Ph.D.Dissertation of Architecture and Architectural Engineering

An Interpretation of Spatial Heterogeneity through the Compositional Properties of Buildings:

- Topology and the Atmosphere of Interconnected Spaces-

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Abstract

This study is concerned with the interpretation of spatial heterogeneity through the compositional properties of buildings. The background of this idea goes back to the postmodern architectural critique, which deemed Modernist spatial strategies, both in architectural and urban design, to be catalysts of homogenous spatial effects. Attempts to reverse these spatial effects through design have taken several turns since the early 1960s, of which one line was concerned with the critique of the “abstract” homogenous space and introducing concepts of the human experience of space that is inherently rich with qualities and emotional reactions toward the environment, while the other, design-oriented, was predominantly focused on creating complex forms as a means of diversity. A number of these approaches that aspired to heterogeneity sought theoretical substantiation through concepts borrowed from science and philosophy, of which the relationship with architecture is often superficial and without clearly defined cause-effect relationships. One of the concepts used in this manner is the concept of topology borrowed from mathematics, where the dynamic properties of topology are employed as a conceptual resource and a design process methodology in the production of complex forms that oppose the Euclidian grid geometry associated with modernism.

This study investigates and critically approaches the problematic “homogenous” space that the aforementioned design approaches seek to address, and rereads the “homogeneity” of modernist space as a low level of diversity originating from the openness and fluidity of spatial composition. In this regard, the present study attempts to surpass formal approaches and to frame spatial heterogeneity in terms of the architectural composition that reverses these effects, suggesting a compositional strategy of interconnected spaces and reading heterogeneity in the manner such spatial setting renders the atmosphere of space.

To structure this argument, this study commences with the concept of topology, reading it through a network of spatial relationships in the building. Thus, rather than focusing on formal aspects of architecture, it focuses on spatial relationships and the structure of space as the key aspects of topology. It further embodies this concept as a compositional strategy that changes the character of the interior and creates variations in the atmosphere through communications of individual spaces. Diversity of space is created as a diversity of atmosphere through the differences of individual spaces, which arise when the spaces are connected in a way that the individual characters overlap. By acknowledging the atmosphere of space as a component, the abstract arguments of heterogeneity and topology of space approach the human experience of space. This three-step argument (topology – composition – atmosphere) constitutes a theoretical foundation for the understanding of spatial heterogeneity that this study puts forward. After identifying the compositional principles of a building that are advantageous for creating such spatial effects, case studies that encompass

this kind of composition are analyzed, the theory is tested, and conclusions are drawn.

With the argument stated herein, this study positions homogeneity and heterogeneity not as two opposites (rectilinear and curved, ordered and disordered), but it rather gives a nuanced understanding of spatial diversity through the complexity of spatial relationships, aiming to emphasize the importance of the “thoughtful making of spaces” than the preference for one or the other. The concept of topology as a description of the structure of space implied through the composition, relationships of spaces, and the definition of boundaries acquires a new interpretation in this context as a denominator of spatial complexity. Hereby this study establishes theoretical grounds and gathers design knowledge for the understanding and design of spatially diverse atmospheres, as well as their value in the sense of human experience.

Keywords: spatial topology, heterogeneous space, design concept, space design, architectural space, architectural composition

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1. Introduction

1.1. Study Background and Purpose

In the last, nearly sixty years, architectural theory and design have been in a quest for heterogeneity, as a response or a critique of what is often referred to as the homogenous space of modernist architecture and urban design. The development of concepts of space and the transformation of architecture from an art of form to an art of space is an occurrence closely entwined with the emergence and development of modernism,[1] where the spatial paradigm stood behind several early modern architectural movements. Nevertheless, modernist spatial strategies were later widely condemned for their homogeneous spatial effects. Architectural styles that followed, starting with postmodernism, attempted to establish architecture as heterogeneous and autonomous, contrary to the homogeneous building tradition affiliated with the Modern Movement.[2]

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[1] Adrian Forty, *Words and Buildings: A Vocabulary of Modern Architecture* (New York: Thames & Hudson, 2000), 256.

[2] Robert Somol, "Dummy Text, or The Diagrammatic Basis of Contemporary Architecture," in *Peter Eisenman: Diagram Diaries. Introduction by R. E.*

However, the adjective “homogeneous” as a description of modernist architecture and urban design is, in the context of critique, used ambiguously. The homogeneity understood as a lack of diversity is associated with various aspects of modernism that range from architectural projects to urban design, from the spatial composition of De Stijl and Bauhaus to CIAM urban planning. The homogeneity of modernist architecture is commonly associated with the design based on the grid, subordination of design to geometry, aesthetic purity of form, the abstraction of space, focus on space, the neglecting of the social dimension of space, political ambition to create a new democratic society by abolishing the differences, etc. In phenomenological revisions of the Modern Movement, the concepts of space around which these architectures evolved were condemned as naïve in their approach to “lived space” as an abstracted matter.[3] Furthermore, in the context of critique, the modernist “universal” space was often equated with Newton’s *absolute space* and Euclidean geometry. The lack of diversity in the built environment that critics were addressing is thus aligned with abstract scientific and mathematical concepts that are not available to human perception.

Consequently, the quest for heterogeneity that characterized architectural production from the early 1960s had a number of turns and different approaches to this problem. The architectural design was

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Somol, Peter Eisenman and R. E. Somol (London: Thames & Hudson, 1999), 9.

[3] For example, Christian Norberg Schulz refers to Sigmund Gideon's (*Space Time and Architecture*) and Bruno Zevi's (*Architecture as Space*) account of Modernist space to be “realistically naïve.” See: Christian Norberg-Schulz, *Existence, Space & Architecture* (New York: Praeger Publishers, 1971), 12.

predominantly focused on formal innovations as a means of diversity. At the same time, space was left out of focus. The "postmodern turning point with its formalistic dimension" that Antoine Picon describes in *Digital Culture in Architecture* can be understood in this context.[4] Postmodern ideas of *complexity* and *collage* that fell into recombination and citation of historical references[5] may be perceived as a contrast to modernist formal and aesthetic simplicity. Despite the *complexity and contradiction* that Venturi advocated in his book,[6] addressing not only architectural form but also the problem of complexity of spatial composition, in postmodern architecture, space was left out of focus.[7]

In the following period, the architecture of Deconstruction attempted to create heterogeneity by deconstructing the building's forms, fragmentation, discontinuity, and juxtaposition of architectural elements,[8] whereby it eliminated the underlining modernist grid. Achieved complexity of architectural form through heterogeneity and fragmentation aimed to "express conflicting logic of its surrounding."[9] For example, in the design for Wexner Center for the Arts in Columbus, Peter Eisenman attempted to

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[4] Antoine Picon, *Digital Culture in Architecture: An Introduction for the Design Professions* (Basel: Birkhäuser, 2010), 63.

[5] Jeffrey Kipnis, "Towards a New Architecture," in *Folding in Architecture*, ed. Greg Lynn (Chichester, West Sussex ; Hoboken, NJ: Wiley-Academy, 2004), 57-58.

[6] Robert Venturi, *Complexity and Contradiction in Architecture*. 2d ed. (The Museum of Modern Art Papers on Architecture. New York : Boston: Museum of Modern Art ; distributed by New York Graphic Society, 1977).

[7] Adrian Forty, *Words and Buildings: A Vocabulary of Modern Architecture* (New York: Thames & Hudson, 2000), 268-69.

