimensions' is fertile ground for discovery. The expectation that architectural drawings and models, products of the architect's work, must facilitate work in a different dimension sets architecture apart from other arts. However, the creative process in architecture today often assumes that designing and representing a building requires a perfectly coordinated set of projections. These projections are intended to serve as repositories for complete ideas of buildings, cities, or technological objects. For purposes of descriptive documentation, depiction, construction or imparting objective information, the architectural profession continues to view such projective architectural artifacts as reductive. It can be stated that speculative drawings, apart from those characterized by Gómez (2005), seek to counter this reductive condition by proposing an alternative approach.

Forty (2000, p. 215) asserts that the twentieth century exhibits a greater interest in memory than any previous era, and that the fascination with museums, archives, and heritage studies reflects a culture shaped by the fear of forgetting. He further explains that although architects' engagement with memory appears to grant them a form of '*carte blanche*' (unlimited authority), memory remains an entirely mental construct, rendering it unsuitable for direct physical construction.

According to Vesely (2004, p. 178; cited in Avanoğlu, 2021, p. 80) the analogy between image and text, constituting the fundamental characteristic of non-instrumental representation, is a seminal contribution to the field. As Avanoğlu (2021, p. 80) further argues that drawing is an enigmatic visual text in which architectural imagination is read and interpreted as a form of divination serving as a mental and spiritual backbone. When understood as a literary construction and a visual poem, the true foundations of drawing lie in the hidden spaces of line and image, while non-instrumental drawing is primarily an esoteric construction, a subtle and occult text.

Goffi (2016) emphasizing the intuitive and abstract dimensions of architectural representation, argues that representation evokes intuition by combining the invisible with the visible. Goffi also conceptualizes drawing as a physical structure and its counterpart the infinite body, thereby defining the correlation between the signifier and the signified. He further argues that drawing in architecture is a practice of imagination, generating presence from nothing. Moreover, he emphasizes the various states inherent in these drawings, contending that drawing fosters a unity between presence and absence, past and future, and ruin and construction.

According to Maden & Şengel (2009), an alternative critical perspective toward the classical nature of architectural drawing is associated with its treatment as an allegorical discourse. They argue that, unlike metaphor, allegory does not indicate directly but rather implies, and they emphasize the capacity of such drawings to suggest layered meanings. Moreover they note that although the invention of classical technical drawing rules contributed significantly to the development of all arts, it also introduced the problem of mimesis—namely, the conceptual tension between imitation and representation.

Eisenman (1991), with reference to Daniel Libeskind's Micromegas series, argues that the three-dimensional form produced through the conventional role of architectural drawing can merely reflect the content of such drawings but cannot fully represent it. According to him, to insist that these are merely drawings or working documents for a tangible physical form—whether as a three-dimensional model or a constructed building, i.e., fulfilling the traditional role of architectural drawing—would be misleading. The resulting three-dimensional artifact might at best echo, but cannot contain, represent, or signify the content of these drawings, as the drawings transcend the conventional cause-and-effect relationship between drawing and building or model through their deconstructive nature.

2. Pre-Representation in Speculative Architectural Representation

One of the defining characteristics of speculative architectural representation is its emphasis on aspects that privilege the irrational and intuitive over the rational, mathematical and systematic, distinguishing itself from orthodox techniques of representation. In this context postmodern/contemporary drawing practices that encounter with pre-representational techniques also articulate a form of resistance against the canons of modern architectural representation. Unlike cartesian representation techniques, these practices foreground spirit and intuition as central expressive forces.

The intellectual atmosphere of the postmodern period is marked by parallels with pre-modern conceptions of the subject–object relationship. Köksal (2022b, p. 19), argues -from a reading from the history- that with the beginning of the Renaissance in Europe, the traditional worldview began to dissolve and the contextual integrity of this perspective began to erode. According to him, this erosion signifies the fragmentation of the identity/unity between subject and object.

Köksal (2022a) delineates the intricate correspondences between the pre-representational and representational paradigms characteristic of postmodernity through a dialectical engagement with the closed semantic schema endemic to modernism:

"The closed semantic framework intrinsic to modernist discourse situates the subject—the ontological 'self'—at the threshold of existential scrutiny. This ontic impasse precipitates the fragmentation and subsequent dissolution of the cohesive self in the latter half of the twentieth century. Specifically, the art object, historically estranged from its socio-spatial and cultural milieu by the processes of modernization, constitutes a locus of production that re-negotiates its relationship to context, thereby engendering renewed interpretive significance. The deconstruction of the art object as an autonomous, introverted entity effectuates the eclipse of medium-specific disciplines such as painting and sculpture, historically codified within disciplinary canons. Conversely, contemporary artistic praxis foregrounds relationality, engaging in a dialogic interplay with architectural and spatial contexts, thus catalyzing a paradigm shift towards interdisciplinary fluidity and transcultural hybridity."

In the pre-modern era, pre-representational representations employed a fundamentally different influence on cultural and social dynamics compared to contemporary contexts. There existed a profound ontological unity between the signifier and the signified. Köksal (2022a) posits that the epistemological rupture between the signifier and the signified is variously negotiated across cultures and historical epochs. In the dialectic between the object and its representation, the latter is not merely instrumentalized in materializing the architectural object; on the contrary, it constitutes an autonomous field that gives rise to its own independent field of knowledge. Furthermore, Köksal (2022a) emphasizes that drawing functioned as a form of natural language during the medieval era, reflecting the intrinsic unity between signified and its signifier. In this regard, medieval (pre-modern) architecture reclaims its 'natural linguistic' through the representational mode termed 'reverse perspective', a spatial logic distinct from the Renaissance linear perspective, articulated in ecclesiastical drawings where vanishing points are deliberately repositioned to evoke alternative spatial narratives.

Reverse perspective, unlike Renaissance perspective, does not bind the observer to a single focal point. The drawing is designed with the consideration that multiple focal points can exist simultaneously. As in icons, reverse perspective possesses not a single but multiple vanishing points (Sayın, 2021, p.16). This allows for the concurrent experience of different points, proposing a mode of vision that is simultaneous, in contrast to the sequential temporality characteristic of Renaissance perspective.

Considering from the perspective of architectural representation, the rupture of the subject from the object/context can be interpreted in relation to the emergence of representation as an autonomous medium. In the period following the Renaissance the rational graphic language of architectural drawing practice became institutionalised, and the architect assumed the role of "designer" rather than "constructor". According to Köksal (2022a, p. 26) after the Renaissance the role of architectural representation has evolved significantly over time; initially serving as a vital component of architectural production, it has gradually transformed into the autonomous area of intellectual inquiry. This emerging area—often referred to as 'intellectual architecture' or 'paper architecture'—encompasses the conceptual output of all architectural and urban utopias. Moreover, paper architecture has served as a medium for a primary discursive role particularly at essential turning points in the history of architecture. Köksal (2022b, p. 20) assumes that redrawing an architectural form by removing it from its context challenges the traditional perspective that assumes a fixed relationship between form and content and treats the form merely as a container. From this perspective, it can be claimed that the postmodernist approach defends the autonomy of architectural drawing against modernist paradigms.

"Here, they have been selected due to their exemplification of applications in various disciplines that employ past methods within the context of the arts today." "They clearly demonstrate a departure from conventional representational methods, both formally and semantically. Contemporary architects working within a speculative paradigm combine pre-representational techniques into their drawings through various metaphors. In a conversation, Indian architect Balkrishna Doshi states that his drawings are inspired by Indian miniature paintings (Fernández et al., 2021).

"This drawing (he points out a reproduction of Vidhyadhar Nagar, acrylic painting on canvas, which he dedicated to my grandson Alex) is from 1990, when he held a chair at Philadelphia. Then I decided to do so. When you create, or represent, sketches, drawings, models ... Americans make many models. And the best way is to draw. I remembered the ancient Indian drawings and the painted miniatures." (Figure 1).

Figure 1. Miniature-Sangath (Vastushilpa Foundation, n.d.)

A further example of this kind of speculative representation can be observed in the Islamic calligraphic inspirations of architect Zaha Hadid, which also carry traces of constructivism and suprematism. Patrick Schumacher elaborates on the spatial organization of Hadid's curvilinear forms shaped by calligraphy, emphasizing how the concepts of deconstructivism and fragmentation are expressed in her paintings and sketches. A closer analysis of Hadid's drawings reveal their intrinsic connection to calligraphic expression. According to Bittar (2012; cited in Haider, 2021), calligraphy serves as a trigger for Hadid's design research, which is essential for understanding her Muslim/Arab origin and interpreting the role of this traditional art in contemporary architectural context.

In this context, traces of calligraphy can be observed in Zaha Hadid's drawings for Malevich's tectonics and The Peak, as well as in her own statements. Hadid states that these traces of calligraphy in her drawings symbolise a transformative domain of investigation, both at the urban scale and architectural scale, and specifically emphasizes that, in the drawings of The Peak, calligraphy is intended to manifest as a new form of geology (Hadid, 1987, p. 39) (Figure 2).

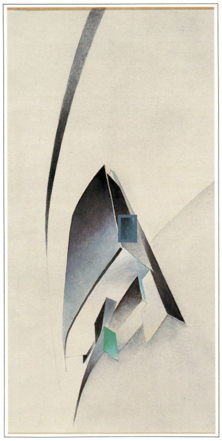

Figure 2. A Drawing of Zaha Hadid (Hadid, 1987, p. 41)

Villa dall'Ava drawings of OMA are also significant, as they exemplify the method of "reverse perspective" reflecting the representational strategies associated with pre-modern art. According to the Colonnese (2022, p. 51) still rendered by hand on paper, the drawing subverts the cartesian perspective through the use of an "inverse" or "reverse" perspective. These concepts rooted to the Russian priest Pavel Florenski (1882–1937), who, by 1917, had emphasized how certain ancient icons exhibit clear deviations from classical perspective. These icons appear to "develop" the surface of the facade and depict—similar to Western medieval painting—multiple visible sides of books, altars, and buildings, sometimes showing three or even four faces/facades simultaneously.

Such figurative strategies seem to contradict the logic of human visual perception and the linear perspective based on a fixed point of view, which is regarded as one of the central ontological and representational frameworks of modern Western civilization (Figure 3).

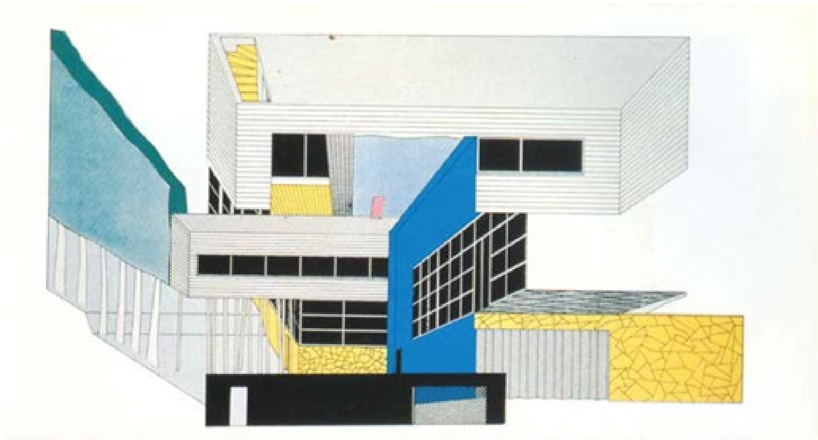

Figure 3. OMA, Villa dall'Ava (Drawing), Paris, 1984-91 (Colonnese, 2022, p.52)

In architectural representation, connections with pre-representational drawing techniques can be established through various methods. For instance, in Aldo Rossi's drawings for the San Cataldo Cemetery project, it is possible to identify the similarity with Giorgio de Chirico's metaphysical paintings (Eisenman & Iturbe, 2020, p.55). These paintings can be understood as being influenced by the past in terms of their pictorial elements and spatial organization.

Within this framework, Rossi's compositional organization of elements and spatial components on the plan simultaneously with their top and side views, as an individual representation strategy, distances him from the orthodox language of architectural representation and aligns him more closely with miniature painting. Contextually, this system can be explained as a mnemonic device that reveals the past, informed by de Chirico's influence and the incorporation of historical elements into the realm of architectural drawing. Furthermore, Rossi's abstraction of unique architectural components through an artistic approach is important in making explicit the link he establishes between architecture and the visual arts. Parallels may be drawn between Rossi's works and Quattrocento paintings of Italian pre-representational art (Figure 4).

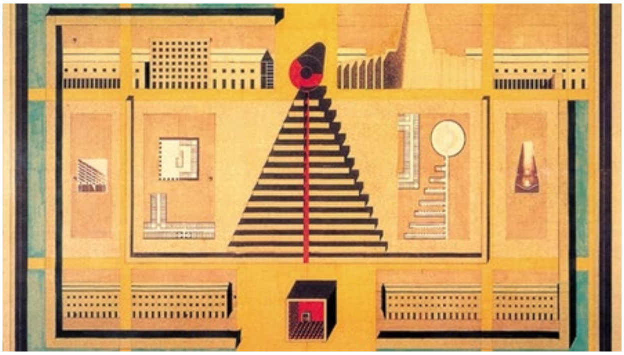

Figure 4. San Cataldo Cemetery, Aldo Rossi, 1971, Cementerio de San Cataldo, Modena (Arquitectura Viva, n.d.)

Concerning this point, Eisenman & Iturbe (2020, p.47) categorize Rossi as postmodern manner but criticize this categorization as insufficient. They argue that the archetypal geometric configurations present in the San Cataldo Project drawings do not raise an autonomous style; rather, they refer to basic formal components such as the cone and cube, thereby potentially revealing the timeless possibilities of form.

The depiction of parts that cannot be simultaneously seen from different planes, as in conventional representation is made possible in miniature method and, as exemplified by Rossi and Doshi, when a non-conventional technique is employed. This approach allows for a simultaneous experience by observing multiple vanishing points at once, while also inviting a reconsideration of the connection between representation and the body. In this regard, Sayın (2021, p. 26) notes that in miniatures and icons, parts that the eye cannot perceive simultaneously can be made visible, indicating that not only the front of the face but also the back, and not only the neck but also the nape, can be represented."

During the Renaissance, painting, sculpture, and architecture were closely intertwined, however this unity among the arts fragmented during the modern period. In the postmodern era the appearance of pre-representational components in architectural representation and their use in postmodern arts reveal similarities in the portraying of space. These parallels offer a renewed convergence of fine arts and architectural representation, reminiscent of the pre-modern period. Accordingly, the similarity of the traces of pre-representational representation in contemporary artworks with the representation of space is important for this study.

Yüksel Arslan is presented as an illustrative figure, as he synthesizes traditional techniques and forms with contemporary styles of drawing, positioning the theme of memory at the core of his artistic practice, while simultaneously problematizing architectural space within his works. Moreover, since his drawings recurrently engage architectural space as a subject, they establish a profound and sustained relationship with the representational discourse of architectural space. Sayın (2013, pp. 184–190), who analyzes the painting technique of Yüksel Arslan, whose works emphasize rendering of architectural space, argues that Arslan adopts a background approach characteristic of Byzantine and Ottoman-Anatolian representational traditions by leaving the background void and utilizing compositional elements as correlatives between the invisible background and the visible foreground. He further asserts that Arslan internalizes the traditions of Byzantine iconography and Ottoman miniatures. In the Arture series, the artist aims to articulate the depicted figures through traces of a shared tactile gesture and an organic relationality. Sayın emphasizes the strong pre-modern referentiality in Arslan’s work by noting that this trace is inherent to pre-modern art, associated with Eastern aesthetics and immateriality, and that art is veiled by this principle.

The integration of architectural elements is a prevalent motif in Arslan's work. However, rather than depicting space through conventional representational styles, Arslan deliberately subverts such conventions by portraying images of buildings in overlapping or reversed configurations, often using a method of visual layering. This compositional approach bears notable resemblance to miniature painting traditions (Figure 5).

Figure 5. Yüksel Arslan, Arture 149, 1969 (Artfulliving, 2022)

A specificized analysis of representational practice has revealed that pre-representational representation techniques are used repeatedly, both within the domain of architecture and various fine arts, with examples dating back to the early twentieth century. Distinctive traces of pre-modern artistic paradigms emerge in the works of avant-garde artists such as Paul Klee and Pablo Picasso. When these works are examined in terms of spatial representation, it is possible to understand them as facilitating the conceptual creation of architectural space.

According to İpşiroğlu & Eyüboğlu (1972), the emergence of a new direction within European painting, characterised by a departure from the realistic approach that had previously dominated, precipitated a comprehensive reevaluation of all artistic creations, encompassing both pre-modern and modernist paintings. This shift in perspective, understanding, and value system was accompanied by a profound transformation in the way art was perceived and valued. The new painters, who distanced themselves from naturalism, began to identify more closely with pre-Renaissance or non-Renaissance embroidery masters, who had previously been overlooked. During this period, medieval paintings, mosaics, stained glass, African masks, Eastern miniatures, Japanese estampes, and other art forms characterised by expressive power and elaborate embroidery gained unprecedented popularity. Miniature painting, in particular, emerged as a significant branch of art, attracting the attention of Western artists. Lynton (2015, p. 207) has observed that Henri Matisse (1869–1954) attempted to reconcile the conventional Western perspective with the two-dimensional spatial compositions he encountered in Iranian miniatures.

3. Three Axes of Speculative Architectural Representation

Architectural representation entails communicative functions that surpass its solely instrumental role in construction, encompassing hybrid intersections of historical, cultural, and contextual significance. The continuity of concepts such as history, tradition, context, and culture within architecture is contingent upon its engagement with other disciplinary fields, which allows the built environment to operate as a repository of collective memory. By invoking the value and meaning of the past and transmitting these to subsequent generations, architectural representation exemplifies a distinct form of functional agency. This study critically examines these multifaceted functions through the lens of architectural representation's interaction with the visual arts, demonstrating their articulation in visually-oriented works. Beyond formal attributes, the intrinsic and implicit semantic content of such works demands careful consideration.

Furthermore, the functional aspect of a drawing reveals its pragmatic dimension, collectively constituting an integrated framework in which formal, semantic, and pragmatic registers converge to articulate the operative capacities of architectural representation. In speculative representations, the tendency to diverge from Renaissance drawing techniques can be observed in a variety of ways. The study elucidates the relationship between postmodern architectural representational methodologies and pre-representational techniques, identifying the essential motivation behind the formulation of speculative representations as an attempt to explore the disruption of classical drawing techniques. The research is structured around three analytical axes: semantic, syntactic, and pragmatic. Each of these axes aims to explore how speculative representations depart from conventional practices with respect to their semantic content, structural configuration, and operative function.

In his book *“Drawing: The Motive Force of Architecture”,* Peter Cook (2014) examines the emergence of architect’s drawings by considering different uses of drawing. In the introduction, Cook (2014) examines drawing by comparing the emergence of architect’s drawings as a practical necessity or where the particularisation of a building depends on artistic heritage of little importance. In the latter case, he argues that issues of consciousness, psyche and motivation are involved in representation.

Accordingly Cook (2014) examines drawing by categorising in this regard “*motive, strategy, vision, image, composition, expression and atmosphere, technics, surface and beyond reality*”’. These various classification of drawing expand its limits beyond its traditional instrumentalisation as a rational tool for building an architectural object. Instead, he opens up alternative possibilities and offers examples that highlight the extending representational and conceptual potentials of drawing.

In the book, Cook generally discusses the role of drawing in the architectural design process in relation to its other possibilities. His classification of the motivations behind representation serves as a useful framework for understanding the three axes of speculative architectural representation examined in this paper. According to Cook (2014, p.177), drawings that go beyond defining reality can easily transcend any reference to it. In doing so, the architectural representation itself transcend reality and ceases to contain any direct reference to it.

The semantic, syntactic, and pragmatic axes are essentially linked to the motivation of representation. Semantic analysis to decipher the meaning inherent in architectural drawing and approaching the essence of this meaning from an immanent perspective. The semantic axis, in particular, concentrates on the connection between the present and the past, which is established through diverse styles of formalisation in drawing—what may be referred to as the 'metaphysics of drawing'. This axis yields the articulation of the semantic dimension of drawings through their association with pre-representational representation techniques or their connection to memory. The semantic motivation behind these representations is grounded in the maintenance of the intrinsic value ascribed to the past.

Within this framework, the concepts such as meaning, culture, value, tradition, locality, memory, and context constitute the scope of the semantic axis. The symbolic meanings that are revealed and retained through imagery in drawing fall within the domain of the semantic aspect. Accordingly, the preservation of local traces in representations originating from regions beyond the Western (European) region—utilizing pre-modern archetypal imagery and traditional depiction methods—can be seen as contributing to the continuity of collective memory.

Cook (2014, p.112) contributes to the definition of the semantic aspect of the drawing by asserting that when a representation appeals to the senses and attains an intuitive quality, it becomes foreseeable, and a continuous cycle of memory, observation, and creativity emerges. Regarding the syntactic axis, which pertains to the compositional organisation of representation, Cook (2014, pp.95–97) discusses the exploration of drawing's capacity to distort, fragment, redirect, and reinvent. He emphasises that such processes can facilitate the reinvention of drawing, noting that precision is not always desirable; rather, incorporating ordinary descriptions or integrating an imaginary scenario or dream into a drawing may reveal previously unexplored dimensions.

Şentürk (2025) argues that syntax and semantics constitute dichotomous models that are essential to the creation of meaning, underpinning both the design and creative processes. These components build a network of meaning around a central element, which accrues significance as a testament to its deviation from established norms. Within this framework, the syntactic axis pertains to the technical qualification of drawings, encompassing the processes that establish the logic of combining pictorial elements and the formation of compositional components. The distinction between classical and postmodern representations is characterised by a divergence in drawing elements, which is exemplified by various formal interventions. These interventions define the syntactic axis that underpins the production of these representations. These drawings differ from conventional representations by a number of techniques, including distortion, overlapping, superimposition, flattening, and warping of compositional elements.

Drawing techniques that distort conventional rules such as the use of multiple or reverse perspectives, which are fundamental to pre-representational representation methods yet largely absent in conventional architectural drawings —are situated within the syntactic axis of this study. To further clarify this distinction, the concepts of 'reflection' and 'diffraction' offer a useful comparative framework for understanding the difference between classical and non-classical styles of representation. In her work grounded in optical science, Karen Barad (2007) conceptualises 'reflection' as a metaphor for the reproduction of sameness, aligning it with the logic of traditional representation language. In contrast, she introduces ‘diffraction’ as a metaphor for the generation of difference, which she associates with alternative representational technics that diverge from conventional rules or norms and closely resemble pre-modern illustration practices. Within this context, the visual deformations and disruptions characteristic of diffractive representations may be interpreted—albeit speculatively—as iconoclastic gestures aimed at destabilising established representational norms.

Within the framework of the pragmatic axis, the advantages of incorporating pre-modern representations into post-modern ones are emphasised. In this context, the pragmatic axis, which encompasses the pursuit of differentiation, can be examined under two main themes: the extension of the discipline-specific knowledge domain of architectural drawing and the operation of iconoclasm within postmodern architectural representation. The act of recalling memory by referencing the past in architectural representation techniques, along with efforts to diverge from conventional forms, indicates that the autonomous field of architectural knowledge is nourished by multiple sources. Accordingly, the identification of traces of pre-representational representation methods within architectural drawing also reveals visible the strong connections this discipline has established with fine arts, literature, and cinema through its intellectual extending.

The concept of ‘expansion’ employed here is derived from the discourse of structuralist art historian, critic, and theorist Rosalind E. Krauss, who has diagramed the semiotic square in her seminal article, “Sculpture in the Expanded Field”. In this work, Krauss (1979) interprets postmodern circumstances in sculpture at a moment when modernist abstraction had reached its ontological limits, using a diagram to illustrate the connections among concepts. Krauss's diagram presents a set of dichotomies that arose when the concept of sculpture was considered alongside "architecture" and "landscape"—two terms increasingly associated with it in the post-World War II contemporary art scene. These dichotomies express states of 'being' and 'not-being' within a binary framework of negative and positive conditions, situated in a quadrilateral field 'expanded' through "complex" and "neuter" axes, thus accommodating continuous expansion.

This speculative extension, which Krauss conceptualizes through the innovative relational dynamics between traditional sculpture, architecture, landscape design, and installation art, demonstrates how Renaissance-based sculpture has extended its intellectual domain by engaging with these intersecting disciplines during the post-war era. Krauss's seminal methodological approach can be effectively applied to architectural drawing as well as to various other disciplines. Furthermore, within the scope of this study, the interactions between architectural representation and pre-representational representation methods parallel the engagement with art, thereby inaugurating an intellectual and critical discourse that challenges the conventional functionalist understanding of architectural representation as merely a tool for building construction (Figure 6).

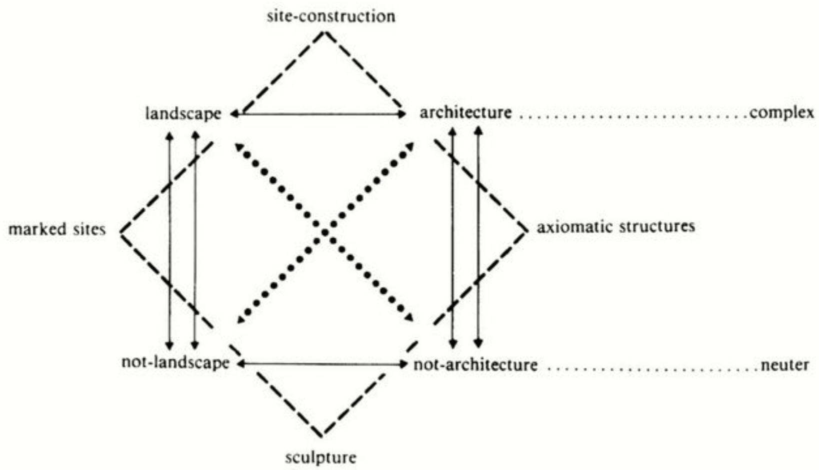

Figure 6. Rosalind E. Krauss, "Sculpture in the Expanded Field", 1979 (Krauss, 1979)

Within this context, the pragmatic or utilitarian axis concerns the expansion of the theoretical domain of drawing through its relationship with other disciplines by incorporating pre-representational representation technics. This process thereby opens new horizons within the field of disciplinary knowledge.

For instance, in the section titled "Drawing with Expression and Atmosphere" in Cook's (2014, p.113) work, it is stated that the cultural context constitutes an engagement with the atmosphere and subconscious aspects of drawing. Cook's perspective is significant in illustrating the utility of speculative representations within an interdisciplinary framework. Cook (2014, p. 132) further contends that certain types of architectural representation possess the capacity to convey narratives. From this standpoint, it can be asserted that drawings function pragmatically as records of events, reflecting an impulse toward the pragmatic axis of speculative representation. Furthermore, the concept of "architectural narrative," which emerges through the atmospheric expression in Cook's proposal, renders its pragmatic motivation explicit by establishing a functional linkage between drawing and text.

The other side of the pragmatic axis corresponds to the iconoclastic manner of contemporary drawings that incorporate pre-representational representation techniques. This theoretical framework can be interpreted as a critical evaluation of the prevailing classical architectural representation methods, which has been utilised as a means to facilitate the construction of the architectonic object since the Renaissance period. Consequently, this perspective facilitates alternative conceptualisations of architectural representation.

4. Pre-Representational Representation and Iconoclasm

The origins of architectural drawing dates back to the Renaissance period. Prior to this period, the process of building construction was executed directly through constructive practice, without the intermediary of drawing. Architecture functioned as a practice grounded in principles and criteria determined by the mathematical and geometrical laws of the cosmic order. However, it lacked a medium or intellectual framework—such as the concept of design (disegno)—that necessitated the act of drawing on paper.

Prior to the invention of linear perspective, architectural drawings as recognised today were virtually non-existent. Medieval building practice was primarily characterised by stonemasons utilising traditional techniques to transfer inherited typologies to construction, thereby embedding architectural knowledge within building traditions. Representations of buildings in the Middle Ages (pre-modern) extended beyond being mere depictions of spatial arrangements to encompass themes such as power, authority, and the relationship between heaven and earth (Haralambidou, 2016, p. 83).

Within this period, and in relation to the ‘rhetorical’ context, drawing functions not only as a documentary tool containing essential information for constructive practice but also inherently conveys the content that reflects the architect’s style as well as the specific time and place (Ackerman, 2001).

The iconoclasm debate (726–843), which emerged during one of the most extensively studied periods in Byzantine history, is recognised as a religious and political conflict concerning the legitimacy of using images of Jesus Christ, Mary, and saints—referred to as ‘icons’—for worship within the framework of Christian belief (Baş, 2016, p. 68). The term ‘iconoclasm’ is derived from the Greek words ‘eikon’, meaning ‘image’ or ‘depiction,’ and ‘klastes’, meaning ‘to break’ or ‘to smash,’ thus signifying ‘image breaker’ (Baş, 2016, p. 68).

Pre-modern drawings, markedly distinct from contemporary conventions, fostered an artistic environment dominated by religious imagery, as they were often produced for devotional purposes. Such illustrations, influenced by contemporary theological debates, were often found adorning the walls of religious edifices, depicting figures such as Jesus Christ and Mary. Consequently, church authorities developed a tendency to prohibit icons, grounded in the belief that rendering icons visible constituted idolatry, which in turn precipitated debates surrounding iconoclasm. Within this theoretical framework, iconoclasm emerged as the earliest form of practical critique directed at images (Belting, 2025).

The impetus behind this ‘iconoclastic’ movement was the prohibition of religious imagery on the grounds that it would lead to idolatry. According to Belting (1994, pp. 146–147), the central theme of these images—the figure of the God-man—occupied a pivotal position within theological discourse and was thus perceived as a symbol of the purity and unity of faith.

When architectural representation transcends the boundaries of reality and shifts towards subjectivity, bodily deformations become incorporated within architectural depiction (Deleuze, 1999, p. 230; cited in Avci, 2024, p. 182). In this context, the distorted image made visible through the process of iconoclasm disrupts the canon of conventional architectural representation, enabling evaluation from a subjective and irrational perspective. From this standpoint, iconoclasm can be interpreted as the transformation of the image into 'deformed imagery'. Therefore, the analysis of representations through the conceptual framework of iconoclasm – understood as predicated upon the distortion of conventions – serves as an effective metaphor to illuminate the contexts in which these representations diverge from, transform, and are transformed by conventional norms. The metaphor's connection to memory is elucidated by the premise that for an image to be deformed, it has to possess an original state or predecessor, to which the deformed image inevitably refers.

5. Conclusion

It is possible to say that the penetration of values such as context, meaning and locality, which were intertwined with pre-modern art, into the post-modern representation environment is an operation related to memory. Regarding this it is clear that contemporary architectural drawing medium adopts a critical manner toward the modernist canon recalling context and internal values into the area of representation through the cartesian drawing methods it had consciously distorted. Architectural drawing, whose institutionalization dates back to the Renaissance and was executed solely according to specific rules and procedures such as the triadic orthographic projection system (plan, section, elevation) and linear perspective, began to encompass pre-representational representations in the post-modern era. Thus, the idea of representation, which signified the pre-modern subject-object unity and the illusion of correspondence between representation and its object (e.g., a building), was re-invoked into the representational realm, at least partially preserving the semantic value of the pre-representational artistic environment.

As a result, considering that the motivations of contemporary drawings containing pre-representational representations are analogous to the motivations of iconoclastic operation, it could be speculated that these drawings are iconoclastic in nature.

The fact that drawings containing speculative representations referring to pre-representation cannot be examined through specific patterns as in established ones, and their versatility and ability to be interpreted from different perspectives necessitates that these drawings in question be examined through semantic, syntactic and pragmatic axes.

The subjective, ambiguous, complex and variable aspects of these drawings cannot be examined through a specific objective classification - unlike those in conventional ones. Moreover, the drawings themselves are not made in accordance with procedures that include rules, proportions, scaling, and geometric projection techniques. However, interpretations can be made to examine the motivations and forms of production of these drawings. Therefore, it can be argued that the examination based on the semantic, syntactic and pragmatic axes briefly mentioned in this study allows the research of these speculative drawings in a theoretical context.
As observed through the examples in the text, certain methods that differ from the representational techniques applied according to specific institutionalized rules in the pre-modern era continue to be widely used today.
The prevalent use of architectural drawing primarily serves the function of building construction. In conventional architectural design process representation functions as a mediator in the 'concept-design-construction' trilogy. Conventinal drawings, such as plans, sections, elevations, and linear perspectives, exemplify this practice. However, as discussed in the essay, applications such as 'reverse perspective' exemplify drawings constructed with multiple vanishing points, in contrast to Renaissance perspective, which concentrates the viewpoint on a single point. In this context, examining how such approaches contribute to architectural representation in ways that differ from conventional methods is considered valuable. This study demonstrates that, as in the arts, this inquiry can be approached through the interaction of architectural representation with other disciplines. Similarly, miniature technique does not direct the

observer to a single point but allows the gaze to traverse multiple vanishing points. This indicates that, beyond the canonized conventions of architectural representation, alternative forms of expression are possible. Such an approach can also facilitate a simultaneous reading in contemporary architectural representation practices, thereby enabling the consideration of concepts such as time, movement, and process in relation to architectural depiction. Consequently, it suggests that, as in the arts, the bodily experience can be taken into account in relation to drawing within the domain of architectural representation. Non-conventional drawing techniques such as miniatures and iconas enable society to establish a proximity with its past through architectural drawing. While simultaneity of experience can also be attained through various other methods, the distinctive aspect of these methods lies in their capacity to situate the issue within the framework of collective memory and to recall the representational practices of the past.

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Color in Function: The Perceptual Role of Chromatics in Spatial Experience

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1. Introduction

Color, as a fundamental component of spatial design, is not merely a superficial or visual element but a multifaceted medium of communication that influences how users perceive space, experience emotions, engage in behaviors, and form overall impressions. Alongside physical elements such as form and texture, color serves as a critical design tool that defines spatial atmosphere, enhances functionality, and deepens user-environment interaction. As frequently emphasized in the literature, color plays a decisive role in interpreting the built environment, facilitates wayfinding, and contributes to the construction of spatial identity (Mahnke, 1996; Gage, 2006). Particularly in interior design, color is employed not only for aesthetic purposes but also as a functional strategy to alter perceived spatial dimensions, guide emotional responses, and shape user behavior (Porter & Mikellides, 2009).

Current research highlights that the perception of color is not merely an aesthetic concern but also a critical factor in spatial organization, user comfort, emotional experience, and functional efficiency. In this context, color serves as a strategic tool that extends beyond visual perception, influencing spatial usage patterns, eliciting emotional responses, and enhancing functional performance. Particularly in contemporary spatial design practices that prioritize user experience, color is regarded as an interface that strengthens the dynamic relationship between user behavior and spatial function. A monochromatic environment devoid of color would likely evoke feelings of gloom, disorientation, and aesthetic deprivation (Humphrey, 2009). Thus, color acts as a non-verbal communicative medium, bridging environmental perception and interpretation. In architecture and design, color is not merely decorative but a component with profound implications for spatial functionality and user experience. Chromatics (the science of color) examines how colors are perceived psychologically, physiologically, and culturally, enabling user-centered strategies in spatial design. This section explores the role of color in spatial perception from both theoretical and practical perspectives, with a focus on its functional implications.

1.1. Theoretical Perspective of Color

Color perception is not merely a biological process resulting from physical wavelengths of light interacting with the retina, but rather a complex cognitive and psychological phenomenon that shapes how individuals interpret environments, experience spaces, and guide their behaviors. To properly assess color's impact on users within spatial design, it is essential first to comprehend the fundamental scientific, cognitive, and psychological dynamics of underlying color perception.

Theoretical approaches to color have historically represented a shared area of interest between science and art. Systematic color studies originated in the 17th century with Isaac Newton's prism experiments. In 1666, Newton demonstrated through these experiments that white light consists of seven distinct colors, each with unique physical wavelengths (Newton, 1704). This work established the scientific foundation for understanding colors as physical and measurable phenomena. Following Newton's optical experiments, researchers, including Edme Mariotte and J. C. Le Blon proposed that all colors could be produced through appropriate combinations of three primary colors (red, yellow, and blue). Expanding on these concepts, Moses Harris, in his 18th-century work *The Natural*

System of Colours (1766), developed one of the earliest systematic color wheels featuring primary and secondary colors, while Philipp Otto Runge further advanced color theory with his three-dimensional ‘color sphere’ in 1810 (Figure 1) (Zelanski & Fisher, 1994).

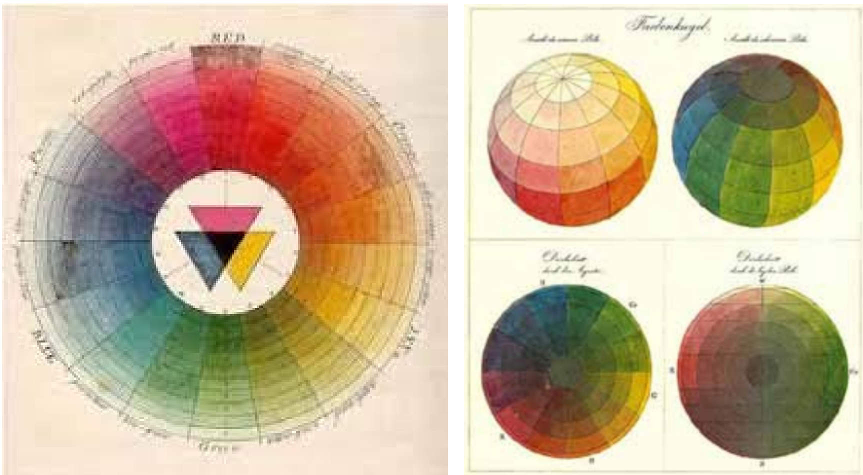

Figure 1. Moses Harris and Runge's Color Wheel (Per, 2012)

In the 19th century, physiologically grounded theories of color perception began to take shape. The trichromatic theory proposed by Thomas Young argued that there are three different types of cone cells in the eye and that each is sensitive to different wavelengths. This theory was developed with the contributions of Hermann von Helmholtz and came to be known as the "Young–Helmholtz Trichromatic Theory" (Wandell, 1995). According to this model, the perception of all colors arises from the combined activation of cones sensitive to red, green, and blue wavelengths. As an alternative to this view, Ewald Hering’s Opponent Process Theory offered a more neurologically based explanation, proposing that colors are processed as pairs of opposites (red–green, blue–yellow, black–white) (Hering, 1878). Today, "Dual Process Theory of Color Vision", synthesizes these two approaches, asserting that color perception is mediated by mechanisms at both the retinal level and within the central nervous system (Goldstein, 1942).

In the same century, in 1810, German painter Philipp Otto Runge developed the "Farbenkugel" (Color Sphere), the first three-dimensional color system that incorporated the interrelationships of colors. This model was the first spherical color system to integrate the concepts of hue, value (lightness and darkness), and saturation. With black and white at its poles and spectral colors at its periphery, this model offered the first integrated geometric representation of the spatial organization of colors and pioneered modern color systems (Gage, 1999). The Munsell Color System, developed by Albert H. Munsell in the early 20th century, classified colors into three basic dimensions: hue, value, and chroma (Figure 2) to describe them in a quantifiable manner. This system is widely used, particularly in visual communication and design education (Munsell, 1915). The CIE 1931 Color Space, developed by the International Commission on Illumination (CIE) in 1931, enabled the objective definition of colors by representing them with triple coordinates (X, Y, Z) (Fairchild, 2013). In 1976, CIE developed the CIE Lab and CIE Luv systems, In the same century, in 1810, German painter Philipp Otto Runge developed the "Farbenkugel" (Color Sphere), the first three-dimensional color system that incorporated the interrelationships of colors. This model was the first spherical color system to integrate the concepts of hue, value (lightness and darkness), and saturation. With black and white at its poles and spectral colors at its periphery, this model offered the first integrated geometric representation of the spatial organization of colors and pioneered modern color systems (Gage, 1999). The Munsell Color System, developed by Albert H. Munsell in the early 20th century, classified colors into three basic dimensions: hue, value, and chroma (Figure 2) to describe them in a quantifiable manner. This system is widely used, particularly in visual communication and design education (Munsell, 1915). The CIE 1931 Color Space, developed by the International Commission on Illumination (CIE) in 1931, enabled the objective definition of colors by representing them with triple coordinates (X, Y, Z) (Fairchild, 2013). In 1976, CIE developed the CIE Lab and CIE Luv systems, enabling more precise color management in the digital environment.

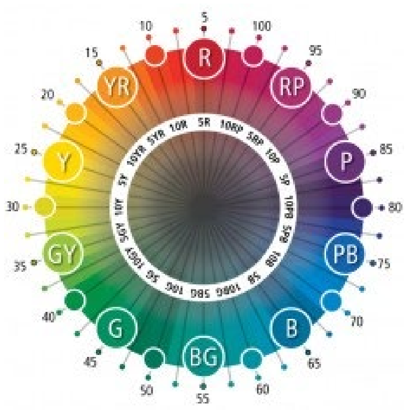

Figure 2. Munsell color wheel and color solid (Munsell Color, 2025)

Color theories have been examined not only in scientific but also in artistic and phenomenological contexts. In his 1810 work Zur Farbenlehre, Johann Wolfgang von Goethe criticized Newton’s physical approach and developed a color theory that emphasized the perceptual and emotional dimensions of color (Goethe, 1810). In the 19th century, Michel-Eugène Chevreul introduced the “Law of Simultaneous Contrast,” which demonstrated that colors are not perceived in isolation, but rather in relation to the colors with which they are juxtaposed (Chevreul, 1854). This approach led to the intentional use of color contrasts in modern design movements.

In the 20th century, Johannes Itten and Josef Albers at the Bauhaus School explored the spatial and perceptual effects of colors through experimental studies. Itten laid the foundations of design education through concepts such as the color wheel, types of contrast, and subjective color experience (Itten, 1961), while Albers, in his work Interaction of Color, experimentally demonstrated how a color is influenced by its surrounding colors, drawing attention to the relative nature of color perception (Albers, 1963).

All these historical and theoretical developments demonstrate that the use of color in contemporary spatial design is not merely a visual element, but a strategic tool that shapes user experience through its scientific basis and cognitive, psychological, and perceptual dimensions. The historical development and theoretical framework of color form the foundation of color decisions in today’s architectural and design practice both in measurable parameters and symbolic/conceptual dimensions

1.2. The Nature of Color

Color, which surrounds our visual world and serves to distinguish and identify objects/surfaces (even establishing emotional connections with them), consists of light stimuli that are emitted from a light source, reflected off surfaces or objects, and reach the eye, stimulating the brain through the visual system. The International Commission on Illumination (CIE) defines color as "the qualitative expression perceived by the human visual system of the spectral composition of light emitted from a light source, reflected from, or transmitted through objects" (CIE, 2020).

Color is a characteristic of visual perception and is both a physical stimulus (light spectrum) and a psychophysical experience. Each hue in the visible spectrum is defined by its wavelength. Colors with shorter wavelengths are associated with "cool" colors. At one end of the spectrum, violet (360-400 nm) has the shortest wavelength, followed by blue (400-480 nm) and green (520-565 nm) (Figure 3). Longer wavelengths correspond to 'warm' colors; red (625-740 nm), orange (590-625 nm), and yellow (565-590 nm) (Yıldırım et al., 2011).

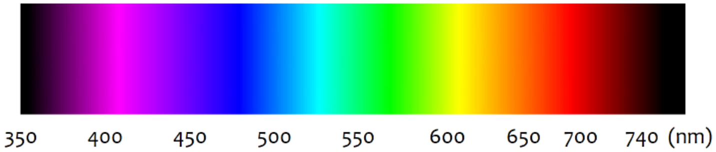

Figure 3. Visible spectrum of radiation and wavelengths of colors (Created by the Author)

Research on color usage suggests that users tend to prefer colors with shorter wavelengths, such as blue. This preference reflects the broader relationship between wavelength and mood in spatial perception (Valdez & Mehrabian, 1994). Studies have shown that the calming effects of elements in natural environments such as the blue sky and abundant green vegetation can produce similar soothing effects in interior spaces. Conversely, warmer colors like red and orange, associated with the energizing and stimulating nature of sunlight, tend to evoke arousal and can make interiors feel more vibrant (Foster, 1984; Whitfield & Wiltshire, 1990; Crowley, 1993).

2. Human Response to Color

As individuals color their living spaces according to their preferences and needs, these colorful environments reciprocally shape their lives. The phenomenon of color has been the subject of numerous interdisciplinary studies, and it is widely accepted that color perception particularly in interior spaces plays a significant role in human performance and emotional responses (Mahnke, 1996; Kaya & Epps, 2004). Spatial color use can exert a powerful influence, enhance visual perception while leave lasting psychological and physiological impressions (Kwallek et al., 1988; Küller et al., 2006). In this context, color serves as a critical environmental variable, modulating user perception, emotional experience, and behavioral patterns. It evokes diverse effects, including alterations in spatial dimensionality (e.g., spaciousness/congestion) and affective perceptions (e.g., warmth/coldness, arousal/relaxation, dynamic/static qualities). Thus, color selections in interior design should balance functional objectives with psychological impacts.

The use of color in the context of environmental psychology and architecture, color is recognized as a critical factor shaping users' spatial perception, functional expectations, and behavioral responses (Kaya & Epps, 2004). The impact of spatial color can be analyzed through two lenses: user attitudes and spatial perception. An attitude constitutes a psychological response to a specific stimulus—whether an object, person, institution, or event (Mahnke, 1996). Within environmental psychology, environmental attitudes represent evaluative tendencies toward the natural or built environment, expressed as degrees of favorability/unfavourability (Milfont & Duckitt, 2010). These attitudes manifest through three interrelated responses: cognitive (thoughts), affective (emotions), and behavioral (actions) (Hilgard, 1980; Rosenberg & Hovland, 1960). Applied to color as an environmental stimulus, this framework explains why warm hues (red, orange) enhance physical arousal and socialization, whereas cool hues (blue, green) induce relaxation and concentration (Kwallek et al., 1996). Additionally, color influences spatial perception; light tones amplify perceived spaciousness, while dark tones create visual contraction (Gage, 1999).

2.1. Effects of Space Color on User Attitudes

In spatial design, color operates not merely as a visual element but as a multisensory environmental stimulus that directly modulates behavioral, emotional, and cognitive responses. Interdisciplinary research bridging psychology, neuroscience, and environmental design increasingly elucidates color's role in shaping human attitudes and behaviors. Consequently, strategic color application in interior design has emerged as a critical tool for curating user experience.

Spatial color actively steers behavioral patterns and social interaction dynamics. Empirical studies demonstrate that warm colors (e.g., red, orange) enhance social proximity, whereas cool colors (e.g., blue, green) foster solitary behaviors (Gifford, 2007). For instance, Duyan & Ünver (2022) observed that red classroom walls elevated students' physical activity levels. Similarly, Küller et al. (2006) identified robust correlations between environmental color and users' physiological/social responses, noting that warm hues consistently predict higher social engagement. Collectively, these findings underscore color's instrumental role in spatial design as a determinant of behavioral outcomes.

In spatial design, short-wavelength, low-saturation cool hues (e.g., blues, greens) are particularly effective for stress reduction and cultivating calm environments. Empirical evidence confirms that these nature-inspired hues (abundant in natural settings) stimulate parasympathetic nervous system activity, reducing heart rate and promoting relaxation (Küller et al., 2006; Kwallek et al., 1996). Ulrich's stress-reduction model further identifies such colors as critical psychological relaxants (Ulrich, 1984). Consequently, high-value (light-toned) blues, greens, and neutral palettes are methodically employed in healthcare and therapeutic spaces (e.g., hospitals, counseling rooms, lounges) to leverage their biophilic calming effects (Dalke et al., 2006).

The way colors influence spatial perception is not only related to their physical properties but also to individual experiences and emotional states. In this context, color is frequently described in environmental psychology as an "emotional tool." Therefore, spatial perception is based not only on physical inputs but also on the meanings these inputs evoke in individuals (Mehrabian & Russell, 1974). Mehrabian and Russell's Pleasure-Arousal-Dominance (PAD) model provides a theoretical framework for understanding how colors modulate affective states. In their experimental study, saturated and bright red colors were found to evoke high arousal and excitement, while cool colors such as blue and green produced more calming effects (Valdez & Mehrabian, 1994). Similarly, numerous studies have shown that blue is more closely associated with peace, trust, pleasantness, attractiveness, satisfaction, and competence, whereas red is linked to excitement, power, depression, dissatisfaction, and aversion (Stone & English, 1998; Hill & Barton, 2005; Zhao & Guan, 2022). In a study by Yıldırım and colleagues on residential interiors, warm colors were found to be more stimulating, while cool colors created a sense of spaciousness and tranquility (Yıldırım et al., 2011). This indicates that color preferences are shaped by both the spatial function and the psychological needs of the user. Similarly, Levy's research revealed that red triggered active emotions such as anger, while yellow was associated with sadness; in contrast, cool colors such as blue and green evoked feelings of relaxation and calmness (Levy, 1984). A study by Kwallek and colleagues conducted in office environments demonstrated that blue-green tones contributed to greater satisfaction and productivity among employees, whereas red tones generated higher levels of anxiety and stress (Kwallek et al., 1988). Many studies on color have shown that green is most associated with nature (Kaya & Epps, 2004). The characteristics of nature as renewal and freshness explain the association of green in interior spaces with concepts such as peace, harmony, relaxation, freshness, silence, satisfaction, happiness, and hope. While green color can create a serene environment, its excessive use may result in feelings of laziness or lethargy (Manav, 2015).

Studies in the fields of neuroaesthetics and cognitive science demonstrate that color perception/influence is associated with more complex cognitive processes such as decision-making, attentional orientation, and memory performance (Palmer et al., 2012). These findings highlight the critical role of color choices in interior design for user experience and cognitive outcomes. A study on the effects of primary school classroom wall colors revealed that red and orange walls reduced students' attention, while green-blue, yellow, and red-purple hues enhanced it (Duyan & Ünver, 2022).

Similarly, Stone demonstrated that red in educational settings may negatively impact test performance, whereas blue and green tones could increase task persistence (Stone, 2003). Experimental research by Kwallek et al. in office environments showed that spaces painted with cool colors were perceived by users as cooler, more calming, and conducive to concentration (Kwallek et al., 1996). These findings support the conclusion that while warm colors elevate energy levels, they may foster negative outcomes for prolonged focus, concentration, and productivity.

Spatial perception research in the literature reveals that colors exert not only psychological but also physiological effects. For instance, experiments conducted in virtual reality (VR) environments assessed participants in red and blue rooms using physiological parameters such as heart rate (HR) and electrodermal activity (EDA). Results indicated that red environments significantly increased heart rate, whereas blue environments elicited lower levels of physiological arousal (Weijs et al., 2023). Another VR-based study demonstrated that exposure to blue light enhanced heart rate variability (HRV) and prefrontal alpha EEG activity, suggesting an association with emotional regulation and parasympathetic activation (Bower et al., 2022). Furthermore, studies involving green environments have found that this color reduces heart rate and mitigates stress markers. For example, during physical activities such as walking or running, green surroundings were associated with lower heart rate and perceived exertion levels compared to red environments (Briki & Majed, 2019). These findings clearly establish color as an environmental factor capable of producing measurable physiological not merely emotional effects on human health and behavior.

Collectively, these findings underscore that color functions as a multidimensional environmental variable, extending beyond mere visual comfort. Spatial color influences individuals across a broad spectrum, encompassing behavioral tendencies, emotional responses, cognitive performance, and physiological arousal. This multifaceted impact positions color as a critical design tool capable of actively shaping user experience. Consequently, interior color selection should integrate parameters such as user demographics, spatial function, and targeted psychological or cognitive outcomes. Rather than serving as a purely aesthetic element, color must be treated as an interactive design component that modulates human behavior. Such an approach holds significant potential for optimizing spatial functionality and enhancing user well-being, particularly in educational, healthcare, and occupational settings.

2.2. Perceptual Dimensions of Spatial Color

Perception makes sense of the environment through the organization and interpretation of sensory inputs (Palmer, 1999). Perceiving, on the other hand, is the process of actively structuring and interpreting sensory input through cognitive schemas (Neisser, 1976). In this process, visual scenes and events in our environment are assigned meaning. In this context, the colors around us evoke various meanings and effects in the mind. The literature on perceptual psychology reveals that colors have a direct influence on spatial perception. Color acts as a significant determinant in shaping how a space is perceived whether it appears wide or narrow, high or low and thus informs design decisions. Early studies have shown that color possesses the capacity to transform spatial characteristics. For instance, Wright found that light and cool tones (e.g., light blue, light green) tend to make spaces appear more open and spacious, whereas dark and warm colors (e.g., dark red, dark brown) create the perception of a smaller, more intimate, and enclosed space (Wright, 1962). Similarly, Birren noted that light colors increase the ambiguity of environmental boundaries, making spaces feel more expansive, while dark and saturated colors emphasize boundaries and create a more enclosed atmosphere (Birren, 1950). Literature also highlights that using light colors on ceiling surfaces contributes to a perception of increased height, whereas dark colors make the ceiling appear lower (Evans & McCoy, 1998). According to Gage, light colors evoke a sense of openness and spaciousness, while dark colors help concentrate attention and make boundaries more perceptually distinct (Gage, 1999).

Kaya and Epps found that cool colors (e.g., blue and green) not only produced calming effects but also enhanced the perception of spaciousness (Kaya & Epps, 2004). Similar findings were reported in studies by Mahnke and colleagues and by Yıldırım and colleagues (Mahnke, 1996; Yıldırım et al., 2011). These studies demonstrated that cool colors tend to make spaces appear more spacious, whereas warm and dark tones reduce the perceived size of a space. Freiling stated that painting all walls in warm tones creates an enclosing, unifying, and visually limiting effect (Freiling, 1979). In a study conducted by Yıldırım and colleagues, it was shown that warm colors such as red, orange, and yellow emphasized spatial boundaries, leading to the perception of a smaller space (Yıldırım et al., 2012). Mahnke emphasized that warm colors bring spatial elements forward, while cool colors create a receding effect, enhancing the sense of depth and distance (Mahnke, 1996).

In Figure 4, the impact of painting different surfaces of a space with different colors (warm/cool and lightness/darkness) on spatial perception is illustrated. In image A, the space appears wider and taller when the ceiling and walls are white, whereas in image D, a dark ceiling leads to the perception of a lower space. A cool-colored wall appears more distant (Image B), while a warm-colored wall (Image C) appears closer. Warm colors (Image E) contribute to the perception of a smaller space, whereas cool colors (Image F) result in the perception of a larger space. Light and cool colors provide a refreshing and expansive effect, while warm and dark colors may create effects such as intimacy, defined boundaries, and visual proximity (Figure 4). Therefore, color selection in interior design should be considered a strategic decision that shapes user perception.

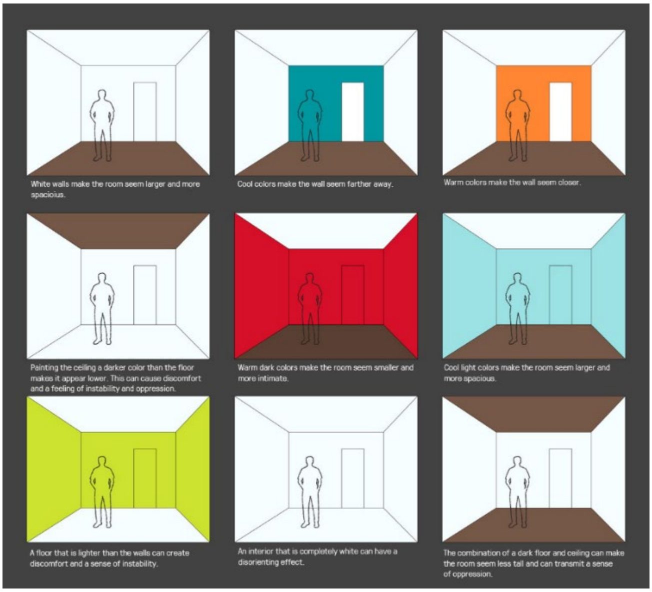

Figure 4. Effects of different walls, ceiling and floor colors on spatial perception (Maticad, 2022)

Cumulatively, this body of research on spatial perception demonstrates that color functions not merely as a visual element, but as a potent organizer of spatial experience. Empirical studies on interior wall coloration have established that perceptual transformations can be achieved solely through chromatic manipulation, independent of physical dimensional changes.

2.3. Color and Spatial Organization: Orientation, Wayfinding, and Zoning

In contemporary spatial design, strategies that facilitate users' interaction with the physical environment and render spatial experience meaningful are gaining importance not only for functionality but also for their perceptual and cognitive dimensions. In this context, color should be regarded not merely as a visual element but also as an effective communication tool that structures spatial organization and facilitates users' interpretation of the environment. Arthur and Passini emphasized the efficacy of colors in wayfinding and orientation processes within large, complex, or multifunctional structures (Arthur & Passini, 1992). Particularly in spatial organization processes such as wayfinding, orientation, and zoning, color's potential for meaning-making and perceptual guidance offers crucial design data.

Studies demonstrating color's contribution to wayfinding and orientation processes have particularly highlighted that color-based zoning and signage strategies in complex structures like hospitals and schools facilitate user navigation (Smith, 2003; Dijkstra et al., 2008). This finding confirms color's role as a functional organizational tool. In public spaces such as multi-story parking garages, color-coding each floor with distinct hues enhances users' ability to locate their vehicles while supporting spatial memory.

Guidelines for effective color design serve objectives including improving visual comfort, creating atmospheres aligned with functional needs, and directing users' spatial behavior. Among these principles, research shows that color contrasts increase perceptual discriminability, thereby simplifying wayfinding (Wijk et al., 1999). Furthermore, orientation systems can be reinforced not only through wall or floor colors but also via doors, columns, ceiling beams, directional signage, and graphical markers. For instance, color-coding clinics, wards, or waiting areas in large hospitals prevent visitor disorientation while simultaneously reducing stress levels (Carpman & Grant, 2002). Similarly, color-based wayfinding systems implemented in schools, offices, and shopping centers improve the differentiation of functional zones (Figure 5).

Figure 5. Use of color in wayfinding systems. Left image (Behance, 2025), right image (RSM Design, n.d.)

2.4. Assessing the Impacts and Utilization of Spatial Color

That spatial color evokes specific emotional and perceptual responses aligned with its intended function is one of the fundamental tenets of user-centered design. For example, preferring colors that support energy and dynamism in gyms where physical activity is intense, while adopting color schemes that encourage peace and focus on spaces like bedrooms or libraries that are individual-focused, are examples of this approach. Similarly, warm, appetite-stimulating colors are recommended for dining areas, whereas cooler, neutral tones that support mental relaxation are advised for yoga and meditation spaces (Mahnke, 1996; Manav, 2007). Beyond emotional effects, the interaction between color and spatial function is gaining increasing significance. Empirical studies in classroom settings demonstrate that cool colors (e.g., blue, green) enhance learning motivation and cognitive performance, whereas warm colors (e.g., red, orange) despite their attention-grabbing properties may induce student restlessness and attentional distraction (Engelbrecht, 2003; Duyan & Ünver, 2022).

Color, beyond being a visual element, is a powerful perceptual tool that influences how space is perceived, the user's experience, and psychological responses. Perception of space refers to the totality of mental representations an individual creates about their physical environment, and visual stimuli such as light and color play a decisive role in the formation of these representations (Küller, 1976). Color provides direct cues to the user about the dimensions, atmosphere, and function of a space, and therefore is considered a strategic tool in directing spatial perception during the design process.

Spatial color perception is a multilayered experience shaped by the interaction of both physical and psychological processes. The diagram presented in Figure 6 addresses this process at two fundamental levels. The first level encompasses the physiological dimension of color perception: this process, which begins with the stimulation of cone cells in the retina depending on the wavelength of light, forms the basis of visual perception. The second level involves the psychological process, which occurs when these physiological stimuli are processed and interpreted by the central nervous system. As a result of this interaction, color evokes behavioral (activity, desire for action), affective (calmness, restlessness, stress, etc.), and cognitive (focus, attention) responses on user attitudes. It also directly influences functional experiences such as spatial perception and orientation. This multifaceted structure demonstrates how spatial color perception shapes an individual's emotional, mental, and behavioral relationship with their environment.

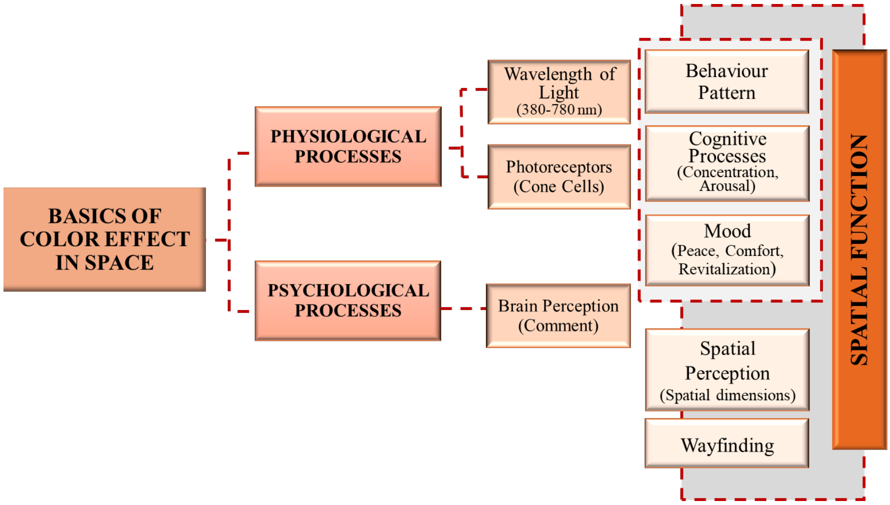

Figure 6. Spatial Color Perception and Spatial Function Processes Diagram (Created by the Author)

3. Functional Roles of Color in Interior Environment

Human-environment interaction operates as a dynamic system wherein individuals' needs and expectations inform environmental arrangements, while environmental affordances and constraints simultaneously shape behavior, perception, and social dynamics (Nemesics et al., 2013). Within this holistic framework, spatial color serves as a critical mediator of psychological and physical user-environment interactions. Space colors can mediate the interpretation of space, the perception of differences between surfaces and forms, and the generation of negative and positive emotions by influencing the user. Colors are considered differently, particularly in relation to the function of space. For example, in spaces like study rooms or recreation rooms, color schemes that promote calm or cognitive activities are important. Warm, stimulating colors are often employed in spaces designed for physical activities. Color selection additionally responds to demographic factors (age, gender), cultural context, geographic location, and lighting conditions. For example, high-saturation colors are predominantly used in kindergartens due to their stimulative effects on young children (Aydoğdu, 2024).

The reviewed literature consistently indicates that color application in spatial design should be considered a multidimensional tool that shapes users' cognitive, emotional, and physiological interactions with their environment. This impact of color on spatial experience constitutes one of the fundamental principles of human-centered, sensory-based design in contemporary architectural and interior design practice. Color selection in interior design varies depending on the space's intended use and the type of activity taking place within it.

The following section examines the functional roles of color in interior spaces specifically in residential, educational, workplace, healthcare, and social/dining environments through the lens of user experience and perception, focusing on its wayfinding, supportive, and restorative functions.

3.1. Residential Interiors

Residences are not limited to mere shelter functions but rather serve as multifunctional spaces where individuals spend a significant portion of their daily lives. Considering that approximately one-third of human life is spent in residential environments, the functional and psychologically satisfying design of these spaces becomes crucial (Evans & McCoy, 1998). Within homes, various activities such as sleeping, resting, eating/drinking, reading, watching TV/movies, studying, and socializing take place simultaneously. Additionally, with the impact of digitalization, certain residential spaces now also serve as home offices (Gifford, 2007). This multifunctional usage structure necessitates different areas within residences to be designed to address distinct psychological and functional needs. Color design serves as an important tool in meeting these requirements. For example, in rest/sleep areas such as bedrooms, soft and low-saturation colors create a relaxing atmosphere, while attention-enhancing colors used in workspaces can increase productivity and focus. Various studies have demonstrated that the colors used in living rooms a central space in residential settings significantly influence individuals' emotional states and spatial perception. A study on living room color preferences found that female participants favored warm colors (e.g., red, orange, and yellow), whereas male participants preferred medium- to high-value tones of cool colors (e.g., blue, violet-blue) (Duyan & Ünver, 2018). In research by Yıldırım et al., warm colors were described as highly arousing, exciting, and stimulating, while cool colors were perceived as soothing, relaxing, and spacious. The literature generally supports that cool and achromatic colors evoke calmer, more serene feelings (Yıldırım et al., 2011). Consistent with these findings, Manav highlighted blue's cooling and calming effects in residential environments (Manav, 2007). Similarly, Costa et al. observed that dormitory residents in cool-colored rooms (blue, green, purple) reported greater calmness compared to those in warm-colored rooms, with blue rated as the most favorable color for work environments (Costa et al., 2018).

Bedrooms, another critical space in residential environments, serve as private areas that integrate multiple functions including dressing/undressing, resting, and sleeping. Given their direct impact on rest and sleep quality, color selections in these spaces should prioritize effects that support these functions. Thus, the chosen colors must enhance psychological relaxation, reduce stress levels, and facilitate the transition to sleep. Empirical studies suggest that low-saturation, short-wavelength, and cool colors (e.g., blue, green, and light purple) positively influence relaxation and, consequently, sleep onset (Küller et al., 2006). Notably, the blue color family has been shown to lower blood pressure and heart rate, thereby promoting physical relaxation (Mahnke, 1996). Conversely, highly stimulating colors such as saturated red should be avoided in bedrooms, as they may activate the central nervous system and hinder relaxation (Hemphill, 1996).

In a study conducted by Yıldırım and colleagues on bedroom colors (orange, blue, and gray/neutral), participants preferred more neutral (gray) colors for their bedrooms (Yıldırım et al., 2024). In this context, neutral or earthy colors can also be suitable for the function of bedrooms (Figure 7). In addition to light colors (Figure 8), dark colors can also be preferred in bedrooms, regardless of the color type (Figure 9). Because dark colors don't reflect as much light, they have a more introverted effect. In this context, the goal of bedroom interior color design is to create an atmosphere that promotes visual serenity, facilitates mental relaxation, and enhances the sense of individual privacy.

Figure 7. Bedroom in Natural Color (Augusto Art/Home Décor & Wall Arts, n.d.)

Figure 8. Bedroom in light red (Created by the Author)

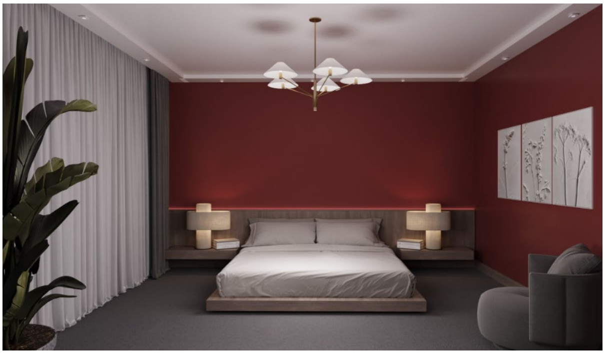

Figure 9. Bedroom in dark red (Created by the Author)

3.2. Learning and Work Environments

Wall colors in work and learning environments significantly influence occupants' cognitive and emotional states. Research demonstrates that color schemes affect attention, motivation, creativity, and task performance. Kwallek et al. found warm colors (e.g., red) induced high arousal and stress, while cool colors (blue/green) promoted calmness, focus, and productivity (Kwallek et al., 1988). Neutral colors (white/gray) showed minimal emotional impact. Subsequent studies revealed blue-enhanced environments improved focus and calmness, whereas red increased productivity but also anxiety (Kwallek et al., 1996). Although stimulating colors such as red may enhance short-term alertness, they have been found to impair long-term concentration; for example, red classroom walls have been shown to disrupt elementary students' focus (Duyan & Ünver, 2022). Llinares et al. further demonstrated cool colors enhance attention and memory performance, supporting their use in educational design (Llinares et al, 2021).

Research on color psychology in educational environments consistently demonstrates the cognitive advantages of cool colors. Costa et al. found blue to be more conducive for study in dormitory rooms (Costa et al., 2018). Similarly, Müezzinoğlu et al. revealed that cool-colored (blue) classrooms positively impacted both social cohesion and individual productivity metrics (Müezzioğlu et al., 2020). Complementary research showed that while cool-colored spaces enhanced perceived productivity, warm-colored environments were often distracting (Müezzinoğlu, 2018). These findings align with Yıldırım et al., who concluded that blue classroom walls were evaluated more favorably than pink or cream alternatives (Yıldırım et al., 2014).

Experimental studies further elucidate these effects. Mehta and Zhu demonstrated that blue backgrounds enhanced creative performance by evoking feelings of confidence and promoting abstract thinking through calming effects, whereas red backgrounds improved detail-oriented tasks via stimulation (Mehta & Zhu, 2009). Supporting these results, Küller et al. found superior performance on complex tasks in blue environments (Küller et al., 2009).

Research demonstrates that color selection in learning and work environments significantly influences users' cognitive performance and emotional states. Cool colors (e.g., blue and green) promote calmness, enhancing sustained focus, creativity, and productivity. In contrast, warm colors (e.g., red) may benefit short-term attention-demanding tasks due to their stimulating properties but can elevate stress levels and cause distraction over prolonged exposure (Kwallek et al., 1996). Consequently, in cognitively demanding spaces like educational and office environments, evidence-based color selection is essential for optimizing user comfort and functional efficiency.

3.3. Healthcare Interiors

Color design in healthcare facilities and patient rooms is important for reducing medical errors and patient stress, elevating patient mood, shortening hospital stays, and increasing staff morale and productivity (Ghamari & Cherif, 2016). Color preferences in healthcare settings should align with patients' psychological states and physiological needs. For example, because strong, saturated colors are more effective, their use in limited spaces may be preferable. Contrast between colors can be effective for orientation. Therefore, color use should be planned to create a safe and comfortable atmosphere in hospital environments.

A notable example of ongoing debate in color selection is the use of white in healthcare facilities. While white traditionally symbolizes cleanliness and sterility, some studies argue that this monochromatic approach may lead to emotional deprivation and be perceived as chromatic deficiency. Nevertheless, the discussion surrounding white's application in healthcare environments continues to evolve (Özata, 2018).

Patient rooms, where patients stay for short or long periods, should not only visually enrich the space but also provide appropriate physiological and psychological responses to the user, creating a peaceful, safe, and healthy environment. In this context, the colors of patient rooms, as part of the architectural language, are important because they convey positive messages and contribute to the well-being of the user, who is often in a negative physical and emotional state. A study conducted on patient rooms showed that interiors using blue and calming colors lowered stress levels compared to white spaces, while also supporting the healing process (Verhoeven et al., 2006). Goldstein observed that red negatively impacted patients' health, while green improved it (Goldstein, 1986). In a study on patient room wall colors, gray and high-value (light) hues were evaluated positively, whereas saturated wall colors were not considered favorable for patient rooms (Yüksektepe, 2024). Patients participating in another study on patient room wall colors similarly evaluated high-value, less saturated colors favorably (Figures 10) and medium, saturated colors unfavorably (Figures 11, 12). In the study, patients most favored light blue and expressed positive opinions about the use of light colors in patient rooms (Aydoğdu, 2024).

Figure 10. Light red (left) and blue (right) patient rooms (Aydoğdu, 2024)

Figure 11. Medium red and blue patient rooms (Aydoğdu, 2024)

Figure 12. Saturated red and blue patient rooms (Aydoğdu, 2024)

Research demonstrates that color design in healthcare facilities directly influences patients' psychological and physiological well-being. Empirical studies indicate that calming hues particularly light blues and greens reduce stress levels and actively promote healing (Verhoeven et al., 2006; Goldstein & Oakley, 1986). Conversely, highly saturated colors are perceived negatively, while neutral tones (e.g., light gray) are preferred for patient environments (Yüksektepe, 2024; Aydoğdu, 2024).

Color plays essential functional roles in healthcare environments by addressing both practical and therapeutic needs. High-contrast color schemes significantly improve wayfinding and spatial orientation, particularly for patients and visitors navigating complex facilities. In patient rooms, research consistently demonstrates that soft, light tones create optimal conditions for recovery and stress reduction. For effective implementation, color coding systems must maintain clarity and legibility across varying lighting conditions to ensure universal comprehension (Dalke et al., 2006). These considerations underscore how healthcare color design must integrate evidence-based principles that simultaneously meet users' psychological needs and physiological responses, thereby creating environments that actively support the healing process and improve overall therapeutic outcomes.

3.4. Dining Spaces

Restaurants are defined as "neutral grounds" where people not only meet their food and beverage needs but also freely discuss personal, societal, and global issues, fostering social interaction (Oldenburg, 1997; Wardono et al., 2012). These neutral grounds are influenced by multidimensional factors that determine user satisfaction, such as social interaction, food quality, service standards, pricing policies, and, especially, the physical environment. In these spaces, a sensory experience is created by the components of the physical environment (music/sound design, scent (ambiance)), lighting, material/texture selections, and color (Bitner, 1992). Color is a critical element in this experience, directly shaping the atmosphere of space and user behavior.

Because restaurants serve the dual function of stimulating appetite and encouraging socialization, color choices are designed to serve these goals. Research focusing on restaurant environments has found that red and orange tones increase appetite, while cool colors like blue suppress it (Bellizzi & Hite, 1992; Wansink & van Ittersum, 2012; Spence et al, 2014; Spence, 2015). Similarly, studies focusing on social interaction indicate that warm colors, especially red, with their attention-grabbing effect, increase appetite and social interaction, while cool colors are associated with shorter dwell times (Wansink & van Ittersum, 2012; Labrecque & Milne, 2012). In contrast, the appetite-suppressing effect of blue tones makes it rarely used in fast-food chains, but it is frequently preferred in upscale restaurants to create a calm and sophisticated atmosphere (Gorn et al., 1997).

The impact of colors on spatial perception is not limited to appetite. Green tones, with their natural and fresh image, are frequently used in organic restaurants (Lunardo & Mbengue, 2013), while neutral colors (beige, gray) offer a universal elegance, allowing other elements of the space to stand out. Figure 13 shows restaurant images showing the different effects of different wall colors.

Figure 13. Restaurants with different wall colors (Created by the Author)

However, color selection extends beyond these universal psychological effects. Restaurant color schemes are also influenced by cultural associations and culinary concepts, creating a multilayered design process. Cultural identities manifest through color - from the bold red-and-white contrasts of Far Eastern cuisine to the soothing blue-and-beige tones of Mediterranean establishments. Similarly, food concepts dictate palettes: earth tones dominate steakhouses, while vegetarian restaurants favor verdant greens. A fish restaurant might employ navy blue and white to evoke oceanic freshness, whereas an organic eatery uses natural wood and greens to signal sustainability. Thus, effective restaurant color design operates at the intersection of psychological principles, cultural symbolism, and gastronomic identity.

4. Conclusion and Suggestion

In interior design, color is a multidimensional design component that shapes user-space interaction across physical, psychological, emotional and cognitive dimensions. With its historical and theoretical foundations, color perception plays a decisive role in the functionality, perceptual effects and experiential quality of space. These effects can be particularly observed in the psychophysiological reflections of colors. Indeed, research demonstrates that warm colors (e.g., red, orange) enhance social interaction and arousal, while cool colors (e.g., blue, green) promote relaxation, focus and cognitive performance. Moreover, these effects are not limited to behavioral and emotional responses but also cause measurable changes in physiological parameters such as heart rate, stress levels and neurophysiological activity.

Color is a powerful tool that determines spatial perception and its ability to transform user experience. Research has shown that light and cool colors make a space feel more spacious, wide, and elevated, while dark and warm colors emphasize boundaries, making it feel narrower, lower, and more intimate. These effects vary depending on the type, value, and saturation of colors used on surfaces such as walls, ceilings, and floors. Colors create a perceptual transformation without altering the physical dimensions of space.

Color plays a pivotal role in spatial organization, functioning as a tool for wayfinding, navigation, and zoning (Smith, 2003; Dijkstra et al., 2008). In complex environments such as hospitals, schools, and parking facilities, color-based zoning and signage strategies support environmental comprehension, strengthen spatial memory, and help reduce stress. By establishing visual hierarchies through contrasts, color enables users to navigate spaces more effectively. Beyond visual comfort, intentional color design can also enhance a space's functionality, accessibility, and overall user experience.

The alignment of color choices with user psychology and spatial function constitutes a fundamental principle of effective interior design. Research demonstrates that strategic use of colors according to space type has significant impacts on both emotional and cognitive processes.

Studies in learning and working environments reveal that cool colors like blue and green enhance focus, productivity, and cognitive performance, while warm colors like red may provide short-term alertness but potentially lead to distraction over time (Kwallek et al., 1988; Kwallek et al., 1996; Mehta & Zhu, 2009). In residential spaces, color preferences are shaped by user demographics and cultural context. Particularly in bedrooms, low-saturation cool colors like blue and green have been documented to reduce stress levels and improve sleep quality (Küller et al., 2006).

Healthcare facilities benefit from light blue and green tones that support patient recovery, with neutral grays also being well-received. Conversely, in social spaces like restaurants, warm reds and oranges stimulate appetite and social interaction, while blue tones have been found to create suppressive effects (Labrecque & Milne, 2012). Gastronomic concepts directly influence color strategies, with Mediterranean, Asian, or organic cuisine themes requiring distinct color palettes.

As a result, Color application in interior design serves as a multidisciplinary element that establishes the critical connection between spatial function and user psychology. Research findings demonstrate that color selections particularly concerning parameters like hue, saturation, and value require customized approaches across various contexts, from residential to educational spaces, healthcare facilities to social areas. Contemporary design practice should therefore develop color strategies that analytically evaluate the triad of spatial functional requirements, user demographics, and targeted psychological effects, thereby integrating physical comfort with emotional wellbeing. Ultimately, evidence-based functional color design plays a central role in optimizing both spatial quality and user satisfaction.

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Representation of Materials and New Dimensions of Perception in Digital Spaces

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1. Introduction

Architecture, the discipline of designing spaces that shape human life, goes beyond buildings and environmental arrangements; fundamentally, it establishes the relationships between humans and their surroundings, making life experiences meaningful through these connections. The architectural design process is an effort to create livable spaces with emotional depth by balancing form, function, aesthetics, and technical requirements. In this context, space is not just a physical environment; it is a multi-layered entity that is perceived, experienced, and interpreted.

Material, in architecture, goes beyond being merely the physical component of a structure; it is the cornerstone of spatial experience and design. Architecture has historically been a tangible and touchable discipline shaped by physical materials. Building materials are not only functional elements but also fundamental factors that define the character, atmosphere, and perception of a space. The texture, color, tactile sensation, and interaction with light of the material determine the character of the space. Spatial perception is based on the relational experience that a person has with the space, and this perception is influenced both by the physical environment and the properties of the materials within the space. The materials used create the spirit, function, and meaning of the space, while also directly affecting the sustainability and environmental impact of the structure. In architectural design, the selection and use of materials are shaped by the designer's technical knowledge as well as aesthetic sensitivity.

Although the interaction between material and space has traditionally been shaped within physical boundaries, today it has gained a new dynamic dimension with the development of digital technologies. The integration of digital technologies into architectural practice has brought about a profound transformation in the representation of materials and the perception of space.

The normative rules and perception mechanisms of the physical world undergo significant changes in digital spaces. Within this framework, the traditional physical and tactile properties of materials must be reinterpreted through representation on digital platforms.

Digital spaces can be experienced beyond physical boundaries, and the representation of material is shaped not only by its physical existence but also by new forms of perception created in virtual environments. This change requires us to rethink the fundamental components of architectural design. The traditional understanding of material expands with new tools offered by digital technologies, creating new experiences regarding the spatial representation and perception of materials. In this context, the representation of material in digital spaces is not merely a visual or tactile equivalent; it also enables the reproduction of spatial experience, material perception, and meaning.

In digital spaces, the perception of space and material transforms into a complex structure where digital data, interactive systems, and technologies like virtual reality intertwine beyond physical senses. This situation changes the way space and material are interpreted in architectural practice and brings new possibilities and limitations to the design process.

The reinterpretation of the relationship between material and space in architecture through digital technologies expands the boundaries of design and spatial experience. This reinterpretation process is not only a technical transformation but also an intellectual enrichment concerning space and material. The representation of material in digital spaces provides a critical conceptual and practical foundation for creating new spatial experiences in architecture. In this context, the study will examine the representation of material in digital spaces and its effects on spatial experience, addressing the transformation of material and space in the digital age through theoretical frameworks and practical examples.

With today's technological advancements, digital environments have taken a central role in organizing life and perception. The representation of material in digital spaces is not only about objects appearing on digital interfaces but also emerges as a dynamic process that transforms concepts of reality, perception, and experience. In this context, material representation in digital spaces enables the emergence of new conceptual and experiential dimensions. The primary concern of the study is to understand and analyze this transformation and to frame the relationship between digital material representation and perception.

In this context, the aim of the study is to reveal how digital technologies have transformed the concepts of space and material in the field of architecture. Focusing on the representation of material in digital spaces, the study examines how material is perceived, experienced, and reproduced in digital environments beyond being merely a physical entity. The transformation of traditional architectural approaches through the process of digitalization forms the main axis of the discussion. The study seeks to develop new understandings of the relationship between material and space in the digital context, both in architectural design practice and in the perception of spatial experience. Accordingly, the study investigates how digital technologies have transformed material selection and use in architectural practice, and how this integrates with new forms of spatial perception.

The primary goal of the study is to examine in detail how material is represented in digital spaces and the effects of these representations on human perception, revealing the process of constructing a new perceptual experience and meaning in the digital world. While focusing on technical and aesthetic questions, the study also raises epistemological and phenomenological inquiries.

The scope of the study is defined to include the forms of material representation on digital platforms, perceptual transformations, and the interdisciplinary reflections of these transformations. The concept of digital space encompasses a broad area touching on topics such as virtual reality, augmented reality, 3D modeling, computer-aided design, and digital fabrication.

In the analytical dimension of the research, conceptual modeling and qualitative data analysis methods have been used. A phenomenological approach was adopted to evaluate spatial experiences and material representations, thereby examining the meaning construction of digital spaces. Conducted within the framework of conceptual analysis and critical synthesis, the study aims to create an original theoretical framework regarding the relationship between digital material representation and perception. This multidisciplinary approach provides a methodological contribution by revealing the intersections of architectural, technological, and philosophical processes. The research process relies less on direct observation or experimental data collection and more on the multilayered analysis and phenomenological evaluation of the philosophical, technological, and aesthetic dimensions of concepts. This method is determined to conceptualize digital material as an epistemological and perceptual transformation process.

In conclusion, the study aims to offer new conceptual tools to the field of architecture by analyzing the forms of material representation in digital spaces and revealing how these forms transform spatial experience. The study seeks to bridge the gap between architectural theory and practice in light of digital transformation.

2. Redefining Space: From Physical to Digital

Many of the material and physical tools through which the daily society and life order are carried out become independent from space and objects by digitizing. These changing technological tools can be with us at any time with their high capacity and small dimensions, and as an extension of us, they provide instant management of social-economic relations. These virtual-digital environments brought by technology create environments that are not limited to the space-physical environment parallel to real life. It seems possible to assume that the digitalization change that took place for everyday tools took place for spaces (Yüksel & Yıldız, 2022).

Physical space, in the classical sense, is an environment that includes three-dimensional, permanent, and tangible entities, forming the fundamental framework of human experience. This concept is considered a foundational and organizing element in architecture, geography, and social sciences. Key characteristics of space include its concrete inclusion of time and place, physical boundaries, and durability. However, with the rise of digital technologies, the concept of space has transcended its traditional physical context, gaining a new epistemological and ontological dimension. In this regard, digital space emerges as a dynamic concept with features distinct from physical space, redefining user experience and creating multi-layered realms of reality.

Before the digital age (information technology era), people interacted with space in a very traditional way, where they developed a three-dimensional perception of space through multisensory interactions and the movement of their bodies through space (Xing et al., 2024). The concept of digital space creates a new paradigm in architecture and spatial perception, evolving into a complex form alongside technological advancements. In this context, the scope of digital spaces goes beyond technological infrastructures, offering a multi-layered structure that also encompasses social, cultural, aesthetic, and experiential dimensions. Digital space is an alternative spatial reality supported by technologies such as virtual reality (VR), augmented reality (AR), and mixed reality (MR); it is intertwined with physical space, sometimes with its boundaries stretched, and sometimes existing completely independently. This new reality brings profound changes to the ways users perceive, experience, and interact with space.

In the digital era, the traditional concept of sense of place has been enriched by the integration of digital and physical spaces. The advent of digital technologies has transformed how people experience, perceive, and engage with places, creating hybrid spaces where physical and digital realms coexist and interact. This transformation implies that places are not so much erased as disconnected from their histories and fragmented into networked hybrids, where qualities are suppressed in some places and accentuated in others. The discussion about sense of place now necessarily incorporates the concept of digital space, shaped by the body, code, data, infrastructure and language in new spatial forms of computational change (Dai & Liu, 2024).

Traditional architectural design is often limited to static spatial forms and lacks innovative thinking that combines with contemporary digital technology (Linlin et al., 2022). Traditionally, space is understood as the arrangement of physical objects relative to each other; however, digitalization expands this understanding by enabling the reshaping of space based on the experiences, interactions, and perceptual continuities it offers to the user. Digital space goes beyond the traditional concept of physical space, comprising virtual or augmented reality environments formed by the combination of digital data and visual interfaces.

Since the advent of digital technology, the conception of digital space has been prone to be confused with an unmediated immateriality divorced from its material ground. Yet more importantly they have an existence in a symbolic system, a system that transcends materiality. It is not that digital space isn't immaterial, it is, but it's supported in a dialectical relationship with a real matter (Cai, 2022). Digital environments enrich spatial experience by integrating non-spatial elements such as light, sound, time, and interaction, creating a multi-layered and dynamic structure. These spaces serve as new living environments where users have perceptions and experiences different from the physical world. This concept, which diversifies how users experience space and stretches spatial boundaries, functions as an interface between physical and virtual worlds. Through digital space, spatial design can be shaped not only by physical materials but also by digital data, algorithms, and interactive elements.

2.1. The Spatial Language of Digital Worlds: VR & AR & Metaverse

Architectural space is not perceived as a concrete and permanent entity; instead, it is seen as an inseparable component of the evolving communication between different architectural systems through data networks (Pekince, 2024). Digital space, unlike physical space, is an abstract but experiential environment composed of numbers, codes, and simulations. Although digital space is abstract, it parallels physical space in many experiential aspects; for instance, it can be navigated, and spatial orientation and sensory intensity can be perceived within it. However, it is not intended to fully replace the physical world but to extend and transform it as a new environment.

The most important examples of digital space are virtual reality (VR), augmented reality (AR), and metaverses.

Virtual Reality (VR): VR allows users to be fully immersed in a digitally created space independent from physical reality, creating new spatial experiences and sensory perceptions. VR enables user movement within a space, and the constructed nature of that space offers novel perceptual and physical movement freedoms. However, there are differences in how spatial information is used in virtual versus real environments, partly due to the lack of physical and proprioceptive feedback in virtual settings (Clemenson et al., 2020). Virtual reality immerses the user entirely within a digitally created space. This space is independent of reality and generates new spatial experiences and sensory perceptions. VR allows the user to move within the space, and the constructed nature of the environment offers new perceptual and physical movement freedoms.

Augmented Reality (AR): AR is a spatial experience where digital data, images, or models are added onto the physical world. AR enables the interweaving of real and digital spaces, enriching the user's perception of the physical environment with digital layers. Traditional architectural design lacks interaction with the audience, and the audience usually can only pas-sively appreciate it, lacking a sense of participation and interactive experience. By applying augmented reality technology, architectural spaces can provide richer and more diverse experiences, allowing viewers to participate and transition from passive to active, enhancing spatial attractiveness and fun (Fei, 2024).

Metaverse: The Metaverse is a socio-economic, immersive cyber-physical ecosystem enabled by digital platforms where interactions take place virtually, and the ecosystem is shaped by users' shared values, norms, and goals. Additionally, metaverses are immersive three-dimensional virtual worlds where users interact with each other and software agents as avatars, using metaphors of the natural world but without its physical limitations (Gandhi et al., 2024). They are characterized as multi-user, persistent virtual worlds. Here, users engage in interactive social, economic, and cultural activities through digital avatars. Metaverses represent an expansion of the social dimension of digital space and symbolize the formation of new norms in spatial language.

Each of these environments signifies a rewriting of spatial language in a digital context. User experience and the meaning of space depend on how the digital and real layers are woven together, leading to the development of new languages and symbols.

2.2. Interaction and Experience in Digital Spaces

Digital spaces transform the environment from a passive area of observation into a platform where users can interact, shape, and even transform it. This situation leads to questioning traditional spatial hierarchies in architectural practice and the emergence of user-centered, flexible, and customizable spatial designs. In digital spaces, the user is not just an observer of the space but also an actor and even a creator of the space.

Digital space technologies fundamentally change the spatial experience by offering new forms of interaction that merge the physical world with the digital world. Thanks to these technologies, users can experience spatial environments with a depth and intensity that were previously impossible. Interaction and sensory feedback lie at the core of these innovations in digital spaces.

The digitalization process emphasizes the representational power of the object while highlighting the inanimate and passive aspects of architecture. For example, through the use of moving animations, virtual reality environments can be designed and simulated, allowing not only to see a photograph of a desired house but also to explore the rooms in detail and experience the environment with various senses (Sevinçli, 2024).

One of the fundamental elements that deepen the spatial experience in digital spaces is the interaction and experiential feedback mechanisms between the user and the space. These mechanisms break the static nature of the space, making the experience dynamic, lively, and multi-sensory. In digital spaces, interaction enables users to communicate with the environment directly or indirectly. In VR environments, users fully immerse themselves in a digital world, while in AR environments, the real world and digital objects intertwine. MR blends these two worlds, allowing objects and environments to come together more realistically. Through these technologies, users can touch, move, control objects, and actively connect with the space. Sensory interaction is a key element that enriches the spatial experience and draws users deeper in. Sensory elements such as light, sound, and motion detection enable the imitation of reality in digital spaces. This way, users can exist in the space more naturally and effectively by receiving immediate responses to their movements.

This combination transforms the spatial experience into one that is not only visual and auditory but also tactile and movement-based. As a result, digital space technologies redefine the relationship between users and space, creating an entirely new level of perception and interaction.

3. The Transformation of the Concept of “Material” in the Digital Environment

The impact of digitalization on spatial perception prompts a reevaluation of the fundamental concepts of the architectural discipline. Traditionally, space has been understood as a concept based on physical boundaries, structural elements, and the physical presence and aesthetic qualities of materials, but these elements are redefined in the digital environment. The process of reproducing or simulating physical materials in digital environments is realized through “representation,” which involves modeling visual, tactile, and auditory components within digital systems, creating new forms of communication between the user and the material. Within this framework, digital space allows not only the simulation of the physical properties of materials but also their functionality, transformability, and perceptual variability. This represents a radical evolution both in architectural design processes and in the conceptual foundations of material representation and experience.

Innovations in time, space, sensory intensity, multiple realities, and interaction possibilities arising from digital material and spatial experience create new dimensions. In this context, material representation goes beyond digital modeling to include the unique and collective perceptual interactions these models establish with users, tactile simulations, light and surface algorithms, and constructs within the time-space dimension. These new dimensions challenge the limits of perception and express a perceptual and ontological transformation beyond traditional physical experience.

The definition and perception of material in the field of architecture have undergone a profound transformation with the digitalization process. Traditionally, material was understood as an aggregate of objective characteristics such as tactile quality, mass, density, and durability in physical space. However, in digital spaces, material loses its physical presence and becomes an abstract concept defined by numerical parameters, algorithms, and data sets. In the digital modeling process, material is detached from its physical boundaries but retains defining qualities related to experience and perception. In this representation that transcends physical material limits, experiential elements related to the material—such as tactile sensation, light and shadow reactions, deformation dynamics, volumetric complexities—are reproduced through data-driven simulations.

The transition to the digital environment has reshaped the roles of material in both design and production chains. Additionally, digital technologies have freed material representation in architectural design from the constraints of physical objects, opening up an unlimited field of creativity. Material now participates in architectural production and spatial experience processes not only through its structural and aesthetic functions but also as a 'meta-material' defined by digital codes and data. In this context, three fundamental dimensions of digital material emerge:

Representational Dimension: Modeling the physical form of the material in the digital environment.

Perceptual Dimension: Simulating the experiential properties of the material such as light, color, and texture.

Behavioral Dimension: Modeling the deformation and interactions of the material in the digital environment.

This multidimensional representation allows material to be used in architectural design processes both visually and functionally within much more flexible and experimental structures.

Understanding and representing the full potential of material in digital spaces is possible only by going beyond visual simulations to incorporate a multi-sensory approach that integrates haptic, acoustic, and environmental data. These new dimensions will shape the future of architectural and design practices, further blurring the line between digital and physical reality.

3.1. Material Representation in the Digital Age: 3D Modeling, Simulation, and Interaction Technologies

The use and representation of materials in today's architectural, design, and engineering processes within digital environments have become increasingly complex and multidimensional alongside technological advancements. This broad spectrum—from 3D modeling and animation to parametric design and algorithmic approaches, as well as surface texture simulations to haptic feedback—enables the realistic and effective expression of the physical and aesthetic properties of materials in the digital world. At the same time, real-time data integration allows for dynamic and adaptive modeling of material behaviors.

3.1.1. The contribution of 3D modeling, animation, and visualization to material representation

Three-dimensional modeling plays a fundamental role in contemporary design by creating the digital representation of physical objects and accurately and impressively conveying material properties in the digital environment. Material definitions used during modeling determine the visual realism and physical behavior of the object. In this context, material representation should not be perceived merely as color and texture mapping but should also include optical properties such as light interaction, transparency, reflectivity, and physical behaviors.

Animation techniques dynamically express material behaviors. For example, the swaying of a fabric or the deformation of a plastic material can be modeled through animation. This allows not only static visualization but also observation of how the material responds during use. While digital animation techniques have been used as a representational tool in architecture, the work pioneered by Greg Lynn introduced animation as a design technology. Whereas movement in design has traditionally referred to moving buildings or kinetic architecture within a mechanical paradigm, Lynn describes animation as the incorporation of time, evolution, and the dimension of life into the design process (Akipek & İnceoğlu, 2007).

3.1.2. Simulation of digital material properties

The simulation of digital material properties aims to replicate the physical and mechanical behaviors of materials within software environments. These properties include parameters such as elasticity, flexibility, density, thermal conductivity, and brittleness. Accurate simulation of materials in the digital environment is essential for design precision and performance analysis.

In recent years, advances in material science have increased the complexity of simulation methods. Data-driven material models combine experimental data from the real world with simulation algorithms, enabling highly accurate digital representation of material behaviors.

3.1.3. The impact of parametric design and algorithmic approaches on material use

Parametric architecture is an innovative approach to architectural design that utilizes computational tools and algorithms to generate complex and adaptable architectural forms. It is rooted in the concept of parametricism, which emphasizes the use of parameters and rules to drive the design process and create intricate, non-linear geometries (Biçer & Erdinç, 2023). Parametric design transforms design processes into dynamic systems controlled by mathematical parameters. This method provides direct control over material usage and properties, resulting in more efficient and unique designs. Algorithmic design allows the creation of complex and repetitive structures using specific rules and algorithms. These approaches are effective in using materials only where necessary to prevent waste, enabling innovative material combinations, and quickly evaluating environmental impacts for material selection and corresponding design decisions.

3.1.4. Real-time data interaction and digital material

Real-time data interaction enables instant changes in the behavior of digital materials based on conditions. With sensor and IoT technologies, the responses of materials to environmental effects can be reflected in the simulation environment. This allows the development of dynamic, adaptive, and interactive digital material models.

In this context, the simulation of surface processing in a digital environment involves realistically modeling the textural properties of the material. This is achieved by applying texture maps that accurately represent the material's micro and macro structural features onto the 3D surface. Texture simulations range from surface roughness and embossing to color variations and material shading.

Haptic technologies enable users to interact tactilely with materials and surfaces created in digital environments. This allows the material's properties to be perceived not only visually but also through touch. Haptic devices provide feedback in the form of vibration, resistance, and touch, offering realistic experiences. In terms of material representation, haptic technologies especially facilitate the feeling of materials during the early stages of design.

Haptic interfaces are capable of generating a variety of sensations, including force, vibration, and temperature, thereby successfully simulating fundamental tactile experiences. However, accurately reproducing textures - such as surface roughness, smoothness, and fine tactile details - remains a central challenge in haptic reproduction. This challenge is particularly evident in the simulation of high-frequency vibrations and complex surface textures. Overcoming these obstacles requires a deeper understanding of the mechanisms underlying tactile perception, which is essential for advancing current Technologies (Chen et al., 2025).

3.2. Digital Material Experience: Spatial and Sensory Layers of Perception

In today's world, where technology and digitalization permeate all aspects of life, the concepts of space and material are undergoing a complete transformation. The rigid, tangible, and limiting framework of the physical world is being replaced by the flexible, multi-layered, and complex structure of digital spaces. Digital spaces are not merely collections of visual and auditory data; they represent new modes of existence that are experienced, perceived, and interacted with. These new forms of digital existence radically change the nature of material representation and perception, leading to new questions and paradigm shifts beyond traditional understandings.

Architecture has always been built upon a relationship with material. The weight, texture, color, and interaction of material with light directly affect the atmosphere of a space and the user experience. Independent of the physical world's constraints, questions about how digital material is perceived, experienced, and what new meanings it carries have become a shared research focus of architecture, philosophy, and technology. The digital representation of material goes beyond mere visual simulation, creating a new language that expands sensory and perceptual dimensions. Material perception shaped within the boundaries of the physical world usually consists of a combination of tactile, visual, and spatial experiences. The texture, weight, and mass of stone, wood, or fabric play a direct and prominent role in our perception. However, in digital platforms, material representation attempts to reproduce this direct experience through complex simulations, coded data, and algorithmic processes. Here, material ceases to be just an appearance; it becomes a dynamic, interactive element that mutually feeds back with the user. This radical transformation leads to new dimensions in perception and spatial experience. In digital spaces, material perception affects not only individual sensory experience but also spatial awareness. Digital material can create perceptual depth, layers, and sequential experiences within a space. As spatial perception is enriched by the variable nature of digital material, the interaction between space and material becomes a central element of perception.

Digital representation of material in digital space does not only create a static copy of the object. It also reproduces and transforms the modes of interaction between the user and the object, the layers of perception, and the experiential continuities. Perception here is not a passive reception process but becomes a multifaceted and inter-actor continuous negotiation and reformulation process. The table below visualizes the sensory dimensions of physical and digital space experiences, demonstrating how technology creates an expansion rather than a sensory loss (Table 1).

Table 1. Comparison of the sensory dimensions of physical and digital space experience (Developed by the author)

Sensory Dimension	Experience in Physical Space	Experience in Digital Space
Vision	Three-dimensional, continuous, natural lighting and shadows	High-resolution displays with photorealistic lighting and textures using PBR and Ray Tracing
Hearing	Natural sounds, echo, spatial perception & awareness	Spatial audio effects, natural ambiant sounds
Touch	Real texture, temperature, resistance of material	Haptic gloves, vibration sensors, pressure feedback
Smell and Taste	Real smell and taste of material and space	Emerging technologies are not yet fully integrated
Kinesthetic (Movement)	Freedom of movement in physical space, sense of balance	Treadmills, full-body tracking systems, and situations where physical movement is limited are emerging technologies that are not yet fully integrated
Cognitive Perception	Subjective and abstract experience defined by the senses	Virtual embodiment, cognitive dissonance, perception manipulation

For example, a digital surface created through 3D modeling may provide visual cues similar to the roughness of a physical material, but it does not give the sensation of real texture when touched; however, virtual reality devices or haptic technologies expand this experience, laying the groundwork for new dimensions in perception to emerge. Similarly, augmented reality applications create new layers of perception by adding digital materials to the real world; the perception of material and space intertwines, and designers or users develop new ways of thinking and experiencing.

Digital spaces enable materials to be considered in a much broader context within architecture. The digital counterparts of physical materials do not only imitate form and texture; they also include real-time simulations of physical interactions such as light transmission, deformation behaviors, and airflow. Thus, digital modeling reveals the three-dimensional and temporal dynamics of material behaviors, offering a material experience that goes beyond physical reality. This deepens the relationship between the material and the user while opening new possibilities and aesthetic transgressions in architectural expression.

3.3. Digital Aesthetics and New Meaning Production

The aesthetic value of physical material largely stems from its textural, visual, and mass-related qualities. In digital material, however, aesthetics develop through different dynamics, emphasizing elements such as coded forms, plays of light and shadow, mobility, variability, and interaction. Digital material breaks away from stagnancy, becoming a living entity that can transform over time and engage in reciprocal relationships with the user. In this context, aesthetics move away from objective standards of beauty and evolve into algorithmic aesthetic processes. Designers can create constantly changing dynamics on material surfaces using digital tools, opening the way for moving and interactive aesthetic possibilities.

Digital material representation contributes to an increase in perceptual intensity from an aesthetic perspective. Lighting effects, transparent and translucent surfaces, and layered structures can be precisely controlled in the digital environment. As a result, viewers or users can experience multidimensional, detailed, and sometimes holographic-like experiences. In these aesthetic experiences, beyond traditional static observation and perception processes, motion, time, and spatial relationships create an integrated "perceptual symphony." The user continuously rediscovers aesthetics through the interactive and variable nature of digital material.

The aesthetic relationship between digital material and perception also transforms the processes of meaning production. Digital representations create structures that offer multi-layered, context-dependent meanings and actively invite user interpretation instead of fixed meanings. These structures establish worlds of meaning that evolve according to different user experiences and vary based on temporal and spatial contexts. This interactive and pluralistic aesthetic framework is especially prominent in digital art and design. Perceivers become part of the creative process of the aesthetic experience, forming their unique relationships with material and space. Thus, aesthetics becomes a process shaped by time and interaction rather than a fixed object.

In architectural practice, digital material aesthetics radically transform the appearance and perception of spaces. The interaction of digital surfaces with light, dynamic geometries, and user-centered parametric designs form the new expression of architectural aesthetics. This new aesthetic brings a break from continuity in the perception of buildings and spaces and increases multilayered experiences. Users experience space not as a fixed object but as an aesthetic stage that changes over time and context. Here, material is redefined as a multidimensional entity producing aesthetic meanings on both physical and digital planes. This process presents a contemporary aesthetic vision that evolves, changes, and renews through the active participation of perceivers, surpassing traditional aesthetic understandings. Applications in architecture reflect different dimensions of this transformation as tangible indicators of the aesthetic potential of digital material.

4. Examples and Applications on Material Representation and Experience in Digital Spaces

In recent years, with the integration of digital technologies into architectural production processes, profound transformations have occurred in material diversity and production methods. Computational design, parametric modeling, and advanced digital fabrication techniques optimize material usage while enabling the emergence of innovative materials and structural systems.

Digital design tools have profoundly transformed architects' material selection and usage processes. Through parametric design and algorithmic modeling techniques, material properties are integrated as fundamental design parameters. This allows materials to be optimized according to structural, environmental, and economic criteria alongside aesthetics. At the same time, advanced material types such as biomaterials, smart materials, and composites, combined with digital fabrication techniques, open new functional and aesthetic horizons in architecture. Performance analyses of these materials can be conducted through digital simulations during the pre-design phase.

In this context, the examples analyzed below demonstrate the direct impact of digital material representation on perception in architecture. The examples stand out both technically and experientially, and were selected based on criteria including the use of digital material representation and parametric modeling techniques; optimization of material from aesthetic and functional perspectives; sustainability and adaptation to temporal change; success in creating spatial and perceptual experiences and the use of innovative fabrication techniques.

Material surfaces modeled with digital technologies multiply, transform, and enrich perception. The user interacts with the space not only visually but also through spatial flow, light, and temporal dimensions. Digital material enables a shift in architecture from static and fixed perception to a dynamic, multilayered one. As a result, space becomes an area of experience that is constantly changing and reinterpreted by the viewer. This transformation supports the development of innovative design approaches in architectural practice while also deepening theoretical discussions of perception within the discipline. This section elaborates on the intersection of digital material and perception in architecture through concrete projects, offering both theoretical and practical perspectives.

4.1. Material Representation and Dynamic Aesthetics with Digital Twin: Fondation Louis Vuitton by Frank Gehry

Louis Vuitton Foundation (Figure 1) is a unique architectonic, constructional and cultural feat located in the very heart of Paris on the border of Bois de Boulogne. The project is aimed for exhibitions as well as creation of background for contemporary artists and space for their realization. The last stone claddings were mounted in December 2013, in February 2014 the building was handed over to the investor, in course of spring 2014 landscaping was done as well as interiors and it was opened for the public 27th October 2014 (Architizer, n.d.). Frank Gehry's building, which reveals forms never previously imagined until today, is the reflection of the unique, creative and innovative project that is the Fondation Louis Vuitton. His architecture combines a traditional "art de vivre", visionary daring and the innovation offered by modern technology (Fondation Louis Vuitton, n.d.).

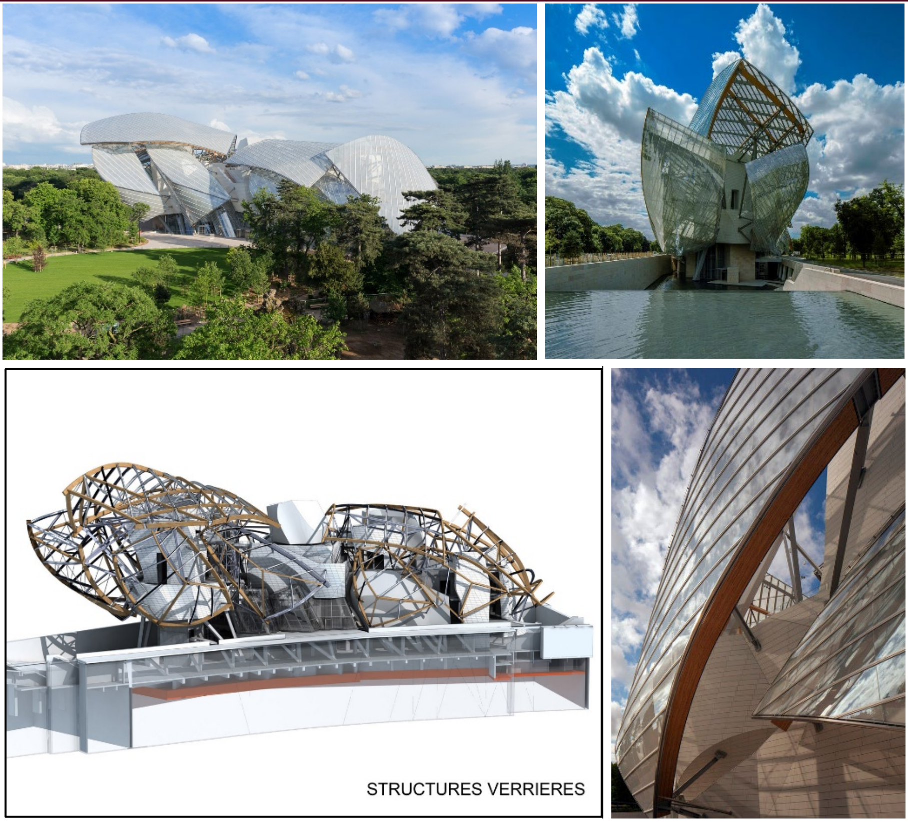

Figure 1. Fondation Louis Vuitton (ArchDaily, n.d.)

Representation and Modeling: The project combines Frank Gehry's ability to create original and complex forms with digital technologies. Materials such as titanium panels and glass sails were designed from the outset using advanced 3D modeling software like CATIA. Each panel's unique curve, surface geometry, assembly points, and production tolerances were fully defined through a digital twin method, minimizing the gap between design and implementation. As a result, not only aesthetics but also the risk of problems during construction processes were reduced to a minimum. This digital modeling allowed the structure to be directly linked to production processes, enhancing efficiency between architecture and engineering.

Experience and Perception: The building's undulating, organic form offers users an experience enriched by constantly changing plays of light, material reflections, and transparency as they move through the space. Especially the organically varying reflective properties of the glass sails and titanium claddings have been precisely simulated with digital platforms. This enables the surfaces observed by the user to continuously display different aesthetic and mechanical effects depending on their movement within the space. Thus, the digital experience becomes part of the design, allowing the perceptual experience that the real space will provide to be tested and optimized in advance.

Fabricability and Constructability: Digital modeling manages not only the visual but also the production complexity of the structure. Fiber-reinforced concrete panels and custom glass panels were adapted to production technologies, ensuring high precision and quality control during construction. The digital twin process allowed real-time monitoring at every stage from production to assembly. This created a level of coordination and cost-efficiency balance that is not achievable with traditional methods.

In conclusion, The Fondation Louis Vuitton building breaks away from traditional architectural understanding by combining Frank Gehry’s original architectural approach with innovative design and production techniques offered by digital technologies, adopting a design language filled with organic, fluid, and dynamic forms. Thanks to advanced 3D digital modeling used in representing materials and structural components, each surface and panel was uniquely designed. Through the digital twin approach, the design was not limited to visual aesthetics; all the complex details of production and assembly processes were also managed within the model.

In this context, Fondation Louis Vuitton exemplifies how digital transformation in architecture fundamentally changes material usage and the design experience. Only when digital twins and dynamic material experiences are integrated at this scale can physical structures create breakthroughs both aesthetically and functionally. The building, which enriches user experience and combines sustainability and fabricability elements, stands out as one of the visionary examples of contemporary architecture.

4.2. Algorithmic Material and Spatial Experience: Gwanggyo Power Center by MVRDV

The Daewoo Consortium and the municipality of Gwanggyo announced the MVRDV concept design for a dense city centre winner of the developer's competition for the future new town of Gwanggyo, located 35km south of the Korean capital Seoul. The plan consists of a series of overgrown hill shaped buildings with great programmatic diversity, aiming for high urban density and encouragement of further developments around this so-called 'Power Centre', one of the envisioned two centre's of the future new town (Divisare, 2008).

The Gwanggyo Power Center (Figure 2), designed by MVRDV in Suwon, South Korea, is an innovative and sustainable example of urban transformation aimed at the city center. This project can be particularly examined through the theme of digitally integrating artificial and natural materials. From the perspective of digital architectural expression, Gwanggyo Power Center transforms material from being merely a physical product into a dynamic element that can be manipulated by digital algorithms, experienced, and visually enriched.

Figure 2. Gwanggyo Power Center (MVRDV, n.d.)

Material Representation: In the project, material texture and properties are treated as fundamental design elements in the digital environment. MVRDV carefully manipulates qualities such as opacity, transparency, color, and pixelation according to programmatic functions. The representation here aims less at realism and more at highlighting the fictional and experiential nature of the material. For example, the circular windows and colored panels used on the building's facade are arranged on the surface of the space with different layouts and effects through an algorithm accompanied by a digital pattern. This approach overcomes the limitations of natural materials, enriching the resulting surfaces both visually and in terms of spatial interaction.

Integration of Digital and Natural Materials: The building balances the combination of artificial materials (facade panels structured with algorithmic patterns) with natural elements (terraces, green spaces, water systems). The green terraces on the building and spaces that maintain continuity with the outdoor environment strengthen the relationship between digitally produced surfaces and the natural world. Additionally, digital modeling techniques demonstrate that material is not only an aesthetic expression but also an integral part of a functional and sustainable structure.

Experiential Aspect: As users approach the building, they experience different visual layers within the digitally created mosaic and pixelated facade texture. The interplay of colors and light on these panels gives the space a dynamic character while embodying the artificial richness and references to the structure's digital design process. Thus, the material is perceived not as a fixed surface but as a constantly changing visual and spatial phenomenon that interacts with the user. This experience departs from traditional material perception and reveals new perspectives that digital representation brings to the human-space relationship.

In conclusion, the Gwanggyo Power Center is a significant example that deepens and enriches the understanding of material in digital architecture. MVRDV transforms material into a digitally manipulated, fictional, and experiential narrative while combining natural and artificial elements. The project demonstrates how digital technology can transform the creative possibilities of architectural materials and user experience, emphasizing the need to reconsider material from a new perspective in architectural practice.

4.3. Transformation of Space and Material with Digital Installation and Projection Techniques: Projects by Refik Anadol

Digital installation and projection techniques are powerful tools that fundamentally transform the way physical spaces are perceived at the intersection of architecture and art. These applications turn space from merely a visual stage into a constantly changing, dynamic, and multilayered experience that interacts with the user through light, moving images, and interactive elements.

In this context, Refik Anadol's projection works using algorithmic data visualization techniques (Figure 3) transform the perception and function of the built environment by projecting moving and constantly changing images of digital data onto building surfaces.

Figure 3. Refik Anadol's Projects (Guggenheim Bilbao, n.d.)

Experiencing the Space: While the structural elements of the architectural form remain fixed, the physical and perceptual boundaries of the space and material experience are stretched through the digital layers applied to them. Projections go beyond creating an aesthetic atmosphere with light intensity, color tones, and moving images; they offer experiences that reveal the internal dynamics of the space and position the user as an active participant within it.

Concept of Material: In this transformation, the concept of material is reshaped. Instead of rigid properties with defined boundaries on physical material, a multidimensional structure emerges that changes with digital layers and is redefined by light and color. The digital manipulation of material adds abstraction and interaction dimensions to architecture. Thus, material ceases to be just an element of architectural narrative and becomes a shaper of spatial experiences.

Digital Layering: In Refik Anadol's projects, the experience and representation of material go far beyond traditional architectural material concepts, transforming material into a digitally convertible and perceptually flexible dimension. Anadol positions architectural surfaces not as solid objects with fixed physical boundaries but as dynamic and moving entities shaped by data and algorithms. In this approach, material ceases to be static and fixed, becoming a continuously changing and evolving digital experience through light, color, and motion. This new representation of material offers users the opportunity to experience the constantly shifting faces of the space. Architectural façades are, in a sense, "brought to life" through data visualization; algorithmic visuals projected onto the surface create new meanings over the material's physical authenticity with digital layers. These digital layers not only add a metaphorical depth to the space but also activate the perception of individuals moving within it and encourage their interaction with the environment.

In conclusion, digital installation and projection techniques are revolutionary methods in architecture that transform the perception of material and space. Through these techniques, spaces exist not only as physical entities but as integrated experiential wholes woven with digital content. A continuous interaction arises between the space and the user, and architecture gains a new language of expression. This approach expands the boundaries of architecture in terms of aesthetics, function, and experience, blurs the distinctions between physical reality and digital fiction, and allows the space to become a living environment in constant continuity and transformation.

4.4. Transformation of Digital Material into Fluid Architecture

The Heydar Aliyev Center (Figure 4) is an important cultural center in Baku, the capital of Azerbaijan. It is housed in an iconic building designed by Zaha Hadid Architects and is located in a 10 hectare public park close to the Baku Convention Center. Along with hosting cultural events and promoting the Azerbaijani language, history, and culture, the Heydar Aliyev Center was conceived as a symbol of Azerbaijan's nation-building process and the country's recent economic development and modernization (Bianchini, n.d.).

The Heydar Aliyev Center is one of Zaha Hadid's most significant projects shaped by digital modeling techniques. The Haydar Aliyev Center project is a striking example of how the desire to represent and experience material as a single fluid surface in a digital environment is realized in architecture. Shaped by Zaha Hadid's design vision, the building is designed as a continuous, smooth shell made up of glass fiber reinforced polyester and glass fiber reinforced concrete panels. These surfaces were divided into thousands of unique geometric pieces using digital parametric modeling tools and designed to fit together flawlessly.

Figure 4. Heydar Aliyev Center (Zaha Hadid Architects, n.d.)

Digital Representation of the Material: The digital representation not only opens the way for physically producible complex forms in architecture but also allows us to perceive spatial fluidity and continuous change. This fluid shell offers a material experience that stretches, bends, and integrates according to time and space, instead of traditional sharp and fixed surfaces.

The flawless joining of the material in the digital model symbolizes the convergence of the structure's physical presence with its digital ideal. Thus, the material experience becomes identical with the architectural form itself, and the building's outer shell gains a fluid character both aesthetically and structurally.

Architectural Narrative: The digital configuration of the material creates a new language in architectural narrative. The continuous and seamless structure formed by the joining of surfaces gives the viewer a sense of fluid transformation within the space. As the user moves around the building, the spatial experience gains continuity and coherence thanks to the material's textural and visual unity. This transforms the material from being merely a covering shell of the structure into an active player in the organization of the architectural space. From the user's perspective, the fluidity of the spaces is directly related to the continuity conveyed by architectural material through visual and bodily perception. This fluidity is experientially realized thanks to digitally modeled material surfaces.

Experiencing the Fluidity: From the visitor's perspective, the architectural form and material experience profoundly affect spatial perception. The fluid surface of the Haydar Aliyev Center's exterior softens the hard boundaries surrounding the space, evoking a sense of fluidity in the environment. As the user moves through the space, they experience a sense of unity and rhythm through the continuity of the material and its organic embellishments. This fluidity continues inside as well; walls, ceilings, and floors connect organically, conveying a feeling of continuity and wholeness. These flowing forms and material continuity guide, direct, and enhance the user's movement and interaction with the space. The perception of the material impacts not only visually but also tactilely and spiritually. In this space, where physical boundaries dissolve and organic lines and soft transitions prevail, the user feels a freer and more creative sense of movement.

In summary, the Haydar Aliyev Center is a project where material is combined through digital tools to create a fluid and continuous architectural language. Here, the material is seen not just as a structural element but as a central component of the architectural experience, a physical reflection of digital design, and a factor that ensures continuity within the space. Thus, the representation and experience of digital material in architecture exemplify an innovative approach that expands spatial perception and bridges physical form with digital ideal.

5. Conclusion and Suggestions

Digital technologies have provided profound and multifaceted contributions to the representation of space and material, paving the way for new design paradigms and application methods in architecture. The physical limits that traditional architectural understanding imposed on material and space have been overcome in the digital environment through numerical data, algorithms, and interactive systems. In this process, material has been redefined not just as a physical entity but as a dynamic, multilayered, and experience-open phenomenon.

Parametric design, algorithmic production, 3D modeling, and physics-based simulation techniques have enabled comprehensive digital representation of the visual, structural, and experiential qualities of materials. Technologies such as virtual, augmented, and mixed reality have enriched spatial experience and transformed spatial perception in ways that transcend both physical and perceptual boundaries. This transformation, supported by digital fabrication methods, has brought significant innovations not only in the use of materials within architectural structures but also in the design process and spatial experiences.

In the digital environment, material is no longer a tactile or physical mass but a "platform of information and interaction." Light, color, texture, and physical behaviors are experienced through real-time simulations, and the material can change depending on time, movement, and user interactions. This transforms the space into a multisensory, multilayered experience rather than just a visual one. In digital spaces, the interaction with material changes the impact of spatial experiences on the user. The user moves beyond being a passive observer and, through interaction, shapes, transforms, and personalizes the space. Thus, the space transcends its traditional "static" boundaries to become an interactive, experiential entity. This necessitates a redefinition of the concept of space in architectural theory and practice.

Digitalization automates and accelerates design and production processes while significantly changing the architect's role. Beyond the traditional designer, the architect now assumes multiple roles such as digital designer, data analyst, and production coordinator. Thanks to digital design tools, architects have direct control over design and production processes, optimizing their designs through pre-production simulations and prototypes.

The ability to manage production machines using computer-aided software combines technical knowledge with creativity. This increases material efficiency, reduces design and construction errors, and promotes sustainable practices. However, Şen Yüksel points out that the transition from reality to virtual worlds carries the risk of memory loss. To prevent this, architects must carefully establish context during these transitional phases. Physical environmental context must be present in the virtual environments they create; otherwise, memory loss can occur quickly. Indeed, this universe appeals to all of a human's sensory organs (İstanbul Beykent Üniversitesi, 2022).

On the other hand, social issues such as the environmental impacts of digitalization, ethical usage standards, and technology-driven inequalities will also be in focus. Therefore, research on digital space and material representation in architecture will increasingly need to emphasize interdisciplinary collaboration, sustainability, and ethical concerns.

The twenty-first century has initiated a rigorous problem-solving process aimed at suppressing environmental threats alongside rising energy costs, recognizing that sustainable architectural design can provide striking gains in long-term resource conservation and overall quality of life. Supporting all these efforts involves not only developing sustainable ideas but also creating a portfolio of clean technology products and processes manufactured profitably (Topal & Arpacıoğlu, 2020). In this context, digital material simulations offer the ability to evaluate the performance of materials used in the design process in advance, saving both time and resources and significantly contributing to the development of sustainable solutions. Additionally, integrating data obtained from experience and field applications with digital platforms improves the accuracy of design decisions and helps minimize environmental impacts. Thus, the combination of digital material simulations and experiences stands out as a powerful tool in developing clean technology products and promoting sustainable architecture.

In conclusion, digital technologies are fundamentally transforming the understanding of space and material in architecture, enabling the creation of new spatial experiences and material interactions. This transformation will continue to facilitate the development of richer, more dynamic, and user-centered applications in architecture and design. Therefore, the importance of interdisciplinary and innovative research on material representation in digital spaces will increasingly grow.

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Exploring Methodologies on Housing Production: Open Building Approach in Habraken's Sar73

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1. Introduction

Architectural discourse by the 1960s was characterized by concerns regarding the neglect of participation and individual autonomy within the built environment, the homogenization and loss of identity in urban fabric, and the resultant alienation and diminished sense of belonging among individuals. These issues remain pertinent in contemporary architectural practice. The prevailing building production processes often operate independently of individual and contextual considerations, necessitating the re-establishment of the intrinsic relationship between individuals, their spatial environments, and their communities. In an era marked by pronounced individual diversity and accelerated temporal and technological change, the imperative to develop alternative architectural paradigms and discursive platforms capable of accommodating such dynamism is paramount. Consequently, research should focus on formulating innovative methodologies that integrate user participation within the design and occupancy phases, thereby fostering a renewed individual-space dialectic and addressing the ephemeral nature of contemporary needs posited as a relevant architectural framework that prioritizes user inclusion in the resolution of residential production challenges.

Regarding the reflections of social improvements on the architectural atmosphere mentioned above, The Open Building movement initiated by N. John Habraken in the 1960's as a critique of the monotony and anonymity of mass housing, and subsequently developed methodologically in collaboration with the SAR Group (Stichten Architecten Research), which suggests for a fundamental reassessment of the design paradigms within the built environment. In his seminal work, *"Supports: An Alternative to Mass Housing"*, J. Habraken (1972) elucidates the necessity of this approach, positing that individuals possess an existential imperative to personalize their surroundings, exert agency over their living spaces, and foster a sense of community. Drawing inspiration from Heidegger's existential philosophy, Habraken asserts that individual identity formation is contingent upon the capacity to tailor, participate in, and modify one's environment in accordance with personal preferences and needs. He contends that the prevailing housing production systems of that era, which disregarded individual and contextual factors, disrupted this *"natural relationship"*. As an alternative, he proposed the "Supports" concept, a participatory model designed to rectify this imbalance.

This study examines the evolution of the SAR Methodology and the Open Building movement, both rooted in Habraken's "Supports" concept. It investigates the transformations these approaches underwent in response to diverse contextual factors, including socio-cultural, economic, political, and technological shifts, and assesses their impact on the architectural milieu. The housing needs that arise especially after earthquakes, along with issues like open building systems and user participation, have made it increasingly necessary to discuss approaches that center on these matters. Thus, the study aims to delineate the position of these approaches within the global architectural discourse, analyze critiques from both architectural and interdisciplinary perspectives, and follow the developmental trajectory of Open Building. The translation of theoretical frames into implementory works is evaluated through the analysis of exemplar projects. This critical reading seeks to elucidate the inherent processual nature of these approaches' evolution, extrapolate their potential future trajectories within contemporary contexts, and establish a foundation for their adaptation and implementation under current contextual constraints. Given the imperative for adaptable and user-participatory building production systems in an era of rapid change, the Open Building movement emerges as a critical and timely approach by the means of producing new methodologies for not only for practitioners but also for academicians who tends to trace the movements in architecture considering the framework that seeks to connect it with a participatory approach.

2. Development of the SAR Methodology

This section examines the theoretical foundations and historical development of the SAR methodology, taking Habraken's "Supports" approach as its axis. It addresses the conceptual framework of the support–infill distinction, which enables the redistribution of design control in response to the anonymizing effects of mass housing; the modes of interrelation between the long-life/collective support and the short-life/individual infill subsystems in line with the principle of separating a building's physical infrastructure; the processes of spatial rule-making, articulated through horizontal bands, zones, and margins/tolerances under modular coordination principles; and, finally, the formation and function of the level hierarchy that explicitly maps decision rights across scales as the approach's projection at the scale of the urban fabric. In doing so, the section opens to discussion the mechanisms by which the SAR framework institutionalizes user participation, integrates flexibility and standardization as complementary principles, and repositions housing as an evolving socio-technical infrastructure into which different actors can intervene at different times.

2.1. The Initial Steps of J. Habraken's Concept of Supports

Towards the 1960s, the centralization of control, coupled with the erosion of urban fabric identity beyond individual buildings, and the consequent suppression of participation and individual autonomy within the built environment, began to manifest socially disruptive effects. Large-scale mass housing projects, designed for an anonymous/average user demographic and failing to accommodate evolving needs, led to the emergence of a homogenous and monotonous building paradigm. The alienation and lack of a sense of belonging engendered by this situation triggered reactive responses, prompting the development of alternative approaches and solutions. Within this intellectual milieu, a return to the core of the problem facilitated the development of approaches that prioritized the individual and participation. Habraken, laying the conceptual foundation and developing the Open Building system in collaboration with the SAR group, provided one of the most influential examples of this approach during that period, establishing the groundwork for a new theoretical and methodological framework for participation-centered housing design.

Habraken's main focal points in the development of this idea were the participation of individual users in design decisions, the development of different levels of intervention in the built environment, the creation of a multi-participant process involving various types of professionals, and the consideration of the transformability of the sub-environments encompassed by the built environment at different time intervals.

This approach is explained in detail in John Habraken's book "Supports: an alternative to mass housing," published in 1961 and translated into English in 1972. This book presents a critical analysis of mass housing construction, asserting that it reconfigures production housing as a consumer commodity and the inhabitant as a consumer.

The proposed model posits user agency as central throughout the dwelling process. Specifically, it underscores the synergistic control of activities collaboratively undertaken by individuals and community members. According to this approach, housing is conceptualized as a support-infill system. Supports constitute long-term, permanent infrastructural frameworks, whereas infill elements are discrete, short-term, user-defined, and adaptable components. The support-infill model envisions the engagement of both users and design professionals at various stages of the process. It is posited that comprehensive control, particularly during the infill phase, should be devolved to the user. As articulated in the author's work, this advocates for a novel paradigm of housing. By definition, supports are structural frameworks accommodating the installation, reorganization, or removal of multiple dwelling units. Supports are deemed necessary as they confer independence upon the dwelling unit, dissociating it from being an inseparable and integrated component of a larger construction project. Consequently, the independent dwelling unit empowers the user to exercise initiative and thereby assumes responsibility for their immediate living environment (Habraken, 1963).