[8] Giuseppa Di Cristina, "The Topological Tendency in Architecture," in *AD: Architecture and Science*, ed. Giuseppa Di Cristina (Chichester: Wiley-Academy, 2001), 7.

[9] Picon, *Digital Culture in Architecture*, 63.

reconcile two grids (inner campus grid and the city grid), resulting in a distorted and broken form. Less prevailing strategies strived for heterogeneity through programmatic complexities, creating events, and focusing on political relevance. These strategies are visible in Bernard Tschumi's and the OMA's projects in the late 1980s.[10] The program-oriented approaches embraced the orthogonal geometry of modernism, and in this fashion, deemphasized the importance of form as a means of complexity. [11]

At the beginning of the 1990s, several new concepts and design ideas appeared in revisions termed "topological architecture" or "topological tendency in architecture."[12] These include Stephen Perella's concept of *Hypersurface Architecture,* Peter Eisenman's *Folding in Time,* Jeff Kipnis' architectures of *DeFormation,* Greg Lynn's *Animated Form,* the concept of *fold* and *blob* architecture, etc. What these approaches have in common is the tendency toward complex forms interpreted through the mathematical concept of topology. Since it was defined as a mathematical discipline in the early twentieth century, the study of topology has been used in architecture (and art) in various interpretations. Topology was a source of inspiration that gave a new outlook on space and shifted focus from dimensions to the relationships between spaces. [13] However, the architectures of the 1990s did not focus on topology as a study of

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[10] Kipnis, "Towards a New Architecture," 59.
[11] Kipnis, "Towards a New Architecture," 59.
[12] This term was used in 2001 AD Reader *Architecture and Science* edited by Giuseppa Di Cristina to denote a number of architectural concepts revolving around complex pliant geometries. See: Di Cristina, "The Topological Tendency in Architecture."
[13] The uses of the topology are discussed further in the dissertation.

invariants[14] but rather the geometric properties of bodies. Instead, topology as a "geometry of rubber sheet" was used as a conceptual resource for creating complex and curved forms (folds, blobs, etc.) and as an operative technique (twisting, bending, distorting, etc.). [15] Thus, from this period onward, the most common association with topology in architecture became the form of a complex curve. The term "topological architecture" in literature is associated mainly with the projects and design ideas that appeared in this period and thereafter.

These new conceptions used several scientific and philosophical references for the substantiation of their ideas.[16] The most prominent was Deleuze's concept of the fold. The process of folding was a conceptual resource that inspired forms. Still, the architects also found the conceptual value of the fold in Deleuze's remark that the *pli* (the French word for *fold*) is etymologically related to the word complexity.[17] Other significant conceptual resources were René Thom's *catastrophe theory* as well as the ideas of morphogenesis that *D'Arcy Thompson* brought forward in his book *On Growth and Form.* Yet, these scientific references were merely an inspiration. The real potential in these fluid forms was to create a new architecture without historical references.[18]

The booming of the topological approach in architecture was empowered by the rise of digital technologies that altered the modes of

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[14] Branch of mathematics that studies properties geometric bodies that do not change when the said body is subjected to a continuous deformation.
[15] Di Cristina, "The Topological Tendency in Architecture," 7.
[16] Di Cristina, "The Topological Tendency in Architecture," 7.
[17] John Rajchman,"Out of the Fold," in *AD: Architecture and Science*, ed. Giuseppa Di Cristina (Chichester: Wiley-Academy, 2001), 35.
[18] Kipnis, "Towards a New Architecture," 60.

architectural production and allowed architects to experiment with the new forms. However, these architectures' formal and aesthetic approaches must be understood in a larger historical context, i.e., as a continuous part of formalistic developments that started with postmodernism.[19] On a conceptual level, topology offered an alternative to Euclidean geometry associated with the homogenous effects of modernist spatial and organizational ideas. Furthermore, topological operations (such as bending, twisting, stretching, etc.) were used in the design process as form-finding techniques that offered an aesthetic and functional alternative to both collage of historical references of postmodern architectures and juxtaposing and discontinuity of the architecture of Deconstruction.[20] Instead, these architectures' fluid and continuous forms allow for uniting conflicting contents, thus, cohesively and coherently creating a heterogeneous whole.

However, formal innovation through geometry was only one aspect of the topological approach in design brought forward. These architectures had a renewed interest in space. The fluid and continuous forms gave architects an alternative spatial organization that could embody different programs in a continuous and cohesive manner. The advocates of this design approach suggested that such architectures overcame the problems inherited in the modernist concepts of organization and design of space. This was enabled by fluid forms that allowed for different programs and spaces to mix cohesively but also to adjust to the given surrounding blending into different contexts by smooth integration.[21] In this manner, on

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[19] Picon, *Digital Culture in Architecture*, 63.
[20] Di Cristina, "The Topological Tendency in Architecture," 7.
[21] Kipnis, "Towards a New Architecture," 59; Di Cristina, "The Topological Tendency in Architecture," 7.

an urban scale, these complex structures allow an overcoming of the modernist strategy of erasure and replacement, as well as the postmodern collage, by creating a system that embodies differences without conflicting them.[22] These aspects of topological architecture seemed significant for urban design as they counter the sleek and utilitarian modernist approach to design implemented without a context. Hence the advantage of using the mathematical idea of topology translated to architecture as curved surfaces and forms (apart from new formal aesthetic) was twofold: 1) it offered a conceptual shift away from Euclidean geometry that is often put in context as one of the generators of homogeneous effects in modernist architecture; 2) it generated space that embodies diversity on both architectural and urban scales.

Following accounts of topological architecture and their endeavors to achieve heterogeneity in urban and architectural space, formal topological developments are, on the one hand, a continuous part of a formalistic turn that started with postmodernism.[23] On the other hand, they involve a parallel narrative on social aspects of space, political role, and the autonomy of architecture that also revolves around the questions of homogeneity/heterogeneity of space. This narrative encompasses ideas originating in postmodern geographies where space is understood as a mode of control and social order in post-Fordist society [24] (ideas that can be

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[22] Kipnis, "Towards a New Architecture," 59; Di Cristina, "The Topological Tendency in Architecture," 7.

[23] Picon, *Digital Culture in Architecture*, 63.

[24] Michael Hensel, Achim Menges and Christopher Hight,"En route: Towards a Discourse on Heterogeneous Space beyond Modernist Space-Time and Post-Modernist Social Geography," in *Space Reader: Heterogeneous Space in Architecture*, ed. Michael Hensel, Achim Menges and Christopher Hight (Chichester, U.K: Wiley, 2009), 23.

traced back to the critique of modernist spatial concepts and utopian planning in Lefebvre's *Production of Space*), and more recent concerns involving problematic that Deleuze put forward in *Postscript on the Societies of Control*.[25]

Lefebvre's book was focused on the critique of "abstract space" of modernist architects and sought to bring forward the ideas of space as lived and produced through social interaction, as opposed to an abstract space upon which the architects operate. However, Lefebvre's account on the multiplicity of space did not provide a practical idea of how to actively employ such an understanding of space in the design.[26] This is the point where the questions of autonomy and the political role of architecture commence. While some architects do not consider that architecture should have an active political role, but merely create spaces for the needs of society,[27] others agitate that architecture can and should take an active political role through the creation of spatial organizations and forms that encompass diversity and multiplicity.[28] These ideas burdened architects

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[25] Douglas Spencer compares Patrik Schumacher's account of new spatial organization with Deleuze's description of "control society." See: Douglas Spencer, "Architectural Deleuzism: Neoliberal Space, Control and the 'Univer-City'," *Radical Philosophy* 168, (2011):12.