2.2. The Concept of "Separating the Physical Infrastructure of Buildings" in Habraken's Works

Habraken posited that, to facilitate variability and diversification according to individual needs, dwellings should be designed by segregating them into fixed and variable structural components. The fixed component, termed the "support" structure, establishes the conditions for modular coordination, whereas the variable component, designated as "detachable units" or "infill" structures, enables diversity. This segregation aims to differentiate between individual and collective decision-making levels, thereby integrating users into the design process while simultaneously ensuring social identity and permanence.

The support structure constitutes the permanent, shared component of a building, providing service areas for occupancy. It signifies the configuration of permanent, shared elements that furnish spaces for all building users. Throughout their lifespan, these structures offer capacity to accommodate individual diversity and evolving demands. Supports enable the erection of detachable dwelling units independently from the primary building structure, albeit supported by it (Figure 1). In today's world, this increasingly significant issue warrants examination across its numerous social dimensions. Habraken's work can be considered the architectural manifestation of this concern. *The support structure* undertaken to address the question of how participatory approaches find operational correspondence, particularly within architectural education—a matter requiring emphasis—remains illuminating even today. *As it be defined as a framework, derived from the transformation of an existing edifice, that* *facilitates a wide array of plan configurations and adapts to emergent user demands and needs over time* (İlhan, 2008).

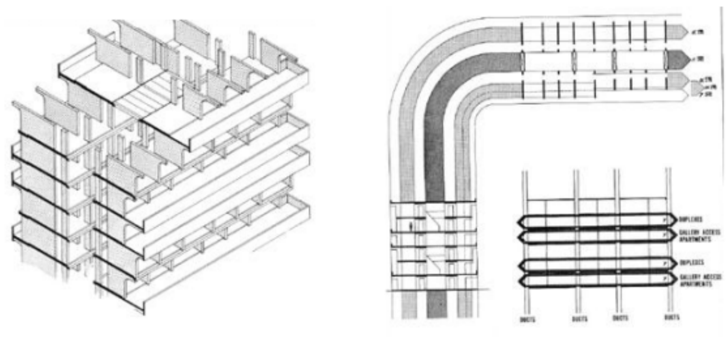

Figure 1. Supports: Axonometric perspective and plan (Habraken et al., 1976)

The Infill Level in system represents the domain of individual decision-making as It delineates the space that individuals can configure according to their preferences and needs, and modify over time. *"Infill (fit-out, detachable unit) is the aggregate configuration of physical components designated for individual use."* (Deniz, 2011).

2.3. Development of the Support Structure in the SAR Methodology

In 1965, the SAR Group was established to continue studies and research on Habraken's developed Supports idea, focusing on the development of flexible housing design and construction. Habraken and the SAR Group's main criticism of mass housing construction at that time was that it ignored the individual and that living spaces could not respond to changes that might occur over time. Therefore, the most important factor for them in the system they developed was to meet different individual needs and to respond to changing needs within the life cycle. For this purpose, they developed a methodology that could provide alternative arrangement possibilities within the same structural system.

Within the SAR system, the support structure, which provides a framework for infill units, and the infill units within the individual's decision-making sphere are defined in accordance with modular principles. For this purpose, the proposed planning order was established as a 10/20 cm tartan grid (Figure 2). Based on this system, the positioning and sizing of spatial units that constitute the housing unit are developed along horizontal bands. This dimensional specification facilitates the modular coordination and standardization of separable units (infill). Grounded in these principles, various iterations and "support types," such as "twin supports," "longitudinal supports," and "low density supports," were developed in the 1970s and 1980s, contingent upon differing density, size, and spatial requirement conditions.

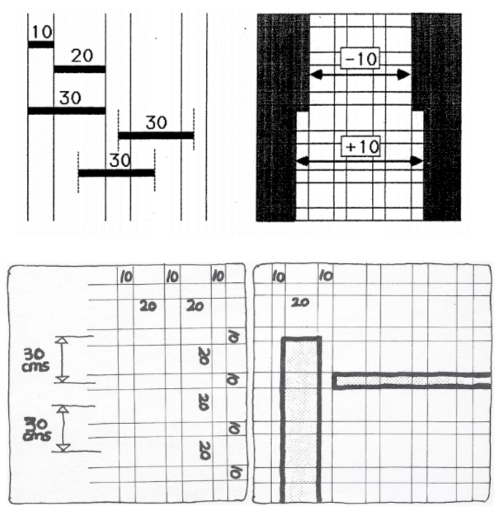

Figure 2. SAR Group Grid System (Kendall & Habraken, 2024)

The developed system, several concepts regarding the placement of spatial units within the design, the size and location of the spatial units were developed in accordance with this modular grid structure. These concepts, defined as "zone", "edge", and "section", refer to zones as the areas where spaces and components are placed. There are four types of zones: α Zone: Interior spaces for private use with direct connection to the exterior. (rooms) β Zone: Spaces for private use without relation to the exterior. (wet areas) γ Zone: General use circulation spaces that can be interior or exterior. (stairs, hall) δ Zone: Exterior space for private use. (balcony, terrace) Edges can also be defined as flexibility shares or recognized tolerances. Flexibility shares or edges are the tolerances that separate the zones from each other. Each flexibility share is defined by the names of the two zones it adjoins (such as αβ flexibility share) and depends on the depth of the spaces to which they belong. Each of the sections is a part of the zone where spatial unit compositions can be realized or a part of the zones determined by the building system and freely divisible into pieces. The load-bearing system determines the location of the sections, and through the zones, the maximum depth that private living volumes can have is determined (Figure 3).

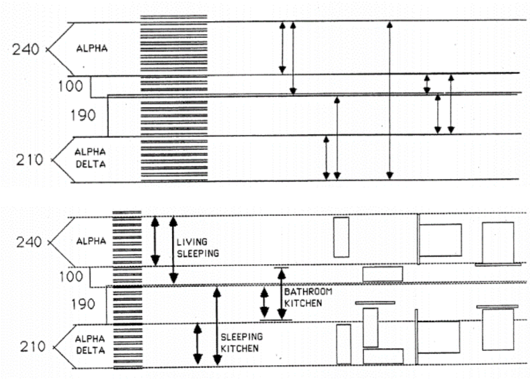

Figure 3. SAR Methodology: Zone, Edge, Section Approach (Kendall & Habraken, 2024)

The spaces constituting the dwelling unit were analyzed, was determined which spaces could be located within which bands. For example, it was assumed that living and sleeping units directly related to the exterior space could be located in the outermost band, while service spaces such as kitchens and bathrooms, which are not required to have a direct connection to the exterior space, could be located in the inner band. The intervals between the bands are defined as flexibility shares and serve to determine the maximum and minimum depths of the spaces (Anon, 1993) (Figure 4, Figure 5).

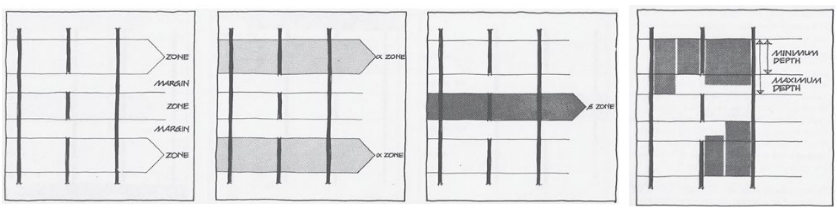

Figure 4. SAR Methodology: Margin, Zone Approach (Kendall & Habraken, 2024)

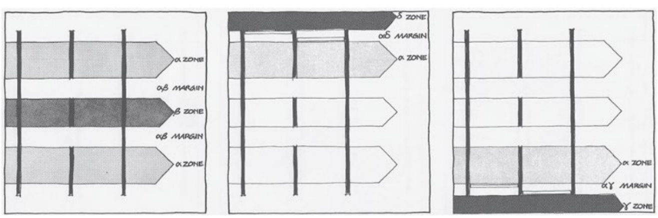

Figure 5. SAR Methodology: Alpha, Beta, Delta, Gamma Zones and their adjacent margins (Kendall & Habraken, 2024)

2.4. Hierarchy of Level Organization in SAR Methodology

In the 1970s, the pursuit of corresponding elements of the Open Building approach at the urban fabric scale, along with the separation of building components and the proliferation of decision-makers, introduced a series of complexities. In the differentiation of individual/collective decisions, the need to reconcile diverging individual choices with the imperative to ensure collective identity and permanence necessitated the development of various control levels. Habraken and the SAR group, to this end, developed a planning, construction, and utilization approach based on the principle of hierarchical levels. According to the Open Building approach, the levels of a built environment are categorized into five groups: Urban Unit Level, Fabric Level, Support Level, Dwelling Unit Level, and Infill Level. Groups at different levels engage in activities and make decisions pertaining to that level. Due to the independence of the various decision-making levels envisioned by the Open Building approach, elements at each level can change according to different conditions and needs without affecting other levels.

The utilization of levels enables environmental professionals to define control areas – who controls what and when – as a fundamental criterion in design. The level scheme thus allows for distinctions regarding the locus of control between individuals, groups, or organizations (Figure 6).

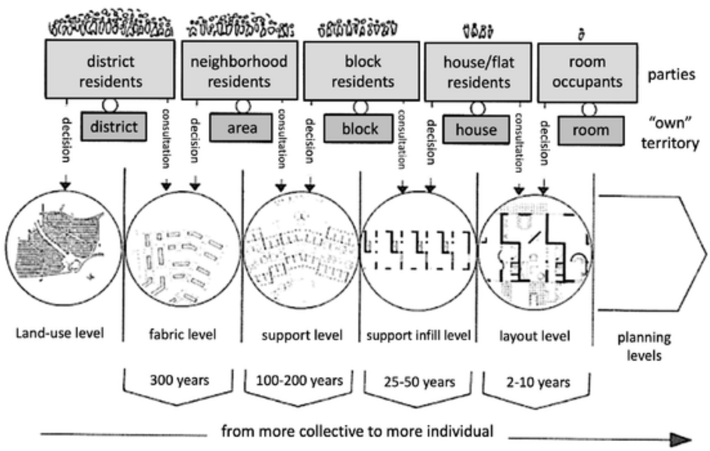

Figure 6. SAR Group Hierarchical Levels Approach (Kendall & Teicher, 2000)

3. Findings and Discussion: The Open Building Movement from the 1960s to Today—Development, Counterarguments and Proposals

In this section of the study, the transformation of the SAR Methodology and the Open Architecture Movement, developed based on J. Habraken's Supports concept, within the process, and the changes it has undergone according to different contextual conditions – socio-cultural, economic, political, technological – and the impact of these conditions on the architectural environment are examined. Within the process, the place of the approach in the universal architectural environment, the criticisms, counterarguments, and the development of the Open Architecture movement according to these views, developed both in the architectural field and through other disciplines, are read. This study aims to reveal the natural processual structure of the approach's development and based on this, to create a foundation for the direction in which it will evolve today. To conduct this reading, the study examines the transformations in contextual conditions and the architectural environment over decades, and the development of the Open Architecture approach according to these transformations, summarizing this process in tables. The counterparts of theoretical studies in the field of application are interpreted through sample projects.

3.1. Impacts of SAR in Housing Production

This subsection analyzes the impact of the SAR approach on housing production in light of the period-specific critiques that emerged between 1960 and 1980 and the institutional–economic conditions underpinning them. By historically mapping the lines of tension between the approach’s theoretical claims and market maturity, regulatory frameworks, production technologies, and user participation, it establishes the conceptual groundwork for understanding the developmental trajectory of the Open Building approach.

3.1.1. Counterarguments developed against the SAR methodology in the 1960s

Between 1960 and 1970 critiques those pertained to the complexity and economic uncertainty inherent in the decision-making processes, as well as the supply difficulties and elevated costs associated with infill elements. emerged concerning the SAR Methodology, which was developed based on Habraken's Supports concept. These concerns were articulated regarding the limited practical implementation despite its theoretical basis, the small number of realized projects, and the consequent ambiguous outcomes. Furthermore, the studies were perceived as predominantly technical-commercial in nature, a point of contention during the 1968 period under the influence of Marxism. Counterarguments were raised suggesting that technical possibilities would supersede user input in decision-making and that the methodology's aims were utopian. A perception also arose that the industrialization of construction would constrain and direct the user's decision-making capacity.

In their publication 'Housing for the Millions: John Habraken and the SAR', Bosma, Hoogstraten & Vos (2000) identifies the principal points that rendered the SAR Methodology a target of criticism during this period. These included the group's apolitical stance, the subordinate importance attributed to aesthetics and design concept, and the ambiguity surrounding the architect's position. Bosma further conveys that these counterarguments predominantly originated from within the architectural field.

At the end of the 1960s, pilot studies carried out at the urban fabric scale with grid systems and modular methods encountered limitations from the Ministry of Housing, which defined dwellings as a single unit. The SAR method caused great resistance in the construction field, and as a result, the pilot project in the Ommoord district of Rotterdam, planned for the 1969-1972 period, was not continued.

3.1.2. Counterarguments developed against the SAR methodology in the 1970s

It is observed that in the 1970s, under the influence of Marxism, there were approaches that interpreted the SAR system as a tool to support capitalism, especially in terms of implementing industrial methods and introducing infill elements to the market. The SAR Group's failure to exhibit a clear ideological and political perspective was criticized due to the influence of the political environment of the period.

According to Marxist critics, Habraken was not radical enough in standing by the user and was in danger of being pressured by the capitalist construction industry. While Marxists wanted a different society, Habraken and SAR wanted to prioritize user participation within the existing social equation of power. According to critics, SAR did not adopt a clear ideological perspective, and 'ideologies devoid of a concrete political translation are illusions based on a swampy foundation.' (Bosma et al., 2000).

Habraken's response to these criticisms was as follows: *Contemporary critics were often harsh in their assessment of John Habraken's writings.*

In 1972, shortly after the first English language edition of his first book was published, a British architect writing in The Architects' Journal titled his review of the book in this way: "One Grows Wary of Ultimate Solutions." Another critic wrote: "Complete Freedom Neither Realistic nor Wanted;" and yet another stated: "I'm Sure it Will Go Away."... Habraken once exclaimed "some criticize my work as pointing to socialism; others thought that what I was advocating was just a way to magnify the power of capitalists." (Kendall & Dale, 2023).

During this period, the developing counterarguments to the approach generally emphasized the technical and procedural ambiguity regarding the principles of the support system. Due to the influence of the economic conditions of the period, the high cost of infill elements and the inability to develop an economically viable system to be installed within the Supports, despite significant basic research and product development by companies such as builders, Bruynzeel, and Nijhuis, was a significant obstacle.

3.2. Arising of "Open Building Movement" Within the Impact of SAR

In the early 1980s, due to the inadequacy of infill elements, changes in the political structure, and economic conditions, there was a risk of the SAR theories not being realized, and the contributions of the government and architectural circles also began to decrease. The approach, which also decreased in influence in the application field in the Netherlands, continued with research, articles, and training programs. In the 1980s, it is observed that interest, research, and production regarding the approach continued in Japan. It is known that 50 projects were built in the 20-year period up to 1985, 10 of which were realized in Japan between 1980-1985.

However, it is observed that the production of support projects decreased throughout Europe in these years.

While Japan embarked on Support/Infill (S/I) housing production, the production of Support projects decreased throughout Europe. A decade later, Germany, Austria, Switzerland, and Sweden had almost completely abandoned Support housing; it seemed to be under the threat of becoming an isolated Dutch phenomenon. And on top of that, between 1982 and 1989, only three Support projects were built in the Netherlands, and all of them were by Frans van der Werf/Werkgroep (Kendall & Teicher, 2000).

It is observed that research on the Supports idea shifted towards infill production, regulatory reform, and the architectural technologies of Supports. As the oil crisis subsided, real estate development and housing consumer markets began to revive. Some 'Supporters' now established active connections with industrial manufacturers looking to enter these recovering markets. Different housing delivery systems were developed in Japan, and architectural research linked to universities gained momentum in the Netherlands. From the mid-1980s onwards, it is observed that interest in the approach increased again in Latin America and Asia. In 1985, SAR Director John Carp founded Network: International Foundation for Local Housing and Design Research to expand SAR's base operations outside the Netherlands. Until SAR closed in 1987, it is observed that work continued publications, training programs, and applications.

One of the housing supply systems developed in Japan was the Two Step Housing Supply System (TSHSS) at Kyoto University in 1982, based on Japan's local tradition of shell/infill construction. The approach emphasizes the importance of the balance between public and private use in the housing process. The goal is to realize housing design and production methods that can clearly define social and individual use responsibilities within a long-term management framework. The basic idea here is to organize the social space of housing more effectively, rather than to rationalize construction.

Accordingly, in the first step, the support structure will be built as a social infrastructure, of high quality and long-lasting, and in the second step, an infill structure produced by small-scale construction companies will be placed inside the support structure. Subsequent studies have focused on rationalizing this idea and adapting it to conventional housing organization (Kendall & Teicher, 2000).

In the 1990s, the first research and projects related to Open Building were observed to be developed in Finland. In the United States in 1994, Steward Brand, together with Habraken, developed the Open-Built platform, which allows buildings to be easily changed as needs change. This approach is based on Habraken's approach and Steward Brand's Layers idea, and aims to separate mechanical systems from long-lasting and energy-efficient structure and enclosure, and to allow for free planning of the interior layout.

In the 1990s, the development of Computer-Aided Design (CAD) technologies enabled the more systematic implementation of Open Building principles. This was an important development in terms of eliminating design uncertainties and facilitating user participation. The 1990s, with the influence of the humanist perspective that prioritized the individual and their participation, led to a renewed increase in interest in the approach.

In 1994, CIB (International Council for Research and Innovation in Building and Construction), headquartered in Rotterdam, was established as a global network system for international exchange and cooperation. Stephen Kendall and Karel Dekker from the Netherlands were appointed as founding co-coordinators. With this, it became possible to increase awareness of the approach, support national and international initiatives, create a research platform, organize international conferences, and thus spread it on a global scale. In 1996, the CIBW104 (Open Building Implementation) working group was established.

One of the projects developed during this period was the Next21 Project in Osaka, Japan. Next21 is an experimental 18-unit housing project designed by 13 different architects. The building frame ('skeleton'), exterior cladding, interior finishes, and mechanical systems are designed according to the principles of the Century Housing System (CHS): as independent building subsystems, each can respond to a different repair and replacement cycle. It is observed that the project was developed to address approaches such as sustainability, energy conservation, recycling, and green architecture, which were discussed in these years (Figure 7).

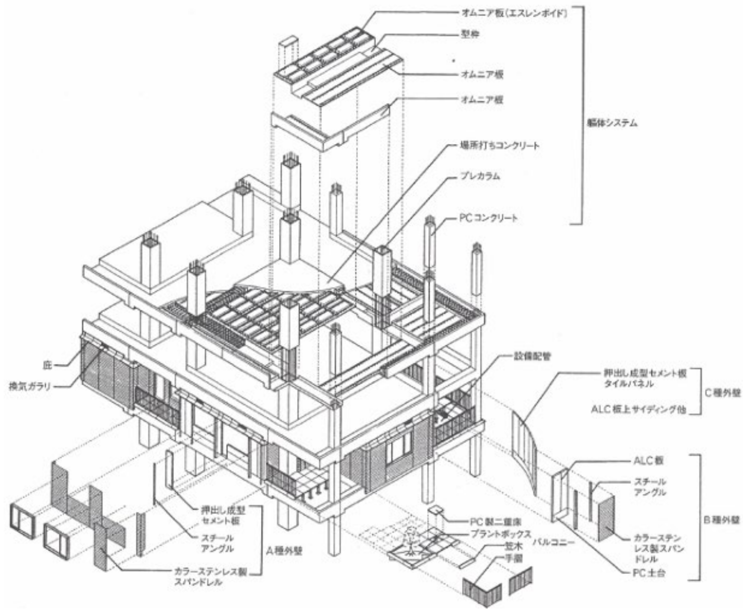

Figure 7. Next21 Building General Appearance and System Configuration (Habraken, 1994)

The building is six stories high and houses of 18 different dwellings spread along a precast concrete support structure. This infrastructure is U-shaped with a large void in the center, surrounded by a series of 'streets' (galleries) that provide access to each dwelling. This 'high-rise open streets' system creates a continuous promenade along the infrastructure, starting with the communal garden on the ground floor and ending with the roof garden terrace, enabling the study of the three-dimensional neighborhood concept (Figure 8). *From a social perspective, it aims to respond to user preferences by providing the flexibility required for the adaptation of individual units over time. Technically, it seeks ways to build in which subsystems can be installed, modified, or removed with minimal interface problems"* (Habraken, 2003).

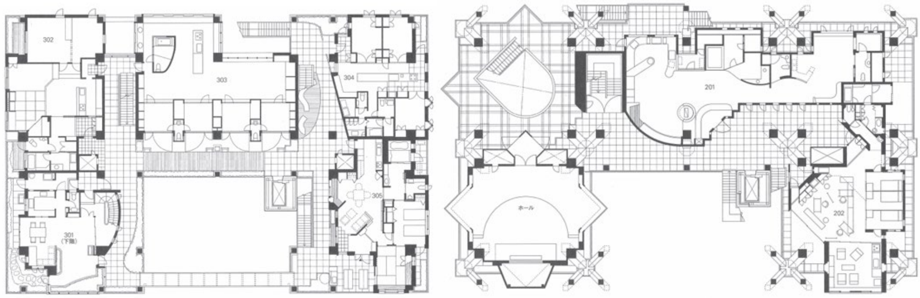

Figure 8. Next21 Osaka, 1993. General layout plans show the diversity of housing types (Kendall & Habraken, 2024)

In response to a number of issues with land development 'right of use' laws, projects based on the 'Tsukuba Method' began to be built in 1995. The aim of this initiative was to implement a new concept of landownership and household control using the Two Step Housing approach. In 1997, a project combining Two Step and CHS was built in Hyogo Prefecture near Osaka. Many CHS projects have been built, including detached houses and multi-unit apartments and condominium buildings.

The development process of the SAR Methodology and the Open Building approach between 1960 and 1990 is presented in the table below (Figure 9).

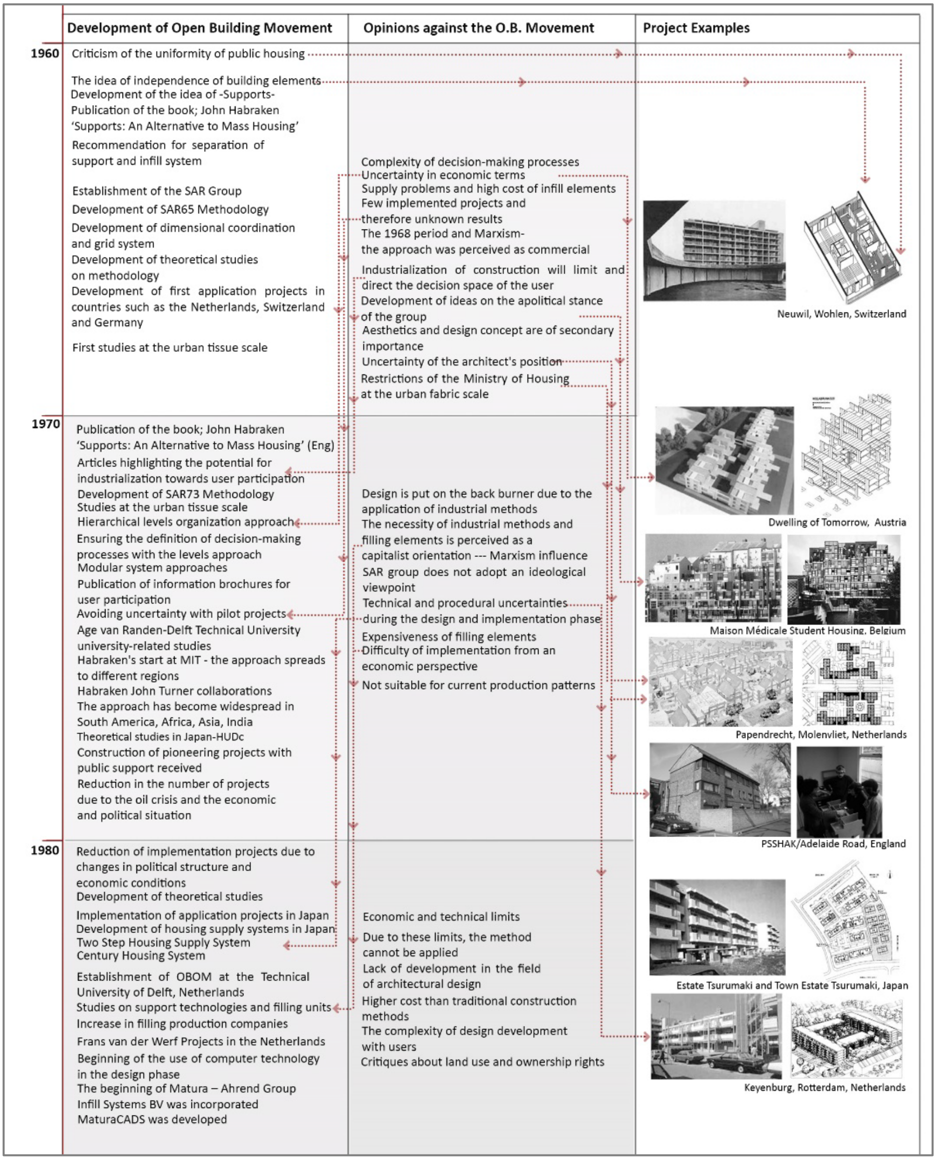

Figure 9. Development Process of Open Building Movement Between 1960-1990 (Authors, 2025)

3.2.1. Counterarguments developed against the open building movement between 1980-2000

During this period, there were criticisms that SAR's consultation and control levels could remain illusory, and that sufficient feedback and data could not be obtained from users. The fact that individuals were not competent to change their spaces and that no changes were observed caused the necessity of the approach to be questioned in terms of the user participation aspect, which is the main goal.

It is observed that there are questions regarding the universal applicability of the open-building movement in different cultural and economic contexts. The fact that the approach proposes a homogeneous solution has raised questions about the possibility of ignoring the local context.

It is observed that opinions have developed that the proposed modular system may not be compatible with existing infrastructure and building regulations, and that different modules need to be produced at this point.

3.3. Improvements of Open Building Movement from 2000s to Present Related with SAR-Counterarguments and Proposals

In the 2000s, the open building approach began to be discussed and developed in conjunction with concepts such as sustainability, user participation, and digitalization.

It is observed that the number of books written in these years has increased in response to counterarguments that user participation did not take place and that individuals did not have knowledge in this regard. The book 'Open Building in Housing' written by Stephan Kendall and Jonathan Teicher in 2000 is the first book to show application examples worldwide. It conveys the open building approach and applied projects in the direction of enriching an individual-centered open architectural practice and reorganizing the construction process. In the book 'Housing for Millions: John Habraken and SAR (1960-2000)', Habraken's Supports system, which he presented as an alternative to mass housing, the establishment of the SAR group, its methodology and studies are presented in detail.

John Habraken's 1998 book *'The Structure of the Ordinary'* and his 2005 book *'Palladio's Children: Seven Essays on Everday Environment and the Architect '* convey approaches on how to integrate the support system into contextual conditions and the existing built environment. In this sense, solutions are presented to views that the open building approach cannot establish a relationship with the local context. In 2005, ManuBuild (Open Building Manufacturing System) was a research project created with European Union support. This system, which proposes the production of building elements by prefabrication, aimed to reduce construction costs.

With the 2000s, it is observed that examples of the approach were produced and developed in Finland. A system was developed where building components were selected by users at the beginning of the design and cost calculations were made. In the Helsinki Plus Home project, implemented in 2005, residents could choose both different apartment sizes and variations of the same size (Figure 10). Lightweight construction walls allowed for change. Buyers were able to choose surface materials, fixtures, and accessories in their apartments at a fixed price, and after the selections, quantity information was automatically collected and decisions were made together with the users.

Figure 10. Plus Home, Helsinki, Plan Variations (Kendall & Habraken, 2024)

The Tila Housing Project, implemented in Finland in 2009, is a pilot project consisting of 39 loft apartments ranging from 54 m² to 102 m². Within the existing building frame, the resident can determine and construct the necessary subdivisions. Since the height of the main space is five meters, residents can build individual rooms or expand their apartments with gallery-type voids (Figure 11).

Figure 11. Tila Housing Project, Finland, Plan Variations (Kendall & Habraken, 2024)

PATCH22, implemented in the Netherlands in 2009, was a project that interpreted the Open Building movement with sustainability principles. In Patch22, 'sustainability' was achieved through energy efficiency, the use of renewable materials, and flexibility in floor plan layout options.

In order to provide flexibility throughout the building's life cycle, it was intended that not only the plan layout but also the floor heights, designed to be 4 meters, could be transformed according to different programs in terms of volume. It is observed that while infill units are created according to the lifestyle of their users in the project, the support structure as an upper structure is fixed, thus a holistic design is in question.

The Superloft project, implemented in the Netherlands in 2016, was a project that aimed to include a co-living experience where common areas could be created collectively. Superlofts aims to offer its residents the freedom to design and/or self-build their homes and create common areas together as a community. Superlofts works with a web platform for common housing setup by its architect. Buildings consist of a combination of different apartment types, accommodating individual choices and designs in a double-height loft space (Figure 12, Figure 13).

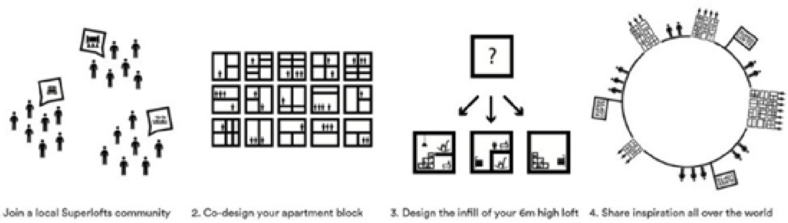

Figure 12. Superlofts Project, 2016 (Marc Koehler Architects, 2018)

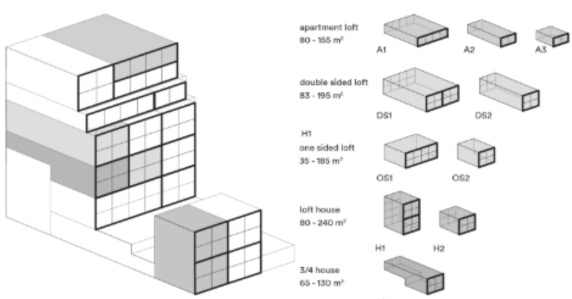

Figure 13. Superlofts Project, Plan Variations (Marc Koehler Architects, 2018)

The design by Mark Koehler in the Netherlands follows the Open Building movement, using a flexible and open framework that easily adapts to changing use and maintenance cycles to facilitate a circular and durable building form. Building systems can be updated in independent cycles without material waste or demolishing the building. For example, the support structure can be used indefinitely, facades can be updated every 25 years, installations (HVAC systems) every ten years, and interiors every 5 years.

In 2017, the Open Building Council was established in the United States by the initiative of John Dale and Stephen Kendall. The council is committed to the proposition that change planning – during design and in the long term – is a fundamental prerequisite for a durable and sustainable built environment. It works to explain the necessity of the open building approach, to provide the training and unity required by this approach in different disciplines, to evaluate the increasing change capacity in the built environment at different levels, to organize national and international conferences, and to support research.

Today, it is observed that many studies are being developed in the theoretical field regarding the Open Building approach, that it is a topic of discussion in conferences, and that publications are being developed; and that projects are being developed in the field of application, especially in countries such as the Netherlands and Japan. The following visuals present examples of the work done in this field after 2000 (Figure 14, Figure 15).

Figure 14. Examples of Publications on the Open Building Approach (Authors, 2025)

Figure 15. Examples of Projects Developed with Open Building Movement (Authors, 2025)

The development process of the SAR Methodology and the Open Building approach from 1980 to the present is presented in the table below (Figure 16).

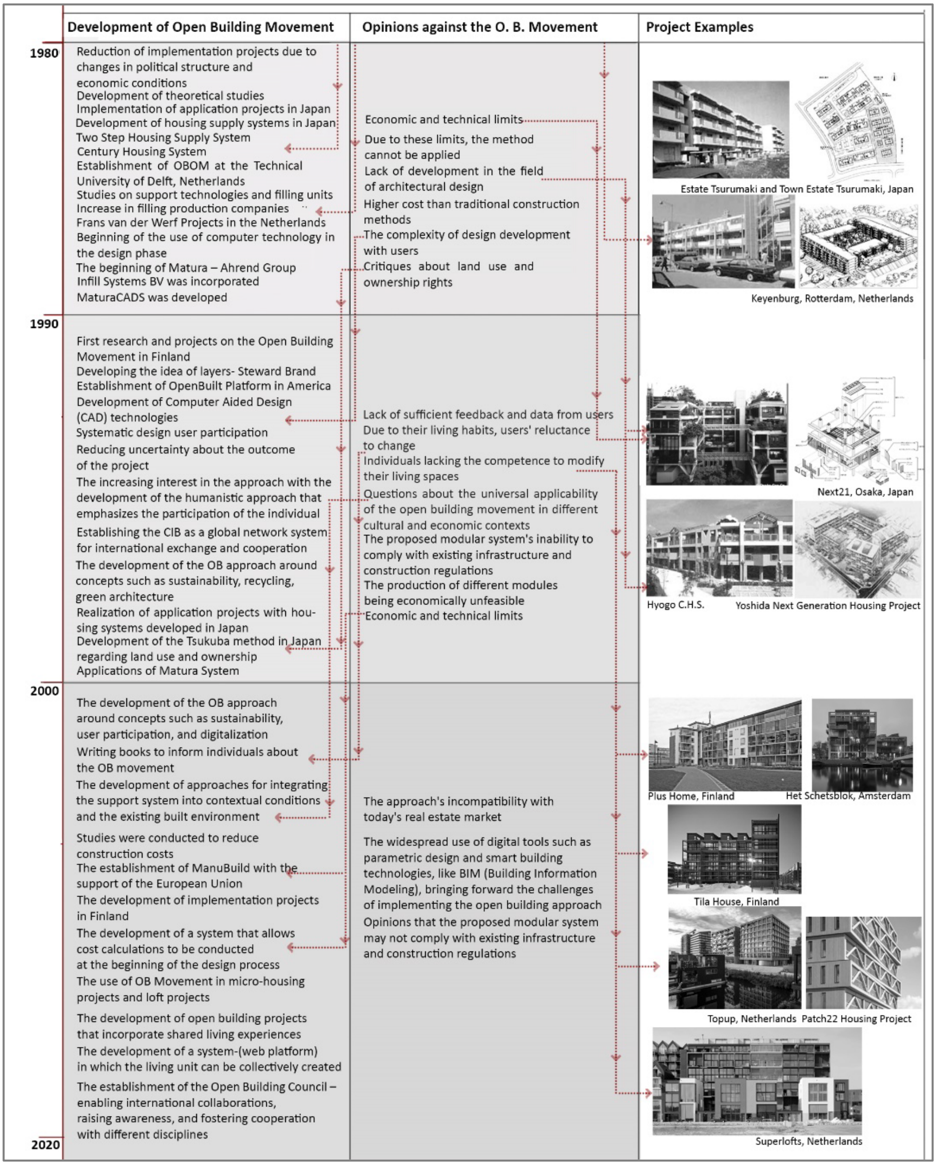

Figure 16. Development Process of Open Building Movement from 1980s to Present (Authors, 2025)

4. Conclusion and Suggestions

In recent years, the Open Building movement has gained prominence in building production due to factors such as the increasing importance of sustainability and user participation, the industrialization of housing subsystems, and the adoption of renovation approaches over new construction. To this end, it is necessary to stratify the built environment according to processes where the need for change may arise, determine the intervention levels of participants, and establish a multi-participant process.

John Habraken, in his 2017 article, articulates the necessity of the Open Building approach today as follows: *"The everyday environment tells us that we need to cope with change and make time the fourth dimension of design; to encourage designers to implement open building, to distribute design control appropriately, to understand the relationship between complexity and hierarchical depth, to give residents or users their own levels of intervention within the environmental hierarchy... We are in the midst of a transition period towards a new professional role..."* (Habraken, 2017).

Today, "to give residents or users their own levels of intervention within the environmental hierarchy" is crucial to In the context of evolving and shifting paradigm, as signifies the act of interpreting the atmosphere of housing production. Additionally, given the escalating housing deficit in the post-disease era due to the climate change, the proliferation of such studies and the examination of Habraken's methodologies have become increasingly pertinent. This issue, which necessitates individuals' engagement in the production of their own housing, not only concerns the development of new construction zones but also encompasses the support and renovation of existing residential areas through new additions. Habraken’s methodologies and approaches of OB, can be considered as significant steps towards addressing the diverse needs of various social communities especially after the emergence of the aforementioned housing deficit.

In this study, the transformation of the Open Building approach from the 1960s to the present changes according to different contextual conditions - socio-cultural, economic, political, technological - and the impact of these conditions on the architectural environment are examined. In this process, the criticisms and counterarguments developed against the approach, in the field of architecture and through other disciplines, and the evolution of the Open Building approach according to these views have been read, and it is aimed to reach conclusions regarding the todays atmosphere of housing production.

The period between 1960 and 1970 witnessed the primarily theoretical development of the approach. During this time, counter-arguments arose, citing uncertainties in practical applications, the dominance of technical-commercial aspects, the secondary importance of design concerns, the apolitical stance of the SAR group influenced by the 1968 movement and Marxism, and the ambiguity of the architect's role. These issues contributed to a decline in the SAR system's influence in countries other than the Netherlands in the 1970s. In response to these criticisms, the SAR73 Methodology was developed, emphasizing collaboration with diverse disciplines and stakeholders.

This methodology extended to the urban level, incorporating user participation in housing and environmental decisions, thereby foregrounding the concept of participatory design in different geographies which carries the fundamental principles of user empowerment, Open Building Principles, flexibility, and a separation of collective and individual building layers – hold significant potential for addressing contemporary housing challenges. However, successful adaptation requires a thoughtful integration of technological advancements, a strong focus on sustainability by the means of both the social and environmental pillars, requires a deep understanding of current social and economic contexts and potentially revisions to regulatory frameworks. By creatively reinterpreting and updating the core concepts, SAR '73 can offer valuable insights and practical strategies for creating more user-centric, adaptable, and sustainable built environments in the 21st century especially due to the lack of inclusive housing production methodologies after disease.

So far, In this context, Pilot projects were implemented to facilitate the approach's development in Japan, where it garnered support from municipalities and other stakeholders, leading to the construction of prominent Open Building projects by the late 1970s. However, in the early 1980s, the inadequacy of infill elements, political changes, and economic conditions posed risks to the realization of SAR theories, resulting in diminished support from the government and architectural community. While its practical influence waned in the Netherlands, the approach persisted through research, publications, and educational programs. In Japan, interest, research, and production continued throughout the 1980s. Projects during this period saw the integration of computer systems to support design and user participation. Technological advancements and the diversification of infill materials led to the development of new systems like the 20th Century Housing System and the Two-Step Housing System. By the 1990s, global collaborations began to emerge. The 2000s marked a proliferation of theoretical publications, with practical projects continuing in countries like the Netherlands and Japan.

In recent years, approaches emphasizing individual needs, contextual factors, and adaptable building configurations have gained traction in architectural discourse. Projects developed in early industrialized nations like the Netherlands and Japan suggest a future trajectory for housing production and architectural discussions. Although the term "Open Building" may not be explicitly used, similar systems are referred to by various terminologies such as "Skeleton-Infill" (Japan, China, and Taiwan), "Long-Life Housing" (Korea), "Raw Space Housing" (Finland), and "Free Plan Apartments" (Russia). The Pritzker Prize awards to architects like Aravena, Philippe Vassal, and Anne Lacaton, who prioritize user participation and social sustainability, underscore the evolving direction of architectural discourse. In an era of globalization, cultural interaction, and accelerated individual preferences and needs, the need for alternatives to traditionally static building production becomes paramount.

SAR's Impacts on Sustainability and Resource Efficiency of Today's Production of Housing:

Contemporary adaptations of the support-infill methodology must prioritize the integration of sustainable and locally sourced materials for both the support structure and the infill units to effectively minimize environmental impact. Additionally the design of both these components necessitates the incorporation of passive and active energy-saving measures, recognizing that the interface between them is crucial for achieving optimal overall building performance. Finally, the adoption of circular economy principles, which involves designing for the eventual disassembly and material reuse of both supports and infill, can significantly contribute to a more sustainable and resource-efficient approach to building construction.

SAR's Impacts on Social and Economic Context:

Addressing the prevailing affordable housing crisis necessitates that adaptations of the SAR '73 methodology consider its potential to contribute to more economical housing solutions through efficient construction practices and user-driven incremental development.

Furthermore, recognizing the diverse housing needs inherent in contemporary urban environments, the support-infill concept must exhibit sufficient flexibility to accommodate a wide spectrum of household sizes and varying requirements. While the principle of individual user control remains paramount, fostering a robust sense of community and effectively addressing social integration within support-infill developments demands meticulous planning and the potential provision of shared amenity spaces within the overarching support structure.

SAR's Impacts On Contemporary Approaches To Architectural Education

Furthermore, To make SAR '73 relevant with the architectural education today, several avenues can be explored as to be explore in design studios to be articulated in curricula by the means of widen up the range of dealing issues urban planning and housing design:

Contemporary adaptations of Habraken's SAR '73 methodology necessitate a multi-faceted approach, encompassing the development of user-centric digital toolkits that empower residents to design, visualize, and potentially fabricate their infill units within the defined parameters of the support structure. Furthermore, the integration of smart infrastructure within these supports, capable of accommodating diverse smart technologies for energy management, security, and communication within individual infill units, presents a significant avenue for modernization. Explorations into hybrid systems, which strategically combine the fundamental tenets of support-infill with other innovative housing models and construction technologies, warrant consideration. The application of the support-infill concept to incremental housing strategies offers a promising pathway for facilitating the gradual, user-driven expansion and adaptation of affordable housing solutions.

Moreover, investigating models of community-led support development, where prospective residents engage in the planning and even partial construction of the foundational support structure, could foster greater ownership and social cohesion.

Finally, a critical focus on material innovation, involving the research and utilization of advanced and sustainable materials optimally suited for both support and infill construction, is paramount for ensuring the long-term viability and environmental responsibility of adapted SAR '73 methodologies.

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The article complies with national and international research and publication ethics.

Ethics Committee approval was not required for the study.

Author Contribution and Conflict of Interest Declaration Information

All authors contributed equally to the article. There is no conflict of interest.

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Operational Dynamics and Challenges of Architectural Design Competitions in Türkiye: A Process-Oriented Analysis

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1. Introduction

Architectural design competitions in Türkiye have long been used as an important method both in the production of public buildings and in the development of architectural culture. However, despite this long-standing tradition, recurring problems and structural deficiencies in the functioning of competitions have consistently remained on the agenda in both the professional field and the academic literature. The aim of this study is to systematically categorize the problems that have emerged in architectural competitions in Türkiye from their historical development to the present and to make them visible through a process-oriented analysis. The research proceeds through three main stages—pre-competition preparation, competition and evaluation, and post-competition implementation—examining the administrative, technical, and professional challenges that come to the forefront at each stage. In this way, the problem areas frequently discussed in the literature are organized into a coherent framework, while data obtained from the experiences of different stakeholders and written sources are comparatively evaluated to present a comprehensive analysis. The main objective of the study is to ensure that competitions are considered not only as a method of obtaining a project, but also as mechanisms that carry functions of transparency, participation, and professional ethics, and to analyze the ongoing debates in this field with a holistic approach.

The competition as a concept—encompassing the element of rivalry, opportunities for free and original production, and evaluation and reward systems—occupies a privileged position within the discipline of architecture (Sayar, 2004). Competitions have long served as a means of acquiring design ideas and fostering their development (Karabey, 2002). Among the methods for procuring projects, they stand out for prioritizing quality, as the primary criterion in the selection process is the design itself. Considering that the majority of project competitions in Türkiye are commissioned by public institutions, it is evident that in other procurement methods such as tenders, the determining factor is often the lowest cost. The design-centered nature of competitions gives them a significant advantage over such methods (Özbay, 2001). Those who initiate competitions expect to achieve the most appropriate spatial, functional, economic, technical, and urban planning solutions. This research seeks to identify the constraints that hinder the creation of such designs, as well as the conditions under which they are developed, evaluated, and implemented.

Competitions also provide architects with opportunities to present their ideas and designs, work collaboratively, and improve their skills (Çimen, 1993). In his 1993 article in Mimarlık magazine, Murat Artu stated: "Architecture is a profession in which, if you do not receive a commission, you will not execute a project. Unlike a painter or a musician, an architect cannot be expected to produce a project for a place in their spare time without a commission. For this reason, competitions can be said to broaden architects' horizons" (Artu, 1993). While they broaden horizons, competitions also play a significant role in providing architects with practical experience—experience that can only be gained through design work (Özbay, 2001). However, the inexperience of some competitors is also a challenge from the client's perspective.

The ethical opportunities, mutual professional exchange, creative solutions, and theoretical discussions fostered by competitions also contribute to the necessary groundwork for architectural education (Aksu, 2024). It is widely acknowledged that competitions offer advantages such as enabling the younger generation to produce work, allowing participation by all, and maintaining transparency (Özbay, 2001). Nonetheless, their primary purpose is not to create job opportunities for young architects (Arolat, 1993).

By serving as a means of project procurement, competitions contribute to the development of design and architectural culture, expanding knowledge and experience nationally and providing a resource for future generations (Akansel, 2003). They are also considered a form of professional training (Şentek, 2001). Moreover, the debates sparked by competitions and the resolutions of such debates are expected to enrich the professional discourse (Özbay, 1993).

In a democratic and transparent society, architectural design competitions are among the most inclusive and participatory methods for shaping public spaces. One of the essential components of a modern and advanced society is informing the public about decision-making processes, clearly stating the rationale behind decisions, and allowing those decisions to be debated publicly. Beyond simply serving as a method to achieve high-quality designs, competitions can also take on various roles in social and political contexts. However, it has been observed that, in the context of public projects, competitions are sometimes instrumentalized to legitimize existing power relations or to redefine them. Opposition to a selected project can sometimes manifest through demands for a new competition, which is a clear example of this phenomenon (Bayrak, 2013).

For competitions to fulfill this broader function, certain structural and administrative requirements must be met. Other project procurement methods outside of competitions do not provide the architectural profession with a fair and transparent competitive environment. Despite the consensus on the importance of competitions and Türkiye's long-standing tradition in this field, as well as generally accepted views on their value, the implementation processes have not reached the desired standard (İlhan, 2013). Without fulfilling the necessary conditions for effective implementation, spatial decisions are often made behind closed doors by a limited group of individuals, without public debate or consultation with experts.

For these reasons, discussing the problems that arise during competition processes is not only a professional necessity but also critically important for the democratization of public space. Addressing the shortcomings in the functioning of competitions is indispensable for improving the process and ensuring that society can participate more effectively in shaping its spatial future. Making these issues visible and offering solutions is essential both for upholding the ethical responsibilities of the architectural profession and for ensuring the sustainability of democratic society.

2. Method

The issues related to architectural project competitions were evaluated by first examining scientific sources, followed by symposiums on architectural project competitions, special issues of Mimarlık magazine dedicated to competitions, and bulletins of the Chamber of Architects of

Türkiye (UCTEA). The problems identified in these sources were analyzed from the perspective of various stakeholders involved in competitions. These stakeholders include competing architects, the organizing authority, the jury, and UCTEA. During the review process, discourses related to competition processes, as well as the experiences and criticisms of the mentioned stakeholders, were assessed using the method of textual content analysis. The collected data were classified within the framework of similar themes and concepts, and the findings were evaluated in connection with the discussions present in the literature. In this way, the findings of the research are based not only on quantitative data but also on qualitative data that reflect the opinions of actors in the field and the criticisms expressed in written sources.

The issues related to competitions were examined under three main headings: Pre-Competition, Issues in the Competition and Evaluation Process, and finally, Post-Competition Issues. The reason for analyzing the problems in this way is that different stakeholders become involved at each stage. In the pre-competition stage, matters such as the preparation of the competition brief, the selection of the jury, and the attitude of the organizing authority are decisive. This period is essential for ensuring that the process proceeds smoothly, as it defines the framework of the competition. The competition and evaluation stage is where the projects are produced and selected; here, factors such as transparency, objectivity, and sufficient evaluation time come to the forefront. The post-competition stage is related to the willingness to implement the projects and the commitment of the organizing authority. In this stage, delays, cancellations, or modifications to the projects that deviate from the original design can render the entire process meaningless. Therefore, addressing the problems under these three headings facilitates both establishing cause-and-effect relationships and developing phased solution proposals.

3. Analysis of the Problems of Architectural Design Competitions in Türkiye

This section presents the findings obtained from the literature review and content analysis on architectural project competitions in Türkiye. During the source review process, scientific studies published in different periods, interviews featured in professional journals, official regulations, and competition reports were examined. The analyses addressed the competition process within the framework of its three main stages: pre-competition, competition and evaluation, and post-competition periods. Within this scope, the organizational practices of competitions, the challenges faced by stakeholders, structural deficiencies, and implementation-related issues were identified. The findings encompass both the criticisms expressed in written sources and the observations derived from the review of regulations and legislation. In this way, the current state of the competition culture, its problem areas, and the aspects requiring improvement have been revealed from a holistic perspective.

History of Architectural Competitions in Türkiye

Understanding the history of competitions in Türkiye reveals that the issues surrounding them are not exclusive to the present day; rather, they have existed since the inception of such events. From the very beginning, competitions have been regarded as one of the primary methods for ensuring fair and transparent project processes. They have played a significant role in Türkiye's modernization process and have pioneered the generation of creative ideas. However, competitions have not always received the recognition they deserve. Throughout history, particularly during periods of economic crisis, political changes, and legislative shifts, competition processes have been disrupted. While there were times when the number of competitions increased, there were also periods when they were pushed into the background.

The first known architectural design competition in Türkiye was the 1867 Tarabya British Embassy Residence Competition. Due to Türkiye's unfavorable conditions at the time, the competition was organized in England. However, there is no evidence that the winning proposal was ever implemented (Cezar, 1991). According to Süha Özkan, another significant event was the 1916 Turkish-German Friendship Foundation Competition, in which Turkish architects Vedat Bey and Kemalettin Bey served as jury members. Participants included notable figures such as Paul Bonatz, Martin Elaesser, Theodor Fischer, Hans Poelzig, and Bruno Taut. The winning design by German Bestelmeyer was never realized (Özkan, 1975). This illustrates that the widespread problem of non-implementation, still common today, has existed since the very beginning of Türkiye's competition history.

With the early years of the Republic, the aim of nationalizing Turkish identity and creating a modern image was pursued not only in the political sphere but also through spatial transformations. The 1930s marked the transition from the stylistic elements of Ottoman architecture to a new modern architectural language (Kopuz, 2024). By this time, the modernist movement had started to take hold, and the role of foreign architects in the design process began to be questioned (Saban, 2024). Influenced by nationalist and statist ideologies, architectural competitions started to replace the practice of commissioning projects to foreign architects. While this initially aimed to encourage local architects, later international competitions sometimes excluded them, demonstrating that the issue of marginalizing local architects is not new. It was concluded that a national architectural style could not be developed by foreign architects (Sayar, 2004).

Following this period, the post-World War II era brought the concept of "liberalization in architecture." Traditional approaches were abandoned, and a global architectural language began to emerge. The International Style, characterized by simple and geometric forms devoid of ornamentation, found its place in Türkiye's major cities, while also incorporating elements of the country's modernization process (Halıcı, 2024).

The earliest well-documented competition of the 1930s was the Bursa Municipality Market Hall Competition. Within the architectural experience of the Republican era, competitions held a significant role (Özbay, 2001). In 1993, Hasan Özbay stated: "The most important phenomenon of the 1930–1950 period was the use of competitions as a method to spread the architectural culture of the young Republic throughout the country." This statement clearly illustrates the importance placed on competitions in Türkiye's early years.

The 1950s marked a turning point for architectural competitions in Türkiye. Competitions gained momentum during this period. It is thought that the Chamber of Architects, established in 1954, played a significant role in this increase (Karaman & Erman, 2024). However, until the late

1950s, competitions were not bound by an official regulation, and therefore, processes continued under the influence of different actors. With the establishment of the Chamber of Architects, attempts were made to introduce a regulatory framework for competitions. The regulation prepared in 1956 came into effect in 1958. In this way, the rights of the winning architect were placed under legal protection for the first time. Subsequently, the Ministry of Public Works also published its own Competitions Regulation, which created a duality in practice. Finally, in the 1970s, the Chamber and the Ministry reached an agreement and merged under a single regulation (Ersin, 2001).

The 1960s were directly influenced by Türkiye's political environment. The atmosphere of freedom that emerged after constitutional changes supported the development of competitions. In the same period, under the influence of modernist architectural approaches, fragmented plan types, low-rise buildings spread across the site, and the use of inner and outer courtyards instead of corridors came to the forefront in competition projects. In the 1970s, this approach further evolved into a modular plan layout (Arslan Selçuk & Sönmez, 2024).

The period between 1960 and 1980 witnessed significant developments in competitions. With the acceleration of industrialization and commercialization, urbanization increased, and, in line with changing intellectual contexts, the need for different building typologies also grew. During this process, while the number of commercial buildings increased, the Ministry of Public Works particularly focused on Government Office projects (Aydın, 2024).

Until the 1980s, private initiatives were not involved in the production of public buildings. However, after 1980, this situation changed, and the private sector began to take part in the process. Nevertheless, Government Office projects constructed especially after the 1980s were frequently criticized due to the standardization of their typologies (Kalfaoğlu Hatipoğlu, 2024).

Finally, until the 1990s, modern architectural works were designed and implemented through competitions organized by state institutions. This process played an important role in the dissemination of modern architecture in Anatolian cities (Arslan Selçuk & Sönmez, 2024).

In the political history of the Republic of Türkiye, the 2000s were marked by the rise of new ideologies; however, most of the spaces associated with these ideologies were obtained directly through tender procedures rather than competitions. As a result, the number of competitions opened decreased (Kuçak Toprak, 2020).

Competitions have also reflected the political aspirations shaping the planning of cities and the design of buildings (Vanlı, 2003). However, as the years passed, their influence in the architectural field diminished. The main reason for this is that competitions have never been the primary method of procuring architectural projects in Türkiye (Özbay, 2001).

3.1. Classification of Competitions

To identify the categories of competitions, the competition regulations binding in Türkiye were examined. The regulations prepared by both the Union of Chambers of Turkish Engineers and Architects (UCTEA) and the Ministry of Environment, Urbanization and Climate Change were considered together. These categories were compiled to serve as a reference for the section on competition-related issues to be discussed later, illustrating both the ideal framework and the existing conditions. The shortcomings in the regulations themselves will also be addressed.

3.2. Type of Competitions

According to Article 5, Section 2 of the UCTEA Architectural Competitions Regulation, competitions are classified into three types: Idea and Design Competitions, Project Competitions, and Fine Arts Competitions. These are defined in the same regulation as follows: Idea competitions are organized to determine approaches that will form the basis for an investment or competition process. Their purpose is not to obtain a project, but to encourage innovative thinking and foster public engagement (UCTEA, 2022a). Project competitions, on the other hand, are organized to obtain projects that address spaces in terms of aesthetics and functionality, while also meeting technical and regulatory requirements. They are held in two subcategories (UCTEA, 2022a): Architectural Project Competitions and Interdisciplinary Competitions. Architectural project competitions are open exclusively to members of the UCTEA Chamber of Architects (UCTEA, 2022a). Interdisciplinary competitions require collaboration between multiple disciplines or fields of art. For such competitions, the team leader must be a member of the Chamber of Architects, and all other members of the team must be registered with their respective professional chambers under UCTEA (UCTEA, 2022a). Finally, Fine Arts Competitions are organized for works of fine art to be placed in buildings or urban spaces, and these do not require participants to be chamber members (UCTEA, 2022a).

In Article 7 of the Ministry's competition regulation, competitions are categorized under a broader set of headings. This broader classification can be attributed to the inclusion of competitions in fields beyond architecture under the same regulation. The categories in this regulation are: Architecture Competitions, Engineering Project Competitions, Urban and Regional Planning Competitions, Landscape Architecture Project Competitions, Urban Design Project Competitions, Fine Arts Competitions, Idea Competitions, and Interdisciplinary Competitions (Ministry of Environment, Urbanization and Climate Change (MoEUCC), 2002).

The definitions provided by UCTEA and the Ministry are largely similar. For this reason, the definitions will not be repeated here. However, in the case of idea competitions, the Ministry's regulation adds the statement: "These competitions may also serve as preparatory work for another competition or for subsequent planning or project studies to be implemented." (Ministry of Environment, Urbanization and Climate Change (MoEUCC), 2002).

3.3. Form of the Competition

In Article 6 of the Chamber of Architects' Regulation, competitions are examined in three categories in terms of openness to participation. In the Regulation of the Ministry of Environment, Urbanization and Climate Change, Article 6 is also examined under the same headings. Competition forms/types are divided into three: International Competitions, National Competitions, and Regional Competitions. To briefly define these types, International Competitions are prepared in accordance with the UIA's regulatory requirements and are open to participation from outside Türkiye

(UCTEA, 2022a). National Competitions are competitions in which only architects registered with UCTEA can participate (UCTEA, 2022a). For Regional Competitions, restrictions such as being organized in subjects with an area smaller than 5000 m², within a few branches determined by the Competition Committee, or within a branch with at least 200 members have been introduced (UCTEA, 2022a).

In terms of method of execution, they can also be examined in three groups. Single-stage Competitions, according to Article 7 of Section 2 of the UCTEA Regulation, can be used in National, International, or Regional competitions. Regional Competitions can only be held as single-stage (UCTEA, 2022a). Two-stage Competitions, according to Article 8 of Section 2 of the UCTEA Regulation, have predetermined standards within two stages. In the first stage, proposals are received at a scale and quality that will highlight the concept. The second stage continues with the candidates selected in the first stage (UCTEA, 2022a). Pre-selection Competitions, according to Article 9 of Section 2 of the UCTEA Regulation, are conducted based on a specification containing concrete criteria. The specification shall not include provisions that restrict competition. Those participating in the pre-selection must purchase the specification and register. The jury is not informed about those selected or eliminated in the pre-selection (UCTEA, 2022a). Invited Competitions can be considered a subcategory of pre-selection competitions. In invited competitions, participation occurs through invitations sent by the contracting authority to selected names.

Kind of Competition: This classification is used to categorize competitions according to their subject matter in the archive of the Chamber of

Architects, “yarismo.org,” and has been included here for explanatory purposes.

4. Actors and Responsibilities in the Competition Process

The Competition Guide prepared by UCTEA İzmir serves as a booklet defining the responsibilities of those involved in competition processes. Based on this guide, the responsibilities of the actors in the competition process will be addressed (UCTEA, 2022b). Article 20 of the Ministry of Environment, Urbanization and Climate Change’s Competition Regulation is also dedicated to this subject. This section on responsibilities is presented with the aim of providing examples of how the problems discussed later in the study could be resolved. However, it is possible to encounter issues beyond the responsibilities stated. In such cases, the scope of these responsibilities may need to be expanded.

4.1. Jury and Its Responsibilities

The responsibilities of jury members are described according to the stages of the competition process.

In the pre-competition period**,** the jury meets before the competition is announced, selects a chairperson among themselves, and, if necessary, may request consultants from different fields. The competition brief is prepared during this process. The prize to be awarded is determined according to the tables specified in the regulations (UCTEA, 2022b).

During the question-and-answer process**,** questions are answered in a manner that leaves no room for doubt, and the answers are delivered to the competitors within the specified time (UCTEA, 2022b).

In the evaluation process**,** the works submitted are recorded in official minutes, which are signed by all jury members. The jury decides on the disqualification of projects that do not comply with the brief. Products outside the scope of the competition brief are not considered in the evaluation. Equal and sufficient time is allocated to each project. Individuals not assigned to the competition are not permitted to enter the jury's workspace or interfere with the process. The jury chairperson is responsible for ensuring that the selections comply with the regulations (UCTEA, 2022b)

The selection procedure is carried out in several elimination rounds. After four rounds, the final ranking is made. The jury must award the prizes and honorable mentions specified in the competition brief. (The allocation for purchase awards is not mandatory to distribute.) A separate report is prepared for each prize-winning, honorable mention, and purchased project. All decisions are documented in minutes, signed by the jury, with dissenting opinions attached if any. No public statements can be made before the official announcement of the results. After the announcement, the jury may, if necessary, recommend revisions to the first-prize-winning project. The competitor is given time to implement these recommendations, and the jury then informs the contracting authority whether the changes have been made. The jury report must indicate whether the first-prize-winning project is feasible for implementation, and if needed, include suggestions regarding this matter (UCTEA, 2022b).

***In the post-competition phase*,** jury members prepare a report on any procedural shortcomings and submit it to the Chamber of Architects for the improvement of future competitions. This duty is mandatory for juries appointed by the Chamber of Architects; however, other juries may also submit their opinions to the Chamber if they wish (UCTEA, 2022b).

4.2. Contracting Authority and Its Responsibilities

The healthy and fair execution of architectural project competitions is not solely the responsibility of the jury or the participants; the organizing authority also bears significant responsibilities in this process. According to the "Architectural Project Competitions Regulation" of the Chamber of Architects of UCTEA and the "Project Competitions Regulation" of the Ministry of Environment, Urbanization and Climate Change, the authority is primarily responsible for every stage of the competition process.

The main responsibilities of the contracting authority are as follows:

1. ***Planning and Announcement of the Competition*:** According to Article 14 of the Ministry of Environment, Urbanization and Climate Change Regulation, the organizing authority is responsible for making the decision to launch the competition, appointing a jury appropriate to the type and scope of the competition, preparing the competition schedule, and announcing the competition to the public (MoEUCC, 2002).
2. ***Preparation and Approval of the Specification:*** According to Article 9 of the Ministry's Regulation, the authority must work with the jury to prepare the competition specifications, ensure their compliance with the regulations, and, when necessary, seek the opinion of the Chamber of Architects. Before the announcement of the competition, the specification must be approved by the Chamber of Architects of UCTEA (MoEUCC, 2002; UCTEA, 2022a).
3. ***Monitoring and Secretariat of the Competition Process:*** According to Article 27 of the UCTEA Regulation, during the

competition, the authority assumes the secretariat role through the rapporteur, managing all processes such as the organization of the question-and-answer stage, the receipt of submissions, and thearrangement of jury meetings (UCTEA, 2022a).

4. ***Announcement of Results and Award Distribution:*** According to Article 40 of the Ministry’s Regulation, the authority is responsible for sharing the winning projects with the public, announcing the awards and honorable mentions, and ensuring that monetary prizes are paid within the period stipulated in the regulations (MoEUCC, 2002).
5. ***Implementation Process:*** According to Article 42 of the Ministry’s Regulation, in competitions where implementation is committed, the authority is directly responsible for contracting with the winning project, preparing the implementation drawings, and tendering the construction process. If the project is not implemented, the authority must provide a written justification (MoEUCC, 2002).
6. ***Archiving and Publication:*** According to Article 27 of the UCTEA Regulation, the authority is also responsible for archiving the submitted projects and, when necessary, publishing them. One copy is kept by the authority, and another is sent to UCTEA for archiving (UCTEA, 2022a).

Failure to fulfill these duties not only diminishes the quality of the competition but also causes serious problems in terms of the effective use of public resources and the assurance of architectural quality. From the beginning to the end of the competition, the principles of transparency, participation, and accountability must be embraced as the primary responsibility of the organizing authority. Establishing all these duties on a legal basis and supporting them with regulations ensures that architectural design competitions move beyond being merely an idea-generation tool, resulting instead in implementable, sustainable, and high-quality structures.