[26] Hensel, Menges and Hight. "En route," 24.

[27] For example, Patrik Schumacher states that ZHA architecture creates spatial organizations that coincidentally fits into neoliberal modes of production. See: Spencer, "Architectural Deleuzism," 12.

[28] For example, Stan Allen's theory of the *field* where the political ideas of multiplicity and diversity are inferred, and TERRIOR's concept of *Third Space* that extends the political objective of the field. Its political project is freedom from institutionalized control: "architecture outside of the constraints of the given brief." See: Andrew Benjamin, John Hong, Gerard Reinmuth, and TERROIR (Firm), *Terroir: Third Spaces*, 2019; Stan Allen, "From Object to Field," in *Space Reader: Heterogeneous Space in Architecture*, ed. Michael Hensel, Achim Menges and Christopher Hight,

with finding new spatial and organizational paradigms that could support this political goal – creating space that is at the same time de-hierarchized and inhomogeneous.

This study attempts to develop a different interpretation of spatial heterogeneity that relates to the same context and background. However, it interprets the heterogeneity of space as a diversity of atmosphere that relates primarily to the compositional aspects of a building. To develop this interpretation the idea of topology is employed, not in the sense of complex curvatures and processes of deformation, but through relationships of spaces within the composition.

Heterogeneity, by definition the "quality or state of being diverse in character or content" (*heteros* "other" and *genos* "a kind") or an entity "consisting of dissimilar or diverse ingredients or constituents"[29] is interpreted as a diverse atmosphere that occurs when spaces of different qualities are brought together through the connections of spaces. A heterogeneous whole constitutes the spaces connected in a manner that their different qualities confirm each other. The quality of space is further interpreted as the atmosphere or ambiance of each space. Atmosphere or ambiance of space is not used in a naturalized manner but as a

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(Chichester, U.K: Wiley, 2009); Some other approaches see the facade/envelope as a political agent of architecture. For example, Alejandro Zaera-Polo proposed that the envelope as organizational and representational means can also become a medium of archtecture's political agency ("The Politic of Envelope"). Jeff Kipnis suggested that architecture of *DeFromation* has the opportunity to become politically relevant through the design of a complex monolith ("Toward a New Architecture").

[29] *Merriam-Webster*, *s.v.* "heterogeneity," accessed May 5, 2021, https://www.merriam-webster.com/dictionary/heterogeneity.

phenomenon investigated in architectural theory, dependent on the qualities and frame of the setting. When individual spaces (ambiances) are interconnected, the overall space is rendered diverse through the differences of the individual parts of the spatial volume. Thus, heterogeneous space embodies the diversity of ambiance achieved through avoiding rigid boundaries of spatial volumes.

This kind of heterogeneous space is then opposed to homogenous space. Homogeneity is, by definition, the propriety of the same kind or alike (from *homos* "same" + *genos* "kind"). It is an entity characterized by a "uniform structure or composition throughout."[30] This kind of space occurs in compositions where spaces are conceived as enclosed discrete units. It can also be related to entirely open and continuous spaces because there is not enough enclosure of any part of the space to create a difference. Thus the quality of heterogeneity of the ambiance is opposed to homogeneity as a lack of diversity or sameness.

Spatial composition plays an essential role in generating a diversity of qualities as these effects are dependant on the relationships, position, and connections of spaces. The composition here denotes how individual spaces within a building are assembled into a whole, their arrangement, relationships, and connections, both in plan and section.[31] This is where the concept of topology as the description of the spatial structure becomes an important aspect of a building in the context of heterogeneity.

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[30] *Merriam-Webster, s.v.* "homogeneity," accessed May 5, 2021, https://www.merriam-webster.com/dictionary/homogeneity.

[31] For architectural composition see for example: Jacques Lucan, *Composition, Non-Composition: Architecture and Theory in the Nineteenth and Twentieth Centuries* (Essays in Architecture. Lausanne, Switzerland Abingdon, Oxford: EPFL Press, 2012.), 11-25.

Topology, as a mathematical study, is interested in the properties that remain the same despite continuous deformation because the structure of the space has not changed. This means that topology is not necessarily related to deformation. It also relates to the structure of space, and for this reason, there are these two very different interpretations of the concept in architecture. This interpretation of topology, which this study brings forward in the context of spatial heterogeneity, is not concerned with dynamic processes of deformation and their potential for creating complex forms but focuses on spatial relationships and the structure of space as key aspects of topology. The topology of a building, in this study, is understood as the structure of the interior space that is formed through open connections between the spaces. The topology (structure) of the space changes when the connections between spaces change. The use of topology in this research is not an exact translation of the mathematical study but rather a useful concept that helps understand/interpret a structurally complex space. In this understanding, the topology of space describes relations and connections between individual spaces within the building (and its surroundings), and how they render the quality of space. Transferred to spatial composition, the topology of space reveals that spaces with complex structures render space heterogeneous, while discrete spaces are necessarily homogenous.

This concept of heterogeneity relates to the same background of modernist spatial conceptions. However, it does not interpret the homogeneity of modernist space through the geometry and order based on the grid, but through unified atmospheres created by breaking the box-like rooms and creating continuous and fluid spaces, and simplifying the

composition. The heterogeneity interpreted in this study negotiates between the two. Hence, it does not define heterogeneity through formal aspects, or the complexity of geometry, but through spatial relationships within the composition.

It is worth noting that the space that we perceive, and therefore the atmosphere, can never be homogeneous in the same strict sense as it is a space of mathematical constructs such as Euclidean space. This means that we can talk about the homogeneity of the space only conditionally. There are only levels of heterogeneity. These are not directly related to any style or historical period, but each study can be observed individually where enclosed and defined spaces are more common for traditional architecture, as are open spaces related to modernism. Therefore, there is no attribution of homogeneity/heterogeneity to the styles and formal aspects of architecture, but rather to the compositional properties of individual projects. Heterogeneity is not preferred over the homogeneity of space, and needs to be understood in the context of the function, need for privacy, social context, etc. Thus homogenous and heterogeneous are shown as a diversity of possible spatial experiences where one is not preferred over the other. The thesis further reflects on the history and interprets the homogeneity of modernist architecture through the idea of spatial relationships.

This understanding of heterogeneous space in architecture limits itself to the effects related to the design of spatial atmosphere and user experience in the sense of aesthetic, spatial qualities. This kind of understanding tends to connect to the discourse on architecture in relationships with human experience present since Schmarsow's *Essence*

of Architectural Creation,[32] the work of Viennese architects in the early twentieth century,[33] as well as some recent phenomenological ideas about the atmosphere. In a broader sense, it continues on Aldo van Eyck's concept *in-between*.[34]

Although such an approach might be only one of the layered understandings of space in architecture, it is isolated from political (and economic) concerns that are often related to the concept of heterogeneity to focus on design knowledge. This does not mean that the study dismisses the possibilities of the political meaning of the proposed spatial organization; it simply leaves it out of focus. At the same time, it brings forward the atmospheric and compositional qualities of interior space and their value in the sense of human habitation. Thus, this study does not see a spatial organization as a politically charged field but as a setting of everyday human experience.