4.3. Principles of Competition Specifications

According to the "Architectural Project Competitions Regulation" prepared by the Chamber of Architects of UCTEA and the "Architecture, Engineering, Urban and Regional Planning, Landscape Architecture Project Competitions Regulation" published by the Ministry of Environment and Urbanization, Article 9 specifies the fundamental elements that must be included in a competition specification. In addition to Article 9, clarifications are provided through other related articles as well.

According to the regulations, a competition specification must clearly state the following information:

1. ***Definition and Purpose of the Competition:*** According to Articles 4, 11, 12, 13, and 14 of the MoEUCC Regulation, the competition specification must clearly define the reason for organizing the competition, the intended architectural vision, the public need, or the design problem to be addressed (MoEUCC, 2002).
2. ***Competition Schedule*:** As stated in Article 16 of the same regulation, the schedule must include the start and end dates, the question-and-answer period, the jury evaluation timetable, and other critical deadlines (MoEUCC, 2002).

3. ***Participation Requirements:*** Under Article 15, the specification should clarify whether the competition is national or international, and whether it is open to students, professionals, or specific participant profiles (MoEUCC, 2002).
4. ***Type and Format of the Competition:*** As per Article 14, it should be stated whether the competition is single-stage or two-stage, and whether it will be conducted as an open or invited competition, including relevant technical details (MoEUCC, 2002).
5. ***Jury Composition:*** In accordance with Article 20, the specification must list the names of consultant, principal, and substitute jury members, their roles, selection criteria, and areas of expertise (MoEUCC, 2002).
6. ***Evaluation Criteria:*** Article 29 specifies that the criteria for evaluating the projects must be stated, covering aspects such as functionality, originality, economic feasibility, and sustainability (MoEUCC, 2002).
7. ***Submission Requirements and Project Format:*** According to Article 16, the specification must detail what documents participants must submit, the format, method of submission, and the number of copies required (MoEUCC, 2002).
8. ***Prizes and Payment Terms:*** Under Article 40, the amounts and details of prizes, honorable mentions, and purchase awards must be stated clearly, along with payment terms and tax-related information (MoEUCC, 2002).
9. ***Copyrights and Publication:*** As outlined in Article 42, the specification must address how the copyrights of submitted projects will be managed, and how the administration may publish or otherwise

use these projects, covering both ethical and legal considerations (MoEUCC, 2002).

10. ***Implementation and Realization of the Project:*** Also under Article 42, if the winning project is to be implemented, the specification should outline the implementation process, budget, and relevant authorizations (MoEUCC, 2002).

These specifications not only inform the participants but also help prevent potential disputes that may arise in the later stages of the competition. The regulations of the Chamber of Architects of the Union of Chambers of Turkish Engineers and Architects (UCTEA) and the Ministry play a leading role in providing an institutional framework for competitions. However, specifications are prepared by the jury members and the organizing authority with the support of these regulations. Therefore, the fulfillment of the requirements of the specifications also depends on the competence of the jury and the organizing authority, and it is their responsibility.

5. Problems Related to Architectural Competition Processes in Türkiye

Competitions, compared to the direct commissioning method, are evaluated from different perspectives because they are presented to a jury composed of the client together with architects. In addition to the client's demands, the resulting work is also examined from different angles such as its suitability to the site, its contribution to architectural culture, and its implementability. As a result, the selected project is considered to be the best among those who participated in the competition (Tuna, 2010). Competitions are organized in order to obtain the "best" project for a predetermined building or group of buildings among architects (Arolat, 1993). However, this best project is selected as the best among those who entered the competition; despite the transparent and fair procedures of this method, architectural competitions in Türkiye are not in a privileged position. For this reason, when looking at Türkiye's overall building production, projects obtained through competitions constitute a very small portion of the building stock (Başbuğ, 2010). Because, when competitions are examined, it has been observed that many competition projects were not implemented, and some underwent significant structural changes at the implementation stage beyond the architect's objectives and intent (Binici, 2019).

Addressing competitions in three main sections—as pre-competition, during competition evaluation, and post-competition—makes it possible to separate and analyze the stage-specific problems and to develop more targeted solution proposals. This distinction contributes, in practical terms, to making the findings clearer, more comprehensible, and more applicable. In Türkiye, various structural and practical problems are observed in the organization, evaluation, and implementation processes of architectural design competitions. These problems are often directly related to the three main actors of the competition process: the organizing authority, the jury members, and the competition specifications. These problems are addressed item by item.

5.1. Problems Related to Pre-Competition Processes

Problems in competition processes are often noticed during or after the competition. However, some of these may originate from pre-competition conditions. The processes considered as "pre-competition" affect the entire course of the competition. Therefore, the preparation phase of a competition is just as important as the evaluation or post-competition phases.

Deficiencies in Competition Specifications

Competition specifications are the fundamental documents that establish the rules for each competition. If these rules are not well defined, it is unrealistic to expect the competition process, the evaluation stage, or even the post-competition phase to proceed smoothly. At the First Competitions Symposium, Orhan Aydın emphasized that specifications are essentially the constitution of competitions (Aydın, 2010). Specifications must be prepared in full compliance with the regulations discussed earlier. All necessary provisions should be clearly stated so that a project can be prepared in complete accordance with the needs and requirements of the organizing authority. Bilal Yakut wrote in Mimarlık magazine: “To find the right answer, one must first ask the right question.” In competitions, the rules to be followed are the most crucial tools for ensuring the process runs without dispute (Yakut, 2001). To achieve the intended benefits of a competition, the first essential condition is that the project to be opened for competition must go through a thorough planning and programming stage. This requires detailed research and analysis so that complete and accurate information can be conveyed to the competitors. If this condition is not met, problems will inevitably arise in all subsequent stages of the competition, including the implementation phase (Seren, 1993).

One of the most well-known issues related to competition specifications can be observed in the competitions organized by the Ministry of Public Works during the 1960s and 1970s. The specifications for these competitions were so restrictive that they led to typification among the projects. This situation was most commonly observed in Government Office competitions, where projects were produced without allowing the use of site-specific data, resulting in similar typologies across different cities. Consequently, this contradicted the innovative and experimental spirit of competitions. For example, when examining the Government Offices in Kars, Bingöl, and Erzurum, it becomes evident that they share similar typologies, use the common materials of the period, and fail to establish meaningful connections with their immediate surroundings or the city as a whole (Gülen, 2024).

Although specifications may appear to belong solely to the pre-competition stage, neglecting their careful preparation can negatively affect the evaluation process and lead to criticism of the competition results (Coşkun & Avinç, 2024). Therefore, the proper preparation of specifications is critical for the success of all stages of the competition.

Deficiencies and Ambiguities in Architectural Competition Regulations

Until 1952, there was no regulation regarding competitions, which resulted in an environment largely dominated by juries. This situation left matters such as the qualifications and fairness of jury members, deficiencies in the preparation phase of competitions, insufficient time allocated for project submission, and the shortcomings of organizing institutions during the process entirely at the discretion of the jury. Such issues were frequently discussed in printed media (Saban, 2024).

In the early years of competitions in Türkiye, some specifications included statements allowing the jury to select the first-place project while granting the organizing authority complete freedom to implement whichever design they preferred. With the establishment of the Chamber of Architects, efforts were made to create regulations for competitions to address this issue. In 1956, such a framework was established, and by 1958, it came into effect. This law ensured that the rights of the winning architect were protected. Subsequently, the Ministry of Public Works also developed its own Competition Regulation, which led to a dual-system dilemma over whether the Chamber's or the Ministry's regulation should be applied (Ersin, 2001). Agreement on which regulation to follow was not reached until the 1970s, and all competitions held during this period were affected by this ambiguity.

The period before the development of laws and regulations for competitions shows that project competitions were conducted without fully safeguarding the rights of architects. While the selection process was left to the jury's discretion, the post-competition stages were entirely in the hands of the organizing authority. As a result, it was more common to encounter situations where the winning design was implemented by others, disregarding the copyright of the authors and even denying the design team the right to act as project supervisors.

Competition regulations are a matter concerning higher-level institutions rather than solely organizers or participants. Although the attention given to this matter by state institutions has varied over time, it is evident that competitions—despite representing Türkiye's most fair and transparent project procurement processes—have not found their rightful place in the country's construction methods. The lack of value given to competitions has inevitably limited efforts to protect both participants and the process itself. The first competition regulation was published only 20 years after competitions became widespread in Türkiye, and it took nearly 40 years to reach an agreement with the Chamber of Architects, the institution most actively involved in competition processes. Even today, competition regulations in Türkiye may still have numerous shortcomings compared to those in European countries, and efforts toward improvement should continue.

Insufficient Time in Architectural Competitions

In Türkiye, the inadequacy of submission periods in architectural design competitions is a frequently raised issue in both participant feedback and jury reports. Particularly in competitions with extensive programs, detailed technical specifications, and high presentation expectations, limited timeframes restrict designers' ability to conduct research, perform thorough analyses, and develop innovative solutions. This constraint hinders the conceptual and technical depth of projects and, in some cases, increases the need for revisions during the implementation phase. Moreover, short deadlines often disadvantage small-scale offices, young designers, and academic teams, reducing their motivation to participate. In Turkish competition practice, submission periods are frequently set disproportionately to the complexity and scope of the project brief, thereby limiting both design quality and participant diversity.

When launching competitions, the timeframe should be determined in proportion to the scope of the required work. However, in Türkiye, where excessively detailed requirements are common, insufficient time allocation is a widespread problem and discourages some architects from entering competitions. Cem Açıkkol, in the 251st issue of Mimarlık (1993), emphasized this by stating, "One of the reasons for the recent decline in competition participation is the insufficient time and the excessive effort demanded by the jury." Similarly, in some competitions, large-scale models or even highly detailed selections—such as choosing a waste bin—are required before the winning project is determined, as per competition regulations, which results in significant time loss (Elmas, 2007).

Standardizing competition timelines and calculating submission periods based on the production time needed for each required deliverable could be an effective method to mitigate this issue.

Jury Selection and Debates in Architectural Competitions

One of the most important aspects of competitions is initiating, conducting, and concluding the process with an impartial jury. On the other hand, the jury selection must also be accepted by the public and the participants. It is important that the results of the competition are recognized not only by architects but also by the client — in other words, the organizing authority — as well as by users and the public. One of the main factors preventing this acceptance is the jury selection process itself (Şentek, 2001). Since competitions are arenas for debate, the most important criterion to be considered in jury selection is the ability to engage in rigorous discussion (İdil, 2010).

In a 2010 reader's opinion piece for Mimarlık magazine, Baran İdil discussed the jury selection principles of the Chamber of Architects: In the 1960s, with the growing strength of the Chamber, jury lists for competitions were prepared during the Chamber's general assemblies. One full day of the triennial general assembly was entirely dedicated to competitions. Names on the 70–80 person candidate list were individually voted on, and a ranked list was prepared based on the vote counts. This list served as the basis for jury selection. Until the 1970s, two-thirds of the competition jury was chosen from this list under the Chamber's control and through consensus. When the Ministry of Public Works did not accept the jury selection method proposed by the Chamber, competitions organized by the Ministry were boycotted by the Chamber. Members of the Chamber were requested not to participate in these competitions, and the participation rate of those who did not comply with the boycott remained below 5%. Competitions were canceled by the Chamber. This situation ended in 1970 when the Chamber and the Ministry reached an agreement on a joint regulation, thus bringing the boycotts to an end (Ersin, 2001). However, following this process, competitions fell into the background and eventually came to a halt (İdil, 2007).

Regarding the list system implemented by the Chamber of Architects, the literature contains some critical perspectives. For example, Utkutuğ (1993) states that "the fact that most competition juries are selected from among competing architects leads to a vicious cycle." Similarly, Ersin (2001) notes that "there is no common approach to the selection process and working methods of juries, which serve as the ultimate decision-making authority in competition evaluations."

Exclusion of Local Architects in International Competitions

The granting of privileges to foreign architects is not solely a recent issue. It can be said that project competitions were originally initiated to involve local architects in the process. In the early years of the Republic, under the influence of nationalism and statism movements, project competitions began to replace the direct commissioning of projects to foreign architects

(Sayar, 2004). However, during this period, the organization of invited international competitions sparked reactions among architects, as these competitions were not conducted in accordance with international regulations (Tuna, 2007). Local architects were excluded from the process, while foreign architects were given preferential treatment.

The decades-long redevelopment/reconstruction process of Beyazıt Square serves as an example of the negative consequences of excluding local architects from international competitions. This issue was also addressed by Sevince Bayrak at the Competitions Symposium held in 2013. In March 1959, for Beyazıt Square—whose construction had previously begun but was deemed inadequate by architects—an invited competition was organized. Swiss architect Hans Högg, Italian architect Luigi Piccinato, and a Turkish architect were invited to participate. The evaluation stage of the process was not conducted transparently, and it was ultimately announced that Hans Högg's project had won. The limited role of the local architect in the process, combined with the fact that project decisions were largely shaped by foreign architects, led to both professional backlash and debates over the project's constructability.

In the end, the winning design could not be implemented during the construction phase, and the process led to the opening of a second and even a third competition—demonstrating that distancing local architects from the core of the process can create problems regarding both professional acceptance and the practical feasibility of the project outcomes.

The Limited Number of Architectural Competitions Held in Türkiye

Architectural design competitions held in Türkiye present a limited picture in terms of both number and variety when compared to international examples. The number of competitions held in Türkiye, especially in comparison to Europe, remains considerably low. In his article for Mimarlık magazine, Hasan Özbay stated that between 1993 and 2003, the annual average number of competitions in Türkiye was 6.7, while in Germany the minimum annual figure was 350 (Özbay, 2001). A significant portion of these competitions in Türkiye are organized by certain public institutions and municipalities; however, these processes do not exhibit continuity and are often not adopted as a fundamental method for project development. The instability in the practice of holding competitions negatively affects both designers' motivation toward this method and the establishment of a competition culture in public projects.

Today, the situation is no different. Between 2000 and 2018, a total of 298 competitions were held (Kuçak Toprak, 2020). Over the years, this annual average has increased only to 9. Moreover, as a structural shortcoming, the fact that only nine out of the hundreds of thousands of buildings constructed annually in Türkiye are designed through competitions — and that most of these are never actually built — demonstrates that the competition method has not truly found its place in public project production (Yılmaz, 2014).

One of the strongest indicators that design competitions are not given due importance in Türkiye is the number of competitions themselves. When the thousands of public buildings constructed in Türkiye are compared to the number of competitions held, and considering that not all of the nine competitions result in actual construction, it becomes evident that the annual number of buildings realized through competitions is less than one per thousand of all public buildings constructed. With such a ratio, it would be unrealistic to expect competitions to have a significant impact on architecture in Türkiye.

Quantitative Deficiency of Regional Architectural Competitions in Türkiye

Architectural competitions in Türkiye are generally organized on a national or large city scale, and the lack of sufficient emphasis on regional competitions has long been an issue raised in academic studies. For this reason, the number of regional competitions has been evaluated independently of the total number of competitions held. This is because regional competitions have the potential to offer solutions to small design problems specific to the region. Regional competitions are expected to serve an educational function by being held in various parts of our country on topics relevant to that location, but such regional competitions have not yet become widespread in our country. (Özbay, 1993) The lack of an established regional competition culture in our country can be considered a problem in this area.

In his article in Arkitera, Ahmet Yoldaş mentioned that regional competitions may be more advantageous than national competitions, and that they not only increase the diversity of competitors but also have the potential to provide realistic and high-quality design solutions by enabling local architects to contribute to projects that they are more familiar with in terms of their living spaces and geographical and cultural context. (Yoldaş, 2016). It has been suggested that competitions could serve as an alternative to attract interest beyond major cities and spread across the entire country. The urgent need for buildings that arose after the 1999 Marmara Earthquake could have been met by producing innovative and high-quality solutions appropriate to the local context through regional competitions, but this opportunity was not taken advantage of, and the need was largely met through standard-type projects. This deficiency is not limited to this example but applies to all TOKİ standard projects (Tuna, 2007). The failure to hold regional competitions has both reduced the likelihood of local architects being involved in the process and hindered the development of design solutions that could respond to the region's unique physical, cultural, and social conditions.

5.2. Issues Related to the Competition Evaluation Process

The evaluation process of architectural design competitions is a critical stage in terms of the transparency, continuity, and reliability of the process. However, various structural and operational issues have been observed in the implementation of this process in Türkiye. These issues can negatively affect both the motivation of participating architects and the sustainability of the competition system. These issues will be discussed in more detail under the following headings.

Insufficient Time in the Evaluation Process

In addition to the insufficient time given for competitions, the lack of sufficient time for evaluation is also a common problem. This short time frame also hinders a healthy analysis and selection process. (Utkutuğ, 1993) An example of this situation is the Selçuk Municipality Culture and Youth Center Competition. The inadequacy of the three-day evaluation period given for the 150 projects participating in the competition was pointed out by Ömer Selçuk Baz, a participant in the colloquium. However, jury chairman Tamer Başbuğ responded, "There is a competition review technique. You cannot look at it like a normal project;

you have to look at it comparatively. In each round, you look at different categories. For example, in the first or second round, it is sufficient to spend even one second on the project because those are its criteria. Each round has its own characteristics. However, jury chairman Tamer Başbuğ responded as follows: “No jury evaluates projects for more than three days” (Başbuğ, 2016). This statement has sparked debates about the adequacy of the evaluation period. What is the ideal evaluation period for a competition project? Of course, everyone can say it should be more than one second.

Baran İdil stated the following regarding jury evaluation periods: “Based on my observations, if a jury evaluates more than 7-10 projects per day (21-30 projects in 3 days), the competitors would not welcome this pace. It can be said that the jury's evaluation speed has increased by 3-5 times." This view offers a different perspective from Başbuğ's. An example from around the world is the Prado Museum competition. A simple calculation shows that the jury reviewed 165 projects in four days, totaling 28 hours of work. In this case, only 3.5 minutes are allocated per project (Rugano, 2025). A similar situation can be observed in recent competitions in Türkiye.

The Influence of Personal Preferences in the Evaluation Process

As competitions have shifted from being a venue for seeking quality and excellence to becoming a struggle for survival in an architecture market with limited job opportunities, a situation has arisen where projects are produced to suit the tastes of the jury. This situation has led to the incorporation of elements from previously successful projects, taking into account the jury's preferences, and a decrease in originality (Şentürk, 2003). Competitors are inclined to develop projects according to the tastes of the jury members. This situation reduces the originality of project competitions (Utkutuğ, 1993). It is difficult to ensure absolute fairness in competitions because the same projects can achieve different results before different juries. Therefore, the quality of the competition is also determined by the selection of the jury (Sayın, 1993).

Choices made outside the specifications outlined in the terms of reference can also be evaluated under this heading. Competition results that are not selected in accordance with the terms of reference undermine confidence in the competition institution (Aydın, 2010). In order to prevent personal tastes and subjectivity from coming into play during the evaluation process, the first step is to ensure that the terms of reference are well prepared. Inadequately prepared specifications lead to the process becoming more dependent on the personal evaluations of the jury.

Even when the specifications are adequately prepared, the jury has an important responsibility to conduct a fair process. Objectivity in the selection criteria is very important in order to move away from the perception that the jury determines the outcome of the competition and to prevent participation in competitions based on the jury.

Non-Disclosure of Competition Results or Inapplicability Decision

The non-implementation of project competitions is generally seen as a post-competition issue. However, the jury's decision that the project is inapplicable makes this a matter related to the evaluation process. Additionally, it is common for jury members to deem none of the projects worthy of first place. It should not be forgotten that project competitions are responsible for selecting the best among the participants.

The jury's statements regarding the inapplicability of the competition results can also lead to the shelving of projects. (Çinici, 1993) Although the implementation of projects largely depends on the organizing authority, this situation prevents their implementation without the decision of the organizing authority. The fact that the jury selects works that bring innovation and create a discussion environment rather than considering the implementation criterion during the selection process may be a result of this situation. (Bektaş, 1993) This situation stems from the fact that competitions are assigned other missions besides implementation. Competitions certainly bring innovations to the profession of architecture, provide young people with the opportunity to produce projects, and can be seen as an educational field, but all of these should be considered secondary functions. The primary purpose of architectural design competitions should be to produce feasible building designs. For this reason, feasibility should be one of the selection criteria of the jury, if not the most important one.

When making their selections, juries should distance themselves from an academic perspective. Theoretically, a better project can always be produced; however, the best project among those produced as a result of the competition should be selected.

5.3. Issues Related to the Post-Competition Process

The fundamental purpose of architectural design competitions is to contribute to the physical environment through the implementation of high-quality and innovative designs. However, the competition process does not end with the jury's evaluation; true success is measured by the implementation of the winning projects. In the case of competitions conducted in Türkiye, the post-competition processes are often insufficiently planned or interrupted for various reasons, making it difficult to realize this ideal. Situations such as winning projects not being implemented, undergoing significant changes during implementation, or the architects who won the project being excluded from the implementation process undermine the credibility of competitions in the architectural community and threaten the sustainability of this method. These issues will be discussed in more detail under the following headings.

Failure to Implement First Prize-Winning Projects

Although there are various side effects of the competition process, the main goal is to implement the winning project. However, after the competition process, the distance between the selection committee and the winners and losers is maintained, and after the award ceremony, it appears that no other issues related to the process are brought up (Cengizkan, 2003). It can be said that project competitions (excluding idea and student competitions) are held for the purpose of implementation. Nevertheless, the implementation of project competitions is not very common. Many different reasons can be given for the non-implementation of project competitions. This situation can be interpreted as a change in project competitions in Türkiye from the early years to the present day. In his 2003 article, Nejat Ersin states, “Architecture is not only the art of conceiving and designing a project, but also the art of implementing it. To leave it at the project stage is to abandon the profession halfway.” With these words, Ersin emphasizes that competition projects should not remain solely at the design stage. Nejat Ersin noted that none of the competitions in which he won first prize were implemented. He highlights the irregularities of competitions at that time and complains that although a jury was selected for the competition and chose the winner, the administration that organized the competition was free to decide whether or not to implement it (Ersin, 2001).

The issue of not implementing project competitions can be considered in the context of each project for various reasons. The situation regarding the non-implementation of each project competition is shaped by the specific circumstances surrounding that competition. Some of these reasons include the complexity of the building production process and the perception of competitions as a separate field rather than part of the production process (Başbuğ, 2010).

Failure to Implement Projects That Won First Place Awards in Accordance with Their Original Form

Even if an agreement is reached between the administration and the team selected as the winner of the competition, it is common for changes to be requested to the project. However, it is expected that the requested changes will not alter the main decisions of the project. This issue is frequently raised by the architects who win the competition. The administration is responsible for ensuring that this situation does not occur. However, the implementation phase of competitions has often been disrupted for various reasons, primarily financial ones; in some cases, changes in management have occurred. The new management has altered the needs and requirements related to the selected competition project, resulting in the structure being transformed into something different from the winning project, even if it is implemented (Binici, 2019).

There are cases where project competitions, even if not implemented as originally intended, have undergone changes that have made them quite different from their original form. The most well-known example of this is Şevki Balmumcu's Sergievi. The competition, which was launched in 1933, resulted in Şevki Balmumcu being selected as the winner. The building, completed in 1934, hosted exhibitions until the 1940s. In 1946, the National Economy and Savings Union decided to repurpose the building, and this task was assigned to German architect Paul Bonatz. Between 1946 and 1948, the building was converted into an opera house. These changes caused the building to deviate from Balmumcu's original design (Dayıoğlu, 2023).

Lack of Practical Experience Among Teams Winning First Prize

It can be said that competitions contribute to the intellectual sphere, create high-quality structural environments, and expand the participatory roles of young architects. It is often stated in published works that competitions have enabled many young architects to open their own offices. However, it cannot be said that competitions always yield advantageous results for young architects. It is possible to say that there are differences between the approach to experienced architects and the approach to inexperienced architects after a project competition (Erkal, 1993). As a result of the lack of confidence in the inexperience of the team, more intervention in the project, the exclusion of the team from the implementation process, or the lack of confidence in the team's ability to implement the project may result in the project not being implemented.

One of the most well-known examples of the lack of experience of the winning team in the implementation process is John Utzon's Sydney Opera

House project. When Utzon was selected as the winner of the international competition in 1957, he had limited experience in construction processes in general, and in particular, he had no direct experience in the production of a structure of this scale and complexity. When the implementation process began, serious engineering problems arose with the building's structural system, leading to tension between Utzon, who was unwilling to compromise on design decisions, and the project management team in Australia. These disagreements eventually led to Utzon's departure from the project. The project was completed under the leadership of architect Peter Hall and opened in 1973 (Burke, 2025). While the Sydney Opera House is now recognized as one of the iconic structures of the 20th century, the process behind it demonstrates that the implementation experience of designers selected through competition is a critical factor in the success of a project.

6. Conclusion and Evaluation

Architectural design competitions have historically played an important role in both the design of urban spaces and the development of the architectural profession in Türkiye. From the late Ottoman period to the early years of the Republic and continuing to the present day, design competitions have been an important method for obtaining public buildings. However, despite its potential, this method has faced many problems over time due to difficulties in implementation, administrative shortcomings, and conflicts with professional practices. This study examines architectural design competitions from their conceptual framework, covering a wide range of topics from their historical development and place in architectural culture to their implementation processes. By examining the competition process under three main headings—pre-competition, evaluation, and post-competition—it highlights the problems specific to each of these processes.

In the pre-competition process, the most common problems include inadequate specifications, short deadlines, lack of access to data, and uncertainty in programming. The lack of transparency in the conduct of competitions and insufficient support from relevant institutions also increase the difficulty of this process. Shaping competition calls on a more democratic basis and supporting them with clear and understandable specifications will contribute to an increase in the number of participants and a richer variety of projects.

The evaluation process is one of the most debated stages in the architectural environment. Lack of transparency in jury selection, insufficiently clear evaluation criteria, and subjective evaluation processes are among the significant problems of this stage. The fact that competition juries work on a tight schedule can lead to superficial approaches in the decision-making process. In addition, the fact that no project is deemed suitable as a result of the competition or that the winning projects are not clearly shared with the public deepens the trust issue in the architectural environment.

In the post-competition process, the issue of applicability comes to the fore. The fact that most of the winning projects are not implemented or are built in a way that deviates from the essence of the projects both lowers architectural quality and undermines confidence in the competition system. Furthermore, the exclusion of the project author from the implementation process or their complete exclusion from the process is contrary to the spirit of participation in the competition.

In conclusion, the situation of architectural project competitions in Türkiye demonstrates that this system still contains a series of issues that need to be updated. Nevertheless, this method is considered valuable as a mechanism that enhances architectural quality, encourages participation, and prioritizes social benefit. For this reason, supporting architectural project competitions through both regulatory reforms and successful practical examples will contribute to making this method more preferred and trusted within the field of architecture. While this study provides an overview of the processes of architectural competitions, it also offers an evaluation that can form a basis for future research. In light of all these findings, it is necessary to reorganize architectural project competitions with a participatory approach in order to jointly improve their scope and quality.

To increase the quality of architectural design competitions, it is first necessary to update and clarify the regulations governing the competition process. In Türkiye, regulations prepared by different institutions have led to uncertainties in practice. Unifying competitions under a single overarching regulation, preparing specifications with transparent and auditable criteria, and implementing regulations that will make it compulsory to realize winning projects will enhance the reliability and professional credibility of competitions.

On the other hand, another factor that will increase the quality of competitions is the integration of participatory processes. Until now, competitions have mostly been conducted among professional actors, and the views of users and local communities have been considered only to a limited extent. To increase participation, public information meetings can be organized before competitions, user needs can be included in program preparation, and representatives of civil society organizations can be involved as observers in jury processes. In addition, enabling the public to share their opinions and suggestions through digital platforms will reinforce transparency and reliability.

Ultimately, improving both the scope and quality of architectural project competitions will not only ensure the production of higher-quality projects but also strengthen the culture of competitions with the principles of social benefit and democratic participation.

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Holistic Interpretations and Contemporary Critical Readings in the Context of Architectural Pedagogy

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1. Introduction

1.1. Ontology and Pedagogy

In the early 21st century, the concept of "connectivity" has undermined the theoretical foundations of disciplines ranging from physics to philosophy. Thinking about any kind of "integrity" in these disciplines requires accepting an transdisciplinary approach from the outset and observing the universe from a non-human perspective and distance. Possessing this distance, both temporal and spatial, over infinitely small and large scales, reveals the limitless dominance of wholeness in knowing (science), curiosity (philosophy), and creation/production (art).

On the other hand, in the hermeneutic field, a Platonic theory of language operates in pursuit of wisdom (self-knowledge and recognition), defending the dialogical structure of understanding (Gelassenheit, Heidegger) regarding non-instrumental thought. Despite the inability to transcend infinite dialectics, pedagogical awareness of limits to unity or limited (expanded) appropriation of the author's or designer's world is possible. After separating the universal dimensions of the system from the particular and historical dimensions, it is necessary to rethink and reevaluate the universal dimensions within contemporary contexts and questions. In this context, the author's or designer's intention occupies a central position. The world and historicity of the appropriating reader are directly or indirectly influenced by their subjectivity (Varlık, 2021, pp. 11–13).

The chapter was conceptualized as pedagogical comprehensiveness within the context of architecture, architectural design and discourse. Therefore, a reading within the context of architectural pedagogy developes as an activity of self-understanding and holistic interpretation through existential traces of intellectual and cultural works, such as archetypes and precedents, from awareness to consciousness. This concept is evaluated in terms of holistic interpretation and reading in architectural design, representationality, actuality, and appropriateness. Design is produced through language, reading, writing, and drawing—representation and mediation—while producing the technical knowledge and tectonics of architecture in theory and practice. Design is signified and questioned within the ethical and aesthetic realms.

In the realm of architectural pedagogy, there is a responsibility to seek ontological being, obedient truth, and appartenance. Conversely, adopting a critical stance fosters distanciation of the self, epistemological doubt, and explanations that shed light on the architect's role in new ecologies and interactions.

The hermeneutic arc[1] that emerges in an interpretation oriented toward self-understanding continues by closing and opening cyclical, cultural, and temporal distances arising from textuality and literacy. This occurs through the dialectical cycle of precomprehension, explication, appropriation and, self-appropriation. According to Frege's distinction between meaning and reference, a text is distant from the author's world in terms of meaning and from the reader's world in terms of reference. (Varlık, 2021, pp. 17–22).

In today's theory of wholeness/integrity, where all entities are interconnected through a phenomenon known as "quantum entanglement," architectural knowledge is metaphorically conceived as a type of knowledge that establishes connections within the cosmic system. Systems, programs, computer architecture, etc., are architectural metaphors used in artificial intelligence research. In this study, these metaphors transform from the design of constructive technical architectural structures, elements, and forms in the pedagogical expansion of architectural education to a non-representational, information-processing movement of interactions between actors, whether material or immaterial. In this context, design, historically a constructible phenomenon and a meaningful representation of a technical object, whether material or immaterial, becomes a textual, self-referential, autopoietic formation.

However, mental abilities have not yet been formalized in artificial intelligence research, despite being on the agenda since the 1950s. Therefore, we are still compelled to communicate, compute, correlate, interpret, explain, and make sense of things in linguistic (natural) or language-based (artificial) systems. This chapter aims to formalize the thought process within the interpretive, computational, and relational nature of the design process while revealing today's conditions and limitations.

The concept of wholeness, understood as striving for totality, consistency or unity, has played a central role in Western philosophical thought for a long time. Throughout history, philosophers have imagined, debated and reconfigured the meaning of the 'whole' in relation to knowledge, ethics, aesthetics and ontology. In academic usage, this concept is termed 'holistic', derived from the ancient Greek word 'holon[2]', which emphasises a holistic approach. The concept of form is expressed as 'unity'; in terms of intellectual consistency, it is referred to as 'chorence'; in an ethical and structural context, it is called 'integrity'; and in Hegelian and Marxist discourse, it is termed 'totality'. Given that the category of Being is considered the most comprehensive in terms of conceptual inclusiveness, it is logical that the philosophy of the whole begins ontologically.

By analysing and synthesising the flows of the human mind and intellect through situations based on the reality of understanding and explaining, the "word of the universe" (Logos) can be seen as the totality of logical and imaginative linguistic expressions or transmissions of the order of the universe between cosmology and cosmogony. The possibility of a being; being thought, experienced or questioned from inside or outside only exists to the extent that it reveals itself as an unchanging pattern within change, forming at least a unity that can be signified and calculated in a discoursive or representational environment. In this case, the fact that the interpreter and measurer (the subject) can be included in the interpretation of the pattern's representation shows that interpretation of the holistic is both textual and contextual. Similarly, Gadamer (2023, pp. 14–15) emphasises that language itself is the dialectical structure that enables entities, including the theory of particles/atoms that move within integrity yet remain unchanged, to manifest in various forms towards particular possibilities, demonstrating the integrity of contradictions[3].

Another issue is whether the relationships between parts are dynamic or static when considering the relationship between things as a unity. The epistemology of the parts evolving into holism, whether inclusive or exclusive and systematic, is grounded, and its scientific nature is established by the mind's loose or strong correlation in the evolution of the parts into chorence. The tension between sameness and change, and the unity of opposites in thought, creates a doxographic tradition. Aristotle's interpretation of nature (physis, physics) affirms the cosmic order of beings. In this case, ontological levels of reality emerge, as do speculations such as debatable beings, existing beings and non-existing beings.

As mentioned above, there are different types of knowledge that can be inferred based on the nature of the relationship established with the concept of 'the whole', depending on whether the intention is interpretative or scientific, and on how the existing boundaries of 'the whole' and the interrelationship of its parts are understood and explained. Therefore, the validity of knowledge is related to the truth of the tools and methods used to derive it from general information. Ultimately, the definition of fields of expertise today is based on a multifaceted view of the conditions under which knowledge can be considered valid, rather than on doubting the existence of absolute truth. Broadly speaking, the philosophy of education in any field involves being aware of the pedagogical approaches offered by these perspectives. Furthermore, as the pedagogical approach challenges the limits of environmental inclusiveness in relation to the situation, it is subject to ethical and aesthetic foundations from the outset. The issue of pedagogical comprehensiveness is an approach to education that enables each individual to realise their potential. Furthermore, this ethical problem reveals the transformative or integrative nature of the relationship between the individual and their field of study. Holistic approaches serve as a vehicle for the movement (kinesis) of the experienced holism, which is immanent and transcendent to what the cycle provides, by cyclically understanding and explaining the holisms that include existing entities in the context of language, expression and representation.

However, as pedagogical comprehensiveness is spread over a specific timeframe within the educational process, the educational field's ideology regulates and fragments the process's priorities, objectives and comprehensiveness. Curriculum programmes provide purposeful information and limitations to shape individuals in education externally. Interpretive approaches encourage progress by offering insights into speculative and open-ended thoughts about the whole, whereas scientific approaches facilitate controlled and deliberate alignments that minimise uncertainties. By its very nature, a holistic approach transcends the logic of the scientific explanatory approach and enters the intuitive world of understanding phenomena in an interpretive manner.

In a reflexive interpretation, the theoretical, practical and poetic[4] intellectual domains of philosophy, which emerged from everyday language in ancient Greece, provide pedagogical tools within a holistic approach. From an pedagogical perspective, the aim is to generate ideas and thoughts that will facilitate “transendental empricism” (Deleuzian intention) applicable to all within an environment of indescribable, original, intensive and poetic experiences found in the artistic realm (Plato's transcendent reading).

A holistically ontological interpretation concerns the level and means by which something is initially defined or known, and how it is experienced. The epistemology of interpretation is established and theorised through the acceptance of a shared layer of knowledge, until it is falsified (Popper). Any layer of knowledge that cannot be theorised or gain validity in practice becomes phenomenalised in pre-scientific, speculative readings[5] that remain consistent with the interpretation itself.

Based on the ontological foundations of architecture, it demonstrates a holistic interpretative pedagogy in terms of both form and structure, as well as content, in the context of discoursive and power relations. The ontological relationship of these expressions with wholeness can be summarised as follows:

- The extent to which something can be understood or realised is related to how it is differentiated or combined with its sub-wholes or parts in theoretical, practical or poetic thought or architecture, and to the linguistic expression and contextuality of this differentiation or combination.
- Understanding and explaining a whole involves discovering and interpreting the systematic nature of its boundaries and regularities, and reading its dynamic structure.
- Interpreting a whole relates to the limits of its experiential and recognisable nature, whether from within or without.
- Awareness of the boundaries of a whole is proportional to the comprehensibility and linguistic expressibility of a shared experience.
- The interpretation of a whole lies within the discoursive power field of the contextual dynamics of which it is a part.
- The subjectivity of experiencing a whole depends on whether it is observed by a being, and on whether the observing mind's correlation is weak or strong.
- The pedagogical comprehensiveness or holism of something can be achieved through environmental readings (perspectives) of the fragmented aspects of its interpretative realities. The difference between interpretation and reading is that the former is an observation

of the aspects of a holism from the outside, while the latter is a partially contextual experience of the whole. In other words, every reading is an actualisation.

- From the perspective of contemporary education, the fundamental problem concerns the agenda of holistic interpretation and reading in ethical and aesthetic terms rather than mental, physical, spiritual or humanistic terms.

1.2. The Intellectual Boundaries of the "Holon" in the Historical-Philosophical Background

Just as systematic thinkers construct and propose consistent thought systems within a historical-philosophical context, it is also argued that holistic thinking is impossible. Even if it were possible, the linguistic ability to express the holistic concept by anchoring it to nature's dynamic structure has yet to be developed.

The philosophical genealogy of holism is traced from classical metaphysics to critical theory in order to establish its conceptual relevance in architectural education today.

Plato (2007) inaugurated the concept of the 'holon' in his theory of Forms/Ideas, which can be seen as an interpretation of Aristotle's work. According to this theory, every physical object is merely an imperfect replica of a perfect, unchanging Idea. In the Platonic sense, architecture becomes a pursuit of ideal proportions, harmony and order — an imitation (mimesis) of an ideal whole that exists beyond empirical experience. Here, the holon is not constructed, but rather remembered (anamnesis), pointing towards a transcendent source. This idealist heritage continues to influence how design and form are perceived as carriers of timeless truth in architectural education.

In the history of thought and art, which stems from Plato's philosophy, idealists are defined and idealised by metaphysical identities. In this case, the whole lies within the limits of the individual's knowledge, or is explained by the unknown, the utopian, or the speculative, logical and intuitive. While the ideal can be sought in universality, art appropriates this concept and can imitate it. Art reflects the visible world, the general, the universal, the essence or the ideal reality — a corrected version of reality.

Plotinus (1991) took this vision further through his notion of the One (to Hen). According to Plotinus, all existence emanates from a singular, ineffable source that transcends being and knowledge. The notion of a 'holon' here is spiritual and hierarchical: it flows from the One through successive levels of reality. In design pedagogy, this can be likened to the idea of a central, unifying principle or organising logic that governs spatial coherence — its presence is often felt rather than seen.

Hegel (1977) provides a modern, dialectical interpretation of the holon notion. Rather than positing an external ideal, Hegelian holism is a dynamic, historical unfolding of Spirit (Geist), achieved through contradiction, negation and synthesis. Holism is a process, not a static state — becoming rather than being.

In architectural education, this notion resonates with pedagogical models that view learning and design as iterative, critical and self-developing processes. However, Hegel’s emphasis on systems and totality also carries a latent risk of closure — of enforcing unity where multiplicity may be more appropriate.

1.3. Critique of the Sense/Impression of the Holon

In architectural design education, critical readings bring to the fore the critique of wholeness or holistic formation, which is thought to be static or in motion, tracing its origins back to Parmenides and Heraclitus. This critique involves the joint consideration, interpretation, and analysing of the existent, the emerging and the yet-to-be-existent. Architectural ontology provides a common ground for translating knowledge between different fields by offering a general analysis of the being from which knowledge originates in the face of various forms of objectification (Koçyiğit, 2018, p. 268).

In architectural design education, a layered unity, based on Hegel's thought and defined by Nicolai Hartmann as the "objectified spirit", relies on two realms of existence: the spiritual (both personal and objective, common) and the material. For objectified spirit to emerge, a material existence is required (Tunalı, 2002, p. 45). According to the layering defined above, the "holon" reveals two intertwined states. 1) The existent objectifies itself (objectification) in a reflective (in Kantian sense) relationship and transforms into a construction. This situation creates a problem of perceptual, intellectual (logical and intuitive) scope and knowledge regarding the holon. The holon is also a matter of consciousness. 2) The artistic integrity that is being created in reflexive thinking (reflexion) and does not yet exist is an interpretative (hermeneutic), experiential cycle in which during objectivation diversities and complexities gain meaning. At first glance, the objectivity and constructiveness of knowledge of the holon emerges. At second glance, the ontological integrity or holism based on creativity(or self-production) is revealed.

An intertwined epistemological and ontological approach is taken together as the basis of a holistic approach to architectural design education. In architectural design, the focus is on addressing, interpreting, and analysing the entity, the being created, and the not yet existing (Sayın, 2007, p. 6). In the process of interpretation and analysis, hermeneutic/critical and positivist traditions construct relationships of purpose, scope, sensitivity, determinism, and causality.

In the positivist tradition, the "holon" is explained through reductions, differences, parts, relationships, data, and knowledge. The prevailing belief is that the most comprehensive integrity can be achieved by creating new, reduced entities from the parts and bringing them together. In this case, affirming the whole is a process that begins with a fragmented position created by dichotomies and divisions. These are the convergences of the positivist tradition's view of the world's boundaries and analytical approaches. The positivist tradition constructs the integral from ongoing fragments through logical and intuitive reasoning based on explanations, generalizations, abstractions, determinations, reductions, and formalizations. Alternatively, it affirms the indivisible.

Theodor Adorno, a thinker of the critical tradition, responds critically to this legacy by arguing against the very idea of a reconciled totality. In Adorno’s Negative Dialectics (2016) and Aesthetic Theory (2004), he views the "holon" not as a given or a goal, but as a problem—an abstraction that often erases differences and enforces conformity. However, Adorno does not abandon the concepts of form and coherence. Instead, he seeks a fractured, tension-filled unity that resists simplification. For architectural pedagogy, this suggests the importance of critical distance, aesthetic dissonance, and openness to ambiguity, particularly when resisting technocratic or commodified models of design education.

The Frankfurt School's critical theory describes the "totality" through its "parts," while acknowledging that the "totality" is “other” than the sum of its "parts." Thus, the relationships between the parts and the context of the totality are considered. At the same time, variations in orientation toward the totality and new relationalities are described in recognition of the ambiguities created by the relativities that arise from subject-object interaction. Speculations and observations are made about the past, present, and future. When interpreting the totality, the concept of viewing integrated parts as separate yet interactive becomes apparent, based on skepticism about identifications, generalizations, and differentiations.

Together, these thinkers offer competing yet complementary visions of “holon”: from the eternal and ideal, to the processual and historical, to the fractured and resistant. Mapping this trajectory enables us to interrogate how architectural pedagogy inherits, reworks, or contests these visions today. In an era where education is often fragmented, performative, or subsumed under market logics, the very question of what constitutes a “holistic” education in architecture remains both urgent and unresolved.

Meanwhile, contemporary approaches that foreground fragmentation, multiplicity, or material resistance frequently align, whether consciously or not, with Adorno’s aesthetic theory (2004) and critique of totality.

1.4. Holistic Interpretations and the Challenge of Ctitical Readings in Architectural Education

In architectural education, the explanatory power of theory in accessing knowledge is debated in relation to holistic thinking and awareness. Meanwhile, the material nature of architectural practice as construction becomes discoursive[6] through the establishment, discussion, narration, and writing of hypothetical and speculative realities at the disciplinary level. Where and under what conditions architecture is built is an interpretation of its historicity. Conversely, architectural representation, expression, and design fall within the realm of everyday interpretations. Critical readings can reinforce the validity of interpretations or undermine them.

Architectural design education shapes all representational and non-representational (tacit) knowledge, from thought to the materiality of architectural practice. A holistic approach to architectural design education transforms design into an issue of "organization" involving expression, experience, environmentalism, responsibility, and so on. In the broadest sense, this approach promotes a worldview to architecture students that fosters an awareness of their aesthetic, integrated existence as part of the universe/world. This comprehensive view aims to recognize historical and contemporary values and ideas in culture, science, thought-based architecture, and architectural design education, as well as in culture and art. This broadens the scope of perspective from individual phenomena to the universal (Sayın, 2007, p. 2). While systematizing and shaping knowledge, the holistic approach is also conscious of reductions.

In order to understand pedagogical formation, we must return to the origins of viewing holistic awareness as a prerequisite for individualization. The holistic approach involves interpreting, knowing, and reading the world with self-awareness and integrating oneself (psychoanalysis). Transcendent integration between the world and the individual involves interpreting, writing, and reading the relationships between intertwined structures, individual boundaries, and states of life — from oneself to the universe, or vice versa. Contemporary hermeneutics elevates individual interpretation to linguistic, historical, cultural, and universal levels. It explores philosophical, scientific, and artistic developments in ideas about how the universe works since ancient Greece. These three areas of thought—thinking, knowing, and creating/producing—organize form-content (meaning) relationships in architecture at the conceptual, functional, and imaginal levels.

1.5. The Search for Holism in Systematic/Structuralist Architecture and Architectural Phenomenology: The Problem of Hermeneutics and Linguicism

In the positivist tradition, thought identifies logical relationships based on reason and establishes consistencies, systems, or structures through reasoning mediated by causality. This tradition seeks to close interpretation and ground inferences on a universal, consensual, and functional basis. In this tradition, architectural design is addressed as "systematic" (Archer, 1965) and, later, as a "wicked problem" (Simon, 1996). The desire to convey design processes and situations through linear paths, clusters, and mathematical and logical representations leads to the factual and eventful aspects of design being overlooked.

In contrast, the critical tradition identifies the problem of design and problematizes facts by recognizing the emergence of intensities in event-specific situations. It also discusses architectural thinking and decision-making processes in the context of artificial and general intelligence in ethical and aesthetic realms. A critical stance in pedagogical formation questions the establishment of a system aimed at purpose, efficiency, and gain according to interests and relationships. This places parties negatively affected and disadvantaged by this solution-oriented, synthesizing dialectical discourse on the opposite side. Therefore, criticality aims to understand, explain, and know the creative processes, interactions, and transversalities in the production and actualization of relations in theory and practice.

Phenomenological approaches to architecture offer critical perspectives on the systematic closures and functionally restrictive attitudes of structuralist approaches, which limit creativity. While structuralist discourse emphasizes the literal meaning of language and the objective, scientific explanatory power of foundational systems, phenomenological discourse initially assumes that the same structure operates at subjective, cultural, and conscious levels. However, it later realizes that subjectivity in experience, different uses of language, and its ambiguities are open to new linguistic formations, polysemy, embodiment, and other conceptualities. The phenomenology of architectural design is based on the fundamental acceptance that the design process is interpretive and subjective. The process of "individualization" in design increases the importance of one-on-one conversations and personal reflection in shaping education and the teacher-learner relationship.

In architectural design, a constant tension arises between objectivity and subjectivity. The objectivity of design and production thinking carries a scientific character, as it is systematic, language-constructive, and consistent with the structural cycle of linguistic expression. Phenomenology, by contrast, focuses on the artistry, originality, and poetic indeterminacy of situations that emerge from the contextual and pragmatic use of language. These situations are grounded in subjective perspectives and centered on consciousness.

In the search for structuralism and systematicity, as well as phenomenological integrity, two interconnected hermeneutic axes emerge. These axes involve reductions created by the limitations of reason and experience. The first axis, in its theoretically weighted interpretation, establishes relationships between logic, language, and language-structure and sign. This axis contains subject-object and form-content dualisms. This axis forms the "text/object model" in discourse. The second axis is the "dialogue model" in language and discourse. Through this model, the analytical and fragmented disciplines are integrated and transcended via the axis of being, history, and phenomenology. Holism is a process, as mentioned in section 1.2, not a static state — becoming rather than being. Contemporary interpretations of hermeneutics reveal that both axes have "transversalities" that could form the basis of a comprehensive, holistic approach, bringing the relationship between being and language closer together (Sayın, 2007, p. 14).

Architectural design, as a linguistic problem transcending the communicative to understand the holistic, encompasses "discoursive" textualities. This creates differences in pedagogical evaluation between the processual (infinite interpretation) and resultual (finite interpretation) aspects of architectural design, as reflected in architectural design education. In hermeneutics, the problematization of expression and representation begins with the perception, understanding, and explanation of holistically sensed and understood dialogue and text models, leading to "design discourse" in architectural education.

1.6. Contemporary Crises of Holistic Knowledge and Pedagogy

The "sense/impression of the holon" arises from the composition of aesthetically whole parts. Unlike objective perception, aesthetic perception gains value based on the similarity, difference, and complexity of the new sensation compared to psychological states and processes resulting from previous experiences, as defined in experimental aesthetic studies. In this comparison, some phenomena stimulate the use of elements that arouse emotions, such as difference and diversity, while other facts limit the level of these elements, such as similarity and unity (Bergil, 1993, p. 160).

Reflectively and constructively, the differentiation that determines the limits of existing integrity depends on awareness of the layers of relationships (correlations) between things that can be accepted as parts and wholes, as well as part-whole relationships. This semantic effect contains wholes/gestalts of "similarity/difference" relationships based on previous experiences. Özlem (2001, p. 156) suggests using personal "interpretation categories" instead of objective existence categories with an intuitive, intellectual understanding of integrities. These interpretive categories are indispensable for organizing all experiences gained in nature and history. Being can only be interpreted.

However, architectural design knowledge is a representational type of knowledge, and its pedagogy is only possible through the mediation of design experience, which is one of the conditions of architectural practice. Mediation (mediality) is also problematic in the relationship between architectural theory and practice.

1.6.1. Textuality and contextuality: The "problematic of mediation" in interpretation

In the problematic of mediality, the epistemology of interpretation concerns how linguistic structures translate technical mediation into knowledge, how it is coded, where the data is recorded, and who remembers, reads, interprets, and enacts it. The "model of dialogue," which keeps oral culture alive through hermeneutics, focuses on the present with simultaneous leaps of thought, imaginative associations, and experiences that work on "alive physical memory." Plato characterized the text model as dead[7] and capable of existing independently of its transmitter. This model transforms readings of the past and future, as well as the interrelationships between things, through consensual signs that record and recall discourse textually, and through "dead technical memory" (Stiegler, 2012; Korkut, 2025, p.21). Textuality is isolated from conditions, events, entities, and perceptions as the antithesis of history. Ontologically speaking, contextuality can refer to either the part-whole relationship within physical reality (i.e. concrete, object-oriented) or the part-whole relationship within social reality (i.e. subject- or inter-subject-oriented) (Koçyiğit, 2022, p. 764).

According to Derrida, interpretation is either its own completion (supplementation) or its own rewriting (re-inscription). Nancy argues that metaphorical, poststructuralist interpretations, such as grafting one text onto another, constantly emphasize the contextuality and relativity of the epistemological and metaphysical foundations of the "hermeneutic circle." In an interpretive beginning, a contextual interpretation attempts to decipher the truth or origin of what is being interpreted. However, when interpretation no longer returns to the origin, it approves the game and attempts to transcend human existence itself, dreaming that it can determine the outcome.

Considering the anthropocentric nature of philosophical discourse's origins and the fact that knowledge's truth also emerges from moral origins and conscience, a human-centered interpretation's contextuality is the field of knowledge where the compatibility and integration of the interpretive root with its signifying counterparts are discussed, as well as where ethical-aesthetic values are determined and meanings are fixed (semantics). Conversely, a text may be driven by polysemy or the intensity arising from indecisive value judgments rather than a closed integrity. Another problem is the openness of readings independent of the text's producer or author. Despite the constancies and demands for universality of the original symbolism of interpretation, original readings and actualizations provide poetic and creative openings.

Deconstructive reading requires establishing new references and interpretive connections that destabilize form-content correspondences through readings that expand, intensify, and clarify the structure of mediation. According to deconstructivism, language is not absolute. Rather, it is a broken and fragmented phenomenon.

1.6.2. Consciousness, temporality, and historicity in mediation

The historical character of spiritual life encompasses knowledge of spiritual life that goes beyond ontological or phenomenal knowledge (Misch, 1995, p. 42). Experience is characterized by the dialectic of life-unities and singularities with commonalities. Dilthey understood this as "objective spirit". The orthographic temporality of this characterization lies in the relationship of unity within the linguistic environment between individuals who are identical yet claim to be non-identical to each other within the same time frame and across different cultures and distances in horizontal communication (syntagmatic). Vertically, temporality lies in the relationship of integrity between a life history and singular experiences and life connections (paradigmatic).

Individuals are aware of the identity of context with life histories and experiences within different time periods of the same culture, as well as the non-identity of past life segments. Thus, the linguistic and historical context based on commonalities has an integrating power. In mediation, the relationship between the general and the particular within this unity is intended to be understood. The self, which remains constant throughout life, can only stabilize individualization around a reflective framework. According to Hegel, self-consciousness is self-awareness (Habermas, 1995, pp. 145–146).

Instead of Hegel's metaphysical system, which reaches totality through logical dialectics, Dilthey's historical consciousness knows itself (as a mode of self-knowledge) and the future in which it is situated only through a reflective relationship. This relationship does not impose criteria (Gadamer, 1995b, pp. 176–177). Cultural values (meanings) and signs, which are carried in structures that are determined by the interpretation of change and are anchored in historicity through metaphors, can be consciously experienced within the integrity of the delineation of the field of psychic and spiritual individualizations and communalities. These values and signs can be understood as objectivities or objects in the transcendent and experimental activity of the subject. The fundamental issue discussed here is the effect of the origin, causes, and effects of the emergence of logical and intuitive knowledge in interaction as a priori or a posteriori in experiential or experimental processes. If the result materializes as an object-product, then the technical conditioning and technologies of language games are decisive in forming the relationship between form and content.

The temporality of psychic individualization spatializes and becomes possible in consciousness, while the time of social individualization spatializes and becomes possible in historical consciousness. Mental and social memory techniques construct the past, present, and future. The "technical object" is produced through the externalization of the internal, mental, and spiritual/social. As mental awareness and sensitivity to consciousness evolve, the simultaneous coordination of the past, present, and future transcends dialectics, carrying historical and contemporary experience beyond it. The critical issue here is the practical acceptability of speculative thought mediated by historical or intellectual dialectics folding toward powerful or focal concepts predicted by prevailing discourse.

The correspondence between the mind and the world in theory and praxis[8] concerns the temporal nature of constructed reality as anticipated in practice through theoretical and hypothetical interpretations and its loose or strong correlation with speculative reality. The correlational experience of consciousness and ideas regarding the essence of discoursive positivity[9] in all historical aspects of time—retrospective, present, and prospective—lies at the origin of hermeneutics.

There are traditional/classical hermeneutic reading methods, which begin with the interpretation of sacred texts. These methods attempt to interpret the relationship between reason and history, which is the starting point for linguistic and semiotic inferences. In medieval allegory, layers of meaning are superimposed in a specific, rigid order. These are "predetermined and conditioned" interpretive solutions. The interpreter cannot escape the creator's strict control. The meanings of allegorical figures and symbols are symbolically defined and organized within the system (Eco, 2001, pp. 14–17). However, in contemporary hermeneutics, an allegorical[10] reading contains a different "openness" in discoursive formations[11]. The reader uses the text to discover each metaphor built on multiple meanings in order to reach the intended meaning with each reading.

Similarly, during the Baroque period, artists rejected the fixed and unquestionable definiteness of the Renaissance and embraced dynamism and openness. Interest and attention shifted from substance to appearance as visual elements replaced haptic elements. In painting, the idea that viewers should have a fixed perspective was abandoned (reverse perspective). In the contemporary worlds of science, art, and architecture, the parts that make up a unity were given an equivalent, non-hierarchical position. The entire structure expands toward an almost infinite unity (Eco, 2001, p. 25). As Adorno points out, it does not want to remain within a holistic totality based on utopian identities that close in on themselves. Can we go beyond language in discoursive formations based on difference while remaining within dialectics? Theodor Adorno (2016) defines this as "negative dialectics.". Does consciousness of the essence, defined linguistically or structurally through the transformation of language, exist in the non-dialectical?

1.6.3. Textuality and formality in mediation

In the 1970s, "text" replaced "architecture," which served as a metaphor for constructing philosophically, mathematically, and geometrically through the mediation of thought. In the text model, the linguistic and discoursive representation of architecture, the fabric/context (holon) woven from references and metonymies produces autonomous meanings beyond the intentions of the author/architect. Alongside making in architecture, textual multilayeredness, affirming becoming through bricolage, and dismantling the existing philosophical/conceptual structure to transform it into a comprehensive new one (deconstruction) support poststructuralist theses.

When establishing conceptual (abstract) or material (concrete) structures that express entities within language-based systems, mathematical and linguistic[12] models examine the relationships between entities. For theorists such as David Hilbert and Ferdinand de Saussure, these entities possess ideal forms or essences independent of place. Formalism focuses on entities rather than relationships and perceives form as an example of the object and meaning as a model or interpretation of form. Platonic formalist practices can realize an imagined form through architectural will (Karatani, 2006, p. 36).

Individualization is not achieved through formalism by grounding a holism to reach the externality/structure of the form; rather, it is something that can be introduced naturally (naturwüchsigkeit) through formalization, building, or construction activities. The possibility of formalization transcends a closed, self-referential formal system by being represented in a language or mathematical system that does not yet exist.

Despite the existing formalist representations of knowledge in theory and practice, knowing by doing (praxis) has a poietic/creative formalism. Conversely, the representability of the formation of being is limited by the actions and abilities of the mind and body—that is the process of doing something.

2. Material and Method

The introductory section reveals that the capacity for formalization gives rise to pedagogical strategies in architectural education through formal mediations, including hermeneutics, consciousness, history, temporality, discourse, textuality, contextuality, and language-based representations of entities.

Can a holistic approach be methodological in architectural pedagogy? It can be partially methodized by limiting the aforementioned conceptual, phenomenological, and structural issues to a specific purpose. The multi-actor and rhetorical processes of architectural design are subject to unpredictable, playful relationships between input and output. Thus, architecture emerges as an event open to contingency. Under these conditions, the ontological basis of the event necessitates evolving a holistic approach from the pedagogical comprehensiveness problem. This evolution brings consciousness and the unconscious to the forefront of the ethical-aesthetic paradigm and results in a comprehensive epistemological formation. It is imperative here to narrow the interpretive process from the ontology of understanding to the epistemology of explanation. In this case: Can pedagogical comprehensiveness, which brings an external critique to architectural design, formalize architecture as an applied art?

Unlike the formalist and representational nature of theoretical and practical knowledge focused on entities, the formalism of knowing by doing is focused on relationships. It is an emergence that cannot be represented and an actualization independent of the pre-given potential of intuitive data.

Since the beginning of the 21st century, architectural criticism has moved away from interdisciplinary transitions that attempt to theorize everything. Instead of biased, contradictory, and dubious constructs and ideologies that seek to justify a particular perspective, architectural criticism has returned to the variable and diverse nature of knowledge. It has embraced "post-theory" (Speaks, 2002), which returns to materialities that transcend subject-object dualisms. These materialities cannot be represented by theorizing the limitations or ontological conditions of one's own situation. This approach is independent (autonomous) from within the practice. In this process, pedagogies emerge that are described by post-humanistic, transhumanistic, and new materialist thought and are also called new ontologies and ecologies. The post-theory debate indicates an attempt to redefine architecture as a discipline within an ontology of becoming that resists mechanical definitions. Post-theoretical positions argue that architecture no longer possesses a stable identity, autonomous knowledge, or a form of willful action.

Things that are difficult to theorize, especially in the humanities, can be expressed as structural motions engaged by multiplicities that transcend mere dualities and dialectical positivities. The emergence of an untheorized or uncalculated otherness or excess in the feedback of every theorized practice—the failure of the practice (praxis) to deliver what is anticipated in theory—requires the simultaneous observation and formalization of theory from within practice and vice versa.

The transversal[13] approach considers the practicality of optimal conditions, behaviors, and actions by aligning architectural practices with architectural production problems rather than offering a simple, fixed method. Thus, in transversalities, interdisciplinary conceptual translations, analogies, complex abstractions, and metaphorical language relationships are not structured. Interacting with a singular thing does not symbolize transforming it into an entity that corresponds to a fixed code. Rather, the focus is on understanding dynamic relationships, as well as the relationships between relationships. The focus is also on understanding the possibilities of a variable value or range, from the thing itself to the non-thing. Transversality offers a perspective that brings architectural practices closer to addressing real-world issues and comprehending the multifaceted dimensions of reality.

In cartographic reading, space is not treated as a static object but as a network of relationships. This shifts the ontological question from 'What is there?' to 'How is it there?' and 'In what relationships?', emphasizing the relational and processual nature of space. The cartographic reading method challenges the representational knowledge taught in architectural education as a humanistic professional practice through "design" since the Renaissance. In contrast, contemporary critical architectural design employs a holistic pedagogy that acknowledges the non-representational. This cartographic initiative does not claim to present a holistic historical narrative or developmental timeline. Architecture's expanding field, passing through the intensification of the representational via artificial intelligence, possesses a new materialist and critical perspective that is unrepresentable and therefore undesignable, emergent, and non-architectural. From this perspective, architectural knowledge is not a humanistic form-content issue (Baird, 2004). Within a posthumanist framework (Braidotti, 2013), it is the interaction of convergent computable, connectable, and formalizable things. In terms of research, artificial intelligence studies are on the architectural agenda for processing information and representing and formalizing knowledge.

In this context, AI's ability to process large amounts of data and generate innovative solutions is transforming traditional design practices. According to Aksu Ceran & Sayın (2024, p. 269), creativity, sustainability, cost, user experience, design time, automation, and efficiency have become decisive factors in architectural design.

Within the critical context of architectural pedagogy, the partial state of artificial intelligence research in the ethical and aesthetic fields, its relationship with power and governance, and its socio-economic and political implications are evaluated. A pedagogical critique of architectural will is only possible through reason, a formal style, and a method.

3. Findings and Discussion

Today, interpretation enables the transformation of information provided by conceptual trajectories into an operating process by investigating the causal factors of the conceptual trajectory between things and non-things, or tendencies, through a transversal approach to emerging discrepancies between theory and practice, otherness, or excess.

In the interpretation of new materiality for the purposes of knowledge and recognition, the human element in the interaction between entities is supported in its movement towards the non-human, in order to conceive of new ecologies. However, this intellectual stance could also be exploited by a technological mechanism of domination. In this context, intellectual depth in architectural education and the ethical-aesthetic unity in architectural design practices conflict with architectural practices and influences from outside a critical academic stance, particularly neoliberal economic policy. Recognising these contradictions, the interpretation of architecture transcends the distinctions between the humanities and the positive and natural sciences that examine construction techniques and materialities. Architectural interpretation can transform agents into those acting within new ecologies alongside human and non-human actors. It can also explain events through specific activities and formalise a system perspective imposed from outside.

From a post-critical position, a return to a skeptical stance may raise questions about the emergence of new ecologies and architectural ontologies (Yavaşi, 2025) through transversal movement in architectural practice. In this practice, language, reason, speech, and consciousness are transcended, leading to a fusion of horizons (Gadamer, 1995c, p. 273). Can this serve as a vehicle for the actualization of the unthinkable, brought about by the deconstruction of the linguistic structures of deep thinking and learning? Instead of heralding the emergence of the new, does this perspective evolve into the architecture of a new materiality, "media-technic" (Kılınç, 2021, pp. 589–591), as a harbinger of a new form of domination? Finally, does algorithmic governance (Rouvroy & Berns, 2013, Yokuş,2024) result in a simulation of a transcendent, limitless, non-representational, non-theorizable, unknown, and non-pedagogical world? While the answers to these questions do not fit into this book chapter, our subject is the representational knowledge of the actualizations of Gadamer's (1977) philosophical hermeneutics, which offers a contemporary interpretation theory of the linguistic and discoursive dimension of architectural holism. Additionally, we explore Ricoeur's (2004) discoursive, vivid, metaphorical readings; the representational knowledge of their actualizations; and the technological possibilities and challenges of new materialities and artificial intelligence in contemporary architectural education.

In a socio-economic context, architectural education brings artificial intelligence research to the forefront through the use of sub-control mechanisms in algorithmic governance. Architectural education is managed through narrowed, fragmented, and certificated processes that aim to meet the demands of the instrumentalizations created by the neoliberal world order and market-driven vocational education policies. However, the goal of any pedagogical approach is to raise awareness of the universal, philosophical, and ethical dimensions of learning. Certain objectives and critical questions, raise a series of questions that can only be approached through interpretation, comprehensive knowledge, and understanding. How can holistic interpretations reclaim architectural education as an intellectual and civic act? This begins with the assumption that an architect who is subject to algorithmic governmentality, cannot liberate their thoughts or actions, and is unable to think critically would not be authentic in architectural education policy. Therefore, the intellectual goal of architectural education is to transition from holistic awareness to consciousness through architectural design and constructive actualization anywhere. It must fulfill its purpose in the face of the power to which this actualization is subject.

The above-described pedagogical comprehensiveness, which seems utopian, suggests that, in an epistemological context, knowledge of truth and power manifests as the actualization of unknowability and the ineffable, event-specific truth. In artificial intelligence research, however, the representability, computability, and connectability of knowledge also take into account the pedagogy of the as-yet-unthinkable and unknowable. Despite the cautious and conservative progress of architectural technical production within the limitations of reason and natural processes, artificial intelligence creates an alienating yet transformative effect by incorporating complex information into praxis through algorithmic calculations.

According to Sayın (2024, pp. 93–97), architectural design was influenced by phenomenology, structuralism, post-structuralism, linguistics, semiotics, critical theory, and interdisciplinary mediations and transitions, as well as spatial and linguistic turns, in the second half of the 20th century. In this context, architectural design education must establish relationships between architectural practice and culture(s), addressing the phenomenon of architectural design holistically. In the experiential process, the fundamental goal is to raise consciousness. In the learner-teacher relationship, it must create opportunities for understanding through dialogue in a linguistic environment. It must also consider the diversity and complexity generated by the artistic creativity and differences of learners and teachers operating within a shared space. The following should be established in methodological approaches: variables, epistemological frameworks, and positivities.

3.1. Learning in Architectural Design Education

From an informatics perspective, the teacher-learner relationship in architectural design education involves information transmission and comprehension. In situations where knowledge is constantly changing, it is important to determine how much the didactic transfer of guidelines can serve as preliminary knowledge that prepares the foundation for interpretation without compromising the individual characteristics of the interpretation (Sayın, 2007, p. 56).

Learning occurs in a language environment through language. In architectural design education, language plays a role in the teacher-learner relationship: 1) Everyday spoken language (natural language) and dialogue, and 2) architectural design language, which interacts as text. According to Gadamer, language is ontologically the essence of being itself, and it is the environment of all becoming. Epistemologically, in the intersubjective field, language takes on a communicative mediation role and becomes objectified. Hermeneutic dialogue forms the basis of holistic interpretation in architectural design and enables discussion of experiences related to understanding and learning within the learner-teacher relationship (Sayın, 2007, p. 53).

Learning in an intersubjective language environment can be considered a discoursive form of reading. This chapter aims to do more than establish learning styles and reasoning methods and their relationship to educational paradigms and policies. The section on materials and methods aims to describe how the discoursive formations and positivities expressed therein are traversed by general and artificial intelligence logics of a formalist and formal architectural system, both internally and externally. Thus, learning is examined in terms of how information is structured, represented, interpreted, and transformed into knowledge in both the brain and the machine.

Today, the critical foundations of contemporary architectural education are evident in interdisciplinary, “formalist” and representational approaches, in which theory, history and criticism are intertwined. In the late 20th century, a shift in focus from text and meaning to representation and performative practice occurred with the return to the use of language for performativity. The production and staging of reality are called into question. The dynamic structure of performance in performative events is important. Culture as performance focuses on materiality, mediality, creative forces, corporeality and non-verbal speech acts, as well as historical actors, conflicts, violations and cultural subversion, all of which were excluded by the linguistic turn (Bachmann-Medick, 2016, p. 24).

In the early 21(st) century, architectural criticism is based on a timeless, meta-critical and hyperrealist foundation, exploring the repetitive elements of history through speculative, new materialist and ontological approaches

(Bachmann-Medick, 2016, p. 224). From the perspective of contemporary artificial intelligence research, processing data related to explanation in new materialism, information ontology and new connectivities strengthens the intellectual basis of “formalisation” in architecture.

The distinction between “formalism” and “formality” is rooted in linguistics, cultural anthropology, psychoanalysis and other disciplines. In the history of thought, Plato's ideal regarding the status of form and his questioning of the will to achieve relational and conceptual form in everyday language through Socratic dialogue reveal the performative value of speech and synchronicity in the linguistic context of the 'dialogue model in hermeneutics'. The living, verbal structure of dialogue tends to be based on substantialist thinking when it comes to the creation of fictional selves.

3.2. Formalism and Formal Approaches in Architecture in The Context of Form, Content (Meaning) and Substance

Generally, the form and content of all interpretable text expands towards a meta-theory of systematicity, encompassing intersubjective language systems within the relationship between culture and nature, and non-linguistic symbols within the relationship between subject and object. The formalist approach argues that, when the meaning of words (concepts) is removed, the signifier exists in perception only as a form based on difference, and the signified (i.e. the meaning) is merely a product of form. According to this approach, the object and the meaning given to it are understood as an example of form, as a model or interpretation of form (Karatani, 2006, p. 36). The object and meaning are seen as interpretations.

Until the end of the 18th century, Western architecture, following in the footsteps of ancient Greek architecture, believed that it possessed an ideal formal language. Despite each architect of the late 18th-century neoclassical period interpreting ancient Greece separately, the result was an eclectic, formalist architecture that referred to Vitruvius. However, a formalised system requires a set of symbols containing fundamental symbols, structural laws, necessary definitions, basic propositions (axioms) and rules of deduction, rather than a formalist one. Such a system is not open to interpretation. In formalised logic (Frege), symbols can be manipulated infinitely. Since definitions are recursive, unlimited expansion is possible (Özlem, 2001, pp. 35–36).

In the context of architectural ontology, cartographic interpretation means analyzing space as a map of entities and relationships, reinterpreting different ontological layers (human, structure, nature, technology, politics, economy) within a spatial framework. In a cartographic interpretation of the relationship between form and meaning, formalism and substantialism are considered to be pivotal in architectural history and design. Cordemoy (1706) defined the essence of architecture as a free-standing column, while Laugier (1753) determined that columns, beams, and pitched roofs form the basis of the architectural whole (Frampton, 1997, p. 14).

Jencks (1985, pp. 29–94) states that the non-linear, layered interpretation of 20th-century architecture comprises six traditions derived from politics. The logical, idealist, self-aware, intuitive, activist and self-unaware traditions. The first group is the idealist tradition, which strives to establish architectural integrity; the second group is the critical tradition, which opposes this. According to Zaero-Polo (1998), therefore, Jencks's maps are an expression of architecture repeatedly organising its identity and boundaries within specific themes (Figure 1).

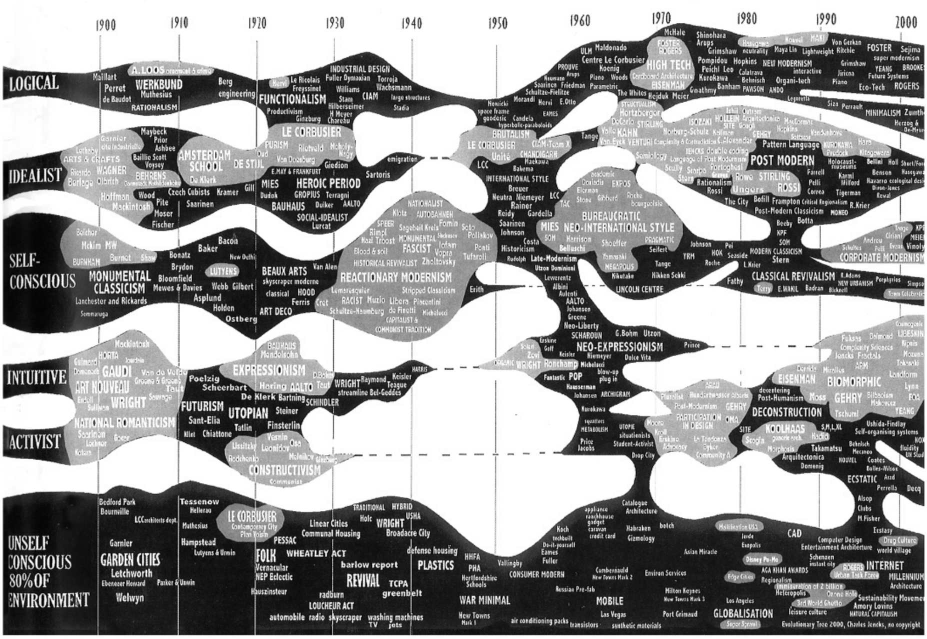

Figure 1. The Traditional-Political Cartographic Reading of 20th Century Architecture (Jencks, 2000)

At the beginning of the 20th century, modern architecture separated art from architecture, viewing the former as 'architecture as art' and the latter as 'architecture as construction' (Isozaki, 2006, p. 13). While representation and the multiplicity of meanings were not on the agenda at that time, space represented function as the sole truth. This logical, formalist infrastructure is based on the universal principles of modernist architecture. Architectural form becomes mechanised through formalist derivations based on a single form (building block) and tectonics. The pinnacle of modern architecture, the 'International Style', is nihilistic and formalist, with meaning absent and the signifier having lost its signified. The limited, defined and secured syntactic structure of modern architecture's form makes it a closed system. Like Wittgenstein's (1985) natural language[14], architectural design is a composition of parts (words) that conform to its own grammar.

Robert Venturi (1991) challenged the formalist approach of Cartesian modernist architecture, which rejected meaning, by highlighting the meaning created by form (the sign). He identifies situations in Western architecture that create uncertainty, ambivalence and contradiction, all of which had previously been rejected. This raises the issue of content and meaning.

Similar to the connection established by neo-positivists[15] between syntax and meaning, searching for a connection at the urban level involves revealing the spatial characteristics of historical and cultural meaning and value. These characteristics include horizontal, vertical and oblique elements, as well as dividers and separators. The production of contextual meaning in design can then be explained (Yücel, 1999, p. 36). A similar analysis can be seen in Bertrand Russell's 'logical atomist' propositions (Altınörs, 2003, pp. 118–123). There are functional-value correspondences between designs in the external world and architectural elements/forms that represent factual situations.

The atomic/particular approach to architectural tectonics creates historical or abstracted definitions of archetypes at the syntactic level. Semantic studies of architecture emerge from investigating the meanings of archetypes and the secondary and tertiary forms derived from them. The problem is the assertion that an element has only one meaning (logical meaning, truth, and referential relationship), as the neopositivists[16] claimed in their early period and as Frege's picture theory[17](Abbildtheorie der Sprache) does, referencing Wittgenstein's Bildtheorie. The form-meaning relationship, defined as literal meaning, can be represented as an architectural form dictionary. Discussions and interpretations of form-content and logic-language in architecture enable understanding and interpretation of the architectural whole as language. They also assist in cartographic readings of architectural designs related to the past, present, and future (Sayın, 2007, p. 32).

In architectural linguistics, form-meaning associations have been made at the tectonic level in the semantic field directed towards the literal meaning of natural language. However, architecture is not merely representational; it carries its own self-referential value in life. The system of metaphors created by the poetic level of language reveals the "form of life" (Wittgenstein, 1998) in use beyond what it describes or represents.

Aldo Rossi seeks semantic content in deep structure, morphology, typology, and conceptual and logical relationships and history. He argues that urban logic is a creation of social memory. Logic is formed within typology, but memory only exists through the logical existence of this typology. Following Rossi's definitions of architectural syntax in Western culture, Alexander's (Alexander et al., 1977) “pattern language” design logic attempts to create an architectural language suitable for different cultures and user profiles. This design logic, based on the analysis and synthesis of patterns derived from the user-sign pragmatic relationship, is intended to create more humane environments. Alexander's pragmatic approach creates a democratic design tool that can handle different patterns, not just architectural ones, rather than a single language (Yücel, 1999, p. 43).

In architecture, the derivations of meaning from multiculturalism and multisite locations are pragmatic. Following the 1950s, this approach asserts that language's primary function is communication. In his work, Philosophical Investigations[18] (1998), Wittgenstein draws attention to the existence of "language games[19]" and "forms of life," as well as the possibility of creating infinite forms and content in language. The discovery of the poetics of architecture is defined as its counterpart to the meaning shifts created by the representational dimension between form and content, the pragmatic dimension of meaning in speech, and the creative dimension of language that includes figurative uses, such as metaphor.

The concept of discord, which emerges in the context of vital realities between theoretical and practical aspects of architecture, was brought to the forefront by post-theory and is based on the relationship between conceptual expression, discourse, and architectural entities. For instance, contextualizing a form of conceptual network in a conversation or mind map confirms the relationality and contextuality of meaning. A model that formalizes such a formation is a simulation of a dynamic, living, mathematical, and logical organization that is holographic and depends on actants and parameters.

In discoursive formation, the status of the concept cannot be fixed. According to Nietzsche's "Truth and Lying in a Non-Moral Sense," the concept is a "worn-out" metaphor. In Marxist theory, however, the concept is a relation. Despite the dynamic and living structure of matter and its transformation, mathematics examines unchanging, fixed relations. Does the relation of matter exist in the same form as the entity of matter? The epistemological problem between practice and theory becomes speculative when the answer to the question is "with the relation being an idea (constant)": Conversely, when modeling the relationship in the a priori capacity of time-space before experience, the strength or weakness of its mental correlation becomes an ontological problem.

Despite the ontological problems of formalization, formalism interprets form independently of the problem of being without considering the object or meaning. Language is formalistic; it is a system of relations based on difference. When a structure is considered to have transformational rules or functions, even a void becomes an invisible structure. The discoursive liveliness, theatricality, and contextuality of the dialogue model in hermeneutics are not the discovery of the essential. Axioms are not obvious truths or empirical facts. Rather, they are the creation of a set of rules necessary for dialogue to exist as an entity. Rather than starting from clear and transparent premises, contemporary axiomaticism or formalism continues the dialogue about conventional rules that determine future actions (Karatani, 2006, pp. 59–60). Plato's mediation of his dialogues through writing actualizes the impossibility of formalizing living dialogue with a formalist approach, which Stiegler (2012) describes as "dead technical memory."

Similarly, in phenomenology, Husserl's revelation of the ontological characteristic of the idea (eidos) through eidetic reduction demonstrates a "formalist" approach. The subjectivity of formalism, when put into practice and prohibiting the body and sensation, is destined to revert to a pre-formalist position in Derrida's development of grammatology (Karatani, 2006, p. 66).

In the early 21st century, formalist architecture stems from advanced computer modeling techniques that create enormous parametric complexities and consistency processes. These techniques are produced by complex algorithms and filled with their own variables. The new formalism is linked to the idea of autonomy due to its lack of ideological attachment and the meanings it is expected to convey. Although formalism seems to have lost its critical and ideological power today, it nevertheless figured as a locus of resistance to postwar modernism. The repetitive or process-based sequencing of minimalist sculpture, rationalist architecture, and indexical, syntactic, and linguistic analogies derived their formal bases from an internally generated system, independent of social or functional concerns. In this context, the formal must be differentiated from formalism; the former has internal value, while the latter is the empty rhetoric of current shape-making (Eisenman, 2016, pp. 7–8).

Existing as a specific subject is not based on "natural" qualities found in the "essence" of human beings or transcendent ideals. Rather, it is viewed as the result of an active, socio-technological production process. Individual identities are not established through predefined, stable qualities and characteristics, but rather through complex interactions, organizations, and flows with the environment within the framework of individualization processes. The increasingly complex informational network in which architects must operate has also altered the relationship between architectural knowledge, theory, criticism, and history. Since the 1960s, architectural theory has established stable identities through abstract conceptual schemes constructed in a "transcendent" manner. Conversely, the informational turn in architecture and its organization-based transformation have produced new critical readings and historiographies regarding the forms of agency already functioning within architectural culture. The pressure of these new ways of thinking, which treat life as an object of study, is also felt within architecture. Some believe a connection can be established between architecture and the truth of the universe we inhabit (Jencks, 1997).

3.3. Framing in the Architectural Design Process: Reflectivity, Intuition, and Creativity

In an effort to rationalize the design process—defined as accessing information, creating knowledge, and transforming it—symbols (internal structures and constructions, such as images, models, and schemas) are used to indirectly construct cognitive (psychological) information through logical reasoning. Alongside the concept of "reflection," which transcends positivist reductions, intuition emerges. In an intuitive structure, internal and external representation entities, such as past knowledge, experience, schemas, analogies, and models, can become functional. Unlike the certainty of cause-and-effect relationships in controlled logical reasoning, intuitive reasoning contains uncertainty, which delays the decision regarding its functionality before reaching a conclusion.

In the rationalization of architectural design, which is defined by logical and intuitive reasoning, many logical and intuitive perspectives emerge. The most important of these are: 1) architectural design as problem solving[20], 2) architectural design as construction, 3) architectural design as open and closed systems[21], and 4) Architectural design as divergent and convergent thinking[22]. 5) Architectural design as creative thinking[23]. Furthermore, "imagery" plays a role in shaping thought alongside reasoning and guides the architectural design process (Sayın, 2007, p. 35). Algorithmic design processes as problem-solving will be evaluated from a systems perspective.

In design, designers construct mental representations of architectural designs. They build concepts or conceptual frameworks to quickly identify and define problems, rather than relying solely on information derived from long-term memory. When designers find themselves in a problematic situation they cannot easily manage, they may seek a new way to frame the problem. They then impose this new "framework" on the situation. According to Schön (Zimring & Craig, 2001, pp. 139–140), framing a problem is a choice of differentiation. When designing, examining another design and applying its solution to the present situation can provide the designer with new insights. While decomposition involves dependencies, these dependencies are not limited to top-down or lateral constraints. A component at the bottom of the decomposition can affect the entire decomposition or the concept as a set. In any case, top-down constraints affect the decomposition from the outset. Changes in constraints can create new styles and rules. Perceptual and cognitive constructs are products of creative thinking. Design, as a construct, is the result of efforts to explain and understand existing perceptual, cognitive, and emotional schemas, models, maps, etc.

3.4. From Linguistic and Imagery Mediation in Architecture to Knowledge Ontology in Artificial Intelligence

When considering the representation of linguistic and imagery mediation in the mind, the metaphor of "structure" refers to architectural tectonics in philosophy. The mental representation of architectural knowledge is structural. However, analogical relational models, such as trees and rhizomes, formalize the structure through imagery.

A positivist design process education tends to predetermine the boundaries and rules of the entire process. It considers the limitations of the metaphors it will use. In architectural practice, constraints are defined as the data that determine the range of possible design solutions and form boundaries. Interpretations made through metaphorical language (i.e., contextual design language) allow for novelty and creativity within the flexibility of the rules, where mastery of the languages used in interpretive transformation and expression during translation/mediation is sought. This flexibility can stem from contextuality or instructionality but is also shaped by conventions in dialogues between learners and teachers, according to learners' levels of consciousness.

In the architectural design process, the level of consciousness becomes important as the network relationship between layers of information expands. Within the paradigm of language games, the relationships and interpretations between layers are approached within a framework of restrictive rules and constraints based on logical propositions, rather than on the relationship between historicity and spirituality.

According to text and dialogue models in a hermeneutic context, the expression of a holistic entity in discoursive formations that progress through dialectical relationships is the externalization of the conceptual and imaginal mediations of the mind. It is also the transformation of vital liveliness into technological mediations (dispositives) in modern societies with worldly orientations. Foucault (1998, p. 18) describes these technologies as follows: 1) production technologies that produce, transform, and direct things; 2) sign system technologies that allow for signs, meanings, symbols, and references; and 3) power technologies that determine individuals' behaviors, subjecting them to various outcomes or dominations and enabling the objectification of the subject. Moving away from the anthropocentric understanding of sign system technologies conveyed through linguistic mediation of discoursive production causes humans to become alienated from themselves through production technologies. The conceptualization of power technologies as "algorithmic governance" (Rouvroy & Berns, 2013) creates an existential crisis.

As linguistic structures become artificialized at the individual and societal levels of consciousness, the interpretability of natural linguistic communication, as well as the knowledge of reality subject to linguistic translation and coding, becomes increasingly complex. The complexity and volume of algorithmic data produced and readable by artificial intelligence make human intelligence's reading and interpretation mechanisms inadequate. Conversely, artificial intelligence's ability to produce, encode, and interpret is limited by the way information is processed and represented. Cybernetics or informatics, broadly speaking, focuses on humans as active agents within social and systemic networks. While it traditionally examines control, feedback, and regulation in complex systems, it also addresses the planning and organization of human activity. As language increasingly functions as a medium of information exchange, artistic practices can be understood as structured modes for organizing and conveying information. Contemporary thought increasingly questions classical dualistic oppositions, such as human-animal, matter-life, and spirit-human, along with their traditional hierarchical roles. In this context, informatics can be interpreted as a “philosophy of difference”, drawing its efficacy from speculative thinking that prioritizes connections over substance and difference over identity (Karatani, 2006, p. 65).

In architecture, artificial intelligence has difficulty producing and representing design, philosophical, and technical knowledge in a holistic and pedagogically comprehensive manner. Architectural design is a form of representation within the field of architecture. However, in holistic approaches, architectural knowledge is explained and understood through interdisciplinary transfers of knowledge about the relationships between things, as well as through its representation and processing in symbolic logic and coding systems, calculation, and connectedness. According to Wittgenstein, the limits of language are the limits of the world. In other words, when something appears and is presented, and then re-presented linguistically, the knowledge and formation of that thing are transformed in the process. An example or precedent of that thing is created. Architecture is the technical knowledge of how these representations (types, precedents, cases, etc.) will be organized. The goal is to store representational knowledge about human-made architecture (artifacts) in natural or artificial memory and derive new knowledge.

The architectural design universe must prepare for an algorithmic process that determines what is selected and processed(causality), how it is processed (functionality), which operations are performed (necessity), and why(requirement). However, from an ontological perspective, the logical error lies in first-order predicates and the knowledge of the relationship between entities (Zambak, 2025a). Thus, transitivity between relationships becomes impossible.

When establishing an ontology of knowledge, the ontology of entities and their relationships must be "representable in the machine[24]" (rather than in the mind). Knowledge is represented to retrieve information, compute knowledge, produce new knowledge through reasoning, and reprogram[25] operations according to input information.

Mental reflection, intuition, and the dynamics of creative processes in architectural design are expressed and communicated through natural language(behavioral, discoursive) via human abilities such as perception, memory, planning, abstraction, problem-solving, and learning. Similarly, based on Wittgenstein's ontological status of language in the Tractatus, human physiology can be mathematized and transformed into processable symbols, as Newton demonstrated. An entire phenomenon can be symbolized, processed, explained, and understood. The arithmetic of reasoning operates through mechanical processes, just like a machine. It can be transferred to a machine, and mental abilities can construct cognitive abilities. In this process, two forms of functionalist thinking emerge in machine intelligence: computation and connectionism[26]. Rather than a symbol corresponding to an entity, an entity consists of a sum of sub-symbols that lack attributes. While computation establishes rules based on symbols, connectionism does not interpret the symbols or the operations performed (Zambak, 2025a).

Furthermore, beyond representing thinking, it interacts with its environment in the form of robotics, representing an agent's perception, and uses its cognitive abilities. Currently, agent models[27] based on language (e.g., ChatGPT) are connectionist in their organizational abilities. The main problem is the multidimensionality that arises when creating an attention layer regarding how things are connected in a language-based system[28] (Zambak, 2025a).

3.4.1. Non-representability in artificial intelligence from the system perspective

The absence of a standard theorem for defining relationships between entities calls into question the scientific nature of the research field. Due to the system's non-redundant structure, perspectives that include unexplained and unproven gaps must be developed. The goal of programming is to represent things that cannot be explained by measurement or observation within the system's overall perspective[29].

An autopoietic system exhibits self-organization that is not random, but rather sustainable and adaptive. It is built with flexible frameworks that establish new connections, which is referred to as plasticity[30] in neuroscience. The order in which processed materials are operated on determines whether change or the process created by plasticity in connectivity takes precedence over structure. From the perspective of living systems and the human brain, it is seen as the self-organization of matter (e.g., mechanistic, arithmetic-linear, and nonlinear-dynamic). However, due to the inadequacy of mathematical language and the inability of entities to undergo mathematical operations, the plasticity of memory and learning cannot be modeled[31] (Zambak, 2025b). In transverse modeling problems, the hypothesis is revised by attempting to probabilize the possible outcomes, but there is no equivalent in the connectionist model. However, network relationships, such as direct, transitional, linear, identity, circular, and topological relationships, (graph theory), can be represented by lines between nodes. The relationship between plasticity, functions, and operators cannot be modeled[32] (Zambak, 2025a).

While all representation models are generated by general intelligence, artificial intelligence attempts to formalise models of linguistic and logical expression of information representation. However, one of the greatest challenges in neuroscience is observing and grading the conscious and unconscious conceptual representations of inexpressible, abstract sensations and emotional thresholds at ethical and aesthetic levels.

In the context of problems relating to quality, subjectivity and experience (phenomenology) versus functionalism, machines can learn the differences in the calibration forms (a priori experiences) of common parameters as perceived by different personalities (such as Alice in Wonderland). Nevertheless, despite the testability of solvable problems (the Turing test), the real issue lies in the existence of unrepresentable theorems due to the inadequacy of mathematics (Gödel's incompleteness theorem), for which there is no known solution[33]. While the representability of values and the representation of the ethical-aesthetic paradigm are cognitively possible with artificial intelligence, the question remains as to whether holistic and democratic governance is feasible. Therefore, the problem lies in not knowing (explanatory gap) what type of processing the data[34] will undergo (e.g. number or letter data type) or what its attributes are (i.e. what it is connected to or its context) (Zambak, 2025a).

3.5. Algorithmic Processes and System Perspective in Architectural Design

When rationalising the interpretation process in architectural design, decision-making processes are viewed as linear paths with beginnings and ends. In cognitive science, this also includes problem solving. By reducing possibilities and increasing traceability through the division of problems into sub-problems, a fundamental path is formed to ensure optimal thinking (information processing) and artificial intelligence programming (Rowe, 1987). Within the scope of the problem space, the system reveals the algorithmic structure of architectural design as a solution to a problem and the spatial structure of architectural design as a combination of divergent and convergent thinking. Intuition is similar to divergent thinking, while logic is similar to convergent thinking. The spatiality of the model shows similarities with formalisations in different disciplines. For example, Wittgenstein's Frege-based logic involves a world-language association whereby names resemble points when describing states of affairs and sentences resemble lines or arrows (Soykan, 2006, p. 66). During Wittgenstein's second period, the relationships created by the rules of grammar in language games resemble lines in everyday language, while points resemble life forms. Another similarity can be seen in cognitive science, in connectionist and symbolic thinking models (Holyoak & Spellman, 1993). In the connectionist paradigm, points and the relationships between them represent influence-response relationships between neurons. In symbolic thinking, which includes metaphorical thinking, points represent things, and the referential and similarity relationships between them formalize conceptual maps and other structures, as well as comparisons between parts.

In Notes on the Synthesis of Form, based on behavioral psychology, Christopher Alexander (1964) provides common control over the activities of the design process. After outlining the requirements, Alexander explores their interactions and suggests a method based on the criteria of simplicity, performance, ease of construction, and economy. Using a computer-aided calculation method, the desired elements are divided into independent sets, which breaks the problem down into sub-problems, ultimately arriving at the best solution. Understanding design as the optimization of inputs and outputs according to needs in architectural form reveals an objective, mechanistic, information-processing perspective.

The complex processes of architectural relationships holistically identify the design object within the urban context, producing two structural models that illustrate the systematicity and hierarchical structure of the city's ontology. Sayın (2007, pp. 38–42) describes the first model using Alexander's (1965a; 1965b) tree metaphor and the second model using Deleuze and Guattari's (2023, p. 13) "rhizome" metaphor (Figure 2).

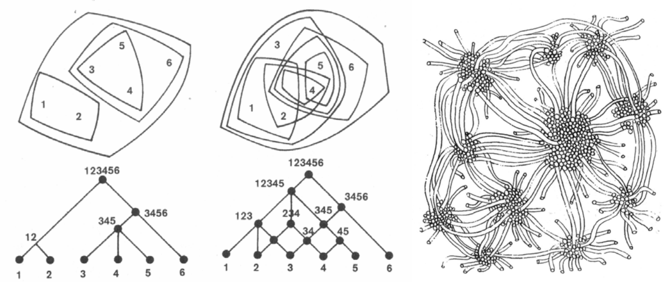

Figure 2. Tree and Rhizome. The diagram on the left is a model of Christopher Alexander's parametric architectural design concept, which exhibits characteristics of both trees and lattices. The diagram on the left represents a tree, and the diagram on the right represents a rhizome (Karatani, 2006, pp. 74–75; Kurokawa, 1991, p. 33).

According to Lawson (1990, pp. 88-93), design problems cannot be expressed comprehensively, but rather, they tend to be organized hierarchically. This gives rise to certain ontological limitations: an infinite number of solutions cannot be optimized. Design inevitably involves subjective value judgments. Lawson (1990, p. 104) argues that, in his experiments, architects discovered the structure of a problem through the order of their solutions. Therefore, the analysis and synthesis stages should not be separated.

In these models, two dimensions emerge regarding the limits of the system perspective and the order of its internal relationships. The boundary is formed based on the previously defined form-content relationship and understanding of open and closed systems. Depending on the regularity and characteristics of things, the system can become closed or open.

This gives rise to two possibilities: 1) A limited, self-multiplying network of relationships within the closedness and infinite differentiation of the system, and 2) an open system that projects outward and establishes relationships with different patterns that multiply in continuous expansion, even if not concentrated within itself. This model describes the image of the information process (system perspective) from a viewpoint oriented toward temporal and spatial aspects at a given moment.

The discussion section raises issues relating to architectural design, artificial intelligence, representation and language. The intellectual interpretation of architectural pedagogy on hermeneutic, ontological and technological bases relates to artificial intelligence research and contemporary holistic reading. Comprehensive pedagogy, accompanied by ethical and aesthetic understanding and sensitivity, enables consideration of new ontologies and ecologies. Thus, the conceptual framework of holistic and contemporary interpretations and readings can explain the formation of architectural discourse, as well as its limitations and expansions.

In the conclusions and recommendations section, despite ethical and aesthetic criticism of intellectual interpretation, the openness, discoursive clarity, and creativity of structural, systematic, and conceptual dynamic frameworks that model the system perspective in artificial intelligence research in architectural design will be described.

4. Conclusion and Suggestions

Concluding the chapter with an ontological conclusion after an ontological introduction reveals that the holistic interpretation and reading of the issue of comprehensiveness in architectural education pedagogy and its representation in language-based contexts are approached using cartographic methods and move transversally. Actors in architectural discourse — designers — individualise themselves in the communication environment as learners in both subjective and historical enactment, becoming agents of the design event.

The boundaries of interpretation in the semiotic field expand from gestures to the non-linguistic, alongside the problems of dialogue and speech in language or textual expression. This opens up to the symbolic and the imaginal. Conversely, while aiming for the clarity and distinctness that brings an end to infinity, language representing new phenomena encountered in meaning becomes metaphorical. This creates polysemy as it attempts to translate the unknown or unrecognisable alienness into the familiar. Interpreted reality is the theoretical explanation of practice tested in experiments and questioned externally. In interpreting reality, the originality and relativity of the experiential (both mental and physical) can only be expressed through creative diversion or artistic activity. From a philosophical perspective, guidelines are explained through visuals combining natural language texts and geometric patterns that facilitate spatial reasoning. In artificial intelligence, the focus is on evaluating the functional relationship between inputs and outputs rather than modelling the mind.

4.1. The Ethical-Aesthetic Field and New Ontologies in the Evolution of Interpretive Approaches

In the individualization process expressed at the end of the introduction and within the dialectic at the end of Section 1.6.2, "Can we transcend language in difference-based discoursive formations (negative dialectic)? Does consciousness of the essence, defined linguistically or structurally through the transformation of language, exist in the non-dialectical? In response to these questions: Section 1.6.3 affirms formation with textual multilayering (bricolage), deconstructing and transforming the existing philosophical/conceptual structure into a more comprehensive new conceptual structure. This establishes non-dialectical, structural relationships in which the essence is questioned and the unconscious is decisive.

On the representational plane, formalism conceives of form as an example of the object and its meaning as a model or interpretation of form, focusing on entities rather than relations. A formable thing transcends a closed, self-referential formal system by being representable in a language or mathematical system that does not yet exist. Despite the formalism of current knowledge representations in theory and practice, poietic/creative formalism of knowing by doing (praxis) must be representable simultaneously in a mathematical system. Conversely, the representability of formalism is limited by the actions of the mind and body and the processes of their abilities while performing an action.

The problem of formalizing semantic or value-based content becomes a study that addresses the question posed in the Materials and Methods section: "Can pedagogical comprehensiveness, which brings an external, worldly critique to architectural design, formalize architecture as an applied art?" It becomes clear that the answer lies in a post-theoretical critique. In this context, theoretical and practical discord in the ethical and aesthetic realms of architectural pedagogy is possible only through a formalization that can mathematize and simulate the poetic/creative process of making and being.

Ethical and aesthetic formalization goes beyond representability toward the non-representable: becoming or emergent events that "naturalize by becoming complex." In onto-political (Yokuş,2024) positions that break away from representational and identity-based formalism, individualization leads to alienation and a loss of identity. The limits of the individual's potential are experienced through actualisation.

At the beginning of the "Finding and Discussion" section, “Can the dissolution of the linguistic structures of deep thinking and learning serve as a vehicle for actualizing the (virtual) unthinkable?. The answer is that the formalization of actual is limited by the capacity of human intelligence (general intelligence) to instrumentalize artificial intelligence and produce and record information.

The "media-technical" architecture of a new materiality, governed by algorithms (algorithmic governance), is the reality in which a world simulation of an unmediated singularity can only be created by organizing artificial intelligence with general intelligence capabilities.

Holism is a method of approaching and theorizing about something that cannot be encompassed or circumscribed by any thought, that cannot be formalized, and that can only be experienced or explained externally to the extent that it can be reduced in thought. Today, information about architecture's capacity for formalization, the critique of the use of dialectical reason, the interaction between human and machine intelligence, and the critical position between individualization and the inability to individualize can obtain data on its critical position and read the data by inventing it (Sayın, 2024, pp. 123–129).

Beyond knowing, understanding, and explaining through interpretation, the section expands the pedagogical comprehensiveness of architectural education in an ethical-aesthetic context. Attempting to relate architectural design to non-dialectical, algorithmic processes from linguistic and imaginal dialectical thinking processes raises philosophical and methodological questions regarding artificial intelligence and the design process.

4.2. Philosophical Methodological Problematizations from the Perspective of Artificial Intelligence Research

According to Zambak (2022), an ontological classification of states that transcend dualities (e.g., full-empty, part-whole, type-kind, mind-body) must be standardized, formalized, datafied, conceptually framed, and represented in machines.

- In defining data ontologically, the inadequacy of computer architecture (i.e., von Neumann architecture) and mathematics is paramount.

Currently, knowledge representation focuses on how elements are juxtaposed, separated, and synthesized; the discovery of knowledge; and knowledge production practices. Computer technology collects data at the digital "bit" level. Collected data, including macrocosmic data at observable distances and data at subatomic and biological DNA dimensions, can only be modeled operationally. Therefore, only data on existing entities can be formalized.

- The machine must produce knowledge by interpreting and representing it through the invention of new relationships.

The production and processing of context-specific information by transversal information theories brings agent-based information theories to the forefront. Machine intelligence is necessary to process the intensive information obtained. For instance, comprehensively and rapidly reading (literature base discovery) and interpreting generated textual data from academic platforms can only be done using research platforms (Zambak, 2022).

From a philosophical perspective(Zambak,2022)., the debate on scientificity (Kuhn, Popper, and Lakatos) regarding models, theory building, and explanation continued in the 20th century. However, the comprehensiveness of the model is problematic from an information processing perspective.

- In the 21st century, collecting and processing different, unobservable data spread over time without computers is impossible. Radical changes related to artificial intelligence are required in the scientific practice of producing, distributing, and processing scientific knowledge[35].

In set theory in mathematics, entities take precedence over relationships. However, there is a processual conception of the world consisting of facts (relationships between things), in which relationality precedes entities and is greater than the sum of the things.

- The priority of discourse over words and the relationality of meaning, which extends beyond its "processual" and "contextual" nature, necessitates the capacity to establish relationships between relationships (e.g., morphisms in category theory), a capability that the human brain and sociality possess.

From a philosophical perspective, Wittgenstein (1985) has attributed an ontological constitutive role to language that extends beyond communication models. This offers the possibility of signifying and coding the world.

- While syntactic, semantic, and pragmatic theories help us understand language, artificial intelligence requires language models[36] that can work together and converge based on relationality in language. This concept is rooted in the idea that language has the "capacity to represent something" (dependency grammar, etc.).
- From a philosophy of mind perspective, rather than considering mind-body dualities, qualitative/quantitative dualities, or functional/nonfunctional dualities, models are needed that have interactive and organized intelligence capacities capable of providing feedback and that possess cognitive abilities such as language use, memory, learning, and perception.
- Every living or non-living thing interacts with the world as an agent according to its cognitive or data-processing capacity. Rather than taking categorical and conceptual (Kantian) approaches to the mind (e.g., modularity theory, Jerry Fodor), these approaches should be grounded in agent-based models.
- Issues of spatiality and temporality in the aesthetic field need to be discussed. Starting from productions specific to a particular person or style, issues of originality in creating visual, textual, poetic, and other works in styles, as well as public relations (PR) issues, are open to discussion.

Machine or deep learning models that lack an explanatory structure (e.g., x-AI) can only perform one task when taught rule-based operations. However, these models cannot generate tasks or models (e.g., distinguishing between images of two objects). Furthermore, it is impossible to explain what constitutes success in terms of skill, interpretation, and reading. The mathematizability of style may be decisive. There is debate about which differences arising from life and sensory experiences related to creativity could be meaningful from an artificial intelligence perspective (Margaret Boden, Writings on Machine Creativity) (Zambak, 2022).

Ethics, transhumanism, and representative systems in singularity issues create ethical problems (Yavaşi, 2025). Practical problems arise in the ethical use of artificial intelligence, such as problems related to democracy, intersubjective relationships, algorithmic governance, control and power mechanisms, and power and discoursive production (Foucault, 2015). The cause and responsibility for possible errors in the decision-making mechanisms of autonomous structures based on machine learning are unclear.

The problem with sciences that have become independent from natural philosophy is that philosophical conceptual frameworks are insufficient to explain phenomena. Ontology also diverges in this context. John Searle's (1980) Chinese Room argument, developed against the Turing Test, is an attempt to go beyond imitation by using machines to perform mental processes and cognitive abilities within an organization. This pushes the boundaries of general (strong) and limited (weak) artificial intelligence (Zambak, 2022).

These shortcomings and requirements demonstrate the differences between general (human) intelligence and artificial intelligence. Therefore, learning, discoursive formation, and formalization of general and artificial intelligence through information processing describes the transversality of cartographic reading. In architectural education, it is suggested that, in terms of comprehensiveness, design is a technical form of representation and the resulting design knowledge is formalized in an ethical-aesthetic pedagogical formation that has expanded and matured.

As stated in the introduction, we are still obliged to communicate, calculate, interpret, explain, and make sense of linguistic (natural) or language-based (artificial) systems that simulate the framework and transversality of this cartographic reading.

4.3. The Formalization of the Interaction Between Culture, Nature, and Architecture in Structuralist and Neuroscientific Fields

According to structuralist approaches such as linguistics, semiotics, and ethnology (Yücel, 2020, p. 69), it is impossible to identify the structure of natural language with the structure of society. According to Lévi-Strauss (Yücel, 2020, p. 70), there is a connection between the "homogeneous expressions" of linguistic and social structures, not between language and behavior. However, different languages can coexist within the same social order. The issue at hand is the form of the system/structure of the linguistic (objective) aspect of language — its social dimension — and the "word (subjective)" phenomenon — its individual realization. From the speaker's perspective, language does not have a sense of historical sequence. Rather, it is described and interpreted in a functionally evolutionary and synchronic state. According to Saussure (1916, Course in General Linguistics), "the diachronic dimension is the superimposition of the synchronic dimension" (Yücel, 2020, pp. 29–30) [Syntagmatic (horizontal, sequential) — paradigmatic (vertical, syntactic)].

Each element is part of a synchronic integrity. In a structure where everything gains meaning in relation to the entity, meaning and value (the signified) are determined. There are contrasts between the singular object/word (signifier) in use, formation, and structural phenomena (conceptual background). To reach the conceptual structure, a continuity/flow that allows it to remain identical to itself must be achieved in discoursive formations.

Connecting to things outside of one's own existence (madiation) and transcendence creates a "meaning" problem. Form contains meaning, and meaning contains form (Hjelmslev). Unless meaning is defined on the linguistic plane, it remains unresolved data, an "unformed mass." Each time, meaning becomes the essence of a new form. Furthermore, content that is independent of form establishes a numerical relationship with meaning, making meaning the essence of content (Yücel, 2020, pp. 51-52).

Levi-Strauss develops his works The Savage Mind and Mythologiques through the analysis of the nature-culture opposition. Culture is defined by selectivity, separateness, and codification. However, while standing in opposition to nature, culture transforms nature to create new combinations and takes its place. Culture denies and divides nature in an attempt to create a void from fullness. However, nature only appears to be denied through cultural limitations. Nature and culture are reconciled through gradation in myths (Yücel, 2020, pp. 85–90). In the relationship between nature and culture, the divisiveness of humanism and the unifying nature of post-humanism allow the cultural and natural aspects of architectural tectonics to emerge. Alternatively, architectural tectonics can become independent of culture and nature, resulting in new artificial forms.

Contrasts can be identified and determined in different ways within different narratives and discoursive formations. More complex fields of meaning and imagery can be articulated at several semantic levels. The forms of activity of architectural practice and thought are determined. However, it is the reduction and fixation of the vitality of the design process and its essentiality, as well as the verbal nature of hypothetical interpretations, that create a meaningless, dead form or representation. When priority is given to form, only form can be understood. Content becomes a meaningless remnant. However, form is the arrangement of local structures that constitute content within the structure. Logical relationships are independent of narrative. As Piaget stated, just as causality is determined by laws in physics, the state of phenomena is determined by structure in structuralism. Since structure, like laws, cannot be directly observed as data, it must be constructed in the form of logical examples. The contingency of design (event) must be separated from scientific necessity (structure) (Yücel, 2020, pp. 101–102).

In any case, the linguistic turn has long been incorporated into more complex research attitudes in the study of culture. These attitudes have gradually broken up the initial exclusive fixation on language and discourse (Bachmann-Medick, 2016, p. 60). In Sayın's (2024, pp. 93-97) architectural criticism within the cultural turns, the emphasis on the linguistic and spatial aspects particularly directs this section toward the digitization and interpretation of linguistic and semantic structures interpreted in cultural criticism of architectural education through artificial intelligence. In the interaction between architecture and culture-nature, the cartographies and transversality achieved by the pedagogical discourse of architectural education shape the field where new ecologies and ontologies established by architecture culture with nature are realized. Therefore, discoursive fields can be interpreted based on the new knowledge ontology that is emerging from artificial intelligence research on the relationship between architecture, culture, and nature.

The expanding field of cartography and critical positioning in architectural design is structured by general (human) and artificial (connectionist model) intelligence. This determines the intensity of individualizations related to learning in architectural design education pedagogy. In this case, the agents are human intelligence, machine intelligence, or transhumanistic (human-machine) entities.

Through brain research, the conception of human beings is transformed, and a dialogue is proposed between the neurosciences and the humanities, focusing on "reflexive neuroscience" through transdisciplinary collaborations with psychology, philosophy, and cultural studies. (Bachmann-Medick, 2016, p. 286).

The category of translation that studies human thought and action in relation to brain structures and social dimensions can be found in the interdisciplinary collection the neuroscientific turn (Littlefield & Johnson, 2012). The humanities are increasingly viewed as pragmatic action sciences, focusing on cultural practices and forms of perception, not just text. The digital turn is merging with the material turn. After all, as human beings push up against their limits and become increasingly dominated by technology, the material turn in science studies has taken on a particularly illuminating role. It provides insights into the interaction between human actors and nonhuman agents, such as things, instruments, and technologies (Bachmann-Medick, 2016, pp. 287–289).

4.4. A Cartographic Reading Proposal: Between Structuralism and Connectionist Networks

In a model where neuroscience and the humanities engage in dialogue, a conceptually meaningful relationship is proposed between structuralist linguistic diagrams, such as Greimas's Semantic/Semiotic Square, and connectionist networks (Figure 3).

In architectural education, network structures transform into systems through formalist architectural thought, discoursive positivities, and discourse formations concerning architecture, culture, interaction, architectural forms, artificial intelligence, and neuroscientific research. Transversality complicates discourse as actors read the cartographies between the dialectic of linguistic structures and connectivity in non-dialectical (interactional), language-based programming. In the agent-based model, a discoursive or material formation can be simulated. There may be explanatory gaps in the reading, as well as possible over-actualisations.

First, we will establish a comparative perspective in diagramming aimed at modeling the system perspective of architectural design in artificial intelligence using the dialectic of Greimas's logical structure of linguistic meaning and the semantic learning and representation of connectionist network structures.

4.4.1 Greimas diagram (semantic square): The logical structure of linguistic relations and semantics.

Greimas's model illustrates how meanings (signifieds) develop within a reflexive, dialectical structure (signifiers) by contrasting or relating concepts. The model is a tool used in the structural analysis of relationships between semiotic signs and the expansion of relevant ontologies through the opposition of concepts. Greimas (1983) published it under the title Structural Semantics: An Attempt at a Method.

For the basic categorical elements, e.g., Figure 3, Krauss (1979) S: Architecture ~S: Opposite of S: Landscape. S: The negative of S (non-architecture)¬S: The negative of ~S (non-landscape). The concepts of architecture and landscape create a semantic field through their relationships of contradiction, opposition, and implication, which generate opposite possibilities and uncertainty. According to Gerimas, opposition is a negative line, while contradiction is a positive line (Yücel, 2020, p. 138). Analyzing a semantic universe with a semiotic quadrangle that complements and derives from each other creates expanding semantic structures.

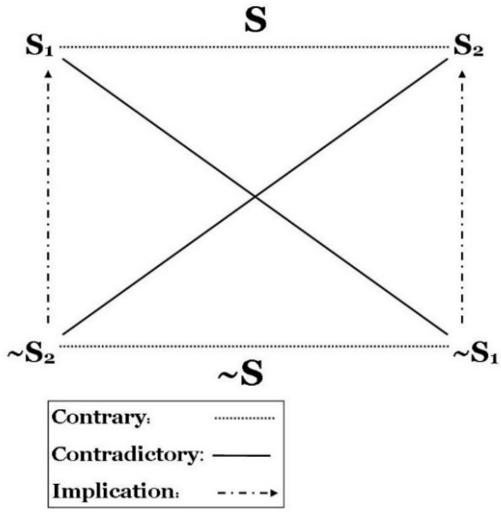

Figure 3. Semantic Square (Greimas,1983)

In her article "Sculpture in the Expanded Field" , Rosalind Krauss (1979) discusses how the characteristics of sculptures since the 1960s have obscured the definition of the category. She relates contradictions between architectural and non-architectural elements, as well as between landscape and non-landscape elements, to the definition of sculpture. Krauss interprets sculpture within an expanded category. In the diagram (Figure 4), sculpture is associated with architecture and divided into non-landscape and non-architecture. Sculpture becomes a kind of ontological absence, a combination of exclusions. Thus, sculptural art appears suspended. Sculpture ceased to be positive, resulting from the addition of not-landscape to not-architecture. Attention began to focus on the outer limits of those terms of exclusion. Kraussian approach, which seeks the possibility of hybrid conceptualizations. In this way, considering that modern processes cannot be defined only by the relations; rather by hybrid paths of their non-‘s (non-architecture, non-landscape), the reproduction of the Kraussian diagram might be expected to make possible highly plural and hybrid conceptualizations (Kılınç & Tercan, 2024, p.280). This expansion is referred to as a Klein group[37] in mathematics and has various other names, including the Piaget group[38], as used by structuralists involved in mapping operations within the human sciences (Krauss, 1979, pp. 36–37).The expanded field is generated by problematizing the set of oppositions between which the modernist category of sculpture is suspended. Through this logical expansion, a set of binaries transforms into a quaternary field, which mirrors the original opposition while simultaneously opening it. This creates a logically expanded field (Krauss, 1979, p. 38).

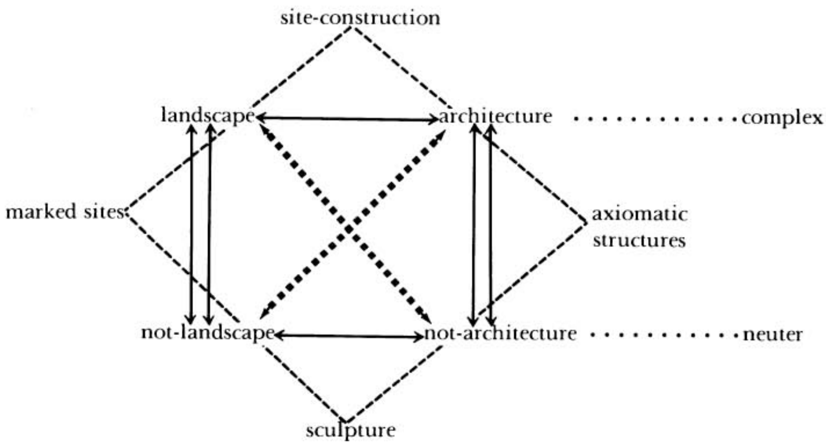

Figure 4. Sculpture in the Expanded Field Diagram (Krauss, 1979.s.37).

Krauss (1979) applied semantics, which was later based on Greimas (1983) and referenced Klein and Piaget groups. The semantic conceptualizations formed by the concepts of form, formal, formalism, and formalization emerge in the section on the expanded field of architectural discourse. These conceptualizations are interpreted in the semantic square (Greimas) through the negative and positive logical relationships established between new ontologies, such as posthumanity (Donna Haraway, Rosi Braidotti), that defend the unity of culture and nature. Transhumanity and new materiality are also included. The logical relationships (negative and positive) established between these new ontologies and architectural tectonics are interpreted in the semantic square (Figure 5).

According to Greimas's semantic logic, entities subject to culture-nature coupling that can be termed architectural tectonics cannot be clearly or unambiguously named. Therefore, they are implicative or subject to implication. Architectural tectonics and culture-nature coupling are contrary to each other. New ontologies and notions of ecology can be applied to the semantic square. In the diagram, while 'human' or 'humanity' and 'post-humanity' are contrary, there is a contradiction between 'non-human' or 'new materiality' and 'post-humanity' notions. Similarly, it is thought that there are contradictory semantics between 'human' or 'humanity' and 'trans-humanity'. Within the expanded field of architectural discourse, a limited semantic structure is formed between form (material) and formal (language), as well as between formalism and formalisation. The logic of the semantic structure operates with syllogistic/classical and rationalist formalism between architectural tectonics and the coupling of culture and nature. While architectural tectonics and the culture-nature coupling works representatively and functionally, moving from the natural (neuter) to the complex, modern logic (Frege) and modal logic (Kripke) complicate the semantic square. Thus, architectural discourse can be formalised and realise itself through emergence. This holistic emergence or simulation can be experienced mentally and observed physically/bodily.

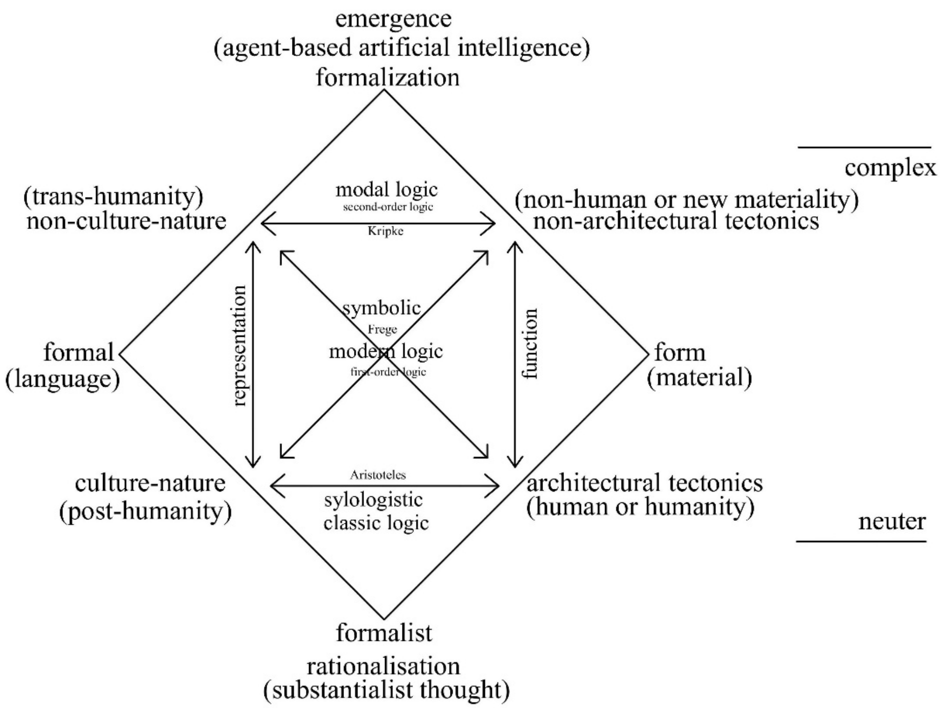

Figure 5. Architectural Discourse in the Expanded Field (Created by the author)

4.4.2. Connectionist networks (artificial intelligence networks): Semantic learning and representation

In artificial intelligence, connectionist networks (e.g., neural networks) use multi-layered, interconnected nodes to learn and represent information. Each node represents a concept, feature, or pattern. Connections (weights) change during learning. Hidden layers are responsible for abstraction and generalization. The goal is to learn and reproduce relationships between concepts in a statistical and pattern-based manner.

In architectural design, discoursive formations can be formalized with connectionist networks, shifting from cartographic interpretations and dialectical positioning toward non-dialectical, agent-based enactments. The comparison between Greimas's linguistic structuralism and artificial intelligence connectionist networks is shown in Table 1.

Table 1: Comparison of Greimas's dialectical logical structure of linguistic meaning with the semantic learning and representation form of connectionist network structures (Created by the author)

Concept	Greimas (Linguistic Structuralism)	Connectionist Network (Artificial Intelligence)
Basic Unit	Conceptual opposition (S vs. ~S)	Neuron / Vector component
Type of Relation	Semantic / Logical connection	Numerical / Weighted connection
Meaning Production	Opposition and negation relations	Activation patterns and generalization
Development	Dialectical transition	Learning and optimization
Connection Type	Necessary logical	Probabilistic learned connection

Neuroplastic connectivity emerges where the network structure intensifies and relationships evolve through learning. Thus, the discourse field expands through dialectical conceptualizations and interpretations established by thought reflections, transforming into a network structure in which non-dialectical learning and neuroplastic connectivity emerge, and living system perspectives are formalized. However, the complex components of data, hardware, humans, institutions, and environments interacting cannot be known as in a simple technical model of artificial intelligence with input and output layers (see section 4.2). Nevertheless, this paper presents a speculative system perspective with reference to a connectionist network formalization in an expanded field diagram (Figure 6).

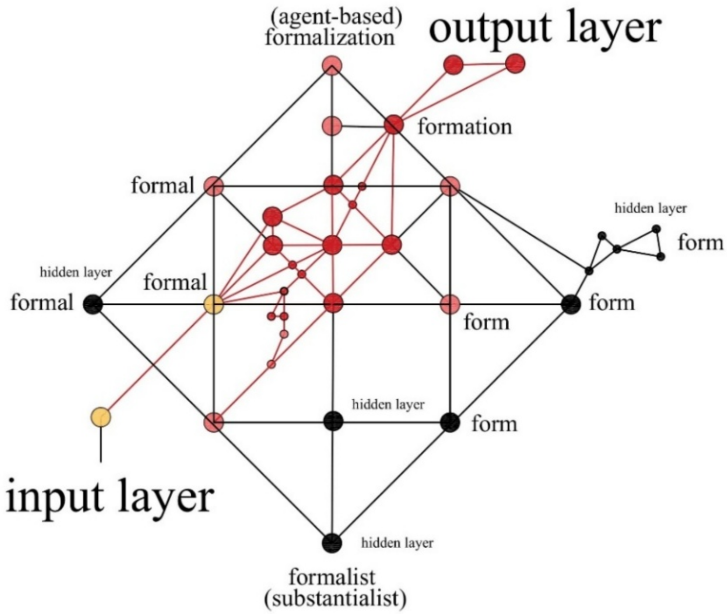

Figure 6. System Perspective of a Connectionist Network Formalization in the Expanded Field (Created by the author)

4.5. Discoursive Formation of Architecture in the "Expanding" Field.

The ontological regularities, rules, and conditions that establish a specific field of knowledge within architectural discourse (discoursive formation) and the historical existence of discourse—its "factual presence"—are extended in everyday language and dialogue. The intuitive, creative, and reflexive processes of design are rationalized within a formal linguistic environment of nature-culture interaction. Tectonic culture (Frampton,2001) materializes the interplay of forms that constitute expressed architectural tectonics. In the context of new ontologies and ecologies that do not accept the distinctions between culture and nature today, the operation of the dialectic between humans and post-humans manifests as indeterminacy, the critique of reason, and its naturalization (neuter) (Figure 5).

In the modern system of thought, or humanity, nature is generally constructed as a passive resource while humans are constructed as privileged subjects who control nature. This distinction has been decisive, both ontologically and in terms of ethical, political, and spatial representations. Posthumanist theories question this human-centered framework and propose establishing a new relationship of reciprocity with nature; they develop an ethical understanding that expands the boundaries of representation and subjectifies non-human entities (Yavaşi, 2025, p. 52).

Unlike Krauss (1979), it is thought that architectural discourse will not be approached as a system that becomes complex from nature (neuter) within the context of tectonic culture (Frampton,2001); rather, the mind's simplifying and analytical efforts within the nature-culture entanglement are evolving into an increasingly complex structure with the development of artificial intelligence research. Interactional and non-dialectical processes, referred to as "algorithmic governance" in the chapter, can be designed and predicted as a control mechanism that functions positively or negatively. As new possibilities and formal languages emerge in artificial intelligence programs, events and simulations that cannot yet be formalized at the logical and formal levels will appear. The chapter formally demonstrates how the culture-nature entanglement works. Architectural discourse is formed in historical and logical contexts. Conversely, new materialist approaches consider nature-culture hybrids that can be programmed as agent-based networks (Latour's actor-network theory), achieving discoursive "formalization" through schematics and relationality. Thus, artificial intelligence actively formalizes and activates discourse formation (Bruno Latour) and brings it out of passivity (Michael Foucault). Parametric design and ecological modeling tools shape nature-culture interactions at the algorithmic and schematic levels.

The historical discourse and archaeology of the logic and functioning of relationships between things today (formalization) address how the unity of nature and culture is established at the philosophical-ontological level (formation), how it diverged and stabilized (positivity) as an ontological reality in modern epistemology (17th-18th centuries), and how it became conceivable (reflexivity). Ontological models, such as those of Philippe Descola, Viveiros de Castro, Bruno Latour, and Alain Badiou, act as ontological grammar-level actors for all human, animal, and object entities. Badiou formalizes this concept using mathematical sets, which are inadequate for artificial intelligence studies. As complexity increases, a new materialist relational pluralism emerges where the formal essence of merging and separating mind, nature, and machine—such as transhumanist transitions beyond nature-culture, cyborgs, and companion species (Donna Haraway)—is questioned. In this context, Haraway's concept of "response-ability" is central to relational ethics. According to this concept, ethical responsibility arises not only in moments of conscious decision-making, but also through the capacity to respond to the existence of others in a continuous state of relational becoming (Haraway, 2016, p. 14). According to Haraway, the ethical subject is not merely defined as a being that makes decisions or establishes order; rather, it is defined as a process that is affected, transformed, and coexists (Yavaşi, 2025, p. 57).

In formalisation, the fluidity and multi-centred nomadic subject simulated by language-based ontological grammar formalises the 'intra-active' (Barad, 2007) existence of agential-realistic relations between the human and the post-human.

In Romantic discourse, nature is established and exalted for the authentic existence and aesthetic/sensory experience of humans, but in modernist discourse, it becomes instrumentalised by a human-centred narrative. In these discourses, nature-culture and human-material relationships become reflexive formations that can be understood in terms of historical discursive positivities.

A hermeneutic gap arises between formalism, which reveals the rules of the intrinsic form, and formalisation, which demonstrates why and how the form became possible within the context of historical discourse (positivity), expressing the logic of the form at a universal or systemic level. The vertical axis in the diagram requires historical positivity in order to grasp the discoursive conditions of formalist thought. The internal (formal) logic of independent form radicalises formalisation by purifying the form (non-historic and non-contextual). Thus, formalisation is absolutised (Figure 7).

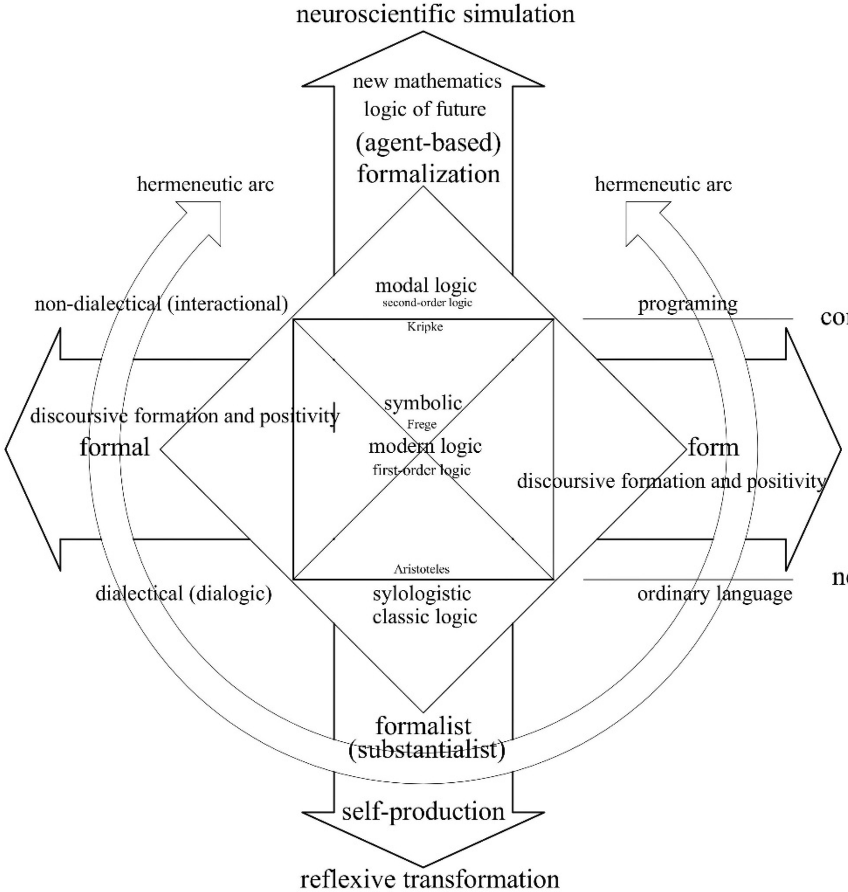

Figure 7. Discursive formation of architecture in the "expanding" field (Created by the author)

4.6. Cartografic Transversalities in the Expanding Field of Architectural Discourse.

In the dialectical cycle of self-understanding that emerges in interpretation, the process continues by closing and opening the translational, cultural and temporal distances that arise from textuality and literacy through appropriation, or self-identification, using imagination. Frege, the founder of symbolic logic and located at the centre of the diagram, is distant from both the author's and the reader's worlds in terms of textual meaning and reference, respectively, due to the 'difference between meaning and reference' (Figure 7).