The proposed spatial composition can be discussed in many different contexts: the political agency, societies of control, surveillance, availability, etc. However, such aspects of spatial organizations can be discussed rather in terms of public buildings and spaces and their

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[32] August Schmarsow, "The Essence of Architectural Creation," in *Empathy, Form, and Space: Problems in German Aesthetics, 1873-1893*, ed. Harry Francis Mallgrave and Eleftherios Ikonomou (Santa Monica, CA: Getty Center for the History of Art and the Humanities; Chicago, Illinois: Distributed by the University of Chicago Press, 1994.)

[33] The work of Adolf Loos, Josef Frank and Heinrich Kulka, as analysed by Christioper Long and Wolfgang Thaler, *The New Space: Movement and Experience in Viennese Modern Architecture* (New Haven; London: Yale University Press, 2016).

[34] Aldo van Eyck, "Das Reich des Zwischen" [The In-Between Realm], *Forum* 8 (1959): 251-269.

relationships with the urban setting. Contrarily, the concept of heterogeneity this study puts forward equally refers to the intimate setting of both – a house and a public building. Nevertheless, a spatial arrangement is never isolated from social conditions. As Robin Evans demonstrated by comparing the matrix plan of medieval Italian villas and the corridor system of English houses, spatial arrangements are indicators of social relationships. The former suggests intimacy and closeness, the latter privacy and segregation.[35] And while these social and cultural circumstances, as well as climate, patterns of use, etc., play an important role in the development of spatial composition, this study merely focuses on ambient qualities and the aspects of space that relate directly to spatial design and tries to interpret spatial heterogeneity/ homogeneity through compositional properties. This is important in emphasizing the qualities of space and their importance in the context of human habitation, but also in generating valuable design knowledge.

1.2. Research Aims and Objectives

Following the concepts defined above, this study sets forth six main objectives:

1) To reflect on the problem of homogeneity of modernism how it is seen in the postmodern critique, and to bring forward particular issues in this discourse.

[35] Robin Evans, "Figures, Doors and Passages," in *Translations from Drawing to Building and Other Essays,* by Robin Evans (London: Architectural Association Publications, 2011).

2) To reflect on the approaches toward heterogeneity and their mainly formal and conceptual ideas.
3) To interpret heterogeneity through spatial relationships and develop this concept concerning spatial composition and ambiance in a building.
4) To indicate that the topology (understood as the structure of space, connections, and relations of individual spaces) has a profound impact on the character and diversity of space.
5) To elaborate on the principles of spatial composition that render the space heterogeneous.
6) To bring forward implications of this interpretation of spatial heterogeneity (and the topology) in the context of the discourse on modernist “homogeneity” and postmodern “heterogeneity.”

The first two aforementioned objectives constitute a theoretical and design background against which the concept of heterogeneity (and topology) developed in this study ought to be understood. Through this historical context, the interpretation of heterogeneity induced in this study obtains value within the discipline of architecture. The historical overview presented through the examination of the literature and design is not a mere collection of facts but rather a critical approach that illuminates the problematic that the second part of this study attempts to approach. Thus, it lays the groundwork for further development of the study.

The following objectives are related to the establishment of a new understanding of heterogeneity and its value in the comprehension and design of architecture. The idea of topology borrowed from mathematics is

used here as a conceptual resource that denotes spatial complexity focusing on the logic of spatial relationships and the structure of space. Interpreted in this manner topology is embodied within the realm of architectural composition. Thus, this study seeks to use topology as a description of spatial relationships within the spatial composition, further uncovering the principles of compositional design that generate the diversity of spatial qualities within a building. The abstract idea of topology becomes tangible as a spatial configuration of interconnected spaces that generates a variety of spatial qualities, allowing different ambiances to come together. The space becomes diverse as the different individual spaces are brought together, confirming each other's quality through differences. After establishing the theoretical foundations for a new interpretation of heterogeneity, this study then uses case studies to exemplify this theory and to determine more closely how the topological relationships are created within a building and how they change the character of space.

Through this investigation, this study creates the possibility for an understanding of spatial heterogeneity as a notion distinguished from the complexity of form, the arbitrariness of spatial arrangements. It gathers valuable design knowledge regarding spatial composition and its impact on the quality of space.

1.3. Literature Review

1.3.1. A Reflection on Previous Studies

The sources that address the heterogeneity of space directly as the quality of space are scarce, especially those that focus on this problem as a design problem. One of the recent studies that addresses this problem is Michael Hensel, Achim Menges, and Christopher Hight's book *Space Reader: Heterogeneous Space in Architecture.* The authors seek to take a new approach to heterogeneous space which goes beyond the form-program paradigm. They suggest that previous attempts to create heterogeneous space, concerned with formal complexity and programmatic diversity, left the concept of actual space undeveloped –understood as a passive result of form-making. They approach space as a complex phenomenon with variable atmospheric properties and phenomenological qualities which can be designed and manipulated with.[36]

Space Reader contains several articles that would field a possible basis for the development of a heterogeneous space's theoretical problems. However, most of these articles do not theorize about the heterogeneous space directly, but serve the authors to ground their idea of spatial heterogeneity in architecture that they bring forward in the concluding chapter – *The Heterogeneous Space of Morpho-Ecologies.* Their theory consists of two parts: (1) creating differences in space by modifying conditions and the character of the space and (2) the understanding of

[36] Hensel, Menges and Hight, "En route," 9-12.

spatial heterogeneity in the sense of the relationships between the spatial conditions, formations, users, and continuous processes of change of these relationships. [37]

Following this, the theory of *morpho-ecologies* proposes creating heterogeneous spatial conditions by generating and differentiating environmental conditions through a performative structure. This structure would represent a material system inspired by biology, with a complex structure on different scales. Similar to living organisms where parts are organized in functional and structural systems, these system parts are also connected in the functional sense. The architecture becomes a system with complex internal relationships which communicate with external forces in the same way an organism does. This kind of structure would not be limited to static enclosures and divisions of space; it would have the performative ability to instrumentalize dynamic atmospheric changes using materials that respond to external stimulation. This system instrumentalizes the form-finding process as the form is a state equilibrium of the system in certain environmental conditions and external forces. It is also dynamic as it changes when the conditions are changed. Instead of the full enclosure, this system aims for arbitrary boundaries - a layered system with different levels of interiority and exteriority. The important characteristic of these systems remains porosity because it enables and empowers interaction with the environment beyond the system. In porous systems, differences between interior and exterior conditions are blurred, and environmental

[37] Michael Hensel and Achim Menges, "The Heterogeneous Space of Morpho-Ecologies," in *Space Reader: Heterogeneous Space in Architecture*, ed. Michael Hensel, Achim Menges, and Christopher Hight (Chichester, U.K: Wiley, 2009) 195-196.

modulation extends to the field. This, however, does not exclude the possibility that a solid material system could also produce the same effects.