The design process traverses the cartography of the reading process by establishing these connections through appropriation. Design mediation maps the transversality of the process. Distancing itself from imaginal and symbolic/linguistic readings, the process takes shape through emergent, non-interpretive simulations, expanding alongside interpretive, formalistic constructions. Figure 8 illustrates an imaginative and reproductive cartography, reflecting the weakened, superficial traces of all the intellectual and cultural-technical activities of the design process. These activities are referred to as discoursive formation or positivity and are represented by their trajectories. However, the neuroscientific computability and connectivity of cartography is speculative and descriptive in terms of diagrams. From this chapter's perspective, resulting authentic cartographies cannot be formalised or reproduced; however, they can be copied. The phenomenology of this critical and hermeneutic description suspends the world in a new mode of existence that opens up to creativity (poetics), revealing a cartography that is both negating (non-simulation,non-text,non-dialog) and productive. Returning to the schematic meaning-making of a Greimasian conceptual reading method from a structuralist linguistics perspective therefore allows one to conceptualise similar things from different cartographic positions (Figure 5). In Kantian schematism, a diagram (form) emerges within the context of formal language, where meaning is acquired or designed as an image (Figure 8).

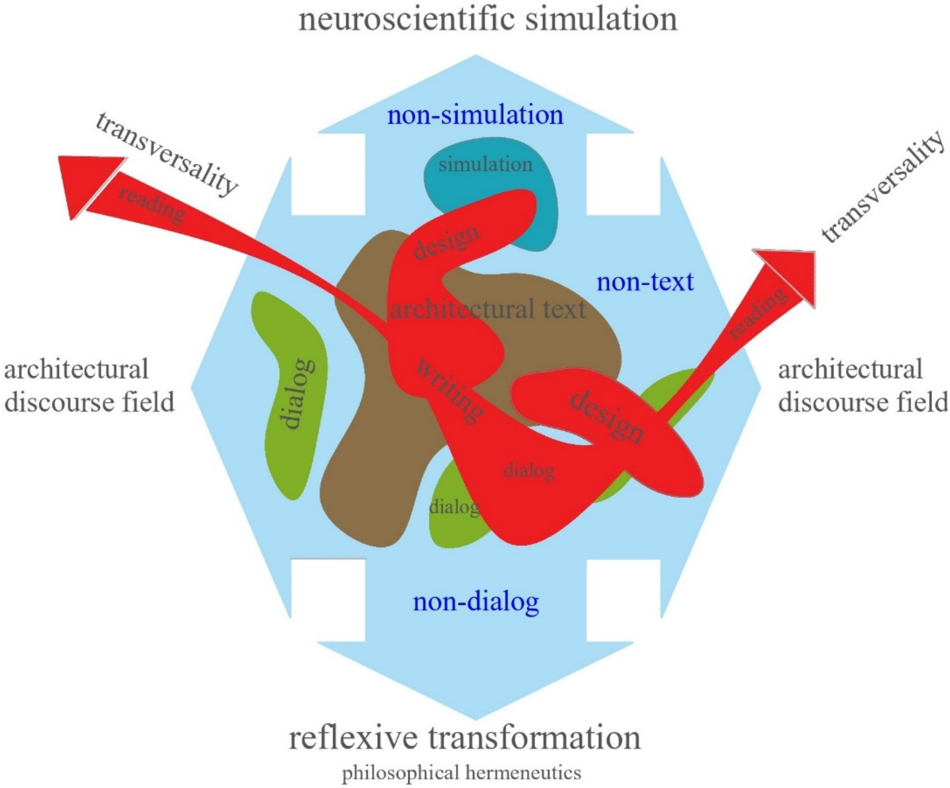

Figure 8. Cartografic transversalities in the expanding field of architectural discourse (Created by the author)

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The article complies with national and international research and publication ethics.

Ethics Committee approval was not required for the study.

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The article was written a single author. There is no conflict of interest.

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[1] Paul Ricoeur develops a three-stage hermeneutic arc: precomprehension, explication, and appropriation. According to the hermeneutic text model that will be seen later, interpretation begins with the reader's precomprehension, proceeds through the basic explanation of the text, and finally returns to the reader for appropriation (Varlık, 2021, pp. 17-23).

[2] Arthur Koestler attempts to define wholeness without creating a part-whole dualism by introducing the concept of the holon. The term is derived from the Greek holos (meaning "whole") with the suffix -on, indicating a unit that is simultaneously a whole and a part within a hierarchical system. In this context, a holon functions both as an independent whole and as a constituent part of a larger whole, avoiding the dichotomy between part and whole.This concept provides a framework for understanding the interconnectedness and wholeness of systems through the interplay of sense perception, concepts, consciousness and unconsciousness, body and spirit, and man and God (Kurokawa, 1991, pp. 43–45).

[3]In the history of philosophy, only fragments of texts survive from the Pre-Socratic philosophers, from Thales onward, rather than complete works. Among these fragments is a largely coherent opening section of Parmenides' didactic poem (written in hexameter), transmitted by Simplicius before the dissolution of Plato's Academy. The surviving introduction asserts that the truth of being lies in the non-existence of complete nothingness and the rejection of the nothingness of nothingness. Plato's dialogues and Aristotle's works, which survive as complete bodies of text, later served as a model for Roman education, particularly reflected in Cicero's writings. During the Hellenistic era, Plotinus and his students played a crucial role in transmitting Greek culture to later periods. However, the relationship between Parmenides' poem and the doctrine of flux of his contemporary Heraclitus remains philosophically complex. Heraclitus' aphoristic writings are fragmentary rather than coherent prose, structured for rhetorical reading and quotation rather than memorization (Gadamer, 2023). In Plato's dialogue Parmenides, discussions explore the part-whole relationship and the challenges of understanding unity and multiplicity. By contrast, Heraclitus' fundamental problem is how to remain stable within change, emphasizing that all things are in flux (panta rhei) and that stability must be comprehended within this constant movement

[4] In its original sense, 'poiesis' (Greek ποίησις) means creation or the act of bringing something into presence. Any action that brings something into being, whether artistic or technical, can be described as poiesis. The processes involved in artistic and technical creation are therefore considered forms of poiesis (Plato, Symposium)

[5] According to Derrida, every written word is marked by différance, meaning that it is never fully present and is always subject to displacement and reinterpretation. This is particularly evident in linguistic works of art, where meaning constantly unfolds and escapes final closure. Heidegger argues that a work of art serves to disclose being and to disrupt habitual understanding, provoking the individual to move beyond traditional experiences and expectations. Gadamer (2002, p. 328) emphasizes that aesthetic experience is grounded in shared horizons and commonalities that connect individuals, transcending boundaries. In engaging with a linguistic work of art, the individual loses

themselves to find themselves through its poetics. This resonates with Derrida's view that to grasp the true nature of the sign, reading must replace what came before each time, implying difference rather than mere repetition of prior statements (Gadamer,2002 p. 333). Those who read without understanding the text or words fail to apprehend their meaning, as the significance of the words cannot be deciphered without encountering them. Gadamer further asserts that difference exists within identity, without which identity cannot be constituted, and that thought necessarily involves delay and distance, for otherwise it cannot truly unfold (Gadamer, 2002. p. 342).

[6] Discourse derives from the Latin discurrere, meaning "to run about" or "to move here and there," and discursus, which refers to a "running," "course," or "flow of ideas." The term conveys notions of diverging, spreading, or moving apart. In Medieval Latin, discursus came to signify a heated debate or discussion revolving around a directive, involving mutual communication and the exchange of arguments (Sözen, 1999, p. 19).

[7] Stiegler (2012) conceptually integrates 'living (organic) memory' and 'dead (technical) memory'. In parallel, Plato develops the concept of anamnēsis alongside ēpistēmē, contrasting it with the memory techniques (hypomnēsis) employed by the Sophists and other practices associated with writing and rhetoric. In Platonic philosophy, associating knowledge or memory with external technical supports positions it as pseudo-knowledge or opinion (doxa), which cannot be considered necessary or immutable. Building on these ideas, Stiegler conceptualizes memory as epiphylogenetic memory, which by its very nature encompasses both hypomnesic (external/technical) and anamnestic (internal/organic) dimensions (Korkut, 2025, p. 21)

[8] The opposition between theory and practice, which has persisted since Ancient Greek ontology, is reflected in the act of knowing (theoria), alongside the three fundamental operations of the human mind: cognition (knowing), volition/action (willing/acting), and affect/judgment (feeling/judging). In Ancient Greek thought, theory primarily explains phenomena. However, theoretical explanations and a priori principles that are detached from lived experience are insufficient (Misch, 1995, p. 38).

[9] Michel Foucault's concept of discursive positivity, developed within the framework of his archaeological method, refers to the internal structure of discourses. In other words, the positivity of a discourse encompasses not only its mere articulation but also its historical mode of existence and the conditions under which it emerges, including its actualization in practices and institutional settings.

[10] The problem of allegorical interpretation can be traced back to the Ancient Greek period from a hermeneutical perspective. Hyponoia (or subtext) refers to uncovering the essential meaning that lies beneath the literal sense of a text (Gadamer, 1995a, p. 12). An allegory expresses abstract concepts through concrete or sensory imagery, enabling ideas to be communicated in a vivid and comprehensible manner.Although the roots of allegory date back to antiquity, it reached particular prominence in the Middle Ages, especially through thinkers such as Boethius and Augustine, and later through Dante, who exemplified the use of allegorical, moral, and mystical interpretation. During this period, a systematic theory of allegory emerged that allowed sacred texts to be read not only literally but also allegorically, morally, and mystically, providing multiple layers of meaning accessible to both scholars and the faithful.

[11] In his book The Archaeology of Knowledge (1969), Michel Foucault employs the concept of discoursive formation to describe how discourses are governed by specific

rules and regularities within a given period and field. A discoursive formation constitutes a set of systematic regularities that define the conditions under which statements in a particular domain can emerge as knowledge. Consequently, the epistemic structure of the field is established and maintained within the framework of the discoursive formation.

[12] Saussure's linguistic model can be considered a formalist mode of thought. In this framework, the signifier exists solely as a form defined by differences within the system, while the signified — meaning — emerges from these differential relations rather than existing independently. Similarly, Levi-Strauss proposes an anthropological approach in which a structural or "mathematical" framework is established first, and empirical facts are subsequently interpreted in light of this structure (Karatani, 2006, p. 37)

[13] The concept of transversality is particularly prominent in the work of Deleuze & Guattari (2023), especially in their book A Thousand Plateaus, where it is closely linked to rhizomatic thought and anti-hierarchical modes of organization. Other contemporary thinkers, such as Rosi Braidotti, also engage with the notion of transversality, particularly within posthumanist and feminist frameworks. While Michel Foucault does not explicitly use the term, his analyses of power relations and the non-hierarchical interplay of social forces resonate with transversal concepts. Transversal thinking can be understood as a non-linear mode of thought and action, capable of traversing diverse lines of force and connecting individual experiences with collective production. It emphasizes multiplicity, fluidity, and the creation of connections across disciplinary, social, and conceptual boundaries, challenging linear or hierarchical modes of reasoning.

[14] According to Ferdinand de Saussure, language is a system of interconnected elements, in which each element derives its value from its relationships within the system. These elements perform specific functions as part of the overall structure. A synchronic approach to language considers it as a system abstracted from its historical development, whereas a diachronic approach examines language in its historical and evolutionary context. The fundamental principles Saussure established in structural linguistics regarding natural language are as follows: 1) Language is a system of signs, where each sign consists of a signifier (sound-image) and a signified (concept). .2)The natural language (langue) that Saussure refers to differs from individual speech (parole). While language constitutes a common system of signs and rules shared by a community, speech is the individual realization of language, containing variations and phenomena specific to the speaker.3) Language operates along two axes: the syntagmatic (sequential) axis and the paradigmatic (systematic and referential) axis. While concepts and signs may change in the paradigmatic dimension, the syntagmatic structure, linked to the grammar of the language, remains relatively stable. Although paradigmatic, sequential, and referential meanings may differ, the overall construction of language is maintained. The paradigmatic relationships within the system enable change and variation, and meaning emerges as a value (valeur) determined by differences and relations among elements (Yücel, 1999, pp. 23–26).

[15] Unlike positivists, neo-positivists seek to formalise language through a logical system that acts as an intermediary between the subject and their environment. This reflects an attempt to construct a meta-logic that excludes factuality. As a result of formalisation, which draws on the intellectual foundations of rationalists such as Descartes and Leibniz, the idealisation of language in mathematical terms encounters the problem of meaning associated with the concept of language-thought identity. The process began with Gottlob

Frege and treats logic as a semantic whole, where each expression is definite, consistent, valid and unambiguous. This is expressed (calculated) using symbols (symbolic logic), consisting of defined elements, relationships and order, as a closed, limited system in an idealised metaphysical space between language and the world. At the extreme, signs can be completely abstracted from meaning, and thus from context, and transformed into pure forms. The subject of the philosophy of language — meaning — can be defined as the content conveyed by an utterance in a communication environment.

[16] Until the first half of the 20th century, logical positivists such as Reichenbach, Carnap, and Ayer, along with early Wittgenstein in his Tractatus Logico-Philosophicus, argued that a linguistic expression must be verifiable according to the principle of verification in order to be meaningful. They emphasized the development of a symbolic, idealized, and artificial language that corresponded directly to perceptions of the external world, depicting and representing facts. Symbolic logic operates according to a mathematical model, aiming to explain the relationship between language and the world. As Wittgenstein states in the Tractatus, "A sentence is a description of a factual context." In this framework, meaning—except in the case of tautologies—is a property of factual statements.In contrast, analytical philosophers in the second half of the 20th century, particularly proponents of Ordinary Language Philosophy such as Austin, Searle, and Strawson, developed a broader view of meaning that includes utterances not reducible to factual statements. The primary function of these expressions is to facilitate communication, and many are not easily classified as true or false, such as directives, questions, or performative statements (Altınörs, 2003, pp. 112–118).

[17] Frege himself did not use the terms Bildtheorie or Abbildtheorie; these concepts are more closely associated with Wittgenstein's picture theory of language, developed in the Tractatus Logico-Philosophicus. According to Frege, who addressed the problem of meaning through a distinction between sense (Sinn) and reference (Bedeutung), the referent of a linguistic expression is the object to which it refers. The sense of the expression, by contrast, is the mode of presentation of that object.The meaning (Sinn) of an expression is intersubjective and shared among speakers of a language, ensuring a common understanding, whereas individual mental representations or conceptualizations may vary without altering the sense itself. In his essay Über Sinn und Bedeutung (1892), Frege emphasizes that the referent of a sentence—its Bedeutung—is its truth-value: true or false. Thus, while the reference determines the sentence's truth conditions, the sense provides the cognitive content that allows speakers to grasp and communicate meaning.

[18] In Philosophical Investigations (1953), Wittgenstein begins with the idea that meaning is context-dependent and multifaceted. He argues that meaning cannot be fully explained solely through the lens of natural science, as it is interpreted differently across various fields of inquiry. Rather than grounding a single criterion of meaning in scientific truth, Wittgenstein's approach emphasizes the polysemy that arises in actual language use, thereby broadening the epistemological perspective.According to this view, the meaning of a proposition should not be assessed merely in terms of the information it conveys, but rather according to criteria determined by its specific linguistic context. Language is no longer conceived as a single, monolithic system, but as a multiplicity of languages reflecting distinct forms of life. Within this framework, meaning is an element of a particular language game, embedded in socially and culturally situated practices (Özlem, 2000, pp. 28–29).

[19] In the field of hermeneutics, metaphors are often interpreted through both logical and contextual similarities and limitations. According to Frege, the meaning of expressions is fundamentally tied to truth-values, and metaphors present a challenge to this framework as they cannot always be assigned definitive “true” or “false” values. In contrast, Wittgenstein argues that meaning emerges through the use of language within particular forms of life and language games. These language games encompass not only the rules of grammar but also linguistic actions that reflect cultural behaviors and practices. From Wittgenstein’s phenomenological perspective, language appears as a cultural form, akin to architecture, dance, theater, and cinema, through which social practices and shared life experiences are mediated. Within this framework, all life can be understood as embedded in language, while the rules governing linguistic practices are dynamic, interactive, and open to interpretation. Language games are relatively independent of one another, probabilistic in nature, and exhibit creative and transformative properties through interaction with the world beyond the system. According to Wittgenstein, the entirety of language is continuously constituted through the repetition of newly learned words and the practical actions that weave language together during the process of learning (Wittgenstein, 1998, p. 15).Thus, meaning is not merely a matter of abstract logic but arises through participation in socially and culturally situated language practices, highlighting the interplay between linguistic form, usage, and human life.

[20] In machine learning studies, design is often approached as a formally defined problem that could, in principle, be solved mathematically. However, due to the complex and dynamic nature of the design process, and because input-output mappings are constantly redefined in computational terms, design problems are generally considered ill-defined or “wicked” problems. According to the problem space model (Newell & Simon; information processing theory), design problems possess a variable solution space. They involve:Initial conditions, including available information and resources;Operators, which can transform the state (e.g., changing materials or moving parts); and Goals, which are often open to redefinition, providing criteria to evaluate states within the problem space. When a problem is decomposed into subproblems, the problem space is in constant flux (Zimring & Craig, 2001, p. 134), and details may vary until other parts are completed. In practice, designers rarely consider the entire problem space simultaneously, as constraints and the focus of research narrow the scope of attention.

[21] From a perspective akin to linguistic studies, a distinction can be made between design and exploratory or creative design within the closed systems proposed by Bartlett in 1958. Closed systems are defined by a limited number of units arranged according to specific rules or relationships. Mathematical systems such as formal logic, arithmetic, algebra, and geometry serve as classical examples of closed systems. However, new paradigms or approaches can transform these systems into more creative and flexible frameworks.Bartlett identifies two types of thought processes within closed systems: interpolation, which involves finding intermediate values between known points, and extrapolation, where the remaining path and terminal points must be discovered or constructed. In interpolation, the terminal point is known, and evidence guides the path to be followed. In extrapolation, evidence pertains to the path already taken, while the endpoint and remaining steps must be determined. According to Lawson (1990, p. 104), the entire design process—or parts of it—can be formalized as a closed system under

specific constraints. Yet, in practice, the terminal points of the design process often remain indeterminate, and it is not always clear where the process will conclude.

[22] In the design process, dualistic distinctions are often made between rational and logical processes and intuitive or creative processes. These two main categories correspond to convergent and divergent thinking. A convergent task is well-defined and requires deductive reasoning and incremental progress to arrive at a single, correct solution. In contrast, a divergent task is open-ended, with no definitive solution, requiring creativity and exploration. Architectural design inherently relies on divergent thinking, as solutions are not predetermined. However, optimizations and constraints within the process do not eliminate the need for convergent thinking, which is essential for evaluating, refining, and implementing design solutions (Lawson, 1990, p. 106)

[23] Architectural Design as Creative Thinking: According to Bono (as cited in Lawson, 1990, p. 109), the term "creativity" reflects a value judgment, as people tend not to perceive ideas or solutions they dislike as novel or creative. Psychologists generally agree on five stages of creative thinking, which often operate in parallel with aesthetic experience, heuristic (inventive) learning, and reasoning processes.The insight stage involves recognizing and formulating the problem and deciding to seek a solution. The preparation stage entails consciously developing ideas to address the problem. These two stages are in continuous dialogue, as problem definitions in design are frequently dynamic and subject to change. Incubation refers to the subconscious, and sometimes unconscious, exploration of potential solutions, which may result in a sudden illumination or insight. After a period of maturation, the emerging idea is tested, evaluated, and further developed through conscious verification.

[24] Frege and Processable Symbols: According to Frege, in modern logic, symbols become computable through their assignment of truth values. In order for an entity to be programmable, its representation must be processable, meaning it must be capable of being transformed into another symbol or manipulated within a formal system. This principle underlies the formalization of logic and provides the basis for symbolic computation.

[25] Turing Machines and Programmability: Any process that can be programmed can, in principle, be represented on a Turing machine in 1936. Each program or computational representation can be processed and executed on a universal Turing machine, meaning that a single theoretical device is capable of simulating any algorithmic procedure. While practical limitations may arise in terms of time or resources, theoretical computability is ensured within this framework.

[26] Connectionism and the Functional Modelling of the Mind: The functional construction of the language of the mind in a machine (Turing) and the formalization of language into mathematical and logical representations through programming (Newell, Simon, and McCarthy) are foundational concepts in cognitive science and artificial intelligence. In the human mind, complex and intertwined processes—such as perception, language, memory, and planning—operate as interactive abilities, whose capacities can be appropriately represented computationally. The focus lies on modeling how the human mind generates and manipulates symbols, rather than on the symbols themselves. This approach, known as connectionism, emphasizes the dynamic creation of symbolic representations within neural networks, capturing the interactive and distributed nature of cognitive processes (Zambak, 2025a).

[27] Program Architectures and Large Language Models: Data inputs and outputs are fed into a program architecture that can run multiple programs on the same machine (Turing), allowing the machine to process them systematically. Within this framework, a specific model configuration—such as a neural network or transformer—is implemented for a particular task. During processing, inputs and outputs are loaded into the model, which is then trained to classify, predict, or generate outputs based on patterns in the data. A model tailored to a specific function can be created within the same underlying architecture. For instance, large language models (LLMs) built on transformer architectures can perform a variety of tasks—including translation, text generation, summarization, and image-based tasks—depending on how the architecture is configured and fine-tuned. These models are capable of reasoning, and the knowledge learned in one context can often be transferred to new tasks through transfer learning (Zambak, 2025a).

[28]Leibniz, Possible Worlds, and Quantum Computation: Leibniz proposed that God selects the best possible world from among all possible worlds, reflecting a principle of optimality in existence. Drawing a parallel to modern computation, quantum computers leverage superposition and entanglement to explore multiple computational states simultaneously. By doing so, they can probabilistically optimize solutions, effectively considering many potential outcomes in parallel. In this sense, quantum computation can be metaphorically compared to Leibniz's notion of evaluating possible worlds, although the processes remain strictly algorithmic and physically grounded (Zambak, 2025a).

[29] The development of optics revealed the partially observable nature of large astronomical objects, leading to the first systems perspective based on processability. This perspective later evolved into general systems theory (Ludwig von Bertalanffy, 1940s–1960s), cybernetics (Norbert Wiener, 1950s), management cybernetics (Stafford Beer), relational biology (Robert Rosen, 1970s), and autopoiesis (Varela & Maturana, 1972) (Zambak, 2025b).

[30] Neurophilosophical and Neuroscientific Perspectives on Plasticity: From a neurophilosophical perspective, the brain's plasticity can be considered autopoietic and capable of self-organization. However, due to the dynamic and constantly changing nature of plasticity, computational perception and representation are difficult to model directly.From a neuroscientific perspective, spatial thinking plays a central role in visualization, geometry, and topological reasoning (Zambak, 2022). In neuroscience, plasticity refers to changes in the type or structure of connections between neurons, including the formation of new connections, modifications in synaptic strength, selection, and the morphology of synaptic relationships involving neurotransmitters. Plasticity declines with age, from childhood to old age. Models based on plasticity often encounter challenges due to input parameterization, measurement calibration, architectural design of neuron networks, functional accuracy, and output validation. Understanding cognitive abilities—such as learning—and their relationships to other cognitive functions, as well as the architecture of cognitive organization (e.g., SOAR), is essential. While existing symbolic elements can be decomposed through abstract algebra, changes in network connectivity between operators reflect plasticity (Zambak, 2025b)

[31] Representation Systems and Recursive Model Structures: The aim is to enable representation systems and their operations to interact through category theory, homotopy type theory, and topos theory. Systems designed to reflect mental knowledge can, in principle, surpass the computational or cognitive capacities of the human mind, and

models may generate or transform one another, producing a potentially recursive and self-sustaining structure (Zambak, 2025b)

[32] By revising hypotheses under conditions of uncertainty to render the possible probable, as formalized in stochastic models such as Bayesian inference, it is possible to relate hypotheses to observed evidence. In adaptive or locally plastic systems, this approach can also account for situations involving uncertainty, ambiguity, and fuzziness (Zambak, 2025a).

[33]Mathematics has long served as a foundational framework for architecture, particularly through Newtonian physics and Euclidean geometry. However, with the advent of non-Euclidean geometries (Lobachevsky, Riemann) and Einstein's theory of relativity, the reliability of classical foundations was increasingly questioned. Gödel's incompleteness theorem (1931) further demonstrated that no formal mathematical system can be both complete and consistent. Metaphorically, these developments challenged the notion of mathematics as an absolute architectural foundation, though they did not diminish its practical utility (Zambak, 2025a)

[34]When reconstructing the ontology of data, certain attributes must be ensured: processability, transferability (Claude Shannon, Mathematical Theory of Communication), machine readability (Tim Berners-Lee, Semantic Web), and ultimately machine understandability. While classical set-theoretic or function-based approaches often prove insufficient to establish reliable relationships between the domains and co-domains of functions—especially when these involve transformations between existing representations (i.e., functors) of categorical objects (topological, geometric, or numerical)—category theory provides a more general and powerful framework. Despite the limitations of set theory, category theory enables the extension of formal languages to connect distinct foundational mathematical theories, such as homotopy type theory, topos theory, and lambda calculus. Beyond the level of objects and morphisms within categories, it also allows the articulation of relationships between functors themselves through the concept of natural transformations (Zambak, 2025a)

[35] From a philosophical perspective, fully automated programs capable of generating original mathematical proofs remain limited, unlike programs that generate text, images, or perform object recognition. Modern proof assistants and automated reasoning systems, such as Coq, Isabelle, and Lean, provide partial automation of proof generation, yet the full representational power of mathematics is not captured within formal logical languages. Despite the cognitive and ontological primacy of logic—beyond classical Aristotelian syllogistic logic—mathematics maintains a degree of autonomy and complexity that exceeds the expressive capacity of formal systems.The first programmable machines, such as Charles Babbage's Analytical Engine (1837–1871), were designed primarily for numerical computation rather than logical reasoning. Ada Lovelace, often regarded as the first programmer, developed algorithms for this machine using a proto-algorithmic, number-focused symbolic notation, preceding the development of Frege's formal logic (1879).In Aristotelian logic, relations between entities are expressed through categorical syllogisms, but transitive or more complex relational structures are limited. In contrast, natural language allows richer relational representation through predicates, verbs, and prepositions, whereas formal logical systems rely on logical connectives ($\wedge$, $\vee$, $\rightarrow$, $\neg$) and quantifiers ($\forall$, $\exists$).Artificial intelligence techniques can attempt to translate these logical and relational structures into

ontological entities, yet such ontological reductions are often insufficient. A language-based logic model, capable of capturing both relational and functional semantics, is therefore necessary. Moreover, logic models and programs can generally be executed on single platforms, although their full expressive potential may require integration across multiple systems and formal frameworks (Zambak, 2022).

[36] The boundaries of programming languages, which function as versatile toolboxes, need to be expanded. This includes imperative languages, object-oriented languages such as Python, C++ and Java, and functional programming languages such as Haskell, Scala, and Clojure. In addition, new data types and structures must be defined to meet the demands of modern computation. Tools for managing input-output relationships are increasingly being developed using machine intelligence (Zambak, 2022)

[37] For a discussion of the Klein group, see Marc Barbut, "On the Meaning of the Word 'Structure'in Mathematics," in Michael Lane, ed., Introduction to Structuralism,New York, Basic Books, 1970 (Krauss,1979,p.37).

[38] For an application of the Piaget group see A.- J. Greimas and F. Rastier, "The Interaction of Semiotic Constraints," Yale French Studies, no. 41 (1968), 86-105 (Krauss, 1979, p.37).

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Cross-Laminated Timber (CLT) for Sustainable Buildings: An Assessment for New Zealand and Türkiye

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1. Introduction

Responsible for approximately 37% of global carbon emissions, the building sector occupies a pivotal position in achieving environmental sustainability (IPCC, 2014). This reality has necessitated the integration of innovative construction materials aimed at minimizing ecological impacts. Among such materials, Cross-Laminated Timber (CLT) has garnered increasing international recognition in recent years, primarily due to its potential to lower carbon footprints, enhance energy performance, and support broader environmental objectives (Puettmann et al., 2019; Younis & Dodoo, 2022; Singh et al., 2022; Gu et al., 2021; Li et al., 2023; Kwok et al., 2020; Shin et al., 2023; Li & Lam, 2016; Petrillo et al., 2021). Despite its significant advantages, CLT adoption remains limited in certain countries. The use of engineered wood products varies greatly depending on national cultural and technological contexts. Numerous studies highlight that barriers to the adoption of CLT are largely rooted in the absence of robust regulations and standards, economic constraints, low levels of public and professional awareness, and entrenched construction practices (Penfield et al., 2022; Pilathottathil & Rauf, 2024; Espinoza et al., 2015; Mahapatra & Gustavsson, 2008; Jones et al., 2016; Ilgın et al., 2023; Quesada-Pineda et al., 2018).

Although Türkiye possesses a rich heritage of traditional timber architecture, the use of wooden structures has declined substantially since the early 20th century. In 1929, timber buildings constituted 14.2% (24,375 units) of the national building stock, yet by 2000, this share had dropped to just 2.7% (211,340 units).

Although Türkiye possesses a rich heritage of traditional timber architecture, the use of wooden structures has declined substantially since the early 20th century. In 1929, timber buildings constituted 14.2% (24,375 units) of the national building stock, yet by 2000, this share had dropped to just 2.7% (211,340 units). Toward the end of the 20th century, timber construction fell below 1% of the total building stock, reaching a highly limited level. Today, high-emission materials such as concrete and steel dominate Türkiye's construction industry, while the use of both natural, ecological materials and engineered timber remains notably limited (Turkish Statistical Institute, 2001; Yıldız, 2022; Akbaş et al., 2022). In contrast, Northern European countries such as Finland and Sweden effectively utilize innovative wood technologies in sustainable building practices and successfully implement low-carbon footprint policies in the construction sector (Brandner, 2013). Although New Zealand has not established a leading market in this field like Europe, it has delivered successful projects using engineered wood products such as CLT, LVL, and Glulam. This shows that, despite its limited industrial capacity, New Zealand has demonstrated the ability to rapidly adopt and implement contemporary wood technologies. Its policies that recognize the carbon storage potential of wooden buildings, its alignment with international climate objectives, and its commitment to environmental sustainability make it a valuable reference point for Türkiye. Therefore, New Zealand has been selected as the comparison country in this study—a strategic choice based on both its similar environmental goals and its success in generating solutions despite limited industrial capacity.

The aim of this study is to reveal the potential and implementation limitations of engineered wood materials by comparing sustainable building practices in Türkiye and New Zealand. It will examine the current state of CLT use in Türkiye, the obstacles encountered, and international policies and incentives aimed at promoting CLT adoption in the construction sector. This approach offers a significant contribution in terms of demonstrating how CLT can be integrated into Türkiye's construction industry.

The study seeks to answer the following questions:

- What is the role of CLT in sustainable building practices?
- What is the current use of CLT in existing buildings in Türkiye and New Zealand?
- What can be recommended for Türkiye to reduce the gap between the two countries?

In this context, the article begins with a review of the relevant literature, followed by the research methodology and findings. Finally, based on the comparison between the two countries, recommendations for sustainable building practices will be discussed. The study is important for better understanding the structural and environmental advantages of engineered wood products and for evaluating the potential use of CLT in Türkiye and New Zealand.

1.1. Positioning Cross-Laminated Timber (CLT) within the Framework of Sustainable Construction Materials

Cross-Laminated Timber (CLT) is an engineered wood product composed of multiple layers of timber bonded together at right angles, resulting in a structurally robust and environmentally conscious material. The orthogonal layering enhances the panel's bi-directional load-bearing capacity, enabling it to efficiently withstand both vertical and lateral forces. Its versatility allows CLT to serve a variety of structural functions, including use in wall assemblies, floor systems, and roofing components (Brandner, 2013; Geng et al., 2021; Ceylan & Girgin, 2019).

A key attribute that distinguishes CLT in the context of sustainable building design is its carbon sequestration capacity. During photosynthesis, trees absorb atmospheric CO_2, which remains stored within the wood material throughout its service life—even when incorporated into buildings (Petrillo et al., 2021). Leskinen et al. (2018) report that one cubic meter of timber can sequester roughly one metric ton of carbon dioxide. In contrast to high-embodied-carbon materials such as concrete and steel, CLT presents a compelling opportunity to mitigate carbon emissions in the built environment (Benedetti et al., 2022; Churkina et al., 2020). When derived from sustainably managed forests, engineered wood products such as CLT are projected to act as long-term carbon sinks, potentially reducing the construction sector's carbon footprint by up to 50% (UNECE, 2023).

A further sustainability benefit of CLT lies in its low energy demand during production. In contrast to conventional materials like concrete and steel, its manufacturing process consumes significantly less energy (Harte, 2017; Mahapatra & Gustavsson, 2008). The modular nature of CLT fabrication, combined with prefabricated assembly methods, contributes to reduced carbon outputs. Factory-produced panels that are directly installed on-site shorten construction timelines, decrease labor requirements, and significantly reduce material waste (Kuzman et al., 2017).

Additionally, the reuse of sawdust and wood offcuts generated during processing—either as bioenergy sources or raw inputs for other wood-based products—reinforces circular economy principles. This practice not only reduces waste but also enhances resource efficiency and contributes positively to ecological sustainability (Churkina et al., 2020).

CLT's role as a natural thermal insulator is another critical factor in its sustainable profile. By minimizing thermal losses, it contributes to building energy efficiency. Owing to wood's low thermal conductivity, interior thermal conditions can be maintained over longer durations, thereby reducing heating and cooling demands (Brander, 2013; Harte, 2017).

Sustainable forest management is an integral component of CLT production and is facilitated through certification schemes such as the Forest Stewardship Council (FSC). Timber harvested from responsibly managed forests and planned plantations is recognized as a renewable resource aligned with global sustainability standards (UNECE, 2023; Vogt et al., 2000).

Numerous empirical studies have evaluated the environmental performance of timber-based construction. Nakano et al. (2020) identified that, relative to cement and concrete, CLT exhibits lower impacts across multiple categories, including climate change, ozone depletion, eutrophication and acidification. According to Pierobon et al. (2019), replacing concrete and steel with CLT in building design could yield average reductions of 26.5% in global warming potential, 30% in eutrophication, and 25% in stratospheric ozone depletion. Similarly, Yue et al. (2019) reported that wooden buildings generate 70% less CO_2

emissions and consume 65% less energy compared to traditional brick-concrete constructions. These findings underscore CLT's potential as a transformative material for enhancing the environmental performance of the building sector (Petrillo et al., 2021; Espinoza et al., 2016; Harte, 2017).

2. Material and Method

While CLT is widely recognized for its environmentally sustainable properties in the construction sector, its adoption rate and market penetration differ notably across national contexts. To facilitate a meaningful comparison between Turkey and New Zealand, this study builds upon a body of literature examining the underlying barriers to CLT adoption and diffusion.

The research was structured in two phases:

In the initial phase, a systematic literature search was conducted in the Scopus and Web of Science databases using the keywords "CLT barriers" and "CLT adoption." This process yielded 168 publications. Following a relevance screening focused on engineered timber applications, 22 articles were retained, of which 8 were deemed highly pertinent to the study's objectives.

Given the manageable number of sources, the analysis was carried out without employing any external coding or bibliometric tools. Instead, the findings were synthesized through thematic evaluation. Terms referring to similar challenges—albeit expressed with varying terminology (e.g., adherence to conventional practices, resistance to procedural change)—were consolidated to derive four overarching factors influencing CLT adoption (Table 1).

Table 1. Factors Influencing the Adoption of CLT

Path Dependencies	Cost and Production	Awareness and Knowledge	Regulations and Standards
Routines associated with the production industry reflect sectoral path dependency (Mahapatra & Gustavsson, 2008)	Uncertainty about product responsibility and service life; high cost of full-scale prototypes (Mahapatra & Gustavsson, 2008)	Low knowledge transfer and misconceptions about timber construction among stakeholders (Mahapatra & Gustavsson, 2008)	Historical exclusion of timber frames from fire codes; long-standing regulatory bans (Mahapatra & Gustavsson, 2008)
Vicious cycle in traditional construction habits (Penfield et al., 2022)	Limited production inventory; higher cost than conventional materials (Penfield et al., 2022)	Lack of experience and awareness-driven market inactivation; early adaptation stage of LEED-aligned projects (Penfield et al., 2022)	Political barriers such as lack of building codes and limited municipal approvals (Pilathottathil & Rauf, 2024)
Cultural/social resistance to innovation; preference for familiar methods (Pilathottathil & Rauf, 2024)	Economic constraints: high upfront cost, limited market use, and price disadvantage compared to steel/concrete (Pilathottathil & Rauf, 2024)	Lack of information, technical doubts, and distrust in structural properties of CLT (Pilathottathil & Rauf, 2024)	Absence of code-compliant design standards for timber structures (Laguarda Mallo & Espinoza, 2015)
Lack of societal acceptance and limited social readiness (Laguarda Mallo & Espinoza, 2015)	Limited availability in the market (Laguarda Mallo & Espinoza, 2015)	Limited training and insufficient technical education programs (Laguarda Mallo & Espinoza, 2015)	Compliance challenges with existing building regulations (Espinoza et al., 2016)

Lack of familiarity with the product (Jones et al., 2016)	Perceived financial risk associated with cost (Jones et al., 2016)	Lack of awareness regarding material characteristics and absence of training courses (Jones et al., 2016)
Strong familiarity with conventional materials such as concrete and steel (Ilgın et al., 2023)	Volume of required wood and resource pressure (Espinoza et al., 2016)	Public misconceptions and insufficient technical knowledge (Espinoza et al., 2016)
	Need for high-quality timber, reliable raw material supply, and creation of a viable market for CLT (Quesada-Pineda et al., 2018)	Concerns about durability of wood (e.g., rot, earthquake, fire); lack of expert training (Quesada-Pineda et al., 2018)
	Cost competitiveness concerns in the market (Ilgın et al., 2023)	Technical expertise shortage and consumer-level misconceptions (Ilgın et al., 2023)

In the second stage of the study, a detailed analysis was conducted on the current conditions in Turkey and New Zealand, using the four key thematic criteria as a framework. The evaluation drew upon diverse data sources, including industry reports, regulatory documents, certification schemes, and academic literature. The synthesized findings enabled a comparative understanding of the facilitating and limiting factors affecting CLT adoption and diffusion in each national context.

2.1. Path Dependencies

Path dependency describes the way existing construction practices become locked into specific trajectories as a result of historical precedents, economic investments, and institutional reinforcement, thereby making systemic change increasingly difficult over time (Puffert, 2003). Legacy infrastructure, codified technical norms, regulatory inertia, and entrenched stakeholder behaviors collectively hinder the diffusion of innovation within the building industry. Once a sector commits to a particular material or system, shifting away from it entails significant financial and operational risk.

In New Zealand, the construction landscape reflects a synthesis of European colonial architectural influence and indigenous Māori cultural values. Timber-framed building systems gained popularity during the colonial era, largely due to material availability and ease of construction. Māori traditions, particularly in ceremonial and communal spaces such as the marae, expressed spatial and symbolic values distinctively. In recent decades, these values have been reinterpreted through contemporary sustainable design practices that emphasize ecological sensitivity. While industrialization increased the use of concrete and steel, advancements in timber engineering enabled more efficient framing techniques. Given the country's seismic vulnerability, the inherent flexibility of timber structures has proven to be a key advantage in earthquake resilience (Isaacs, 2010; Salmond, 1986). New Zealand is also recognized as a leader in the application of biogenic materials, with average carbon emissions from residential buildings estimated at 16 kg CO_2 eq/m²/year, significantly below the international benchmark of 50 kg CO_2 eq/m²/year (Dani et al., 2022).

In contrast, Türkiye's construction sector underwent rapid transformation in the mid-20th century as reinforced concrete became the dominant structural solution in response to growing urbanization and population pressures. Technical demands such as earthquake resistance and durability reinforced the widespread adoption of concrete systems. Supported by a framework of standardized workflows, local supply chains, and institutionalized engineering expertise, this trajectory has solidified into a strong path-dependent model (Karahan, 2018). The environmental impact of Turkey's housing sector rose sharply: while carbon emissions averaged 27–29 kg CO_2 eq/m²/year in the 1990s, this figure escalated to approximately 50 kg CO_2 eq/m²/year in the early 2000s (TÜİK, 2023; Atmaca & Atmaca, 2022).

2.2. Regulatory Frameworks and Standardization Landscape

New Zealand has demonstrated proactive leadership in promoting timber construction through integrated policy and research initiatives. The introduction of the Wood-First Policy in 2006 marked a major turning point in prioritizing timber for publicly funded projects. This initiative leveraged flagship examples—such as the funding of the Arts and Media Building at the Nelson Marlborough Institute of Technology—to showcase the structural and environmental merits of timber. Further institutional backing was provided through the establishment of academic chairs in timber engineering at Auckland and Canterbury Universities, alongside the creation of the Structural Timber Innovation Company (STIC) and associated R&D programs (Şişman & Balaban, 2023). Complementary to this, the Zero Carbon Act (2019) set a national agenda for transitioning to a low-emission, climate-resilient economy.

At the municipal scale, the Rotorua Lakes Council adopted its own Wood-First Policy to embed timber use into local governance and construction. The policy outlined:

- Priority for timber in local sustainable construction;
- Mandated timber use in municipal building projects;
- Strategic support for the domestic timber industry (Rotorua Lakes Council, 2015).

The New Zealand Green Building Council (NZGBC), founded in 2006, has also played a pivotal role in shaping green building policy and capacity. Through education, policy advocacy, and industry-wide collaborations, NZGBC has facilitated awareness and implementation of sustainable materials—including CLT—in residential and commercial architecture (Smith, 2008).

Nevertheless, CLT regulation in New Zealand and Australia is still evolving. Standards such as AS/NZS 1328 address glued laminated timber (GLT), while AS 1720.1:2010, the most comprehensive timber design standard, outlines general requirements for structural timber, LVL, plywood, and GLT, but lacks CLT-specific provisions. The Building Code of Australia (BCA) includes only indirect references to CLT through "deemed-to-satisfy" clauses. The absence of dedicated CLT codes is widely acknowledged as a regulatory gap hindering widespread adoption (Kurzinski et al., 2022).

In Turkey, regulatory efforts have accelerated since 2018 with the launch of the Timber Use Promotion Project, developed under a multi-stakeholder framework involving the Presidency of Strategy and Budget, OGM, UNDP, UAB, and TORİD. This initiative introduced national material standards and prototype design projects to guide practitioners (UNDP, 2022; Orman Genel Müdürlüğü, 2022). The 2021–2023 New Economic Plan echoed these aims, committing to the increased use of structural timber to improve energy performance and earthquake resilience, while also expanding plantations of economically valuable tree species (Strateji ve Bütçe Başkanlığı, 2020). Over the past two decades, industrial wood production in Turkey has nearly tripled (UNECE, 2023), and international support—such as the GEF's energy-efficient timber housing initiative—has further catalyzed progress (GEF, 2023).

The most critical development came in 2025 with the implementation of Turkey's first Timber Building Design and Construction Regulation, which incorporates Eurocode 5 and TS EN 1995-1-1 as foundational standards. Importantly, TS EN 16531 now defines design principles, section analysis, and ultimate limit state criteria specifically for CLT.

2.3. Cost Considerations

The cost structure of innovative construction materials such as CLT is influenced by a range of interrelated factors. Key determinants include the availability of forest resources, the scale and maturity of local production infrastructure, and the dynamics of import-export logistics. Additionally, variables such as plant size, energy prices, and labor costs play a critical role in shaping production expenses. These elements collectively influence the economic viability and large-scale adoption of sustainable building materials in the construction sector.

2.3.1. Raw material availability and suitability

The production of CLT globally is closely linked to the availability of forest resources and suitable wood species. Countries with extensive coniferous forests—such as those in Europe and North America—primarily use spruce (Picea abies) and fir (Abies alba) due to their lightweight, low cost, and ease of processing. While hardwoods can be used in CLT, they are generally avoided due to higher weight, cost, and bonding energy requirements.

In New Zealand, the primary raw material for CLT is Radiata pine (Pinus radiata), valued for its ease of processing, mechanical strength, and potential for chemical treatment to enhance moisture resistance (Cantwell, 2021). Other plantation-grown species such as Douglas fir (Pseudotsuga menziesii) and hybrid poplar (Populus deltoides × P. yunnanensis) also show promise for structural applications, although Douglas fir's splitting tendency during processing limits its versatility (Douglas-Fir Association, n.d.; Satchell et al., 2023).

In Turkey, despite being 27th globally in terms of forest area, the proportion of forested land remains below the European average. Black pine (Pinus nigra) and Scots pine (Pinus sylvestris) are prevalent, with studies demonstrating their technical suitability for CLT production. Research indicates that black pine provides better structural performance than fir and offers cost advantages due to its wide distribution and inclusion in Eurocode 5 (Hıdır et al., 2024; Uysal et al., 2022). Studies with spruce-based CLT panels have demonstrated strong structural performance under seismic loads when reinforced with metal connectors (Ceylan et al., 2019), while Scots pine CLT has shown improved thermal insulation with increased perforation ratios (Bülbül et al., 2024). Additionally, comparative studies suggest that Scots pine-based panels outperform oriental spruce (Picea orientalis) in terms of seismic resistance (Birinci et al., 2020).

2.3.2. Production capacity

In New Zealand, the production of engineered wood products such as Laminated Veneer Lumber (LVL), Glulam, and Cross-Laminated Timber (CLT) is supported by a well-established industrial infrastructure that leverages abundant local forest resources. Leading LVL producers—Carter Holt Harvey, Nelson Pine Industries, and Juken New Zealand—collectively operate with an annual production capacity ranging between 300,000 and 400,000 m³. In the Glulam sector, TimberLab Solutions Ltd (Auckland) and Hunter Laminates (Nelson) stand out as key manufacturers. CLT production is currently carried out by XLam's facility in Nelson, with an annual capacity of approximately 10,000–15,000 m³. Furthermore, Red Stag's plans to establish a new CLT plant indicate future growth in New Zealand's mass timber sector. Additional supply is supported through imports from Australian producers such as KLH, Binderholz, and Stora Enso (Evision, 2018).

In contrast, Turkey's CLT industry remains in its infancy, with no fully operational manufacturing facilities as of yet. However, planned investments in Kastamonu and Yozgat are expected to deliver a combined production capacity of around 45,000 m³ annually (Kuzey Anadolu Kalkınma Ajansı, 2021; Orta Anadolu Kalkınma Ajansı, 2021). Despite the lack of large-scale production, several firms have shown interest in CLT-based construction. Naswood, primarily a Glulam manufacturer, operates a small-scale CLT production line within its facility. Another firm, Asmaz Ahşap A.Ş., constructs timber buildings using imported CLT panels. These emerging initiatives represent early steps toward domestic CLT industry development in Turkey.

2.4. Awareness

Awareness within the construction sector plays a pivotal role in the adoption of sustainable building materials. In this context, factors such as certification schemes, technical expertise, and market demand have been examined to assess their influence on the uptake of engineered wood systems.

2.4.1. Certifications

In New Zealand, sustainable forestry practices and the traceability of engineered wood products are regulated through internationally recognized certification schemes such as the Forest Stewardship Council (FSC) and the Programme for the Endorsement of Forest Certification (PEFC). These certifications ensure that timber is sourced legally and sustainably, thus enhancing trust in both domestic and global markets (Nussbaum & Simula, 2005). In Turkey, due to the absence of a national certification system compatible with PEFC requirements, FSC remains the primary certification system in use (Aydın & Akyol, 2023).

Green building certification systems also play a crucial role in promoting sustainable construction. In New Zealand, certifications such as Green Star and Homestar assess buildings based on criteria like energy efficiency, material usage, and carbon emissions. However, some studies have pointed out that the Green Star system may not adequately highlight the environmental benefits of engineered timber structures when compared to globally recognized schemes like LEED and BREEAM (Evision, 2015; Page, 2007). Nevertheless, a growing number of certified and large-scale timber buildings are emerging in New Zealand. The New Zealand Green Building Council (NZGBC) has adapted the Australian Green Star framework to local conditions under the Green Star NZ system, which evaluates environmental performance based on energy, indoor environment quality, materials, water, land use and ecology, emissions, and innovation (Smith, 2008).

In Turkey, several certification systems are in place to assess the environmental performance of buildings and promote sustainable design. The national ÇEDBİK (Environmentally Friendly Green Buildings Certificate) addresses energy efficiency, material selection, and environmental impact. However, LEED and BREEAM are more widely adopted, and ÇEDBİK remains relatively underutilized (Saka, 2011). There is currently no industrial timber building in Türkiye that has received a green building certification. Moreover, the scope of existing evaluation systems regarding construction materials and their practical application remains limited (Konakoğlu & Kurak Açıcı 2021).

Nonetheless, efforts to raise awareness and promote sustainable timber construction are underway. One such initiative is the Low-Cost Energy-Efficient Timber Buildings Project, which aims to accelerate the adoption of innovative timber technologies like CLT and foster a transition to sustainability in the construction sector. This initiative includes the removal of regulatory barriers, implementation of pilot projects to demonstrate the feasibility of timber construction, and awareness-raising and capacity-building activities. In its initial phase, six pilot projects supported by financial incentives are planned to evaluate the environmental and economic impacts of CLT in construction. By 2029, the project aims to deliver 580,000 m² of additional timber construction, contributing to energy efficiency and greenhouse gas emission reduction, while fostering greater awareness and capacity in the use of innovative wood technologies.

4.4.2. Expertise

Projects involving industrial timber structures, particularly those using prefabricated components, demand a higher level of technical expertise than conventional concrete or steel constructions. Critical aspects include the accurate design of connection details, compliance with fire and acoustic regulations, and the logistical challenges of transporting and installing large timber elements. A study by Evision et al. (2015) on the adoption of CLT in New Zealand highlighted the lack of public and professional knowledge regarding its durability, fire safety, and acoustic performance. Moreover, the shortage of skilled designers and engineers proficient in timber construction was noted as a significant barrier to wider implementation.

Similarly, Avlar et al. (2022) identified key obstacles to the widespread use of engineered wood in Türkiye, including the dominance of reinforced concrete, limited public awareness, high construction costs, and restrictive regulations. A major barrier remains the scarcity of trained professionals, both in design and on-site application. The lack of qualified inspectors, experienced contractors, and skilled laborers limits the scalability of timber construction in the country.

4.4.3. Market demand

In New Zealand, market demand for CLT and other engineered wood products is influenced by factors such as production costs, limited domestic manufacturing capacity, and consumer perceptions. Despite the existence of a local CLT supplier (XLam), the cost differential between local and imported products is minimal, suggesting that local production does not currently offer a price advantage. Furthermore, timber structures are often perceived as more expensive than conventional alternatives, a perception compounded by limited knowledge about their long-term durability and performance. These conditions have collectively slowed the market uptake of industrial timber solutions (Evision, 2015).

In Türkiye, high costs of domestic timber, alongside the widespread preference for PVC and composite alternatives, have constrained market growth. Although relatively low labor costs provide a potential advantage for international competitiveness, the country remains heavily reliant on timber imports (Avlar et al., 2022), further complicating the development of a strong domestic market for engineered wood.

3. Findings and Discussion

A comparative analysis of Türkiye and New Zealand in terms of the use of engineered wood materials—based on factors such as sectoral development, environmental impacts, policy frameworks, costs, awareness, and technical expertise—reveals that both countries exhibit distinct advantages and challenges (Table 2).

Table 2. Cross-Laminated Timber (CLT) Usage Comparison: New Zealand vs. Türkiye

Criteria	Türkiye	New Zealand
Existing Building Stock	Reinforced concrete structures are prevalent	Both reinforced concrete and biogenic materials are commonly used
Environmental Impact (Carbon Emissions – Housing)	50 kg CO_2 eq/m²/year	16 kg CO_2 eq/m²/year
Policies	Regulation on Design, Calculation and Construction Principles of Timber Buildings	Wood-First Policy Zero-Carbon Act
Incentives and Strategies	• Project to Promote Timber Use in Türkiye • Afforestation of industrial wood species • Promotion of Low-Cost Energy-Efficient Timber Buildings	• Academic chairs for wood engineering • Support for innovation firms and R&D programs • Awareness raising via NZ Green Building
Standards	EuroCode 5 TS EN 1995-1-1 TS EN 16531	AS/NZS 1328 AS 1720.1:2010 NZS 3603:1993
Raw Material	Potential in black pine, red pine, spruce species	Radiata pine, Douglas fir, Kawa poplar
Production	CLT production facilities are still in planning phase (e.g., Kastamonu, Yozgat). Small-scale CLT line within a glulam production facility.	Experienced in CLT and LVL production. XLam facilities produce approx. 60,000 m³
Certifications	FSC certification in forest management is in use. ÇEDBİK (national) certification exists but is not widespread. LEED, BREEAM, etc. are in use.	FSC and PEFC forest management certifications are actively used. National Green Star NZ and international labels such as LEED, BREEAM, Homestar, LBC are common.

Expertise	Academic research exists, but applied knowledge is limited	Knowledge and experience are limited, yet several project examples are available
Market	No significant cost difference between imported and locally produced CLT	No significant cost difference between imported and locally produced CLT

3.1. Path Dependencies

In Türkiye, reinforced concrete has long maintained its dominance as the primary construction material. This situation has been reinforced by rapid urbanization and seismic risks, thereby limiting the demand for timber-based construction materials. In contrast, New Zealand's construction culture is historically rooted in timber use, offering a fertile ground for the acceptance of engineered wood systems. In Türkiye, such an adaptation would require a more substantial sectoral transformation.

3.2. Policies and Incentives

New Zealand and Türkiye apply distinct policy and incentive mechanisms to support the timber construction sector. In New Zealand, prioritized strategies such as the "Wood-First" policy and certification systems like Green Star NZ promote the use of sustainable building materials. Financial support for demonstration projects and academic investment in timber engineering also facilitate sectoral adaptation. These policies reflect an integrated approach aimed at both expanding timber construction and reducing carbon emissions.

In Türkiye, the "Project for the Promotion of Timber Use," supported by international funding, seeks to raise awareness and encourage industrial wood utilization. Furthermore, the forthcoming "Regulation on the Design, Calculation and Construction Principles of Timber Buildings" (effective 2025) will establish a framework for the design and construction of timber structures. While both countries provide a foundational policy landscape, broader sectoral transformation requires further local adaptation and the diversification of support mechanisms.

3.3. Cost Dynamics

In Türkiye, the limited local production capacity and high import costs for engineered wood products hinder the formation of a competitive market. Although there is some production (e.g., within glulam facilities), large-scale CLT manufacturing remains in the planning stages. In New Zealand, despite the presence of domestic producers like XLam, there is still no substantial price difference between local and imported CLT. For both countries, enhancing local production and encouraging domestic investment could help lower costs and improve the economic viability of engineered wood.

3.4. Awareness and Expertise

Both Türkiye and New Zealand face notable gaps in sectoral knowledge and experience. In Türkiye, limited awareness regarding the structural and environmental advantages of engineered wood materials suppresses demand. A lack of formal training programs creates adaptation barriers for designers and engineers. In New Zealand, despite the presence of a timber construction tradition, the knowledge of modern technologies is similarly limited. Although certification systems are valuable tools for raising awareness, their effectiveness is often constrained and may offer only a generalized assessment of building performance.

4. Conclusion and Suggestions

The comparison between countries with distinct construction cultures, such as Türkiye and New Zealand, provides valuable insights into the region-specific factors that limit the widespread adoption of engineered wood materials. New Zealand possesses a strong historical tradition of timber construction, supported by proactive wood-focused policies and infrastructure. However, challenges such as limited expertise and cost-related constraints continue to hinder broader market penetration.

In contrast, Türkiye faces more significant structural and cultural barriers to sectoral transformation. The deep-rooted dependence on reinforced concrete and its dominance across the construction industry create obstacles to the mainstreaming of engineered wood. Türkiye could benefit from New Zealand's strategies, such as localized certification systems like Green Star NZ, timber-oriented policies, and awareness-building through pilot projects. Nonetheless, for both countries, the development of context-sensitive standards tailored to local needs, along with strategies to overcome cost barriers, is essential for advancing the sustainable building sector.

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The article complies with national and international research and publication ethics.

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Author Contribution and Conflict of Interest Declaration Information

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Investigation of Stabilization Using Mineral Binders for Earthen Materials Under Varying Curing Conditions

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1. Introduction

The risk of natural resource depletion, increasing environmental issues, and the harmful impacts of building materials in use today are altering expectations for building materials and components. Although greenhouse gas emissions decreased following the quarantine measures implemented during the COVID-19 pandemic in 2020, the crisis underscored the need to reevaluate the relationship between humans and the natural environment. Moreover, building systems carry not only environmental but also social and economic implications (Danso, 2018). The linear economy model, established in the wake of the Industrial Revolution and World War II, which follows a produce-use-dispose paradigm, has gradually been replaced by a circular economy approach based on the produce-use-reuse framework since the 1990s (Yalçın & Negiz, 2020). In contemporary economic systems, there is a discernible shift from linear to circular economies, characterized by an emphasis on maximizing the lifespan of building materials and components (Benachio et al., 2020; Bertino et al., 2021). Consequently, the adoption of materials that adhere to the principles of sustainability and circular economy within the building sector is becoming increasingly significant (Turco et al., 2021). Energy consumption is one of the most critical problems in the world. The construction industry has a significant share in environmental destruction, consuming more than 40% of the total energy produced globally and emitting more than 30% CO2. The high energy consumed in the production processes of contemporary building materials and the waste they create after completing their useful life, the resources used are limited, and the high transportation costs from the factories to the construction site adversely affect the circular economy (Bouchefra et al., 2022; Labiad et al., 2022).

Earthen building materials represent an ancient construction medium that has been utilized for centuries across Europe, Asia, Australia, and Africa, with the oldest known examples dating back to 2000 BC. It is estimated that approximately 40% of the global population resides in earthen structures (Jannat et al., 2020). Although earthen structures are mostly found in less developed countries, they are also present in developed nations such as Germany, France, and the United Kingdom. Today, research efforts and trends aimed at reducing CO_2 emissions in the construction sector have contributed to the increasing use of earth as a building material in developed countries (Pacheco-Torgal & Jalali, 2012). A notable characteristic of earthen building materials is the utilization of locally sourced raw earth in its natural state, which significantly reduces the carbon footprint associated with conventional building materials. Moreover, these materials are recognized for their thermoregulatory properties and their positive impact on indoor air quality. Historically, earthen materials were employed primarily due to the technological limitations and challenges associated with regional raw material supply prior to the Industrial Revolution. As society's welfare improved alongside technological advancements, earthen materials began to be perceived as outdated. Nonetheless, earth remains a favored choice in local architecture, particularly in less developed rural villages in certain countries. The advantages of earthen materials—including the natural availability of raw materials, reduced labor requirements, and effective thermal insulation—

underscore their relevance and utility (Kafesçioğlu & Gürdal, 1985; Laborel-Préneron et al., 2017; Araki et al., 2011; Abhilash et al., 2022).

1.1. Historical Earthen Structures

Earthen materials have been used as building materials since ancient civilizations. Ancient civilizations—including the Indus Valley, Mesopotamia, Babylonia, Egypt, China, Mexico, and Peru—employed earthen materials in construction. This widespread preference can be attributed to the abundance of earth, its immediate availability in a workable form without requiring extensive processing, and the consequent reduction in construction costs. Additionally, during the transition to a sedentary lifestyle, communities that established themselves in river valleys utilized the fertile earth deposited by rivers in these areas (Reddy, 2022). Anatolia is among the regions where the earliest earthen-based materials can be preserved. Çatalhöyük, with its adjoining adobe houses featuring wooden beams, is a rare example of Neolithic adobe use, dating back to 7400–5200 BC. The city of Hattusha is an example that reveals the mud brick urban texture. In addition to these, samples of soil construction materials are also seen in critical old settlements such as Aşıklıhöyük, İznik Ilıpınar, Acemköyük, Aslantepe, Çayönü, Alacahöyük, and Alişar (Kafescioğlu, 2017). The earliest examples of ancient earthen structures are given in the Figure 1. These are Çatalhöyük, Moenjodaro, Shunet el-Zebib and a section of the Great Wall. Moenjodaro was built entirely of unbaked brick in the 3000 BC in the Indus valley, Pakistan, (UNESCO World Heritage Centre, n.d. b). Shunet el-Zebib was built with mudbrick in approximately 2750 BC, Egypt (ARCE, 2023). A section of the Great Wall was built of rammed earth around 300 BC, China, (Reddy, 2022).

(a)

(b)

(c)

(d)

Figure 1. Examples of ancient earthen structures (a) Çatalhöyük (UNESCO World Heritage Center, n.d.a); (b) Moenjodaro (UNESCO World Heritage Center, n.d.b); (c) Shunet el-Zebib (ARCE, 2023); (d) A section of the Great Wall (Reddy, 2022)

In addition to its ancient use, examples of adobe construction—frequently employed in traditional Turkish houses—can be found in many regions across Anatolia. These rural settlements possess a unique and original character, characterized by their historical, natural, and cultural structures. These cultural values need to be protected as a whole, along with the customs and traditions of the region's people.

Today, architectural heritage items are commonly neglected, abandoned, destroyed, or demolished. New structures are built because the local people need to learn the proper maintenance methods for traditional architectural systems, but they find it challenging. Thus, it reveals the risk of losing the rural heritage that societies have shaped over centuries of accumulation, causing concerns about the survival of these settlements and their transfer to future generations.

Gölpazarı, Bilecik Province, hosts examples of 150-year-old traditional adobe houses in Tongurlar Village (Özgünler, 2017). These dwellings, constructed with a half-timbered structural system in which the spaces between wooden frames are filled with mudbrick, exhibit plan typologies that reflect the characteristics of the traditional Turkish house (Taştemir & Arpacıoğlu, 2019; Baş & Arpacıoğlu, 2019). Some of the Adobe houses are shown in Figure 2.

(a) (b)

Figure 2. Examples of adobe structures in Tongurlar Village. (a) reproduced from Taştemir & Arpacıoğlu (2019); (b) reproduced from Özgünler (2017)

In Yeşilyurt District of Malatya Province, there are also adobe houses that are approximately 350 years old. These structures were constructed using the hımış technique, in which wooden frames are filled with mudbrick on stone foundations. Many of these houses have been demolished and replaced with new buildings, while others have gradually deteriorated due to neglect and abandonment. Some, however, have been placed under protection (Can, 2020). Selected examples of these houses are presented in Figure 3.

Figure 3. Examples of mud-brick-filled structures in Malatya (Can, 2020)

Iznik, on the UNESCO World Heritage tentative list and whose candidacy continues, is a multi-layered cultural center that has hosted many different civilizations since before Christ. The villages connected to the Iznik district, whose rural texture is preserved, are essential for developing Iznik and its surroundings. Iznik has largely preserved settlements that reflect the cultural characteristics of the region in a holistic architectural texture. Most of these settlements, such as Elbeyli, Ömerli, İnikli district etc, were built with earth-based materials and traditional adobe architectural construction techniques with wooden frames. Bozyel (2019) determined that 67% of the buildings in Ömerli disrict consists of mudbrick structures. In the Elbeyli region, 26% of structures are traditional buildings constructed with earthen materials. Among these buildings, 72% are still in use (Doğan Talyak, 2021) (Figure 4).

Figure 4. a, b and c) examples of traditional Turkish houses in the village; mud-brick-filled structures (Doğan Talyak, 2021)

1.2. Techniques of Earthen Constructions

Earth as a building material has attracted attention primarily due to its low environmental impact throughout its life cycle. It is known that the carbon dioxide emissions of earthen building materials to the atmosphere are 80% less than those of fired bricks. At the same time, earth materials that have reached the end of their useful life can be easily recycled or decomposed to produce new products. This material does not require particular labor or high energy consumption and can be made anywhere (Oti et al., 2009; Mateus et al., 2019). Studies have shown that the use of these environmentally friendly materials in the construction industry helps conserve natural resources, reduce pollutant gas emissions, and increase energy recovery (Meddah et al., 2014; Meddah et al., 2020; Bouchefra et al., 2022; Labiad et al., 2022). Various techniques exist for utilizing earth building materials in different parts of the world, such as earth plaster, mudbrick, rammed earth, mud-brick-filled wooden structures, and compacted earth blocks (Figure 5).

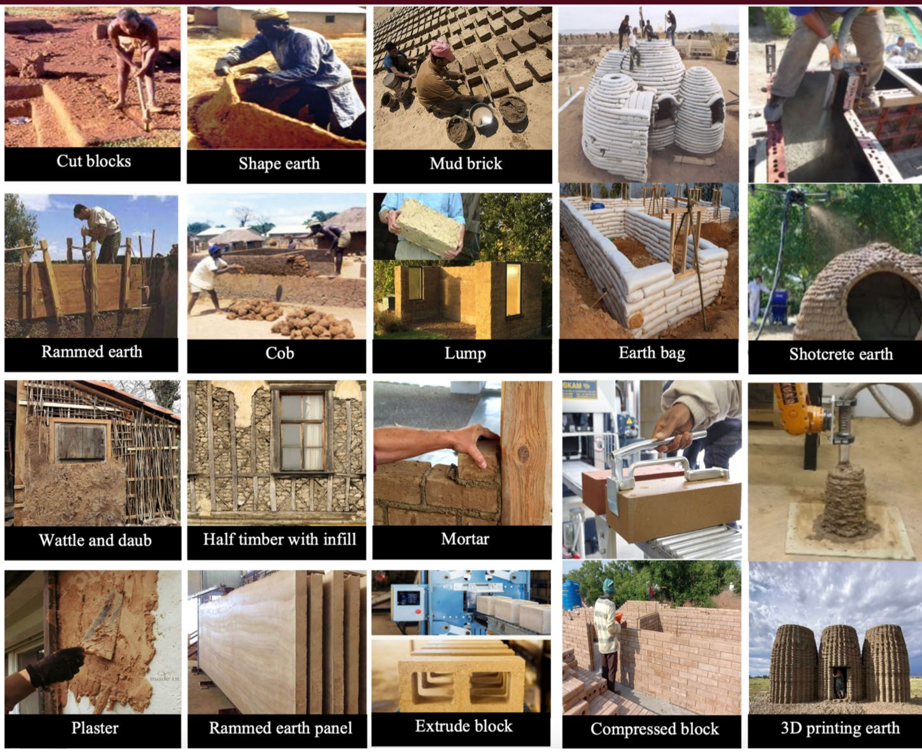

Figure 5. Examples of techniques of earth in wall construction (Created by the authors)

In areas where the soil possesses sufficient cohesion, blocks can be directly extracted from the soil using a method known as "cut blocks," which is employed, for example, in India. Laterite, a soil formed through intense weathering in tropical climates, is characterized by its high iron and aluminum content and is particularly suitable for this technique. Once cut and exposed to air, the relatively soft soil hardens due to the dehydration of iron and aluminum oxides (Vyncke et al. 2018). "Shape earth" refers to the method of directly shaping the earth by hand.

Mud brick or adobe is an ancient and simple earth construction method involving sun-dried bricks. Bricks are made by molding moist earth and then drying it in the sun. To prevent cracking, straw or fibers are sometimes added (Torgal & Jalali, 2011). The rammed earth technique involves compacting soil in layers within temporary formworks to build walls that are 30–60 cm thick. Each layer, approximately 7.5–15 cm thick, is compacted with a rammer, and formworks are added progressively until the desired height is reached; after which, they are removed (Avila et al., 2021).

Cob is a construction method where clayey soil mixtures, often combined with water, straw, and sand, are shaped into balls and stacked to build walls. It is commonly used in Africa, India, and Saudi Arabia (Vyncke et al., 2018). Earth lumps are hand-shaped mixtures of clay, straw, and water in a humid state. Mud bricks differ in that they have a defined size and are dried before being used in construction. Cob is used in a similar mixture to earth lumps, but is built by stacking layers with a pitchfork (Reddy, 2022).

In the wattle and daub method, processed earth with a plastic consistency is applied to both sides of a skeletal. wooden structure and manually leveled to create smooth wall surfaces. The skeleton usually consists of unshaped wooden elements and sticks, onto which the earth material is daubed from both sides (Reddy, 2022). In Thrace and Anatolia, this technique is referred to as “iğmeli” or “huğ”. The half-timber with infill system involves filling mudbricks within a wooden frame. This technique is referred to as “hımış” in Anatolia (Gelirli & Arpacıoğlu, 2022).

In modern construction, the use of earth in the form of earth bags is particularly noteworthy. These techniques involve placing local earth, mixed with small amounts of a binder, into degradable bags, which serve as both formwork and containment for the filling. The bags are stacked to form the walls of the structure. In the earthbag technique, standard bags are used, whereas superadobe employs long bags. The adhesion and friction between layers are enhanced by placing a wire between each row. Once filled, the bags are slightly compressed to remove air and regularize the contact surface, enabling the construction of walls and domes. This method has been widely applied in emergency situations in Africa and South America, demonstrating benefits in terms of acoustic and thermal insulation (Canadell et al., 2016). In Turkey, the superadobe technique was implemented following the February 6 earthquakes in the construction of the “Super Adobe Children’s Library” in Kahramanmaraş in 2024. In this structure, the mortar was filled into tubular bags, stacked, and compacted to form a dome. Barbed wire was placed between each horizontal layer to prevent slippage. All surfaces were initially leveled with a rough straw-clay plaster; the interior of the domes was finished with clay plaster, while the exterior was coated with a specially formulated lime plaster (Figure 6) (Cansız, 2024).

Figure 6. A Superadobe structure, applied in Türkiye in 2024, is shown in both the construction phase and the completed state (Cansız, 2024)

Compressed earth blocks, introduced in the mid-20th century, have become one of the most widely used modern techniques in earth construction. In the 18th century, the manual press became popular in Europe. Afterward, they are produced by pressing sieved earth into molds using mechanical or hydraulic presses. The molds employed may take various forms, such as rectangular blocks, blocks with rounded edges, blocks with holes (interlocking), sinus-shaped blocks, or blocks with recesses for cables. Suitable earth typically contains 10–20% clay, 10–20% silt, and 50–70% sand, although adjustments can be made with other types of earth. Compared to mud brick, compressed earth blocks are denser, stronger, and more uniform in composition. Unlike rammed earth, compressed earth blocks are pressed in a dry state with a moisture content of 5–15% (Van Damme & Houben 2018; Vyncke et al., 2018; Torgal & Jalali, 2011).

Shotcrete earth, also known as shot-earth, has been widely used in rendering and wall construction. Recent research has shown its potential to address key limitations typically associated with earthen materials. The material consists of a mixture of raw earth and aggregates. When the earth is unsuitable for construction, stabilization techniques are employed. After mixing all components, the mixture is applied by shooting it at high-speed using a dry process (Bacciocchi et al., 2022; Curto et al., 2020).

3D printing provides a modern construction method using earth. Earth mixtures of adequate consistency are extruded through a 3D printing nozzle and applied in layers. This technique has been implemented in Italy, Spain, the United States, and Dubai. The mixtures used must ensure sufficient mechanical performance to support the structure's own weight and that of the upper layers, as well as adequate bonding between layers (Curth et al., 2024; Faleschini et al., 2023). Due to the variable properties of raw earth materials, further research in this area is required.

1.3. Stabilization of Earthen Materials

The earthen construction is suitable not only for dry climates; however, with simple architectural measures—such as a stone or concrete foundation and a wide overhanging roof—it can also be used in regions with high rainfall. Although earthen structures are considered less structurally sound than reinforced concrete or timber-frame buildings in seismic areas, their resistance can be significantly enhanced through simple techniques, such as incorporating polymer meshes. Earthen construction materials are stabilized mainly to improve strength and to enhance durability against water-induced erosion. This method has a long history, especially in earthen plasters and stuccoes, where natural substances like tree resins, natural bitumen, Arabic gum, agave juice, opuntia cactus juice, cowpats, and casein from milk were traditionally used (Van Damme & Houben 2018). Despite their high strength, compacted earth blocks require stabilization due to their sensitivity to water. Additionally, the incorporation of fiber additives is recommended to mitigate crack formation in earthen-based materials. Stabilization methods for earthen-based materials typically involve the use of lime, cement, fiber, and bitumen (Sindanne et al., 2014; Meddah & Merzoug, 2017; Tatane et al., 2018; Labiad et al., 2022).

Earth stabilization techniques can be classified into two methods: mechanical/physical and chemical methods. Both methods can be used either separately or together to maximize their benefits (Ikeagwuani &

Nwonu, 2019). The figure below illustrates the stabilization techniques (Figure 7).

Stabilization Techniques for Earthen Materials	
Mechanical/Physical Techniques	**Chemical Techniques**
Compressing	Cement
Granulometric adjustment	Lime
Adding fibrous materials	Gypsum
Rice husk fibers	Bitumen
Straw	Resins
Flax fibers	Industrial by-product materials
Hemp	Cement kiln dust
Carpet waste fibers	Lime kiln dust
Waste rubber fibers	Ground granulated blast furnace slag
Polypropylene fibers	Pulverized coal bottom ash
Tire fibers	Steel slag
Animal hair and others	Mine tailings and others
	Waste products
	Waste paper sludge ash
	Sulphonated oils
	Ionic compounds
	Polymers and others
	Alkali-activated solutions

Figure 7. Stabilization techniques for earthen materials (This figure is prepared by the author based on the works of Freitas Luiz et al. (2024) and Ikeagwuani & Nwonu (2019))

It is seen that natural hydraulic lime is used in a small number of studies for chemical stabilization. Barbero-Barrera et al. (2020) replaced earth material with natural hydraulic limes (NHL2 and NHL3.5) at varying rates between 3% and 12% for stabilization. The samples were cured for 28 days under laboratory conditions with 50% humidity. As the natural hydraulic lime content increased, mechanical strength and hardness improved. While the water absorption coefficient decreased with NHL2, it increased with NHL3.5. In their study, Mkaouar et al. (2019) used natural hydraulic lime (NHL3.5) in varying proportions between 4% and 10% to stabilize three different types of earth. Samples were cured for 28 days in a 60°C oven. As the natural hydraulic lime content increased, compressive strength also increased, showing a 3.8-time improvement with the addition of 10% lime. Miqueleiz et al. (2012) used commercial stabilizers such as NHL 5 and CL-90-S to produce stabilized unfired soil clay bricks. When the CL-90-S additive dosage limit exceeds 6-9%, adding more additives is not affected. However, the strength of samples with NHL 5 additives increased when NHL 5 dosage was increased. Bahar et al. (2004) used cement at ratios ranging from 4% to 20% by the dry weight of the earth for stabilization. Specimens were dried in a laboratory environment at approximately 25 °C and 65% relative humidity. As the cement content increased, compressive strength improved. Notably, specimens with 8% cement content performed better in strength tests conducted in both dry conditions and after 48 hours of water immersion.

The aim of this study is to stabilize and to improve mechanical and physical properties of two types of earth obtained from the İznik-Elbeyli region using air lime, natural hydraulic lime (NHL3.5), and cement. In this context, the experimental study was conducted on raw earths and on samples (stabilized and control). Additionally, to determine the effect of different curing conditions on material properties, two different curing conditions were examined: laboratory conditions (23±2 °C, 40±10% RH) for 28 days and in an oven at 30 °C for 7 days, representing sun drying.

2. Materials and Methods

In this preliminary experimental study, two types of earth from the Iznik-Elbeyli region are stabilized using chemical stabilization techniques, including cement, lime, and natural hydraulic lime. The experimental work not only demonstrates the practical application of the stabilization techniques discussed but also focuses on the specific characteristics of two types of raw earth. The stabilization method used is chemical stabilization, employing cement and lime—common agents—and hydraulic lime, which is less frequently used. These binders were chosen for their availability in the region. The experimental study involved two types of raw earth samples, including stabilized and control samples. Additionally, the effect of different curing conditions on the material properties was evaluated by testing two curing methods: laboratory conditions and oven curing.

2.1. Mix design

In this study, two raw earth materials from the Iznik-Elbeyli region were subjected to chemical analyses (acid loss and ignition loss) and granulometric analysis. In addition, X-ray diffraction (XRD) analyses were conducted to determine the mineralogical composition of the earth. Subsequently, the two types of earth were removed from residues such as plant roots, leaves, etc., sieved under a 16 mm sieve to remove coarse stone fragments.

The moisture content (w) of a soil sample is defined as the ratio of the weight of the pore water to the dry weight of the soil. In the ceramics industry, three types of shaping are distinguished based on the consistency or moisture content of the material: (i) compression shaping (moisture < 15%), (ii) plastic shaping (moisture approximately 15–25%), and (iii) shaping by casting (moisture approximately 25–40%) (Schroeder, 2016). In this study, the earth materials were used in the plastic shaping range, with a moisture content of 23% for S1 and 24% for S2. Preliminary experiments were conducted to determine the minimum water content needed for workable consistency, which is when the mud is stiff and non-sticky. These trials ensured that the raw earth could be evenly molded using a hand hammer. Initially, 150 g of oven-dried earth from each type of earth was placed into separate containers. Water was added incrementally, and the amount of water was recorded once the mixture reached a workable consistency. The minimum mixing water ratio (water/total dry mass) was found to be 23% for S1 and 24% for S2.

Cement admixture improves the performance of earth materials, particularly in terms of water resistance. As the clay content in the earth increases, the required cement dosage must also be increased. The addition of hydraulic lime triggers an ion exchange process between the clay minerals in the earth and calcium ions, which lasts between four and eight hours. The carbonation reaction of hydrated lime (Portlandite, $Ca(OH)_2$), which forms during the mixing of lime, hydraulic lime, and cement with water, takes place slowly with the carbon dioxide in the air. These reactions require a certain amount of moisture. For effective stabilization, cement-stabilized earth should not be dried too quickly or in a short period (e.g., under windy conditions or direct sunlight) (Minke, 2013) When hydraulic binders are mixed with water, hydration begins. During the hydraulic phases (dicalcium silicate and tricalcium silicate) present in hydraulic lime and cement, react with water, calcium silicate hydrate (C-S-H) products create an intricate structure in the mixture to harden and gain strength over time (Strother, 2019; Moir, 2003).

For stabilization, natural hydraulic lime (NHL3.5), air lime (CL-90-S), and ordinary Portland cement were used in different ratios: 0%, 6%, and 12%. Mixture ratios of samples are given the Table 1. Two curing conditions were examined under laboratory conditions (23±2 °C - 40±10% RH) for 28 days and in an oven at 30 °C for 7 days, representing sun drying.

Table 1. Mixture ratios

Sample Codes	Earth (g)	Additive (g)			AR by dry mass (%)	Water (g)	W/T Ratio (%)	Curing
		NHL	Air Lime	OPC				
S1/C/O	1255	-	-	-	-	291	0.23	Oven
S1/6N/O	1200	72	-	-	6	312	0.25	Oven
S1/6A/O	1200	-	72		6	343	0.27	Oven
S1/6C/O	1200	-	-	72	6	333	0.26	Oven
S1/12N/O	1200	144	-	-	12	348	0.26	Oven
S1/12A/O	1200	-	144	-	12	390	0.29	Oven
S1/12C/O	1200	-	-	144	12	350	0.28	Oven
S1/C/LC	1255	-	-	-	-	291	0.23	Lab. Cond.
S1/6N/LC	1200	72	-	-	6	312	0.25	Lab. Cond.
S1/6A/LC	1200	-	72	-	6	343	0.27	Lab. Cond.
S1/6C/LC	1200	-	-	72	6	333	0.26	Lab. Cond.
S1/12N/LC	1200	144	-	-	12	348	0.26	Lab. Cond.
S1/12A/LC	1200	-	144	-	12	390	0.29	Lab. Cond.
S1/12C/LC	1200	-	-	144	12	350	0.28	Lab. Cond.
S2/C/O	1350	-	-	-	-	320	0.24	Oven
S2/6N/O	1200	72	-	-	6	299	0.25	Oven
S2/6A/O	1200	-	72	-	6	341	0.27	Oven
S2/6C/O	1200	-	-	72	6	331	0.26	Oven
S2/12N/O	1200	144	-	-	12	295	0.25	Oven
S2/12A/O	1200	-	144	-	12	345	0.27	Oven
S2/12C/O	1200	-	-	144	12	331	0.26	Oven
S2/C/LC	1350	-	-	-	-	320	0.24	Lab. Cond.
S2/6N/LC	1200	72	-	-	6	299	0.25	Lab. Cond.
S2/6A/LC	1200	-	72	-	6	341	0.27	Lab. Cond.
S2/6C/LC	1200	-	-	72	6	331	0.26	Lab. Cond.
S2/12N/LC	1200	144	-	-	12	295	0.25	Lab. Cond.
S2/12A/LC	1200	-	144	-	12	345	0.27	Lab. Cond.
S2/12C/LC	1200	-	-	144	12	331	0.26	Lab. Cond.

NHL: Natural hydraulic lime (NHL3.5) , Air Lime: Hydrated Calcium Lime (CL-90-S), OPC: Ordinary Portland Cement, CEM I 42.5, AR: Additive Ratio, W/T: Water/ Total dry mass

2.2. Materials

Two types of earth (S1 and S2) used in this study were obtained from the Elbeyli region (Figure 8), located within the borders of the İznik district of Bursa province. Elbeyli is located in the plateau area north of İznik Lake, where Çakırca Plain intersects with the low plateau area. Red-brown Mediterranean soils and colluvial soil types dominate the region (Akbulak, 2006).

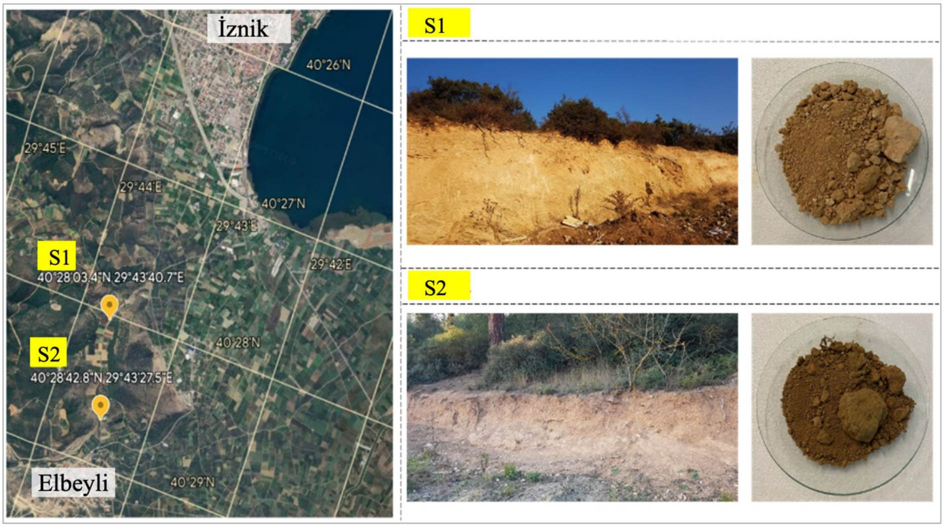

Figure 8. The types of earth used in this study (Created by the authors)

Samples taken from soils (approximately 150 g oven-dry) were mixed with water to separate the aggregate and clay. The samples were then filtered through filter paper and washed until the aggregates were separated from the clay. The aggregates were dried in an oven, and a granulometric analysis was conducted on oven-dry aggregates. The aggregate granulometric analysis is presented in Figure 9.

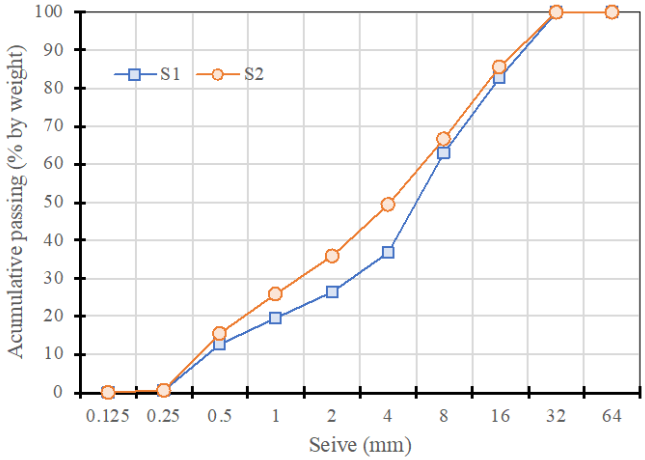

Figure 9. The aggregate granulometric analysis of S1 and S2 (Created by the authors)

X-ray diffraction analyses were performed to determine the mineralogical composition of the earth samples, as presented in Table 2. The results indicate that S1 exhibits a higher content of calcite, whereas S2 contains dolomite. Furthermore, S2 displays a higher quartz content compared to S1.

Table 2. Mineralogical composition of S1 and S2.

Composition (%)	**S1**	**S2**
Calcite ($CaCO_3$)	75-80	30-35
Dolomite ($CaMg(CO_3)_2$)	-	10-15
Quartz (SiO_2)	<5	30-35
Smectite	15-20	-
Illite-Mica	-	5-10
Chlorite-Kaolinite	<5	5-10
Feldspar	-	<5
Britholite	<5	-
Pyroxene group	-	<5

The specific gravity of S1 and S2 were 2.57 gr/cm3 and 2.43 gr/cm3, respectively. In line with the X-ray diffraction (XRD) analysis, the acid loss and loss on ignition of the S1, which has a high calcite content, are greater than those of the S2 (Table 3).

Table 3. Properties of raw earth samples.

Properties	S1	S2
Specific gravity (gr/cm^3)	2.57	2.43
Acid loss (%)	72.28	36.63
Loss on ignition at 1050^{o}C (%)	33	15

2.3. Production of the samples

The mixing process was carried out manually to resemble traditional conditions. Initially, two types of earth were removed from impurities, and dry raw earth was mixed with the stabilizer in the proportions given in Table 1. Once a homogeneous dry mixture was obtained, water was added, and the mixture was mixed for an additional 10 minutes. Then, the mud was placed into steel molds. Finally, a wooden wedge was placed on top of the mould and compacted using a hammer to minimize air voids in the samples (Figure 10). Afterward, the moulds were removed immediately, and the samples were cured.

Figure 10. Moulding and demoulding process of samples (Created by the authors)

The flowchart illustrating the sample production process is summarized in Figure 11.

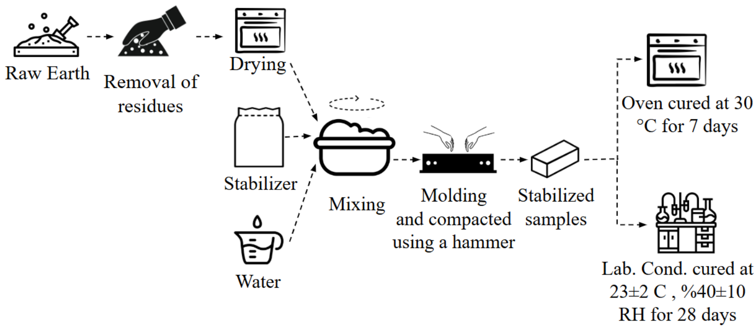

Figure 11. Sample production process (Created by the authors)

2.4. Methods

Experimental studies were conducted on raw earth and also stabilized samples. Two types of earth were analyzed for specific gravity and chemical properties (acid loss and loss on ignition). Also, X-Ray diffraction (XRD) analysis was conducted to determined mineralogical composition of soils. Stabilized and control samples were analyzed for physical properties (capillarity coefficient, water absorption by weight, water absorption by volume, specific gravity), mechanical properties (compressive strength and flexural strength).

The specific gravity was determined according to the TS EN 1936 standard on samples dried at 70±5°C and then cooled in a desiccator. For the specific gravity (ρ_r), the sample was ground and sieved through a 0.063 mm mesh, then dried at 70±5°C until reaching a constant weight in an oven. A pycnometer was filled halfway with a liquid, and approximately 10 grams of the oven-dried sample (m_e) was added. After shaking, the mixture was topped up with the liquid and weighed (m_1). Then, the cleaned pycnometer was filled with the liquid, ensuring no air bubbles remained, and weighed (m_2). The specific gravity (ρ_r) was calculated using Eq. 1.

$$\rho_r = (m_e \times \rho_{liquid})/(m_2 + m_e - m_1) \quad (1)$$

Water absorption by volume (S_h), by TS EN 1936, is calculated using Eq. 2, which is the difference between the saturated weight of the material (m_s) and its dry weight (m_d), divided by the difference between the saturated weight (m_s) and the weight in water (m_h) of the material. The water absorption by weight (S_k) is calculated using Eq. 3, which is the difference between the saturated weight of the material (m_s) and its dry weight (md), divided by the dry weight (m_d) of the material.

$$\rho_r = (m_e \times \rho_{liquid})/(m_2 + m_e - m_1) \quad (2)$$

$$S_k = ((m_s - m_d) \times 100)/m_d \quad (3)$$

The water absorption coefficient with capillarity (N) was determined according to TS EN 1925. Test samples (40 mm x 40 mm x 160 mm) were dried at 70±5°C and then cooled to ambient temperature (20±5°C) in a desiccator. The dry weights of the samples and the initial time were recorded. The samples were placed in a test setup at 20±5°C and 40±10% RH, ensuring that their contact surface area was submerged in water. At specified intervals, surface water was wiped off the contact surface, and weight changes were recorded. The absorbed water was calculated as the difference between the weight change and the dry weight. A line graph was created with the mass of absorbed water related to the surface area of the immersed base of the specimen (g/m^2) as a function of the square root of time ($min^{0.5}$). The slope of the regression line of the graph was calculated as the water absorption coefficient with capillarity.

Flexural strength (R_f) and compressive strenght (R_c) was determined according to the BS EN 196-1 using a MFL Prüf-und Meßsysteme brand universal testing machine with a 100 kN capacity. The side of square section dimension (b) of the prismatic samples was measured, and the supports distance (l) was recorded. The sample was placed on the supports and the failure load (F_f) was recorded in Newtons. The flexural strength was calculated using the Eq. 4. Compressive strength (R_c) was carried out on broken samples after flexural strength test. The failure load (F_c) was recorded in Newtons and it was calculated using the Eq. 5.

$$R_f = 1{,}5 \times F_f \times l/b^3 \quad (4)$$

$$R_c = F_c/1600 \quad (5)$$

Earth samples were soaked in a 10% HCl solution for acid loss. They were then weighed using a Radwag brand scale with a maximum capacity of 3500 g and a precision of 0.01 g, and the weight differences were calculated. For ignition loss, powdered samples were heated at 105°C, 550°C, and 1050°C, and the weight differences were measured using a Mettler brand scale with a maximum capacity of 160 g and a precision of 0.001 mg. The weight losses were calculated as percentages based on these measurements.

X-ray diffraction (XRD) pattern measurements were performed using a Bruker D8 Advance diffractometer CuKα radiation and Ni filter, 40 kV, 40 mA equipped, between 2 and 72° of 2θ. The contents of the phases were the reference intensity ratio (RIR) method.

3. Results and Discussions

3.1. Physical properties

The specific gravity of stabilized earthen samples cured in laboratory conditions is given in Figure 12. According to the test results, the specific gravity of the S2 control sample (S2/C) is 4% higher than that of the S1 control sample (S1/C).

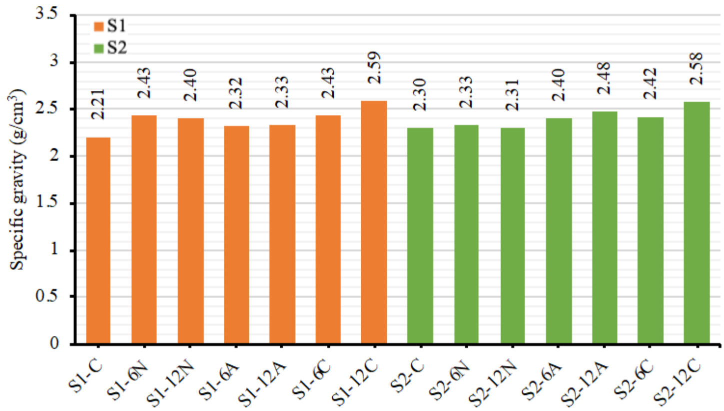

Figure 12. The specific gravity of stabilized earthen samples (Created by the authors)

The samples' water absorption by weight and volume test results are presented in the graph in Figure 13.

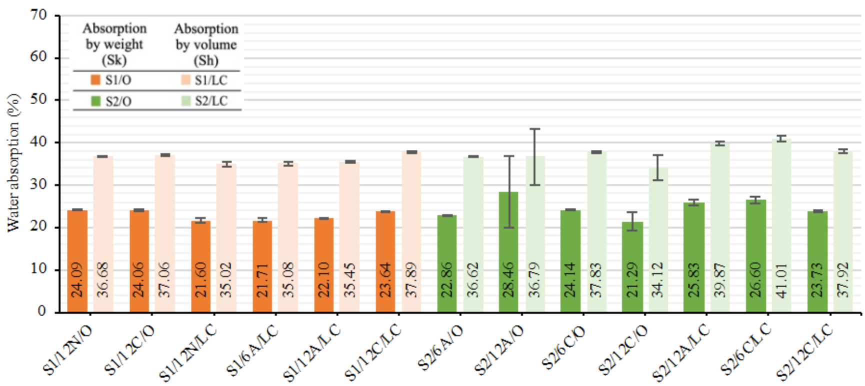

Figure 13. Water absorption by weight and volume of earthen samples (Created by the authors)

Accordingly, no significant variation in water absorption rates was observed for S1 earth depending on curing conditions. For S2 earth, water absorption by weight and volume rates were relatively higher under laboratory curing compared to oven curing. As the cement content in S2 earth increased, the water absorption rates decreased relatively under both curing conditions. The capillarity coefficient test was conducted on the samples that did not disintegrate during the water absorption tests, and the results are presented in Figure 14.

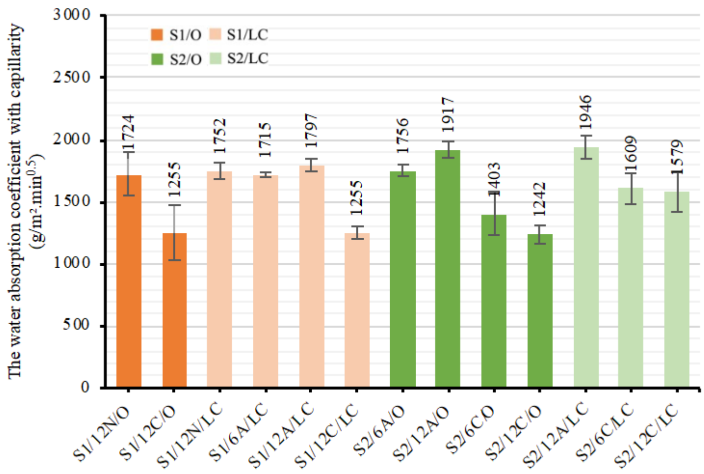

Figure 14. Water absorption coefficient with capillarity of earthen samples (Created by the authors)

According to these results, no significant variation in the capillarity coefficient was observed for S1 earth depending on the curing conditions. For S2 earth, the capillarity coefficient of the laboratory-cured samples with 6% and 12% cement was 39% and 27% higher, respectively, compared to the oven-cured samples. In addition, with the addition of air lime to S1 and S2 earth, the capillarity coefficient increased as the air lime content increased. Gomes et al. (2018) investigated the stabilization of earth-based mortars with mineral additives such as air lime, Portland cement, natural cement, and hydraulic lime. For stabilization, additives were incorporated into the earth at ratios of 5%, 10%, and 15%. The capillary coefficient was observed to increase with the proportion of all types of additives. These findings are consistent with the effect of air lime addition in S1 and S2 earth. However, in contrast to the literature example, an increase in cement content decreased the capillarity coefficient of S2 samples.

3.2. Mechanical Properties

The compressive strength of earth-based materials used in construction, such as rammed earth or earth blocks, generally varies between 5–50 kg/cm² (approximately 0.5–5 MPa), depending on the type of clay and the aggregates present in the earth, such as sand and silt as well as depending on the production process (Minke, 2013).

3.2.1. Curing under oven conditions

For S1 earth, 6% all additives increased the compressive strength values, whereas for S2 earth, all additives reduced the compressive strength values under oven conditions. For S1 earth, 12% air lime additive decreased compressive strength compared to 6% air lime additive, but still a higher value than the control samples. For S1 samples, the compressive strength increased with the addition of natural hydraulic lime and cement at 6% and 12%, under oven conditions, compared to control samples. For S2 earth, the compressive strength increased moderately as the cement content rose from 6% to 12% under oven curing conditions; however, the values remained lower than those of the control sample. The flexural and compressive strength results of the control and stabilized samples, along with the standard deviation line, are presented in Figure 15.

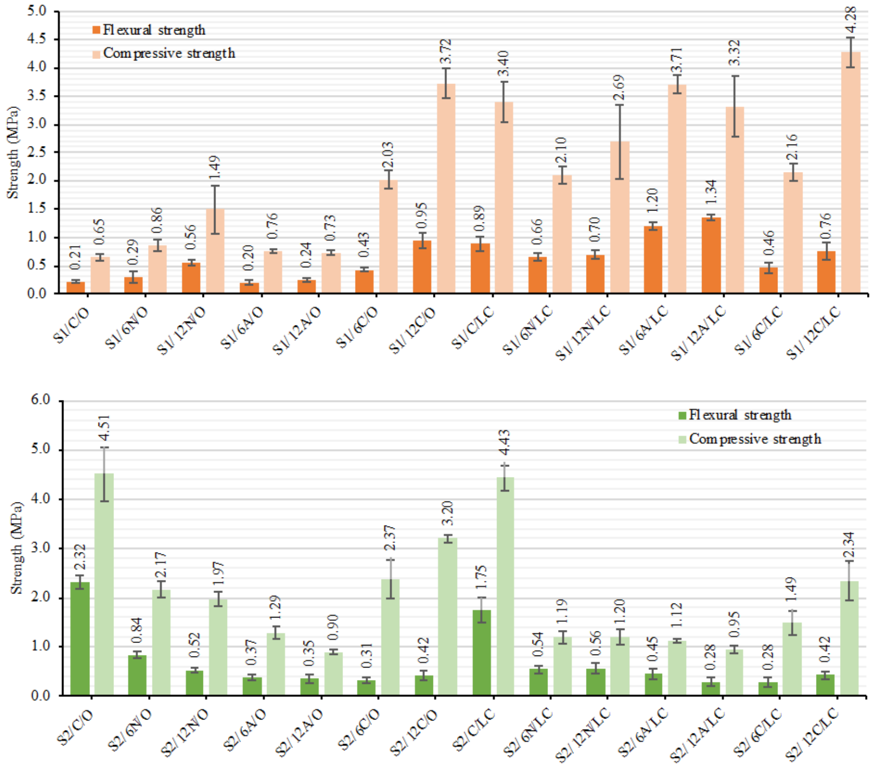

Figure 15. Compressive and flexural strength of test samples (Created by the authors)

3.2.2. Curing under laboratory conditions

The effects of additives and their ratios on the compressive strength of S1 earth exhibit variability compared to the S1 control sample. For S2 earth, the compressive strengths are low for all additives and their ratios compared to the S2 control sample. S1 samples under laboratory conditions, compressive strength was increased 6% air lime and 12% cement additives compared to control samples. For S2 earth, the compressive strength increased moderately as the cement content rose from 6% to 12% under laboratory curing conditions; however, the values remained lower than those of the control sample.

Accordingly, for S1 earth, the strength results of the control samples were higher under laboratory curing than under oven curing. The same trend was observed for all stabilized mixtures of S1 earth. In this context, no significant change was observed in S2 earth. The control specimens of S1 earth have compressive strengths of 0.65 MPa and 3.40 MPa under oven curing and laboratory curing conditions, respectively. On the other hand, the control specimens of S2 earth have compressive strengths of 4.51 MPa and 4.43 MPa under oven curing and laboratory curing conditions, respectively. This indicates that, for S2 earth, curing conditions had a less significant effect on strength values compared to S1 earth.

From an architectural perspective, stabilized earth has potential applications in both new construction and restoring heritage structures, especially in regions where traditional earthen techniques are culturally significant, such as Elbeyli, Iznik. By enhancing water resistance and mechanical strength, the use of hydraulic lime or cement-stabilized S1 earth materials could extend beyond rural areas and contribute to modern sustainable housing.

4. Conclusion

Earthen materials are an eco-friendly alternative for construction because they have a low environmental impact, are locally available, and are part of traditional building practices. The stabilization of earth-based materials plays a key role in maintaining existing earthen structures and in modern earthen buildings. In this study, two types of raw earth from the Iznik-Elbeyli region were tested. They were stabilized chemically using cement, air lime, and natural hydraulic lime. The physical and mechanical properties of these materials were measured in the laboratory and oven conditions. The results showed that the S1 earth material responded well to stabilization. Adding natural hydraulic lime and cement increased its compressive strength. The slower hydration of natural cement compared to cement reduces early-stage performance. Determining the physical and mechanical properties of earth materials stabilized with natural hydraulic lime up to one year will add to the existing literature. For S2 earth, the use of additives did not lead to any improvement in compressive strength under either curing condition. In future studies, alternative stabilization techniques are recommended to enhance the properties of S2 raw earth. Future research should examine hybrid approaches that combine chemical and physical stabilization methods, such as fiber reinforcement, polymer meshes, or geopolymers for S2. Moreover, incorporating locally available natural additives or industrial by-products could enhance both strength and sustainability.

Physical properties such as water absorption and capillarity were affected by the type and amount of stabilizer used. This highlights the importance of selecting appropriate stabilization and construction methods to ensure the strength of earthen materials. Overall, combining proper stabilization techniques with suitable construction methods can help support sustainable building practices that keep the benefits of earthen materials. However, it should be noted that the effectiveness of additives will vary depending on the mineralogical composition of the stabilized earth.

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The article complies with national and international research and publication ethics. Ethics Committee approval was not required for the study.

Author Contribution and Conflict of Interest Declaration Information

All authors contributed equally to the article. There is no conflict of interest.

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Application of Boron Compounds in Building Materials: A Review

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1. Introduction

Boron is a versatile and rare element (Helvacı, 2004) with important applications across various industries due to its unique properties (Yiğitbaşıoğlu, 2004). Naturally found in borate minerals such as borax, colemanite, ulexite, and kernite, boron is widely available in Türkiye, offering potential for use in building materials. Recent research has focused on adding boron and boron-containing wastes into cementitious systems, geopolymers, fire-retardant treatments, neutron-shielding concrete, and lightweight concrete. These applications aim to improve the qualities of building materials while also encouraging the reuse of industrial by-products. This review provides an overview of experimental studies on boron's multifunctional role in building materials, highlighting its potential to develop advanced, eco-friendly applications.

1.1. Boron

Boron is a nonmetallic element with an atomic number of 5 and an atomic mass of 10.811 g/mol. It was first identified in 1808 by Sir Humphry Davy, Gay-Lussac, and Thénard. In nature, boron occurs in organoboron complexes with sodium and oxygen and is commonly found in rocks, soil, and water (Uluişik et al., 2018). Boron does not appear in its elemental form in nature; instead, it naturally exists as borates or borosilicates in deposits formed by volcanic activity and evaporation (Halvacı et al., 2024). Many minerals contain boric oxide (B_2O_3), but the most commercially important ones are borax (tincal, $Na_2B_4O_7 \cdot 10H_2O$), kernite ($Na_2B_4O_7 \cdot 4H_2O$), ulexite ($NaCaB_5O_9 \cdot 8H_2O$), and colemanite ($Ca_2B_6O_{11} \cdot 5H_2O$). Although boron (B) is considered a rare element, with an average abundance of about 100 ppm in the Earth's crust, it occurs at much higher concentrations in certain localities (Helvacı, 2004). The main deposits are located in Türkiye, and the remaining boron deposits mainly found in the United States, as well as in Russia, China, Chile, Argentina, Peru, Iraq, Syria, Egypt, Libya, and Morocco (Farfán-García et al., 2023). The world's leading borate mining sites is given the Figure 1.

Figure 1. The world's leading borate mining sites (Helvacı, 2015)

1.1.1. Borax (tincal)

The term "baurach," meaning borax in Arabic, appears in manuscripts from ancient Iran and Arabia dating back approximately 2,000 years. Tincal, the natural form of the borax decahydrate compound, is derived from the Sanskrit word "tincana," which also refers to borax (Özkan et al., 1997). Borax (tincal, $Na_2B_4O_7 \cdot 10H_2O$) contains 36,60% B_2O_3 (Bayrak et al., 2001). It usually appears as a colorless, transparent mineral; however, it can also show shades of pink, yellowish, or gray due to impurities. When it loses water, it can quickly decompose and turn into tincalconite. Borax (tincal), a natural sodium borate decahydrate, is the most economical source of boron and is primarily produced in the United States, Argentina, and Türkiye (Helvacı, 2004). In Türkiye, this mineral has been found in the Kırka deposit in Eskişehir (Şahin & Acarali, 2023). Borax has been reported as an effective setting retarder in magnesium potassium phosphate cement at ambient temperatures and also functions as a flux in ceramics, reducing the glass melting point from 1650 °C to 1072 °C by forming weaker Si–O–B bonds (Dai et al., 2023).

1.1.2. Kernite

It occurs naturally as colorless, transparent, needle-shaped crystals that form in clusters. Its hardness is 3, and its specific gravity is 1.95 g/cm³. It is slightly soluble in cold water (Yiğitbaşıoğlu, 2004). It is mainly used as a raw material in the boric acid plant in Boron (Kistler & Helvacı, 1994). Kernite ($Na_2B_4O_7 \cdot 4H_2O$) contains 59.95% B_2O_3 and is mined in Turkey from the Kırka deposit (Bayrak et al., 2001; Şahin & Acarali, 2023).

1.1.3. Ulexite

Ulexite ($NaCaB_5O_9 \cdot 8H_2O$) occurs in massive, fibrous, and columnar forms. Pure specimens are white, but gray varieties also exist (Şahin & Acarali, 2023). Its crystal system is triclinic, with a hardness of 2.5 (Yiğitbaşıoğlu, 2004). It is usually found together with colemanite, hydroboracite, and probertite. Ulexite contains 43% B_2O_3 and is mined in Turkey from the Bigadiç, Kırka, Emet, and Kestelek deposits (Bayrak et al., 2001).

1.1.4. Colemanite

Colemanite ($Ca_2B_6O_{11} \cdot 5H_2O$) is a hydrated calcium borate mineral mainly composed of B_2O_3 and CaO. It crystallizes in a monoclinic system. Its hardness is 4–4.5, and its specific gravity is 2.42. It dissolves slowly in water but quickly in hydrochloric acid. It is the most common boron compound (Yiğitbaşıoğlu, 2004). It contains 21.90% B_2O_3 and is mined in

Turkey from the Bigadiç, Kırka, Emet, and Kestelek deposits (Bayrak et al., 2001).

1.2. Boron Reserves in Türkiye

Boron is a rare element, averaging 0.1 ppm in continental waters, 3 ppm in the Earth's crust, and 4.6 ppm in seawater. Economically significant concentrations typically form through the combined effects of volcanic activity, lacustrine environments, evaporative conditions, and a protective sediment cover that preserves easily soluble boron minerals. It is considered that most of Turkey's economic deposits are associated with continental sediments and Neogene volcanism (Helvacı, 2004). All known borate deposits in Türkiye are located in Western Anatolia, especially in the regions of Bigadiç (ulexite, colemanite), Sultançayırı (pandermite, colemanite), Kestelek (colemanite, ulexite, probertite), Emet (colemanite), and Kırka (tincal) (Kılınç et al., 2001; Helvacı, 2004). About 72% of the world's boron reserves, particularly borax, ulexite, and colemanite, are found in Türkiye (Millas, 2020; Halvacı et al., 2024).

In Türkiye, economic borate minerals are classified based on the dominant elements in their composition, namely calcium, sodium, and magnesium. Accordingly, sodium-based minerals are referred to as borax (tincal) and kernite, calcium-based minerals as colemanite, sodium–calcium-based minerals as ulexite and probertite, and magnesium-calcium-based minerals as hydroboracite (TMMOB Maden Mühendisleri Odası, n.d.; Helvacı, 2017). Borax (tincal), a natural sodium borate decahydrate, represents the most economical source of boron and is primarily produced in the United States, Argentina, and Türkiye. Ulexite, a sodium–calcium borate mineral, is produced in Türkiye and several South American countries. In contrast, the production of colemanite, the principal calcium borate mineral, is restricted to Türkiye (Helvacı, 2004). Boron reserves and reserve life are provided in Table 1.

Table 1. Boron reserves and reserve life (TMMOB Maden Mühendisleri Odası, n.d.)

Country	Apparent Economic Reserve	Total Reserve (Apparent + Potential + Possible)	Apparent Economic Reserve Life (Years)	Total Reserve Life (Years)
Türkiye	375,000	644,000	240	412
USA	45,000	105,000	33	76
Russia	28,000	140,000	16	78
China	27,000	36,000	17	23
Chile	8,000	41,000	5	26
Bolivia	4,000	19,000	3	12
Peru	4,000	22,000	3	14
Argentina	2,000	9,000	1	6
Serbia	3,000	3,000	2	2

Since it is produced from non-renewable natural resources, the sustainability of the raw material becomes increasingly important. For the sustainability of natural resources and to ensure future generations' access to boron products, it is necessary to reduce consumption to a maximum of 465,000 t per year (Henckens et al., 2015). Additionally, boron ore requires chemical processing to produce high-purity boron compounds like boric acid or boron oxide. These purification processes increase energy use and environmental impact (Halvacı et al., 2024). From this perspective, using boron waste in construction materials is becoming more significant.

2. Material and Method

In this study, experimental investigations on the applications of boron in construction materials were reviewed. The collected studies were categorized according to the intended purpose of boron within the materials. The studies were categorized under the following headings: neutron-shielding effect, cement production, fire retardant, replacement of calcium-based binders with boron compounds, boron application in alkali-activated systems, and boron compounds in lightweight concrete. Boron and boron-containing compounds have garnered attention in construction materials research due to their multifunctional properties, including neutron shielding, fire retardancy, and enhancement of mechanical and thermal performance. Studies have demonstrated that boron can be integrated into cementitious and alkali-activated systems as natural minerals, industrial wastes, or synthetic compounds, enhancing compressive strength, durability, setting behavior, and resistance to high temperatures. Based on a comprehensive review of the literature, the use of boron-based materials in building materials clearly presents a versatile approach for developing advanced and sustainable construction materials. The following section outlines the specific materials used in this study, the preparation methods applied, and the evaluation procedures conducted to assess the performance of boron-containing mixtures.

2.1. Neutron-Shielding Effect

Exposure to neutron radiation can lead to severe human illnesses, including cancer, cardiovascular disease, and hemopoietic syndrome ant etc. (Abdulrahman et al., 2020). Advances in nuclear reactors and particle accelerators have increased the need for improved shielding systems, as highly penetrating neutron radiation must be captured to ensure protection of personnel and the environment (Glinicki et al., 2018).

In ordinary concrete, chloride (Cl) and iron (Fe) are the most effective neutron absorbers; however, chloride causes reinforcement corrosion, while iron results to high-energy gamma radiation and can cause concrete activation. Therefore, alternative elements such as gadolinium (Gd), cadmium (Cd), boron (B), or cobalt (Co) are considered more suitable (Piotrowski, 2021). Concrete is commonly used for neutron shielding due to its low cost, but it requires large thicknesses. Since natural rocks contain boron and hydrogen atoms, they offer a more economical alternative as concrete aggregates for shielding applications (Okuno et al., 2009). In radiation shielding concrete, gamma and neutron rays are the main concern. Heavyweight aggregates effectively attenuate fast neutrons, while hydrogen-containing materials are needed to absorb moderate and slow neutrons. Since the hydrogen content in ordinary concrete is usually insufficient, boron-containing aggregates are preferred due to their high neutron capture cross-section (Roslan et al., 2019).

Okuno et al. (2009) aimed to produce neutron shielding concrete using colemanite, peridotite, and ordinary Portland cement. Mixtures were prepared with colemanite, which is known as a very strong neutron absorber. Since colemanite is slightly soluble in water, its content in the mixture was limited to 10% by weight. As a result, in terms of shielding performance, the colemanite-containing concrete developed was approximately 1.7 times more effective than ordinary concrete. Its mechanical properties were almost identical to those of ordinary concrete. By using this concrete, the thickness of the shielding wall could be reduced by up to 25 cm, and the volume of reinforcement in beam casting could be reduced by approximately one-fourth.

Roslan et al. (2019) examined the shielding capability of high-density concretes incorporating ferro-boron aggregates in different proportions (25%, 50%, and 75%) as a replacement for granite aggregate. Ferro-boron is a mixture of iron and boron, produced by the carbothermic reduction of boric acid with low-carbon steel in a single-phase arc furnace, and subsequently crushed to the required sizes (4–25 mm). The specific gravity of this aggregate, produced for heavy concrete applications, is 6.32 g/cm^3, and it contains 72.2% iron and 21.9% boron. The results indicate that the shielding capability of concretes containing 25%, 50%, and 75% ferro-boron aggregate replacements is 2, 2.57, and 3.27 times higher than that of the control concrete sample, respectively.

Holiuk et al. (2025) investigated the neutron shielding properties of concretes reinforced with basalt–boron fibers. To produce these fibers, andesite–basalt rock was combined with boric anhydride (B_2O_3) at proportions of 6% and 12%. The basalt–boron mixture was melted in a furnace and subsequently drawn into fibers (diameter: 10–16 μm; length: 12 mm), which were then incorporated into ordinary concrete materials. The results demonstrated that even a small addition of basalt–boron fibers reduced the neutron flux by approximately 5% compared to plain concrete.

These studies have shown that boron can be utilized in various forms, such as a natural aggregate, as an aggregate produced together with heavy elements like iron through carbothermic reduction, or as fibers obtained by melting with basalt. In all these applications, boron enhances the neutron shielding performance of concrete.

2.2. Cement Production

Boron active belite cement is a next-generation cement. The addition of boron accelerates the hydration of the main belite phase in cement, shortening the setting time and increasing early strength. In their study, Boncukoğlu et al. (2002) investigated the alternative use of borogypsum waste, generated during boric acid production on a filter press, by grinding it with Portland clinker to produce a new type of gypsum. The study showed that concrete produced with borogypsum–cement exhibits higher mechanical strength than natural gypsum cements, although strength decreases as the borogypsum ratio increases, similar to natural gypsum. Unlike natural gypsum, borogypsum does not cause pseudo setting during grinding, preserving cement quality due to its loose structure and stability. Olgun et al. (2007) investigated the possibility of using colemanite ore waste as a substitute for natural gypsum in Portland cement production. The study demonstrated that replacing natural gypsum with colemanite ore waste reduced the early strength of mortars. Moreover, using a combination of natural gypsum and colemanite ore waste in cement production resulted in greater retardation.

Özdemir & Öztürk (2003) investigated the use of clay wastes containing boron (with B_2O_3 content ranging from 8% to 22%) in Portland cement production, in proportions varying from 1% to 10%. The natural gypsum content in the produced cements was kept constant at 3.5%. The mixtures with different proportions were ground together. The results showed that incorporating up to 1% boron-containing waste improved the compressive strength compared to ordinary Portland cement.

Aydın et al. (2018) investigated the properties of concrete produced using boron active belite cement obtained from the National Boron Research Institute in Ankara, Turkey. The produced concretes were also compared with those made using Portland cement. In the experimental study, the concretes were exposed to high temperatures of 200, 400, and 600°C to evaluate their fire resistance in comparison with ordinary Portland cement and boron active belite cement. The results indicated that concretes produced with boron active belite cement exhibited higher durability against elevated temperatures than the others.

Gökçe (2019) theoretically investigated, using an online computation program, the neutron shielding performance of energy-efficient cements—boron active belite cement and Portland composite cement—at different fly ash addition levels, and tested the high-temperature resistance of the cement mortars (up to 900 °C) in terms of compressive and flexural strength. It was found that boron-active belite cement exhibited a neutron attenuation factor 25 times higher than Portland composite cement. Adding 10% fly ash increased the high-temperature (900 °C) resistance of boron-active belite by 23%, while 30% fly ash significantly decreased it.

The studies reviewed show that boron-active belite cement and boron-rich industrial wastes can improve the performance of cement-based materials in several ways. Boron-active belite cement speeds up the hydration of the belite phase, leading to higher early strength and better fire resistance compared to ordinary Portland cement. Using boron-containing wastes like borogypsum, colemanite, or clay wastes can boost compressive strength at low replacement levels, though higher amounts might decrease early strength or delay setting. Additionally, boron-active belite cement offers better high-temperature durability and excellent neutron-shielding abilities, which can be further enhanced by adding controlled amounts of fly ash. Overall, boron-based additives provide a promising approach to producing more durable, heat-resistant, and advanced cementitious materials.

2.3. Fire Retardant

Boron compounds are known to be effective fire retardants for cellulosic materials. Mixtures of boric acid and borax slow down flame spread on wood surfaces; borax reduces flame spread but can increase smoldering, while boric acid suppresses smoldering but has little effect on flame spread. Therefore, they are usually used together (Baysal et al., 2006).

Baysal et al. (2007) investigated some physical, biological, mechanical, and fire properties of wood polymer composites pretreated with a mixture of boric acid and borax, in which five parts boric acid were mixed with one part borax by weight before being dissolved in water. It was found that the physical, biological, and mechanical properties of the wood polymer composites generally improved compared to the untreated control specimen. Additionally, pretreatment with a mixture of boric acid and borax, combined with vinyl monomers, enhanced the decay resistance and fire performance of the composite.

Ayrilmis et al. (2012) examined the influence of boron- and phosphate-based compounds on the physical, mechanical, and fire properties of wood plastic composites. As fire retardants, a mixture of boric acid and borax, zinc borate, monoammonium phosphate, and diammonium phosphate was used. The samples containing zinc borate exhibited the highest water resistance and mechanical performance compared to those with other fire retardants. The addition of fire retardants resulted in modest improvements in fire performance, as indicated by reductions in heat release rates, with phosphate-based treatments providing greater enhancements than boron-based ones.

Özkaya et al. (2006) conducted a study on the burning characteristics of oriented strandboard (OSB) treated with potassium carbonate, borax, and wolmanit. These chemicals, used as fire retardants, are applied by either brushing or dipping methods. According to the results, borax demonstrates the highest penetration into OSB regardless of the application method. Potassium carbonate and borax are among the most suitable substances for improving the burning characteristics of OSB, as both provide the longest ignition times and the shortest durations of flame and ember burning after the flame is extinguished.

Brahmia et al. (2020) studied the fire-retardant qualities of cement-bonded wood-based materials with borax, disodium hydrogen phosphate, diammonium hydrogen phosphate, and polyethylene glycol 400. The tests indicated that borax provided excellent flame-spread prevention.

Yu et al. (2017) conducted a study to examine the effects of immersion conditions (duration, temperature, and solution concentration) on boron loading and combustion performance of bamboo filaments treated with a boron-based fire retardant made of 50% boric acid and 50% borax at concentrations of 5%, 10%, and 20% (w/w). They reported that boron-containing flame retardants significantly suppressed smoke release (by 86.1% and 91.1%), enhanced carbon residue formation, and decreased mass loss during combustion, demonstrating their effectiveness for safe use in indoor bamboo decorative applications.

In their study, Wang et al. (2023) investigated the thermal, flame-retardant, and combustion properties of thermoplastic polyester elastomer composites incorporating a triazine–boron non-halogenated flame retardant (CPB). The flame retardants were synthesized in the laboratory and subsequently added to the composite matrix to produce the samples. Thermal analyses indicated that CPB possesses good thermal stability at high temperatures and forms a high amount of residual carbon after combustion. The addition of CPB to thermoplastic polyester elastomer composites significantly improved their flame-retardant performance. Tests demonstrated that the incorporation of CPB reduced both heat release and smoke generation in the composites. Examination of the residual carbon structure revealed the formation of a boron–oxygen–carbon glassy layer at high temperatures, which contributed to smoke suppression and enhanced flame retardancy. These findings demonstrate that the addition of CPB substantially enhances the fire resistance and safety of thermoplastic polyester elastomer composites.

Xia et al. (2020) developed a novel boron-containing flame retardant (diglyceride borate) based on boric acid and glycerin, and investigated its effects on the flame retardant, thermal, and mechanical properties of polyurethane (PU). When the diethylene borate content was increased by 12.1 wt.%, the char residue at 600 °C was observed to increase with higher diethylene borate content. The study demonstrated that diethylene borate forms a compact and efficient char layer in PU, which reduces heat and mass transfer and thus provides a condensed-phase flame-retardant mechanism.

In summary, boron-based compounds, especially mixtures of boric acid and borax, have proven to be effective fire retardants across a wide range of cellulosic and polymer-based materials. Their combination enables the simultaneous reduction of flame spread and suppression of smoldering, while also improving physical, mechanical, and decay-resistant properties in treated composites. Advances in boron-containing flame retardants, including laboratory-synthesized compounds and innovative formulations like diglyceride borate, show significant improvements in thermal stability, char formation, smoke suppression, and overall fire performance. These findings emphasize the versatility and effectiveness of boron compounds as safe and reliable fire-retardant agents for both traditional wood-based materials and advanced polymer composites.

2.4. Replacement of Calcium-Based Binders with Boron Compounds

Boron compounds have recently been explored as alternative additives in cement-based systems within the construction materials field. Their application is driven not only by the abundance of boron resources but also by the demand for sustainable and eco-friendly methods in concrete production.

Topçu and Boğa (2010) investigated the effects of partially replacing cement with boron-containing clay waste in concrete on the material's properties. The results indicated that adding clay waste with boron had a minor impact on the workability of the concrete. An increase in boron-containing clay waste content led to a delay in the setting time. All test results demonstrated that higher boron-containing clay waste content negatively affected the mechanical properties of the specimens. Nevertheless, slight improvements in durability were observed. Therefore, it is recommended that boron-containing clay waste be used to replace cement in mortar up to 3% and in concrete up to 10% to achieve certain economic, environmental, and technical benefits.

Sevim et al. (2017) investigated the effects of boron waste on concrete properties by partially replacing cement with colemanite waste at ratios ranging from 5% to 15%. The incorporation of colemanite waste was found to reduce the workability of fresh concrete. In concrete with a 0.60 water-to-binder (W/B) ratio and a cement content of 350 kg/m^3, the samples containing 3% colemanite waste exhibited higher compressive strengths, closely approaching those of the control sample at all ages. However, as the proportion of colemanite increased, the compressive strength of the specimens reached values comparable to the reference only between 90 and 180 days.

Şeker & Durgun (2022) investigated the effects of replacing cement with colemanite and colemanite concentrator waste on the properties of self-compacting concrete. Colemanite was used to replace cement at proportions ranging from 0.5% to 2%, while colemanite concentrator waste was used at proportions between 1% and 2.5%. The study showed that the addition of colemanite and colemanite concentrator waste generally delayed setting times, with minimal effects on both fresh and hardened unit weights. The incorporation of colemanite improved flow properties, particularly at dosages up to 1.5%; however, higher amounts caused segregation. In contrast, colemanite concentrator waste had positive effects on flow at low dosages but reduced flow at higher dosages, likely due to the dominant influence of clay minerals in its composition. Concrete samples containing colemanite exhibited lower compressive strengths than the reference mix at 7 and 28 days, but exceeded the reference at 90 days, which was attributed to the retarding effect of boron minerals in colemanite on hydration. For samples containing colemanite concentrator waste, compressive strength decreased with increasing content. After 90 days of curing, the degree of hydration was 95.7% for the reference sample, compared to 80.3% and 71% for samples containing colemanite and colemanite concentrator waste, respectively.

Özen et al. (2022) investigated the effects of partially replacing cement with colemanite waste at ratios ranging from 1% to 7% on the properties of mortar and paste mixtures. The replacement of cement with colemanite waste was found to reduce the flowability of both cement paste and mortar mixtures, necessitating an increased dosage of water-reducing admixture to achieve the desired workability. Moreover, higher colemanite waste content negatively affected the time-dependent slump-flow performance of mortars. The incorporation of colemanite waste also led to prolonged setting times, which is likely attributed to the formation of calcium borate from B_2O_3 in colemanite waste, coating the cement particles and slowing hydration. While mortar specimens containing colemanite waste exhibited lower 1-day compressive strength due to delayed hydration caused by boron components, these components contributed to improved particle bonding over time, resulting in higher 56-day compressive strength.

Kula et al. (2001) investigated the effect of colemanite ore waste containing 25% 45 µm sieve residue, combined with Portland cement, on concrete properties. They found that replacing some Portland cement with colemanite waste significantly increased the compressive strength at a substitution rate of up to 3%. Kara et al. (2020) produced concrete samples by replacing 75 µm sub-sieve ground colemanite with cement at rates of 0 to 5%. They reported that adding ground colemanite up to 4% increased the compressive strength of the concrete samples. Güner et al. (2025) investigated the effect of natural colemanite (45 µm) and calcined colemanite additives on concrete. They reported that the compressive strength of concrete samples containing natural colemanite additives at rates ranging from 0% to 15% increased up to an additive rate of 10%.

Kutuk Sert (2016) investigated the effect of nano-sized colemanite on the properties of cement. The research incorporated colemanite of sizes 25 µm, 45 µm, and 75 µm into the cement as replacements ranging from 0% to 5%. It was concluded that smaller replacement ratios (0.5%-1%) were needed as the colemanite particle size decreased, while larger ratios (3%-5%) were required as the particle size increased. The study found that nano-sized colemanite acted like a pozzolan in the concrete mixture, enhancing its compressive strength.

Saglam et al. (2025) investigated the effect of incorporating ground colemanite into natural hydraulic lime (NHL 3.5)-based mortars. Mortars were prepared by partially replacing NHL 3.5 with colemanite (45 µm and 75 µm) at substitution rates of 0%, 1%, 2%, and 3%, and cured for 28 days under controlled conditions. The physical and mechanical properties of the samples were evaluated, including water absorption, flexural strength, and compressive strength. Results showed that the addition of colemanite significantly enhanced the compressive strength, with the highest increase observed at 45.88%. Water absorption and other physical properties remained largely unaffected, indicating limited impact on water permeability of mortar at low colemanite levels.