The second condition of heterogeneity in *morpho-ecologies* arises from the question of how to structure this system and give it spatial organization. Hensel et al. propose a design based on programmatic and formal "blankness."[38] avoiding spatio-programmatic determinism by pre-labeling each unit of space with a definite use. This does not mean that the *morpho-ecological* approach to heterogeneous space has to become an "amorphous field of arbitrary gradient," but instead, they can be initially structured to provide "formal and programmatic bleakness" with the ability to activate the interaction between the agents and space.[39] Spatial organization based on modulating microclimatic conditions does not have a material threshold that divides space into programmatic zones. The design is based on the principles of the development of the architectural environment in interaction with users. The relationship of space and form with the program acknowledges the dynamic and changes of human habitation. This approach opens possibilities for multiple habitation patterns, and the program is not a priori given, but it is a "post-design opportunity." This idea extends Robin Evans' idea of interaction between social formations and spatial organization that he brought forward in the seminal article.

The authors further align their strategy of heterogeneous space of *morpho-ecologies* with the idea that Deleuze and Guattari bring forward in *A Thousand Plateaus* of heterogeneous (smooth) space in the Go game. The

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[38] The concept of "blankness" here refers to Kipnis' idea in "Toward a New Architecture."

[39] Hensel and Menges, "The Heterogenous Space of Morfo-Ecologies," 211.

figures in this game give meaning to the fields. The space is dynamic, and its role is determined in relation to other spaces and the agents. The emphasis of relationships in heterogeneous approach to design is present in both strategies: the atmospheric spatial modulation and dynamic (based on the interactive relationship between form and the environment), and the dynamic of habitation, which relates human activities, programs, and spatial organization. Thus their concept of heterogeneous space recognizes the importance of human habitation in architectural space, but not directly human perception and experience. Furthermore, the heterogeneity is not understood as diversity within a whole but rather as a field of dynamic changes that necessarily brings forward the dimension of time within the concept.

A different idea of spatial heterogeneity concerning spatial relationships is brought forward by Peter Eisenman in *Palladio Virtuel.*[40] Eisenman interprets a shift from homogeneous to heterogeneous space as a shift from Cartesian geometry toward topology in Palladio villas,[41] or (as it is evident from his analysis) a shift of emphasis from dimension and proportion of spaces toward the relationships of spaces. He used the idea of topology as a way of reading Palladio's villas through diagrams. Unlike Rudolf Wittkower and Colin Rowe who were analyzing Palladio's villas through the geometrical nine-square diagrams based on size and proportion, Eisenman created topological diagrams based on volumes that reveal that spaces in the villas are not discrete, but they overlap, creating different

[40] Peter Eisenman and Matt Roman, *Palladio Virtuel* (New Haven: Yale University Press, 2015).
[41] Eisenman and Roman, *Palladio Virtuel,* 10.

spaces or *in-between*.[42] Overlapping the spaces showcases the greater importance of spatial relationships over the size and proportion of space.[43] It thus implies a shift from geometry to topology in architecture, i.e., from homogenous to heterogeneous space. With this, Eisenman related the idea of topology to the qualities of space. However, his account of these spatial relationships that exist between spatial volumes is visible only in diagrams. In reality, villas' spaces are discrete units.

This study uses some of these ideas to develop the concept of spatial topology as a denotation of spatial quality. However, it develops these abstract ideas by embodying them through spatial composition. It further defines the spatial relationships as physical and visual connections between the spaces and elaborates on how these topological relationships within the composition change the character of space. Thus the central idea of the topology proposed here is not in the sense of functional relationships but spatial qualities, atmosphere, and the diversity of space. These ideas are further placed against the context of modernist homogenous fluid spaces and "topological architecture," where they demonstrate how the heterogeneity of space is generated through the design.

The idea of topology as a denotation of spatial relationships is not new. It appeared for the first time in architectural theory in Reyner Banham's essay *New Brutalism* where he used this mathematical term to describe the informal spatial organization in Alison and Peter Smithson's Sheffield University project.[44] He noted that unlike geometry (the main discipline that

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[42] Eisenman and Roman, *Palladio Virtuel,* 10.
[43] Eisenman and Roman, *Palladio Virtuel,* 33.
[44] Reyner Banham, "The New Brutalism," *The Architectural Review, n*o. 708 (1955): 361.

leads the design), the topology had been continuously present in architecture in "a subordinate and unrecognized way – qualities of penetration, circulation, inside and out."[45] In the Smithsons' project, the situation was reversed because the building is shaped through the logic of connections.

Emphasis on spatial relationships, which we here refer to as topology, is visible in Alison and Peter Smithson's design diagrams that are deprived of visual expression and contain only links between the elements. For example, the sketch of Alison Smithson for the 1957 Snowball Appliance house project (Figure 1) shows functional units and their connections drawn as circles and arrows.[46] In the early 1960s, these diagrams were used as representations of complex spatial problems concerning city development and traffic representations.[47]

[45] Banham, "The New Brutalism," 361.

[46] Bojan Tepavčević and Vesna Stojaković, "Representation of Non-Metric Concepts of Space in Architectural Design Theories," *Nexus Network Journal 16*, no. 2 (2014): 291-92.

[47] Tepavčević and Stojaković, "Representation of Non-Metric Concepts of Space," 291-92.

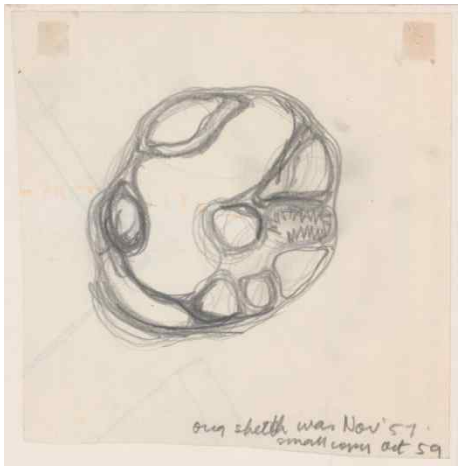

Figure 1. *Alison and Peter Smithson, sketch plan for the Snowball Appliance House, 1957.*
Source: *https://www.cca.qc.ca/en/search/details/collection/object/15375.*

Christopher Alexnder's graphs in the essay "A City is Not a Tree" can also be understood as presenting the city's structure through topological functional connections.[48]

Another approach in architecture that uses topology to analyze space is space syntax. Space syntax includes several theories and techniques that use mathematic and computation to analyze the cognitive and social features of a plan (on architectural and urban levels).[49] The idea of the analysis of spatial relationships through the concept of topology was originally developed by Bill Hillier and Julienne Hanson. In *The Social Logic of Space,*[50] they brought forward the importance of society-space

[48] Tepavčević and Stojaković, "Representation of Non-Metric Concepts of Space," 292.

[49] Michael J. Dawes and Michael J. Ostwald, "Space Syntax: Mathematics and the Social Logic of Architecture," in *Handbook of the Mathematics of the Arts and Sciences*, ed. Bharath Sriraman (Cham: Springer International Publishing, 2018), 1.

[50] Bill Hillier and Julienne Hanson, *The Social Logic of Space* (Repr. Cambridge: Cambridge Univ. Press, 2005).

relationships and methods for investigating this relationship. Space syntax techniques use topology to examine relationships between spatial configurations in a plan and related social structure. The topological properties of space are *permeability* (connections with other spaces, spatial configuration) and *difference* from other spaces (regarding their position in the system).[51] Several space syntax analysis techniques (axial line analysis, convex space analysis, and intersection point analysis) transform the actual plan into a graph[52] where spaces and their connections are presented as a network. Through the graphs, the space is abstracted and analyzed independently of the form. According to Hillier, these graphs not only reflect, but can also forge social patterns.[53]

The way the aforementioned techniques abstract the spaces and the relationships is similar to the interpretation of topology developed in this study. The parallel with the mathematical concept is contained in interpreting spaces as vertices and their connections as edges. However, the present study has a different focus. While space syntax analyzes and abstracts space to research social patterns and human spatial behavior, this study aims to place topology in the context of spatial heterogeneity. Spatial heterogeneity (a problematic category in itself) is a complex space of diverse qualities that this study interprets through relationships between spaces that are visible in topological diagrams. Another difference is that this study distinguishes between several types of spatial connections and

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[51] Dawes and Ostwald, "Space Syntax: Mathematics and the Social Logic of Architecture,"1.

[52] Dawes and Ostwald, "Space Syntax: Mathematics and the Social Logic of Architecture," 1.

[53] Bill Hillier, "The art of place and the science of space," *World Architecture* 185, (2005): 96-102.

mainly neglects those that do not allow for significant interaction between the spatial volumes. This is because the idea of topology is not examined in the context of human spatial behavior, accessibility, or surveillance, but in relation to qualitative characteristics of space – the ambiance and the heterogeneity of the quality. The spaces that topology represents as nodes are actually ambient wholes – spaces with a specific function and are sufficiently defined to be distinguished from other spaces. Heterogeneous space is then interpreted as a complex space that consists of several individual spaces bounded into a whole through prominent connections. The trope of topology is then contained in the importance of these relationships that define the character of a space that essentially changes if any of the connections are broken, or a new connection is added. The ideas put forward, emphasize the importance of relationships of spaces in the context of creating an ambiance of change, and shift the idea of heterogeneity from the form to space.

Most of the approaches mentioned above that use topology as a conceptual resource primarily focus on spatial relationships. Gerard Reinmuth has recently brought forward the importance of relationships in architecture in his study on relationality in architecture.[54] Reinmuth brought this idea in the context of autonomy and the political role of architecture, the crisis of the profession, and the need for transformation. The term "relationality," simply put, means that one should not perceive architecture as an object but as a set of relations. In his argument, Reinmunth does not

[54] Gerard Reinmuth, "Relationality and Architecture: How Refocusing The Discipline Might Reverse The Profession's Seemingly Unstoppable Trajectory Of Decline," *Architectural Theory Review* 21, no. 1 (2017): 89-107.

explain in detail the nature of these relations, except for the importance of thinking about architecture in terms of relations rather than objects. He supports his argument through Andrew Benjamin's ideas from *Toward Relational Ontology*, where singularities only exist in relationships.[55] Reinmunth also refers to Andrew Benjamin's essay *Building, Building,* where the philosopher explains that every singularity is defined through relationships, i.e. objects are after-effects of relationships. Consequently, every building is, as well, a system of relationships, and "incorporated within a network of relations."[56] According to Benjamin, "internal relationality, which can be understood as the intersection of materials, program, and circulation, (knowing that each of these terms will overlap in different ways in certain instances and take on different forms and definitions) defines a *building* as a process."[57]

The importance of framing architecture by relationality, according to Reinmuth, lies in the possibility of obtaining autonomy and agency of the discipline and changing the "professional configuration."[58] The specific contribution of architecture as a discipline lies in the drawing (diagram) that is a tool of representation and a generative tool. With a focus on relationality, architects have the possibility to find agency in their skill to use drawings to represent influences, phenomena, opportunities, etc., making projections concerning changes in relations.[59]

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[55] Reinmuth, "Relationality and Architecture," 99.
[56] Andrew Benjamin, "*Building,* Building," in *The Building*, ed. Jose Araguez (Baden Switzerland : Lars MüllerPublishers, 2016), 312-13.
[57] Benjamin, "*Building*, Building," 312-13.
[58] Reinmuth, "Relationality and Architecture," 99.
[59] Reinmuth, "Relationality and Architecture," 100.

Benjamin's idea of relational ontology puts the building into a broader context of relationships. However, Reinmunth's translation of relations into diagrams implies focus (although he never writes so) on spatial relationships and suggests analyzing and predicting different phenomena through diagrams similarly to the space syntax analysis. This idea again implies spatial topology.

The interpretation of topology in this study is in some respects parallel to the idea of relationality. It has a similar interest in relationships, particularly spatial relationships, and their effects on architecture. However, this idea of relationships, interpreted through spatial topology, has a concrete form in the spatial composition. Spatial relationships in this work denote adjacency and the connection of spaces (rooms) within a building. Their importance is brought into the context of historical and theoretical discourse on spatial heterogeneity/homogeneity.

1.3.2. The Difference With the Present Study

Table 1. *Differences/similarities of the present study with the concept for literature regarding topology and relationships of spaces.*

The concepts from the literature	The main ideas of the established concept	Differences and similarities with the present study
Space Syntax (originally developed by Bill Hillier and Julienne Hanson)	Several theories and techniques that use computation and mathematic to analyze the cognitive and social features of a plan. Spatial configuration -> social life Spaces as nodes and connections as edges. Analyzes connections in the plan. Edges denote connections in plan in the sense of access or visual access Nodes denote spaces as rooms, or intersection of edges, or Topological properties – permeability (the way spaces are connecter) and difference (how are the spaces distinguished based on connections	The role of the diagram is to explain the structure of space graphically and reveal discrete and complex spaces. Spatial configuration -> qualitative variability of ambiance Spatial units as nodes and connections as edges Analyzes connections in space Edges denote three types of connections between spaces Nodes denote spatial wholes - ambiance units

	Relationships embody the social pattern	Relationships reveal spatial wholes – complex and discrete spaces
Relationality in Architecture Gerard Reinmuth and Andrew Benjamin	Deals with relationships in general These can be relationships of materials, function, etc. Suggest diagrams as means of presenting and predicting relationships as an area of expertise of an architect. These can represent influences, phenomena, opportunities.	Deals solely with relationships of spaces and their interactions These are examined in the context of the ambiance and the experience of the users.
Palladio Virtuel Peter Eisenman (with Matt Roman)	Relates topology to the quality of space Represents spaces as volumes Distinguishes three types of spaces based on their position in the villa (central space, transitional space, and portico) Volumes of spaces can be read in several ways and fluctuate. The volumes do not match the actual spaces in the villa plan, and their overlaps exist only in readings	Relates topology to the quality of space Represents spaces as volumes Distinguishes spaces based on their frame, function, and qualities that constitute ambiance Volumes are fixed. The volumes match the actual spaces. Overlaps are created through open connections between adjoined spaces or superimposition. The quality of space is determined as atmosphere, and spaces are defined

	Space is understood as a mere volume. Heterogeneity of space is implied in several ways: overlaps of spatial volumes, emphaisis on relationonships, irrelevance of proportions.	through this Heterogeneity of space manifests as the quality of diversity of spatial ambiance produced through interactions of spaces.
In-between Aldo van Eyck	Reconciles spatial anti-poles (large and small, inside and outside, unity and diversity, etc.)	Composition of spaces that negotiate between enclosed and open

Table 2. Difference of the present study's concept of heterogeneity from different approaches toward heterogeneity in architecture (generalization).