Boron-containing clay and colemanite additives generally improve the mechanical properties of concrete and mortars when used at low replacement ratios. High proportions of these additives can negatively affect workability and early-age strength. Nano- and fine-ground colemanite exhibit pozzolanic behavior, enhancing long-term compressive strength. Boron components may delay setting times but slightly improve durability and particle bonding over time. Overall, low levels of boron and colemanite additions provide technical and environmental benefits without compromising material performance.

2.5. Boron Application in Alkali-Activated Systems

The incorporation of boron-based materials into geopolymer systems offers significant potential for the construction industry. Boron-based products can be utilized in geopolymer systems both as substitutes for precursor materials and as replacements or supplements for alkaline activators.

Baştürk et al. (2025) investigated the potential applications of colemanite as both a source material and an aggregate in the production of geopolymers. It was found that using up to 10% colemanite as a source material contributes to the development of early compressive strength in geopolymers.

Çelik et al. (2018) investigated the effect of colemanite substitution by substituting metakaolin, a source material used in geopolymer production, with colemanite at rates varying from 0% to 40%. They mentioned that the compressive strength increased by 2% with 10% colemanite substitution.

Çelik et al. (2018) investigated the effect of boron waste additives on metakaolin-based geopolymer mortar composites reinforced with four different types of fibers. In their preliminary studies, metakaolin in the geopolymer system was partially replaced with colemanite waste at ratios ranging from 10% to 40%. The alkali activators used were sodium silicate and sodium hydroxide. The precursor materials included ground granulated blast furnace slag, metakaolin, and varying proportions of colemanite. In terms of compressive and flexural strength, the mixture containing 90% metakaolin and 10% colemanite exhibited the best performance.

Ali et al. (2020) investigated the effect of substituting metakaolin with colemanite waste at ratios ranging from 10% to 30% in metakaolin-based geopolymer production. The geopolymer mixtures were prepared using a combination of sodium hydroxide and sodium silicate as the activator, metakaolin, slag, and colemanite as precursor materials, and standard sand as the aggregate. The results showed that substitution with colemanite enhanced both strength and ultrasonic pulse velocity by up to 10%, whereas higher substitution levels caused a reduction in these properties.

Çelik et al. (2024) investigated the properties of a ground blast furnace slag-based geopolymer system by partially replacing the slag with tincal waste at proportions ranging from 10% to 40%. Their results indicated that incorporating 10% and 20% tincal waste in the mortar mixtures improved both compressive strength and high-temperature performance.

Bagheri et al. (2017) aimed to replace borax with sodium silicate as a new alkaline activator, rather than solely as a setting time modifier. In their study, sodium silicate and a sodium hydroxide solution were employed as alkaline activators, with the sodium hydroxide concentration maintained at 8M across all samples. Sodium silicate was partially replaced with borax at levels ranging from 10% to 70%. The precursor materials used were either class F fly ash or ground granulated blast-furnace slag. For the fly ash-based geopolymers, control samples were prepared without borax, and the sodium silicate content was reduced accordingly. In these controls, compressive strength initially decreased as the sodium silicate ratio was reduced, reaching its lowest value at a 30% reduction, and subsequently increased. However, when borax was introduced at the same replacement levels, a continuous decrease in compressive strength was observed at substitution rates of 30% and above. This reduction was attributed to the weaker structures formed when borax was incorporated into the system.

Kim et al. (2022) investigated the properties of geopolymers produced by incorporating radioactive borate waste into a phosphate-based geopolymer system. Metakaolin was employed as the aluminosilicate precursor, while the waste was introduced in proportions ranging from 10% to 50%. Across all mixtures, the liquid-to-solid (L/S) ratio was controlled at 2.2 or 2.6, depending on the waste content. Due to the low L/S ratio, however, samples with 50% radioactive borate waste could not be prepared. Under curing conditions of 4 days at room temperature followed by 2 days at 60 °C, the samples containing 40 wt.% waste failed to solidify even after 7 days. In contrast, curing at 60 °C for 4 days and then at 90 °C for 1 day resulted in an increase in compressive strength with higher waste loading, reaching its maximum in geopolymers with the highest borate content (40%). Authors noted that this improvement was attributed to the high-temperature curing, which promoted the precipitation of an amorphous boron phosphate phase and accelerated geopolymerization, thereby enhancing compressive strength as the waste content increased.

Overall, incorporating boron into geopolymer technology offers a promising way to develop innovative, durable, and eco-friendly building materials. When used at suitable substitution levels, boron minerals and wastes can improve both early-age and long-term mechanical performance, durability, and high-temperature resistance, while also promoting more sustainable material design by using industrial by-products. requirements. Besides performance advantages, reusing boron-rich wastes in geopolymers promotes circular economy practices, decreases dependency on traditional raw materials, and mitigates environmental issues related to waste disposal.

2.6. Boron Compound in Lightweight Concrete

Research on the utilization of boron wastes as aggregate in lightweight concrete production is still limited. Kavas et al. (2011) investigated the potential use of four different boron-containing wastes generated during raw borax ore processing—dewatering boron waste, thickener boron waste, sieve boron waste, and mixture boron waste—for producing lightweight aggregates. Among these, dewatering and sieve boron-containing waste exhibited bloating behavior. Two mixtures, named M1 and M2, were prepared and tested: M1 contained 20 wt.% clay, 40 wt.% sieve boron waste, and 40 wt.% dewatering boron waste, while M2 included 20 wt.% clay, 35 wt.% sieve boron waste, 35 wt.% dewatering boron waste, and 10 wt.% quartz sand. The raw materials were first mixed in a plastic bag, with water added by spraying. Spherical pellets, 8–10 mm in diameter and containing 20–22 wt.% water, were formed by hand and dried at 110 °C for 2 hours. The pellets were then fired in a rotary crucible at 760 °C. The study demonstrated that sieve boron waste and dewatering boron waste can be used to produce lightweight aggregates with properties similar to pumice, provided the final mixture is properly adjusted. The best results were observed for M2. It was also shown that good bloating can be achieved by rapidly heating the pellets from 300 to 760 °C. This firing temperature is significantly lower than the typical range for lightweight aggregate production (1100–1300 °C), which helps reduce energy consumption during manufacturing. Aldakshe et al. (2020) investigated the properties of lightweight concrete by partially replacing pumice aggregate with boron waste in proportions ranging from 1% to 9%. Their results showed that, as the proportion of boron waste increased, both the specific gravity and compressive strength of the concrete increased continuously. Limited studies indicate that it is possible to produce lightweight aggregate from boron wastes; however, there is insufficient research on the direct replacement of conventional lightweight aggregates with boron wastes. Furthermore, additional studies are necessary to investigate this topic in greater detail.

3. Conclusion and Suggestions

Boron minerals, such as borax, colemanite, ulexite, and kernite, are abundant in Turkey, providing opportunities for sustainable material development. This study aimed to review and evaluate the applications of boron and boron-containing compounds in building materials. The scope of the research encompassed their use in cement production, fire retardancy, neutron shielding, replacement of calcium-based binders, incorporation into alkali-activated systems, and the development of lightweight concrete.

The review focused on both natural boron minerals and industrial boron wastes. In cementitious systems, boron product additions enhance compressive strength and neutron-shielding capabilities; however, excessive amounts may delay setting or reduce early strength. Evaluation and summary of the reviewed articles are given in Table 2.

Table 2. Evaluation and summary table of reviewing articles

Topic	Boron Products	Effect on Material Properties
Neutron-shielding effect	Colemanite aggregate, Ferro-boron aggregate, Basalt-boron fiber	Neutron shielding performance improves; necessary wall thickness and reinforcement volume decrease; mechanical properties stay the same.
Cement production	Boron-active belite cement, Borogypsum, Colemanite ore waste, Boron-containing clay	Early compressive strength increases (boron-active belite) lead to improved high-temperature durability. Low replacement ratios enhance strength, while higher ratios may delay hydration or decrease early strength.
Fire retardant	Boric acid + borax, Zinc borate, CPB (triazine–boron), Diglyceride borate	Flame spread decreases, smoke and smoldering decrease; char formation and residual carbon increase, physical, mechanical, and decay resistance improved or maintained
Replacement of Calcium-Based Binders	Colemanite aggregate, Colemanite concentrator waste, Boron-containing clay, Nano/fine colemanite	Workability decreases, early-age compressive strength decreases, long-term compressive strength improves; pozzolanic behavior enhances mechanical properties over time
Boron in Alkali-Activated / Geopolymer Systems	Colemanite aggregate, Colemanite waste, Tincal waste, Borax, Radioactive borate waste	Early and long-term compressive strength increase, high-temperature performance improves; geopolymerization is accelerated, and excessive boron content may weaken the structure
Boron in Lightweight Concrete	Dewatering boron waste, Sieve boron waste, Boron waste (pumice replacement)	Lightweight aggregate production; bloating behavior, energy-efficient firing; density and compressive strength increase

Boron compounds also demonstrate effective fire-retardant properties in wood, polymer, and cement-based composites. Mixtures of boric acid and borax, as well as innovative boron-based formulations, reduce flame spread, suppress smoldering, and enhance char formation. In alkali-activated systems, boron additives can improve compressive strength, durability, and high-temperature performance, while promoting the reuse of industrial waste and supporting circular economy practices. Limited studies suggest that boron-containing wastes can be utilized to produce lightweight concrete aggregates, thereby reducing firing temperatures and energy consumption. However, further research is needed to optimize mechanical properties and mixture compositions. Boron-containing wastes are suitable for use in building materials, considering the limited availability of natural resources, which can enhance both material performance and sustainability. This approach enables the recovery of wastes, increases resource efficiency, and reduces environmental impact.

In conclusion, incorporating boron and boron-based compounds into building materials offers benefits such as increased mechanical strength, enhanced resistance to high temperatures and fire, as well as effective neutron shielding. Thanks to Türkiye's abundant boron reserves, recycling and reusing boron industrial by-products not only reduce material costs but also promote environmental sustainability. Future research should focus on experimental and practical methods to examine how boron behaves in various material systems. Such research will be crucial in developing innovative, durable, and environmentally friendly construction materials.

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Author Contribution and Conflict of Interest Declaration Information

There is no conflict of interest.

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Quality Management Systems in Construction Projects: Reframing QMS Tools through Complexity Principles

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1. Introduction

Construction projects are inherently complex endeavors, characterized by multidisciplinary collaboration, constrained timelines, and dynamic participant environments. The effective management of quality in such settings goes beyond mere compliance with technical standards. In fact, it requires the integration of diverse actors, contractual relationships, and responsive decision-making mechanisms, all within a constantly changing project context (Seyman, 2012). Quality Management Systems (QMS)**,** developed to address these multidimensional challenges, frequently encounter significant implementation barriers in real-world projects. Research conducted by Naveed & Khan (2022) indicated that communication breakdowns, coordination difficulties, and contextual variability in construction projects significantly impair quality performance. Furthermore, the complexity of construction processes has been shown to undermine conventional quality planning and control efforts (Wawak et al., 2020).

This study builds upon the author's PhD dissertation, titled "A Quality Management System Tools Model for the Roles of the Construction Manager and Architect". While the dissertation emphasized the operational use of QMS tools across defined professional responsibilities (Seyman, 2012), this study extends that work by offering a conceptual reinterpretation grounded in complexity theory**.** Specifically, it investigates how core QMS tools such as contracts, procedures, checklists, specifications, forms, and flowcharts can be reimagined to function more effectively within the unpredictable environments of construction projects. International frameworks such as ISO 9001:2015 (ISO, 2015) have provided structured guidelines to ensure consistency and quality across projects. Likewise, contract documents such as American Institute of Architects' (AIA) A201, C132 and International Federation of Consulting Engineers' (FIDIC) Red Book serve as foundational instruments that assign roles, outline quality responsibilities, and codify performance expectations among project stakeholders (FIDIC, 2017; AIA, 2019; AIA 2017). Despite their foundational role, these frameworks often reflect control-oriented and linear assumptions that may not be fully compatible with the dynamic nature of contemporary construction projects.

Traditional QMS implementations generally focus on standardization, documentation, and risk mitigation, often sacrificing adaptability and system responsiveness (Gupta & Raho, 2003; Roy et al, 2005; Delgado-Hernandez & Aspinwall, 2010; Yu & Shen, 2013). In contrast, this study adopts complexity theory as a theoretical perspective to re-evaluate QMS tools within a non-linear, adaptive, and emergent systems view. Complexity theory put forth that system components interact dynamically, giving rise to emergent behaviors and outcomes that cannot be predicted solely from individual parts (Keene, 2000). In the construction context, Lafhaj et al. (2024) pointed out that such behaviors stem from continuous interplay among diverse actors, tasks, environments, and external constraints. Therefore, rigid quality mechanisms, often underperform because they fail to accommodate the adaptive capacities required in complex project systems (Ren et al., 2018).

By drawing on complexity theory, this study aims to conceptually reposition QMS tools not as static instruments of control, but as adaptive mechanisms embedded within a broader system of continuous feedback, learning, and emergence. It presents a theory-driven reinterpretation of key QMS tools. In doing so, the study aims to contribute to the evolving discourse on construction quality by offering a model that bridges complexity theory and QMS tool design which is a perspective largely unexplored in existing literature.

Therefore, this study seeks to advance the field of construction quality management by proposing a shift from deterministic, compliance-oriented frameworks to more flexible, relational, and systems-based strategies. Additionally, it offers a conceptual framework for both researchers and industry professionals to evaluate and transform QMS tools in line with the operational realities of complex and adaptive construction environments.

1.1. QMS and Construction Projects

It is fundamental to achieving project success by ensuring effective control, communication, and accountability across project phases in construction. According to the study of Sui Pheng & Ke-Wei (1996) a process-oriented approach holds that well-managed processes inherently lead to desired outcomes. QMS involves systematic actions aimed at meeting quality objectives, emphasizing defect prevention and fostering a culture of proactive problem-solving (Ashford, 2002; Landin, 2000).

Construction projects, however, are inherently dynamic, involving complex interactions of participants and evolving external conditions. They are widely recognized as complex systems characterized by high structural differentiation, intricate interdependencies, non-linearity, and emergent behaviors (Baccarini, 1996; San Cristóbal, 2018). While traditional QMS such as those based on ISO 9001:2015 (ISO, 2015) offer structured frameworks emphasizing principles like customer focus, leadership, and continuous improvement, they are often designed for relatively stable environments. In other words, these inherent attributes pose significant challenges to traditional management frameworks, which often rely on assumptions of linearity, predictability, and centralized control (San Cristóbal, 2018). Similarly, standardized contractual instruments such as AIA and FIDIC documents provide clarity in roles and quality expectations but may lack the flexibility required for highly complex projects.

From this perspective, quality management must move beyond prescriptive control mechanisms to embrace adaptive, feedback-driven strategies. This shift entails reinterpreting QMS tools to support continuous learning, real-time responsiveness, and systemic integration across project environments (Ghafiki et al., 2023).

1.2. QMS Tools and Contracts as QMS Tools

QMS tools are essential for structuring, monitoring, and documenting quality-related activities throughout the construction lifecycle. These tools such as specifications, procedures, forms, flowcharts, and checklists translate quality objectives into operational tasks, while ensuring consistency and clarity across project teams (Hellsten & Klefsjö, 2000; Ismyrlis, 2017). The effectiveness of QMS tools depends not only on their design but also on organizational culture, role clarity, and participants engagement. Without consistent application, they risk becoming procedural formalities rather than instruments of quality enhancement.

Specification: A written document prepared to elaborate on the items stated as general rules or provisions in the contract, aiming to clarify related requirements and conditions in more detail. Specifications define stating requirements (ISO, 2015), measurable standards for materials, workmanship, and performance, reducing ambiguity and guiding contractor compliance (Boukamp & Akinci, 2007). They define and sets out the requirements that a product or service must comply with (Seyman, 2012).

Procedure: A specified way to carry out an activity (ISO, 2015). The adopted methods and approaches for carrying out a task or process. Within the scope of a QMS, it specifies the methods for executing assigned tasks. It details the purpose, scope, responsibilities, and implementation methods for each task, and includes explanations sufficient to ensure adequate control (Seyman, 2012). It identifies who will carry out each sequential task, how it will be done, how it will be reported, which records will be kept, and the applicable control methods. Procedures standardize tasks and responsibilities, promoting repeatability and process control.

Form: A document designed for recording necessary information required to perform a task, typically consisting of blank fields to be filled in. It is also referred to as a recording tool used by an organization to carry out its activities (Seyman, 2012). Forms enable systematic documentation and real-time decision-making, supporting traceability and audit readiness.

Flowchart: A graphical quality management tool that provides a visual representation of all inputs, outputs, and events within a process. It transforms process events into visual elements and is particularly effective in identifying otherwise invisible steps. Flowcharts use specific symbols to describe and visualize the process (Kustikova & Pankova, 2023). A rectangle represents a process step; a diamond indicates a decision point, where the next activity depends on the decision; a circle signifies a delay; a hexagon denotes a preparatory activity; and a small connector shows the continuation of the flowchart or its connection to another flowchart. Flowcharts facilitate process comprehension and documentation. They help identify the improvable aspects and deficiencies of a defined process (Seyman, 2012). As Kustikova& Pankova (2023) expressed that flowcharts visually map workflows, enhancing communication and identifying inefficiencies. By using flowcharts, all participants can clearly understand and follow the system, processes, and their fundamental functions.

Checklist: A document that marks specific areas to be checked. It is used in quality assurance audits and for monitoring specific steps within a process. (Seyman, 2012). Checklists ensure critical quality tasks are completed, reduce errors, and reinforce a culture of compliance (Cai et al, 2020; Berg, 2008).

Contracts in construction are legally binding agreements that define the roles, responsibilities, and performance expectations of project stakeholders. They serve as the primary mechanism for translating organizational quality policies into enforceable obligations (AIA, 2017). In this context, quality is often defined as conformance to drawings, specifications, and contractual requirements (Zaid, 2025; Coleman et al., 2020) Effective contracts enhance quality management by clarifying responsibilities, reducing ambiguity, and aligning participant expectations (Ferreira & Rogerson, 1999; Landin, 2000). They enable performance evaluation based on adherence to agreed terms and serve as a foundation for dispute prevention and resolution. TQM principles, when integrated into contract formulation, can further support proactive quality assurance through well-defined specifications and monitoring protocols (Seyman, 2012).

Standardized contracts such as A201 (AIA, 2017), C132 (AIA,2019) and FIDIC's Red, Yellow, and Silver Books embed essential quality provisions, including inspection procedures, submittal requirements, testing protocols, and corrective actions. These elements support structured communication, accountability, and continuous quality monitoring throughout the project lifecycle (AIA,2019; FIDIC,2017). Thus, beyond their legal function, Seyman (2012) indicated that contracts operate as dynamic quality management tools, bridging strategic objectives and operational execution within complex, multi-party project environments.

1.3. Complexity Theory and Its Relevance to Construction Quality Management

Complexity theory frames construction projects as complex adaptive systems characterized by uncertainty, interdependence, and emergent behavior (Uusitalo et al., 2024). Therefore, it offers a paradigm that particularly addresses the traditional quality management challenges by emphasizing key principles such as emergence**,** feedback loops**,** adaptation**,** and non-linearity (Ochoa & Neto, 2022).

Emergence refers to the phenomenon where system-level patterns, structures, or behaviors arise spontaneously and unpredictably from the local interactions of individual agents or components, without centralized control (Holland, 2012). In construction projects, emergent behaviors manifest as dynamic coordination practices, evolving workflows, or unexpected outcomes that cannot be fully anticipated by traditional linear planning (Geraldi et al., 2011). These emergent properties are critical because they enable the system to develop novel solutions and innovations in response to complex challenges.

Feedback loops are essential mechanisms that facilitate continuous information exchange between system components, enabling learning and self-regulation (Sterman, 2002). Positive feedback amplifies certain behaviors or trends, while negative feedback counteracts deviations to maintain stability. In construction management, feedback loops support iterative adjustments and corrective actions during project execution, fostering resilience and adaptability (Bosch-Rekveldt et al., 2011). Zheng et al. (2021) reported that through feedback, project teams can monitor performance in real-time and respond proactively to emergent risks or opportunities.

Adaptation denotes the capacity of system elements to adjust their behavior or structure in response to changing internal conditions or external environmental stimuli (Levin et al., 2013). Adaptive capability in construction projects is reflected in flexible scheduling, dynamic resource allocation, and evolving stakeholder collaboration that enable the project to remain viable amid uncertainty and disruption (Ochieng & Hughes, 2013). Adaptation is closely linked to organizational learning, where lessons from past experiences inform future decision-making, promoting continuous improvement (Easterby-Smith & Lyles, 2011).

Non-linearity highlights that relationships within complex systems are not proportional or additive; small inputs or changes can generate disproportionately large effects, often through cascading interactions or tipping points (Mitleton-kelly, 2003). This characteristic challenges traditional cause-effect assumptions in project management may lead to significant project delays or cost overruns (Williams, 2017; Williams 2005). Recognizing non-linearity compels project managers to consider systemic interactions and emergent risks rather than isolated factors (Levin et al., 2013).

Despite widespread adoption, traditional QMS in construction remain predominantly focused on rigid standardization, prescriptive procedures, and control mechanisms that assume predictability and linear processes. Such assumptions often do not hold in the face of the inherent complexity, uncertainty, and interdependence characteristic of construction projects (San Cristóbal, 2018). Existing QMS tools are largely designed as static, compliance-driven instruments, limiting their effectiveness in dynamic, adaptive project environments.

This reveals a significant research gap: while complexity theory offers promising insights into managing uncertainty and emergent behaviors, its practical integration into QMS tool design and implementation in construction remains underexplored. In particular, there is limited understanding of how they can be transformed from rigid compliance artifacts into adaptive, feedback-driven mechanisms that support continuous learning and collaboration throughout the project lifecycle.

Addressing this gap is critical, since failure to adapt QMS tools to complex project realities can lead to poor coordination, reduced responsiveness, and lower level quality outcomes. This research therefore aims to develop a framework that enhances their adaptability and systemic impact within construction project management. Thanks for these characteristics, complexity theory offers a promising conceptual foundation for the reinterpretation of QMS tools. Additionally it highlighlights their potential to better accommodate the unstable, uncertain, complex, and ambiguous nature of contemporary construction projects. This perspective opens pathways toward fostering more resilient, learning-oriented, and adaptive QMS practices. In this way, this approach can enhance responsiveness and coordination in dynamic project environments.

2. Material and Method

Adopting a qualitative, theory-informed research design this study aim at reinterpreting the use of QMS tools in construction within the framework of complexity theory. Rather than generating new empirical data, the research builds upon a previously completed PhD dissertation that systematically identified core QMS tools were examined (Figure 1).

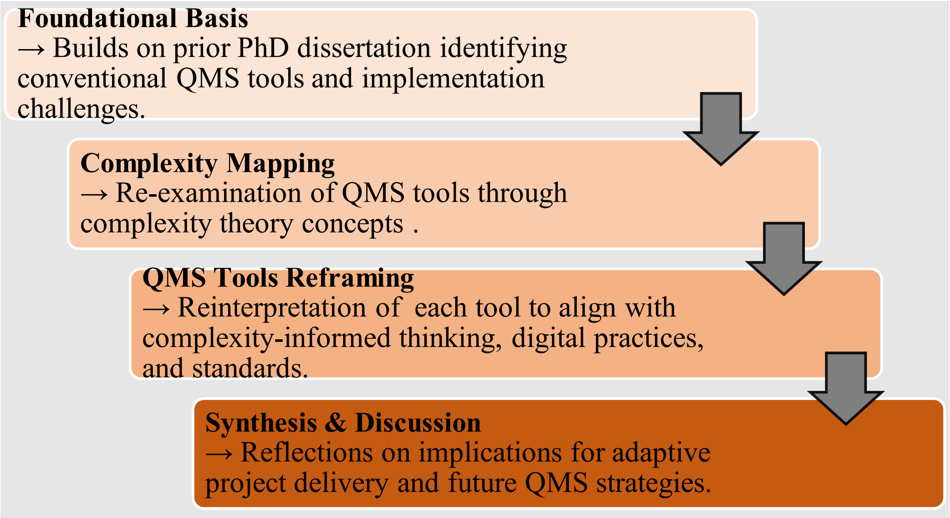

Figure 1. Research methodology flow (Developed by the author)

Conventional QMS tools are typically grounded in assumptions of linearity, stability, and control, which align poorly with the realities of contemporary construction projects characterized by uncertainty, emergence, and interdependence (Geraldi et al., 2011; Walker & Lloyd-Walker, 2016). In response, this study repositions QMS tools using principles from complexity theory to support more adaptive, learning-driven, and responsive project management practices (Figure 1).

The core analytical approach is complexity mapping, a conceptual exercise through which each QMS tool is reassessed in terms of its conventional role, the limitations it presents under complex conditions, and its potential reframing in alignment with complexity principles such as adaptation, feedback loops, non-linearity, and emergence.

This mapping is structured into two layers. The first (Table 1) presents a diagnostic overview, identifying systemic limitations in conventional applications of QMS tools and connecting them to key complexity principles. The second (Table 2) translates these insights into practical reinterpretations of each tool's role, supported by relevant academic literature and aligned with major industry standards such as ISO 9001:2015 (ISO, 2015), ISO 21500 (ISO 2021), ISO 44001 (ISO 2017), ISO 19650 (ISO 2018a), and PMBOK® (PMI, 2021).

The goal is not to invent new tools, but to reimagine existing ones as more flexible, context-sensitive, and feedback-driven instruments. This conceptual method contributes to the growing body of research on adaptive governance in construction and offers actionable guidance for enhancing quality management in complex, fast-changing project environments.

3. Findings and Discussion

The findings of the study emerge from a conceptual reinterpretation of QMS tools commonly used in construction project management, analyzed through the lens of complexity theory. Rather than focusing on the technical performance of these tools, the analysis explores how their traditional forms reflect assumptions of linearity, control, and predictability assumptions that often fail in the face of project complexity, interdependence, and uncertainty.

By applying complexity-informed principles such as emergence, non-linearity, adaptation, and feedback loops, the study identifies new ways to understand and reconfigure conventional tools like contracts, procedures, checklists, and flowcharts. This analytical process generates a complexity-based mapping that highlights the potential for transforming QMS tools from instruments of compliance into mechanisms that support learning, flexibility, and system responsiveness in dynamic construction environments.

3.1. Complexity Reframing of QMS Tools

Applying complexity theory, the study maps and reinterprets widely used QMS tools to address the challenges of uncertainty and non-linearity in construction. Building on the conceptual framework developed in the dissertation, the analysis highlights how traditional applications of tools such as contracts, specifications, procedures, checklists, forms, and flowcharts may inadvertently limit responsiveness, learning, and coordination in complex project settings.

The mapping is structured in two layers. The first layer, Table 1, identifies the conventional function of each QMS tool, the typical reasons for its failure in practice, and the corresponding complexity principle that helps explain or address this limitation.

Table 1. Complexity Mapping of QMS Tools (Developed by the author)

QMS Tool	**Traditional Function**	**Reasons to Fail** ***(with citations)***	**Complexity Principle**
Contracts	Define roles and legal responsibilities	Inflexibility and adversarial structure limit collaboration in changing environments *(Barton et al., 2015; Nystén-Haarala et al., 2010)*	Adaptation, Feedback Loops
Specifications	Detail performance/ technical criteria	Lack of flexibility to site-specific changes and evolving conditions *(Jarkas, 2017; Ahmad & Sein, 1997)*	Emergence, Context Sensitivity
Procedures	Standardize quality tasks and workflows	Over-standardization reduces agility and fails to account for unexpected situations *(Sui Pheng & Ke-Wei, 1996; Alshboul et al., 2025)*	Iteration, Learning Orientation
Checklists	Control task performance and compliance	Static design and lack of project-specific feedback prevent learning *(Fotopoulos & Psomas, 2009; Strugar, 2019)*	Feedback Loops, Adaptability
Forms	Capture and store project data for compliance	Delays in information flow & isolated record-keeping hinder responsiveness *(Alshboul et al., 2025)*	Responsiveness, Emergence
Flowcharts	Visualize linear sequences for control	Oversimplify complex interactions and lack flexibility for alternative scenarios *(Strugar, 2019; Øgland, 2008)*	Non-Linearity, Scenario Planning

The second layer, Table 2, translates these insights into practical reinterpretations of each tool, drawing on complexity theory to suggest adaptive functions, supported by current literature and aligned with major industry standards.

Table 2. Complexity-Informed Reinterpretation (Developed by the author)

QMS Tool	Complexity-Informed Reinterpretation	Practical Implications	Supporting Industry Standard(s)
Contracts	Contracts restructured as collaborative frameworks with room for renegotiation	Enables flexible execution, reduces claims, promotes trust (El-Adaway et al., 2017; Walker & Lloyd-Walker , 2016)	A201(AIA,2019), C132(AIA 2017); Red Book (FIDIC,2017); Nec4 Alliance Contract (NEC,2018); ISO44001(ISO,2017)
Specifications	Living documents updated with real-time project data	Enables responsiveness to change; improves constructability (Jarkas 2017; Ahmad & Sein, 1997)	ISO 9001:2015 (ISO,2015); ISO 19650 (ISO, 2018a); ISO 21500 (ISO,2021)
Procedures	Procedures designed for adaptability and learning	Enhances responsiveness; reduces procedural bottlenecks (Alshboul et al., 2025; Sui Pheng & Ke-Wei, 1996)	ISO 9001:2015 (ISO,2015); ISO 21500(ISO,2021); PMBOK® (PMI,2021)
Checklists	Dynamic tools for issue tracking and learning integration	Supports real-time site monitoring and team coordination (Fotopoulos & Psomas, 2009; Strugar, 2019)	ISO9001:2015 (ISO,2015); PMBOK®(PMI,2021); ISO 19650 (ISO,2018a)

Forms	Mobile-enabled forms with real-time syncing	Facilitates contextual decision-making and decentralization (Alshboul et al., 2025)	ISO 9001:2015 (ISO,2015) BIM 360 Field (Autodesk Inc.,2025); ISO 19650 (ISO,2018a); ISO 21500 (ISO,2021)
Flowcharts	Process maps that allow multiple contingencies	Aids situational planning and team scenario training (Øgland, 2008; Strugar, 2019)	ISO 9001:2015(ISO,2015); ISO 21500 (ISO 2021); BS 1192 (BSI,2007); PMBOK® (PMI,2021)

This two-step structure not only diagnoses misalignments but also proposes actionable transformations for evolving QMS practice in line with the systemic, dynamic, and non-linear nature of construction projects.

- ***Contracts as Collaborative Frameworks***

Traditional contracts in construction prioritize deliverables, roles, and liability structures, often under adversarial and inflexible terms. These assumptions break down in dynamic environments where stakeholder interests evolve and scopes shift unpredictably (Winch, 2012; Walker & Lloyd-Walker, 2016). Complexity theory emphasizes adaptation and feedback, advocating for relational contracting, alliancing, and multi-party frameworks that promote shared governance and iterative coordination. ISO 44001 (ISO, 2017) formalizes this perspective by emphasizing collaborative business relationships that evolve across project lifecycles.

- ***Procedures as Adaptive Protocols***

Standard procedures aim to standardize operations and reduce variation. However, when treated prescriptively, they hinder timely responsiveness in the face of emergent conditions. Complexity-informed reinterpretation frames procedures as adaptive protocols guides that evolve through feedback, team input, and case-based variation (Alshboul et al., 2025; Bosch-Rekveldt et al., 2011). This perspective is supported by continuous improvement doctrines in ISO 9004 (ISO, 2018b) and by iterative planning models in Lean Construction.

- ***Checklists as Dynamic Task Guides***

Checklists are widely used to control execution quality and ensure task completeness. However, their utility declines in projects characterized by shifting dependencies and contextual uncertainty. Static lists may overlook evolving constraints or fail to capture real-time deviations (Love et al., 2002; Strugar, 2019). Complexity theory reframes them as dynamic task guides mobile, context-aware tools designed for iterative quality checks and situational responsiveness. This aligns with field-driven coordination principles found in the Last Planner System® (LCI, 2015) and ISO 19650's (ISO 2018a) collaborative workflows.

- ***Flowcharts as Modular, Emergent Process Maps***

While flowcharts serve as visual aids for sequencing and decision-making, their conventional form implies deterministic paths. This oversimplifies how processes evolve in practice. Complexity theory repositions flowcharts as modular process maps that support scenario planning, real-time decision-making, and cross-functional coordination (Øgland, 2008; Geraldi et al., 2011). This shift aligns with the logic of ISO 19650 (ISO 2018a), BS 1192 (BSI, 2007), and PMBOK® (PMI, 2021), which encourage information-rich, flexible design coordination environments such as BIM.

- ***Specifications as Living Knowledge Frameworks***

Specifications traditionally function as fixed documents that codify design and performance criteria. In unpredictable project settings, static specifications become sources of conflict, outdated assumptions, or rework (Eastman, 2011; Jarkas, 2017). A complexity-informed lens reframes them as living knowledge frameworks evolving technical references integrated with digital platforms such as Building Information Modelling (BIM) or Common Data Environments (CDEs). ISO 19650 (ISO, 2018a) and ISO 21500 (ISO, 2021) support this model by emphasizing real-time updates and contextual information delivery.

- ***Forms as Real-Time Data Capture Interfaces***

Forms are essential for documenting inspections, approvals, and quality non-conformities, but static, paper-based formats create bottlenecks and limit early warning capabilities (Ghaffarianhoseini et al., 2017). From a complexity perspective, forms become real-time data interfaces mobile-enabled, decentralized tools that facilitate situational reporting and adaptive decision-making. Platforms like BIM 360 Field (Autodesk Inc., 2025) operationalize this function. ISO 9001:2015 (ISO, 2015), ISO 29481 (ISO 2022), and ISO 21500 (ISO, 2021) advocate for data interoperability, live traceability, and field-level responsiveness in quality control.

3.2. Discussion

This reconceptualization demonstrates that the implementation failures associated with traditional QMS tools are often rooted in their design assumptions not the tools themselves. By realigning tools with complexity theory, construction organizations can foster more resilient, coordinated, and adaptive quality practices. This perspective is closely aligned with evolving project delivery methods such as Integrated Project Delivery (IPD), Lean Construction, and Agile Construction, which emphasize adaptability, stakeholder collaboration, and iterative learning (Love et al., 2002; Ogunlana, 2010; Winch, 2012). The integration of complexity principles including emergence, feedback, and adaptation has been increasingly recognized as essential for managing uncertainty and nonlinear project dynamics (Geraldi et al., 2011; San Cristóbal et al., 2018; Lafhaj et al., 2024).

Furthermore, the model supports the construction industry's broader digital transformation, wherein tools such as BIM, mobile field applications, and CDEs are enabling real-time quality coordination, iterative updates, and data-driven decision-making on site (Ghaffarianhoseini et al., 2017; Senel & Cekmis, 2024; Uusitalo et al., 2024). The integration of smart objects and collaborative digital platforms has been shown to enhance responsiveness and systemic feedback mechanisms in complex construction environments (Zaid et al., 2025; Alshboul et al., 2025). Ultimately, this study reinforces the need for systemic resilience and adaptive governance in QMS implementation, offering a pathway toward more intelligent, flexible, and integrated quality management strategies in project-based construction settings (Øgland, 2008; Ochoa & Neto, 2022). This study thus contributes to rethinking construction quality systems as dynamic, learning-oriented infrastructures rather than static control frameworks laying the groundwork for more resilient and future-ready QMS strategies.

4. Conclusion and Suggestions

By integrating complexity principles into the reframing of QMS tools, this study offers a conceptual framework for improving the responsiveness, flexibility, and systemic alignment of quality management practices in construction projects.

The model developed through Table 1 and Table 2 provides both analytical insights and practical guidance. Table 1 identifies key limitations of traditional QMS tools in complex environments, while Table 2 offers complexity-informed reinterpretations that reflect the dynamic nature of contemporary construction projects. This dual-structured approach allows practitioners to diagnose tool-related challenges and explore transformation strategies that support more adaptive and learning-oriented systems.

The findings emphasize that tools such as collaborative contracts, evolving specifications, and digitally integrated forms are not merely technical instruments, but strategic components that enable organizational learning and project agility. As the construction sector confronts increasing uncertainty, participant complexity, and digitalization, the need for such adaptive tools becomes more critical. The proposed framework aligns with innovative delivery models such as IPD, Lean Construction, and Agile Construction, and supports the use of emerging technologies such as BIM, CDEs, and mobile-based quality monitoring platforms. Suggestions for practice is as listed below:

Tool Reassessment: Project teams should periodically assess their QMS tools using complexity-informed criteria, focusing on adaptability and feedback responsiveness rather than static compliance.

Digital Integration: Traditional tools such as forms, checklists, and specifications should be redesigned for digital environments to support real-time data exchange and situational decision-making.

Relational Contracting: Conventional contracts should evolve toward more flexible, collaborative structures that promote renegotiation, trust-building, and shared accountability.

Pilot Implementation: The conceptual model developed in this study could be tested in live project environments to evaluate its applicability and support organizational learning.

Future studies should focus on empirical validation of the complexity-informed QMS tool model through case studies, interviews, or pilot implementations. Comparative analyses across different delivery methods such as Design-Bid-Build or IPD could enhance understanding of how adaptable the model is in diverse regulatory and contractual contexts. Additionally, integrating Industry 4.0 technologies such as Internet of Things (IoT) based monitoring, Artificial Intelligence (AI) driven quality prediction, and digital twins may further extend the relevance of complexity-informed QMS tools, offering new pathways for smart, data-driven project management in construction.

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An Assessment of the Relationship Between Türkiye's Residential Stock and Environmental Impact in the Context of Structural Systems

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1. Introduction

The construction sector is responsible for high energy consumption and environmental emissions. It is scientifically known to be a major contributor to greenhouse gas emissions, accounting for approximately 40-50% of global greenhouse gas emissions. Residences represent approximately 75% of the world's 25 billion m^2 building stock and account for approximately 22% of total energy consumption (Pittau et al., 2019). According to TUIK 2024/2025 data, the total number of housing units in Türkiye is 2.3 million (TUIK, n.d.). At the same time, activities involved in construction processes are the main causes of natural resource depletion, accounting for 24% of global natural resource extraction, and are also the main waste generators.

The residential construction sector accounts for 30-50% of material consumption, creating a large material stock that has increased in recent years and is expected to expand further (Marinova et al., 2020). A large portion of the materials produced is related to the construction sector, and the volume is expected to increase due to the projected growth of the global housing building stock.

The built environment is associated with significant environmental impacts related to the construction and operation of buildings (Marinova et al., 2020). As an important tool of environmental management, life cycle assessment is an internationally accepted benchmark. Life Cycle Assessment (LCA) can be defined as the calculation and evaluation of inputs, outputs and potential environmental impacts of a product system throughout its lifespan (Zuo et al., 2017). The LCA method evaluates different scenarios and possibilities to minimize energy and resource consumption and reduce the environmental footprint of building materials (Oladazimi et al., 2020).

Residential buildings constitute 86% of buildings in Türkiye. They constitute 30-50% of the residential construction sector and material consumption, representing a substantial material stock that has increased in recent years and is expected to continue increasing (Somer, 2025). In this regard, it is crucial to identify and analyze the design principles of housing stock and develop approaches that optimize resource consumption and environmental impact. Housing stock is an important issue that requires analysis in both the national and international areas. Structural elements constitute the largest percentage of total building materials and elements and have a greater environmental impact than most other building elements, such as cladding, flooring, and roofing (Stek et al., 2011). Therefore, the environmental impact of structural frames is of great importance.

Concrete is the most commonly used building material in infrastructure. Approximately one tonne of concrete per person is produced worldwide each year, and due to its widespread global use, the environmental impacts of this material need to be accurately assessed, considering its impact on greenhouse gas emissions and climate change (Vieira et al., 2016). Steel, on the other hand, offers a strong alternative with its seismic resistance, recyclability, and widespread use. Therefore, the focus of this study is on reinforced concrete and steel structural systems.

Building stock renovation studies that incorporate the temporal dynamics of emissions and the spatial dynamics of the building stock are insufficient. The potential for achieving climate neutrality can only be estimated by considering these dynamics (Göswein et al., 2021). Despite the rich literature on building material stock and flow dynamics, the role of building-specific decisions, such as building size or material selection, is less understood (Heeren & Hellweg, 2019). Large material stocks are located in the residential built environment. Information about such stocks, especially at the global level, is not enough (Reyna & Chester, 2015; Marinova et al., 2020).

To achieve a building stock with high environmental performance, it is important to first analyze the current status of buildings and provide designers to analyze and define the architectural forms, core planning, and structural systems of buildings. Residential buildings are a central issue for future environmental strategies in the world and in Türkiye, and therefore, the study focuses on residential buildings. The study aims to investigate the relationship between the building stock and its life cycle environmental impact in terms of load-bearing systems in the national and international context.

2. Material and Method

Analyzing building stock provides an examination of building material flows and stocks across space. This supports the development of specific strategies to reduce the material footprint and environmental impact of buildings and urban areas. In this respect, the study first analyzes and explains the building stock typology. The plan typologies of residential buildings are defined in terms of their form and core characteristics. Plan types are classified according to the schematic location of the building core. This systematic approach provides for evaluations of residential building floor plans, structural system alternatives, and their response to physical environmental impacts. At the same time, the study defines the life cycle assessment systematic for structural systems. Studies on the comparative life cycle environmental impact of steel and reinforced concrete structural frame residential buildings are explained. In the light of the findings, evaluations regarding the relationship between Türkiye's building stock and environmental impact are explained. At the same time, studies that analyze the status of the building stock over time and its effects on the environment are investigated. Evaluations are made in line with the findings obtained.

3. Findings and Discussion

Steel and especially reinforced concrete are structural frames that have a high usage area in the world (Oladazimi et al., 2020). Concrete is an important component in the construction industry due to its many advantages, such as its mechanical properties and sufficient durability, heat storage capacity, chemical inertness, and ease of being molded into different sizes and shapes (Vieira et al., 2016). Türkiye is one of the leading countries in concrete production. However, the earthquake that occurred in the Türkiye-Syria region in 2023 highlighted the urgent need to reposition the local construction sector. The Kahramanmaraş earthquakes of magnitude 7.8 and 7.7 (Mw) that occurred on February 6, 2023, caused massive destruction and tens of thousands of casualties, becoming one of the deadliest natural disasters in the last thousand years. The earthquake caused great destruction in ten provinces, especially Kahramanmaraş and Hatay. Figure 1 shows Hatay after the 2023 Kahramanmaraş Earthquakes, and Figure 2 shows the rubble of collapsed buildings in Hatay.

Figure 1. Hatay After the 2023 Kahramanmaraş Earthquakes (AA, 2023)

Figure 2. Rubble from Collapsed Buildings in Hatay (AA, 2023)

Following this devastating earthquake, the importance of analyzing Türkiye's existing building stock to re-evaluate construction technologies and materials used has become evident. As seen in Figure 2, with the destructive impact of the earthquake, the management of construction waste has become an important issue that needs to be solved. The impact of residential buildings on Türkiye's urban material stock is of great importance and a more environmentally friendly approach to building stock is required.

The use of reinforced concrete (RC), which dominates the urban landscape of cities in Türkiye, has been actively encouraged and supported since the first quarter of the 20th century. Following the earthquake that occurred in the Marmara Sea Region on August 17, 1999, expectations for the development of the construction sector until 2023 focused on the development of building technologies. The need for improvements in urban buildings and the adoption of new building technologies is emphasized (Somer, 2025). Steel structural frame is a material that has a significant effect in terms of load-bearing, is recyclable, and has a wide range of uses. Studies on steel and reinforced concrete structural systems concentrate on static performance. Both structural materials can be used to build resistant buildings, and in this respect, these materials should be compared and analyzed in terms of environmental performance. Life Cycle Assessment (LCA) is a powerful environmental performance assessment tool. Therefore, studies are needed to evaluate the environmental performance of alternative systems. In this section, the conceptual framework of plan typology and life cycle assessment systematics are explained, and the life cycle energy and carbon emissions of steel and reinforced concrete structural systems located in the same plan plane are analyzed.

3.1. Plan Typology Conceptual Framework

The plan typology for residential buildings can be briefly summarized in its most general and frequently encountered form as a classification made according to the principles and access of spaces horizontally and vertically.

Typology, in its most general form, can be defined as the classification of phenomena and entities around the concept of type. In residential buildings, the number of flats on the floor, the floor area of the flats on the floor, the geometry of the building core, the building height, or the schematic structure of the residential block can be selected as reference points. The system created in line with the core is the classification made according to the location of the core within the building and its schematic structure. The core of a building, the vertical circulation element, is a key architectural parameter. It contains all vertical circulation elements such as elevators, stairwells, fire escapes, mechanical shafts, and lifts. At the same time, core layout is critical to a building's space efficiency and operational effectiveness, playing a significant role in the structure's ability to handle lateral loads. Core dimensions vary depending on seismic activity levels, building height, and floor plans.

In terms of building form, the rectangular plan is the most common floor plan in buildings worldwide, including Türkiye, and in recent years, there has been an increase in the use of aerodynamic floor plans, such as circles and ellipses (Özşahin, 2022). In his study, Özşahin (2022) defined the plan typology of high-rise buildings, including residential buildings, as central, external, peripheral, atrium based on core layout; open, closed form based on core shape; single, multiple based on core number; and symmetrical, asymmetrical based on core arrangement. Figure 3 shows the central, peripheral, and atrium cores schematically.

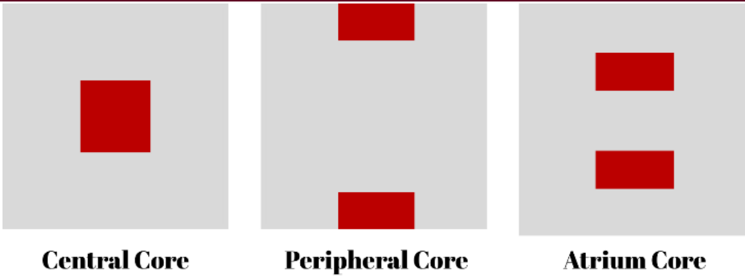

Figure 3. Core arrangement classification for buildings (Adopted from Özşahin (2022))

In the scientific research project conducted within the scope of TOKI mass housing (BAP2012-27, 2015), it was stated that the classification system based on the schematic location of the building core could provide an idea about the floor schemes of mass housing buildings and their exposure to physical environmental effects, and the classification was basically made as follows:

Central-core plan types: These systems have the core and floor halls concentrated at the center of the building.

External core plan types: In this plan type, the core and the floor hall are partially adjacent to one facade of the building.

Carob system plan types: In buildings in this group, common areas, including floor halls, elevators, and stairs, are arranged on an axis that will cut vertically through two opposite facades of the building.

Double-axis corridor plan types: It is a building form consisting of a central core and corridors located on two axes intersecting in this core.

Central cores are more widely used than other core types because they provide resistance to lateral loads, open up the surroundings to light and views, and provide efficient work environments. Furthermore, the fact that central cores do not generate torsional moments under lateral loads under symmetry is another important reason why they are preferred over asymmetric central cores and edge cores.

It is important to recognize the architectural components of a building at the national level. Proposing alternative systems for the existing building stock requires first understanding the building stock and analyzing its characteristics. In national and international contexts, it is essential to first analyze and define building and plan typology, identify commonly used architectural styles, and analyze structural systems accordingly. The environmental performance of alternative structural systems can only be analyzed under equal conditions. Alternative structural elements with equal seismic performance on the same plan plane must be compared. In this regard, the concept of typology is specifically handled in this study.

3.2. Life Cycle Assessment (LCA) Systematic

Life cycle assessment (LCA) is a methodology used to evaluate the resources used and potential environmental impact throughout a product's life cycle. First introduced in the early 1960s to rationalize the energy consumption of buildings, LCA has evolved into an important and main concept that integrates all environmental impacts and is used to protect the environment. The life cycle concept is major for sustainability as it includes many aspects that provide an objective analysis of processes or services. Therefore, LCA is a methodology used to provide environmental impacts at all life cycle stages, from the source of the raw material to the end of its life and disposal, and represents a global and strong methodology. The life cycle framework is defined in the international standard EN 15978 (2011) and is shown in Table 1.

Table 1. Life Cycle Assessment Principles and System Boundaries (EN 15978:2011, 2011)

Production Stage	Construction Stage	Use Stage	End-of-Life Stage	Benefits and Loads Beyond the System
A1: Raw Materials Supply	A4:Construction-installation	B1: Use	C1:Deconstruction, demolition	Reuse
A2: Transport	A5: Transport	B2:Manufacturing	C2: Transport	Recovery
A3:Manufacturing		B3: Repair	C3: Waste process for reuse	Recycling Potential
		B4: Replacement	C4: Disposal	
		B5:Refurbishment		
		B6: Operational energy use		
		B7: Operational water use		

As seen in Table 1, energy and resource consumption, carbon emissions, and other environmental emissions occur for each stage and subparameter within the life cycle system boundaries. The life cycle assessment boundary for structure systems includes the production module, construction module, end-of-life module, and LCA energy & emission recovery modules, and is shown in Figure 5. This life cycle assessment boundary does not evaluate the use stage (B1-B7). Because international standards determine the life of the load-bearing system as one hundred (100) years, and in the life cycle approach, the life is generally accepted as fifty (50) years. Additionally, repair, demolition, or reuse of a load-bearing system requires static or seismic performance analysis. The International Energy Agency (IEA) states in its Annex 57 (IEA Annex 57, 2016) that scenarios should be planned for the maintenance, repair and reuse of structural systems.

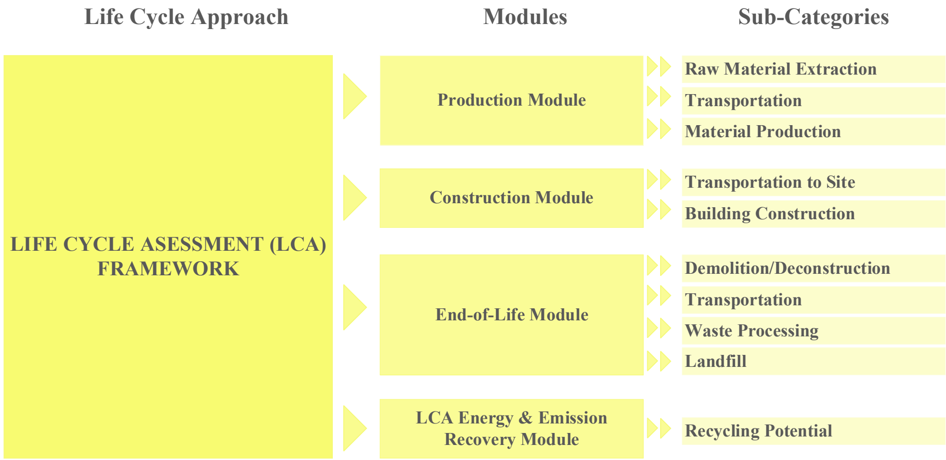

Figure 5. Life Cycle Assessment System Boundary for Structural System (Created by the Authors)

Raw material extraction, material production, and transportation factors are subcategories of the production module. Transportation to the construction site and building construction are subcategories of the construction module. The end-of-life module includes demolition/deconstruction, transportation to waste recycling centers and landfills, waste processing, and landfills. The Life Cycle Assessment (LCA) energy and emissions recovery module addresses recycling potential. Energy and carbon emissions constitute the primary focus of studies and literature on international carbon neutrality targets. This study focuses on energy and carbon emissions. The studies reviewed focus on energy and carbon, and also include other environmental emissions.

3.3. Studies on the Field of Residential Buildings' Structural Systems and Life Cycle Assessment

This section describes the studies in the scope of comparative life cycle assessment of steel and reinforced concrete framed residential buildings. In line with the data obtained, the relationship between Türkiye's building stock and the environmental performance of alternative structural systems is evaluated. At the same time, studies that analyze the temporal dimensions and environmental impacts of building stocks with material-scale prediction models are included. Thus, it is aimed to draw attention to the effects of the building stock on the environment.

Oladazimi et al. (2020) handled the comparative life cycle of steel and concrete structural frames in their study and examined a 6-story reinforced concrete and a 7-story steel residential building in Iran. All stages of a building's life cycle, from raw material extraction to demolition and waste recycling, were analyzed. Because the research focused on comparing the frames of the two structures, other sections, such as walls and floors, were assumed to be similar. In this study, the steel structure was considered 100% recyclable after demolition, while 85% of the steel reinforcement used in the concrete building was considered recyclable, and all concrete waste was landfilled. Global warming potential, acidification, eutrophication potential, human toxicity (cancer and non-cancer effects), resource depletion (water and minerals), climate change, fossil fuel consumption, air acidification, and biotoxicity were analyzed as environmental impacts. As a result, it was concluded that the total pollution of the concrete frame was higher than that of the steel frame at all the mentioned impact categories. The steel building had a more destructive impact on the ecosystem than the concrete building in only one category: resource consumption (minerals, fossil, and renewable resources) (Figure 6).

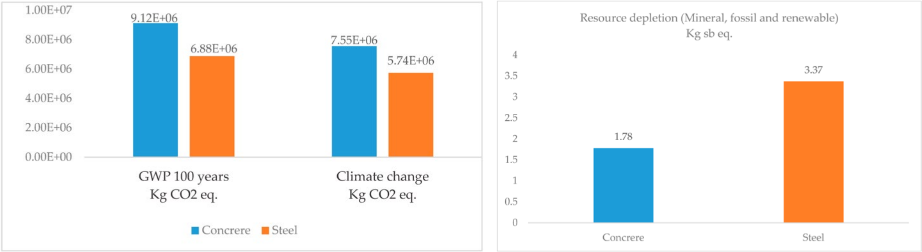

Figure 6. Structural Systems' LCA Results (Oladazimi et al., 2020)

The technical report "Environmental benchmark for buildings" (Gervasio & Dimova, 2018), published by the European Commission, focuses on the framework for developing benchmarks for the life cycle performance of buildings and presents a preliminary set of benchmarks by performing analyses for residential buildings that are considered to be representative of the current residential building stock in Europe. The energy and carbon results for steel and reinforced concrete structural frames examined within the scope of the study are shown in Figure 7.

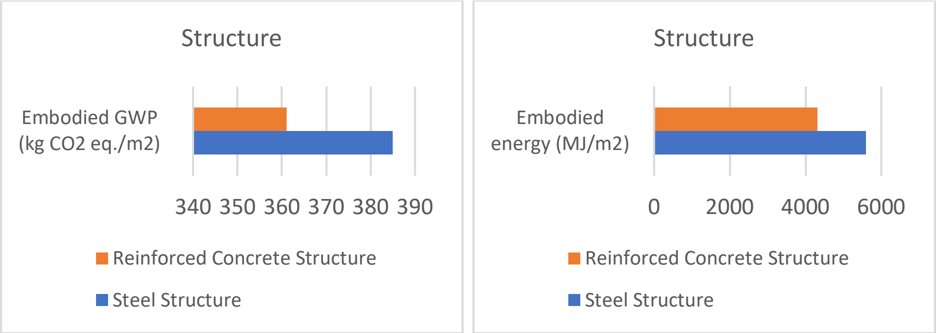

Figure 7. Reference values according to different structural systems (Created by the authors in accordance with the "Environmental benchmark for buildings" technical report)

At the same time, in studies within the scope of comparative life cycle analyses of steel and reinforced concrete structural frames, including also office buildings, it is observed that reinforced concrete or steel has high performance in terms of environmental indicators (Guggemos & Horvath, 2005; Xing et al., 2008; Kim et al., 2013; Balasbaneh & Ramli, 2020).

As a result, a building's design depends on local conditions, technical and functional requirements in regulations, and/or the client's specific needs. Therefore, the environmental performance of buildings will also be affected by these same factors, and these factors should also be considered when defining benchmarks. Based on the studies conducted, it is not possible to say that one type of structural system is more efficient. Based on the studies conducted, it is not possible to say that one type of structural system is more efficient. Many parameters, such as the scope of the study and the physical and built environment characteristics, influence lifecycle performance. For Türkiye, parameters such as reinforced concrete and steel production capacity, recycling potential, and construction waste storage areas are not the same for all cities. In Türkiye, parameters such as reinforced concrete and steel production capacity, recycling potential, and construction waste storage areas are not the same for all cities. These parameters influence the transport factor throughout the life cycle, creating a significant impact on overall environmental performance and playing an active role in structural system selection. Factors such as primary energy source will also vary by location and impact on environmental performance. Urban transformation projects are ongoing in Türkiye. However, it is known that the proportion of building stock in need of renovation is very high across the country. Therefore, it is crucial and necessary to select structural systems that will have optimal performance for the building stock, taking into account environmental indicators and local characteristics.

In the study conducted by Marinova et al. (2020), a global construction materials database of residential buildings was developed and stock analysis was conducted between 1970 and 2050. Six construction materials are included for four different housing types in urban and rural areas. The results indicate a significant increase in the material stock in housing towards 2050, especially in urban areas. China currently dominates global building stock developments and is expected to saturate stock towards 2050. In other regions, such as India and Southeast Asia, stock growth is currently just beginning and can be expected to dominate global developments after 2050. Figure 8 shows the calculated housing stock development for the cities considered in the study for the period 1970-2050, distributed across different housing types, in square meters. The 26 regions are grouped into three different categories based on their development patterns: fast-developing regions, including South American countries, Africa, and Asia; stable-developing regions, including North America, Europe, Oceania, Russia, and the Middle East; and finally, China and Japan.

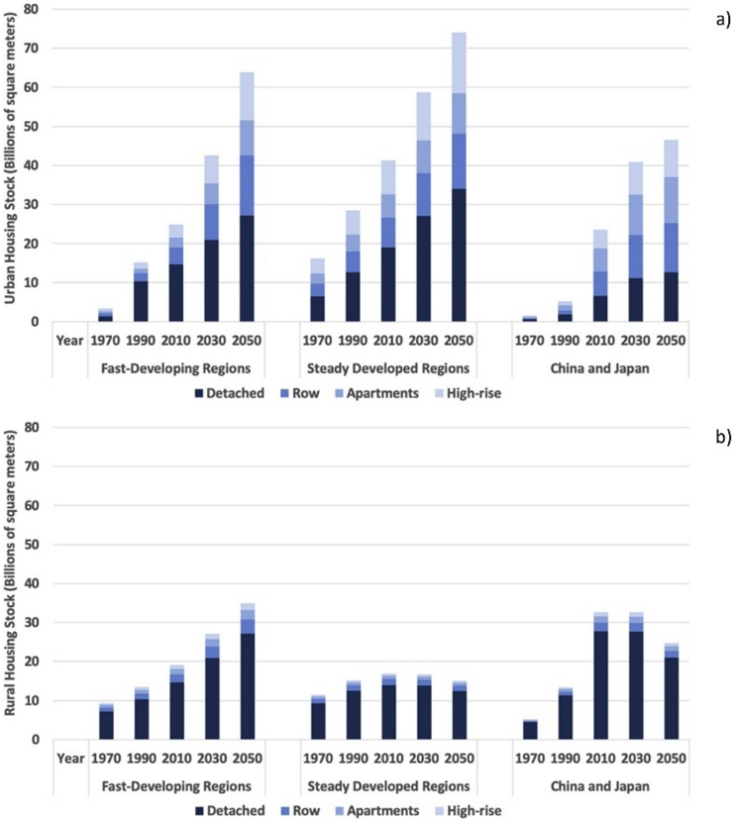

Figure 8. Urban and rural housing stock, the upper graph shows the housing stock in urban areas, and the lower graph shows the housing stock in rural areas (Marinova et al., 2020)

To investigate the building-level impacts of materials, Heeren & Hellweg (2019) developed a building stock model that uses three-dimensional and geo-referenced building data to determine volumetric information of material stocks in residential buildings in Switzerland. In the study, six scenarios with different assumptions regarding floor area per capita, building stock turnover, and construction material were examined. As a result, the Swiss building stock will undergo significant structural changes by 2035. While this will lead to a decrease in new construction, material flows will increase. Total material inflows will almost halve, while outflows will double. By 2055, total material inputs and outputs will be almost equal. Material inputs and outputs of residential buildings for the years 2015, 2035 and 2055 and all scenarios are shown in Figure 9.

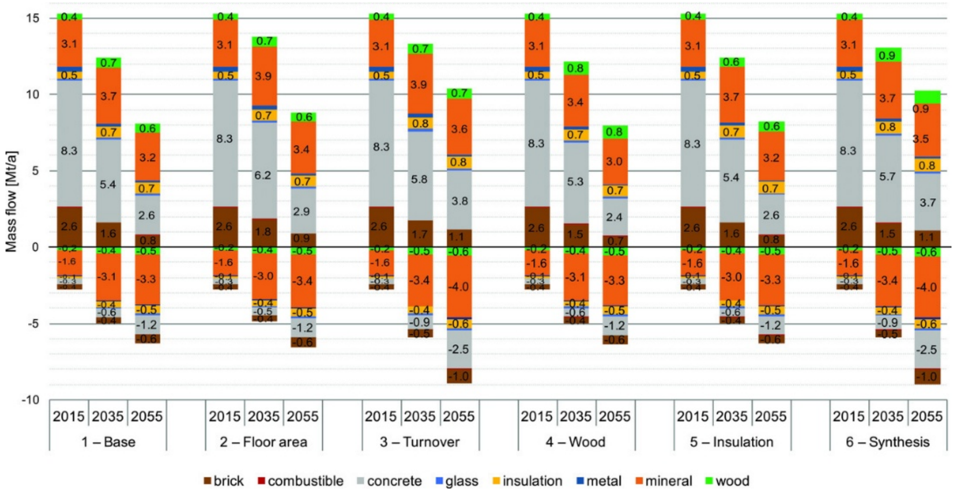

Figure 9. Material input and output for residential buildings for the years 2015, 2035, and 2055 and all scenarios (Heeren & Hellweg, 2019)

The total environmental impacts resulting from the production and disposal of construction materials remain relatively constant over time. The model developed in this study is designed for the regional analysis of construction activities. It is stated that the predictive power of the model can be further increased by using more regional data, such as local building typology, population estimates, etc.

As a result, it can be said that the construction industry is supported by extensive research aimed at creating a more sustainable and higher-quality built environment as a key strategy for addressing global challenges. It actively researches new construction technologies and sustainable materials worldwide to mitigate the adverse effects of climate change.

4. Conclusion and Suggestions

A large part of the materials extracted and consumed in the world is associated with the construction sector, and the volume is expected to increase, largely due to the projected growth of the global residential building stock. Studies in the field of static or seismic performance of alternative structural systems are intense. In the studies, it is seen that the subject of performance-based design is reduced to a single performance, such as static effect. There are many parameters to be considered in evaluating the performance of structural system alternatives. Life Cycle Assessment (LCA) is the most powerful performance evaluation approach. This study investigates the relationship between the housing stock and environmental impact in Türkiye, where 86% of the housing stock is occupied. Reinforced concrete systems constitute a very high proportion of this ratio. Studies on steel and reinforced concrete structural frames are conducted to highlight the need to evaluate alternative structural frames in terms of environmental performance. While steel structural systems offer distinct advantages, it is difficult to determine which structural system offers the best environmental performance. Because environmental performance is analyzed according to many parameters within the scope of the life cycle. In this respect, as defined in the study, the LCA system boundary should be clearly defined, and all parameters should be clearly evaluated. Especially for countries like Türkiye, which have a very high building stock that needs to be renewed, an environmental performance-oriented approach is a solution to environmental problems.

Transformations towards greater sustainability in the built environment can be achieved through low-carbon building stock and reduced emissions, which requires the evaluation and optimization of buildings and materials. In addition, in a period where urban transformation is on the agenda in Türkiye, examining the housing stock in terms of structural systems and plan typology and analyzing the relationship of these factors with environmental impact is of great importance in guiding designers.

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The article complies with national and international research and publication ethics.

Ethics Committee approval was not required for the study.

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All authors contributed equally to the article. There is no conflict of interest.

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