The concepts from the literature	**The main ideas of the established concept**	**Differences and similarities in the present study**
Space Reader: Heterogeneous Space in Architecture	Programmatic bleakness System(biological structure) that regulates the atmosphere	Programmatic determination (or irrelevant) Static spatial configuration
Formal Approaches	Formal operations to create complex forms Recombination and Citation Juxtaposition and Fragmentation Folding and Twisting	Focused on the complexity of spatial composition
Phenomenology	Focus on human perception and inhabitation	Focus on the human experience as well as the design concepts.

1.4. Research value

In relation to aims and objectives defined, this study provides the following:

1) The development of the idea of heterogeneity in the context of the spatial composition (in opposition to formal interpretations), and if further, relates these organizational aspects to spatial structure.
2) It relates the concept of topology (as the denominator of heterogeneity) to the character of space and defines the compositional properties of heterogeneous spaces, thus gathering design knowledge.
3) It postulates an understanding of the heterogeneity of space specific to architecture, which can be designed and experienced. This interpretation places heterogeneity in architecture as a design based on the “thoughtful making of spaces.”
4) It emphasizes the importance of the compositional qualities of space concerning the diversity of space over geometry and formal properties. In this manner, it brings forward the importance of the complexity of spatial relationships within a building.

1.5. Research Methodology

1.5.1. Research Methods

The research method is based on the theoretical and analytical approaches. It was developed concerning the problematic, addressed by the study, which value is grounded in critical theory and design knowledge. The argument this study makes is structured into two main steps. Firstly, it establishes theoretical foundations and the background upon which the study is placed. Through a simultaneous investigation of the literature, theoretical ideas, and buildings that represent these ideas, the problematic of spatial homogeneity/heterogeneity in architecture (that has rarely been discussed directly) is illuminated. This historical and theoretical background encompasses revising the spatial concepts of early modernism, their theoretical and design implications, and the postmodern critique of these spatial strategies and design ideas. It attempted to illuminate why they are deemed homogenous and the nature of their relationship with abstract scientific concepts of space that are commonly used in the context of the critique. It further examined different approaches toward heterogeneity (attempts to reverse the effects of modernist spatial strategies), as well as their theoretical foundations and implications. This has contextualized the study and illuminated the problematic of spatial homogeneity/heterogeneity.

Secondly, the study develops an interpretation of heterogeneity that relates to the background as it suggests how heterogeneous space is generated within the architectural composition. In this part of the study, a deductive method of research was applied. The theoretical hypothesis that

relates the concept of topology with spatial quality was formulated using Peter Eisenman's idea of topology in *Palladio Virtuel.* Eisenman's concept has been further altered and developed through theoretical and design ideas from the literature. The idea of topology was embodied in compositional properties. By this, a theory that explains the role that topology (relationship of spaces) has in rendering the space heterogeneous was developed. From these theoretical ideas, the criteria for the analysis were derived, and the case studies have been selected. Each of the case studies has been chosen based on their compositional properties found to be advantageous to rendering space heterogeneous.

The analysis was conducted through drawings, topological diagrams, and photographs. The results were discussed in the context of the hypothesis and the theoretical and historical background, and conclusions have been drawn.

1.5.2. Research Materials

The argument presented in the dissertation is grounded in previous theoretical work. Therefore the primary recourse for the argument made in this thesis is based on theoretical accounts from several different fields – science/ mathematics, philosophy, and theory of architecture.

Additional analysis is based on the materials related to the architectural projects, their plans, and sections, diagrams and photos obtained from digital and written sources or designated museums, as well

as statements from architects which are documented in interviews or in written sources.

1.5.3. Research Scope

The study focuses on theoretical and design ideas that have a general value regarding specific design knowledge. Thus, the heterogeneity/ topology and spatial composition ideas that this study addresses can be applied to a large diversity of architectural designs. The case studies selected and examined here are from different architects/architectural offices, from a broad historical period, and different geographical and social circumstances. However, they were selected as the representative of compositional ideas that this study focuses on, demonstrating the universality of the principles examined here.

1.6. Organization of the Dissertation

Following the methodology and the structure of the argument, the dissertation is organized into seven chapters.

Chapter 1 introduces the focus of the study, places the research into a context. Then, it defines problems, aims, and objectives and determines methods to approach the outlined problem.

The body of the dissertation consists of two parts. **PART 1** constitutes the background and the context in which it is placed. It illuminates the problematic of the homogeneous/heterogenous space

inherited in the theoretical discourse to lay the groundwork for the argument made in **PART 2.**

PART 1 consists of two chapters. **Chapter 2 - The Problematic of Modernist Spatial Concepts and Compositional Strategies** - discusses the problematic of "homogeneous" space in modernist spatial concepts and architecture. It addresses the metaphors modernist architects used in the relation to the scientific concepts of space (space-time, topology, etc.) and compositional strategies that followed these concepts. It further discusses the critique of the modernist "homogenous" spatial effects and "abstract space" in the later revisions of the Modern Movement. **Chapter 3 - Approaches toward Heterogeneity** - discusses different approaches toward heterogeneity that followed the modernist period with an emphasis on the "topological architecture." It brings forward their conceptual resources, principal design ideas and discusses how they respond to the problematic put forward in the previous chapter.

The main argument of this study – the interpretation of topology in the context of spatial heterogeneity is made in **PART 2.** It consists of four chapters. **Chapter 4 – Theoretical Grounding and Formulation of the Hypothesis** – examines literature and develops a hypothesis about the role of topology (relationships of spaces within composition) in generating heterogeneous effects in space. This section firstly discusses the concept of topology in the context of mathematic and its potential to be used in architecture as a denotation of spatial relationships and the structure of space. It discusses how this concept is used in architecture, develops it in terms of architectural composition, and makes a hypothesis in terms of how composition renders space heterogeneous as a matter of the atmosphere of

space. After establishing the theoretical argument and formulating the hypothesis, these ideas are further examined through case studies in **Chapter 5**. In this section, the case studies are selected and examined through criteria for the analysis derived from the theory developed in the previous chapter. **Chapter 6** – **Understanding, Implications, and the Value of the Concept of Spatial Heterogeneity** – discusses the results from the case studies, whether they prove the hypothesis, and to what extent. It further reflects on the value of such a concept and its implication in the context of the background of the study. It connects the ideas and conclusions from previous chapters in a coherent argument on the interpretation of heterogeneity through the ambiance of space and the role of topology in the quality of space. **Chapter 7 - Conclusion** – summarizes the argument made in the dissertation and reflects upon the value and implications of the study.

PART I - Theoretical Framework

2. The Problematic of Modernist Spatial Concepts and Compositional Strategies

2.1. Modernist Concepts of Space

The critique and the historical accounts of the Modern Movement commonly align the modernist concepts with ideas of space from science and philosophy. Indeed, the relationship between the concepts of space in early modernism and these external concepts of space is rather entangled. The idea of space in architecture appeared first in the German aesthetic in the 1850s and was consequently transferred to architectural and art theory in the late nineteenth century.[60] Until that moment, the concept of space was exclusively a philosophical and scientific problem. In the context of architecture, it was first brought forward by Gottfried Semper, who argued that the principal role of architecture is to enclose the space.[61] However, this idea was not developed in-depth till August Schmarsow proclaimed space to be "the essence of architectural creation" in his inaugural lecture in 1893.[62]

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[60] Forty, *Words and Buildings,* 256.
[61] Forty, *Words and Buildings*, 257.
[62] Schmarsow, "The Essence of Architectural Creation," 281-297.

With this, he shifted the focus of art history from the formal spatial aspect of architecture.

The ideas from German aesthetic theories represent philosophical and intellectual preconditions for the development of the concept of space in early modernism.[63] Nevertheless, it was not until the early twentieth century that these ideas were materialized through design in Bauhaus, DeStijl, Adlof Loos'concept of *Raumplan,* etc. The concepts of space that stood behind these designs were primarily aesthetic ideas that gave architects something to break up with eclectic forms of the past and a way to define beauty.[64] It is a historical coincidence that in the same period science and mathematics came to a great breakthrough in the knowledge about the physical space with the discovery of non-Euclidean geometries, development of the concept of field, and finally formulation of the theory of relativity. These ideas were also immersed in the development of architectural concepts of space. In the early period of modernism, space had numerous interpretations and understandings in architectural discourse, of which *space as a continuum,* i.e., space of Euclidean geometry, often aligned with Modern Movement in revisions, was only one of the concepts.[65] Forty broadly classified these in three categories. The first is the understanding of *space as an enclosure,* which was the most common understanding of space in this period. This tradition originated from Semper's ideas of enclosing the space as a primary purpose of architecture. This volumetric enclosure, Forty notices, is not only in the interior but can be created in the exterior, too. Camillo Sitte wrote

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[63] Forty, *Words and Buildings*, 256.

[64] Cornelis van de Ven, *Space in Architecture: The Evolution of a New Idea in the Theory and History of the Modern Movement* (Assen: Van Gorcum, 1978), XIII.

[65] Forty, *Words and Buildings*, 266.

about this idea in his book *City Planning According to Artistic Principles* (1889).[66] The second category was the idea of *space as a continuum* that was important to *De Stijl* and *Bauhaus* groups: inside and outside space ought to be continuous. The third idea was *Space as an extension of the body,* which understood space as a "protective membrane" relationship with the external world.[67]

The relationship of artistic concepts with scientific ones was often ambiguous. Mutually exclusive concepts of space in science were not mutually exclusive for the artists. For instance, Moholy-Nagy in the *New Vision* put together several different space concepts, which can be aligned with different lines of thought and scientific concepts. On the one hand, he defined space as "space as a relation between positions of the bodies," which puts his understanding of space close to Leibniz's *relational* space. On the other hand, he rejected Semper's ideas of *space as a volume*. His sketch of breaking the volume into surfaces by separating the structural elements causing the voids between them and creating a continuous space aligns with Newton's idea of *absolute* space.[68] Parallels were more often drawn with Einstein's theory of relativity emerging at the time, Minkowski's space-time continuum, and non-Euclidean geometries. Although implying heterogeneity of physical space, these scientific concepts are equally abstract mathematical and physical concepts as Euclidean space is. For example, Jean Badovici appropriated conceptions regarding topological geometry and spatial continuity and relativity postulated by Henri Poincaré in

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[66] Forty, *Words and Buildings*, 266.
[67] Forty, *Words and Buildings*, 266.
[68] LászlóMoholy-Nagy, *The New Vision* (New York: Wittenborn, Schultz, Inc., 1947), 56-8.

Analysis situs.[69] Badovici saw these scientific ideas as an indication of a change in the sensibility of space. Recognizing that time and space are not separable, he pointed out how the sense of space comes not only from the movement but from the sensations that accompany the movement.[70] He further wrote: "We can neither speak of 'absolute location,' nor of 'absolute size,' nor of absolute distance between two points;' we can only speak of interrelationships."[71] In *L'évolution de l'architecture modern en Hollande,* Theo Van Doesburg also reached for the scientific validity of his ideas and predicted that in the future construction would drop Euclidean geometry and plans, and the design will become easier in non-Euclidean computations in four dimensions.[72]

The author who contributed the most in advancing these ideas and establishing architecture as an "art of space" in the English-speaking world was Sigfried Giedion with his book *Space, Time and Architecture* (first published in 1941). As Forty notices, this book did not bring new ideas regarding space; instead, it repeated what was previously said by other authors. However, as it was one of the scarce resources on space in architecture in the English language, it had a pivotal role in establishing and normalizing space as an important category in architecture during the 1950s and 1960s in the English-speaking world.[73] This would later lead postmodern architects to shun spatial concepts and design with neglect of

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[69]Jacques Lucan, *Composition, Non-Composition: Architecture and Theory in the Nineteenth and Twentieth Centuries* (Lausanne, Switzerland Abingdon, Oxford: EPFL Press, 2012), 397.
[70]Lucan, *Composition, Non-Composition,* 397-8.
[71] Jean Badovci, " L'espace et le temps d'après Henri Poincaré," as quoted in Lucan, *Composition, Non-Composition,* 398.
[72] Lucan, *Composition, Non-Composition,* 398.
[73] Forty, *Words and Buildings*, 268.

space and exaggeration of the building's image.[74] Giedion's book set a broader cultural context and historical background from which modern architecture developed.[75] He generalized three main spatial conceptions. The first spatial conception is concerned with relationships of spatial volumes and their interconnections (in Egyptian, Sumerian, and Greek architecture).[76] The second conception started with Hadrian's Pantheon focused on vaulting and "hollowed-out interior space." Through the "intermediary link" of nineteen-century architecture where the spatial unity was gradually vanishing, the development of space in architecture finally culminates with the modernist concepts. This revolution started at the beginning of the twentieth century when a single viewpoint of space was abandoned under the influence of cubism, which rendered bodily movement an important part of architecture and had great consequences on design. The concerns of this spatial conception with movement and continuity changed the relationships of inside and outside.[77]

As Lucan notices, Giedion's "new tradition" of movement in space neglected the depth of the ideas that Theo van Doesburg and Jean Badovici had put forward. The complexity of space-time conception and fourth dimension was reduced to how a building is seen from different viewpoints.[78] However, under the influence of Giedion's book and László Moholy-

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[74] Forty, *Words and Buildings*, 269.
[75] Sigfried Giedion, *Space, Time and Architecture: The Growth of a New Tradition* (Cambridge, Mass.: Harvard University Press, 1973).
[76] Giedion, *Space, Time and Architecture* lv.
[77] Giedion, *Space, Time and Architecture* , lvi.
[78] Lucan, *Composition, Non-Composition,* 398.

Nagy's *Vision in Motion* (1946), the ideas of architecture incorporating the dimension of time became commonplaces.[79]

The scientific references were commonly used for developing or justifying artistic ideas, however, as Antoine Picon remarks, the relationship of Modern Movement with relativity was rather superficial.[80] Paradoxically, implications of these conceptions, which suggest spatial complexity, in design brought forward compositional aspects habitually associated with homogenization, as they contributed to the uniformity of modernist space. Spatial concepts that were initially both aesthetic and functional ideas developed into primarily functionalist doctrine. [81] Furthermore, formal reductionism, together with economical building, brought forward the aesthetic of orthogonal order, right angle, and repetition.[82] Thus, numerous interpretations of space in early modernism that were primarily aesthetic ideas aimed toward fashioning and enhancing spatial experience were reduced to the materialization of Euclidean space that they (on a conceptual level) strived to reject.

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[79] Lucan, *Composition, Non-Composition,* 400.

[80] Antoine Picon, "Architecture, Science, Technology and the Virtual Realm," in *Architecture and the Sciences: Exchanging Metaphors*, eds. Antoine Picon and Alessandra Ponte (Princeton Papers on Architecture 4. New York, N.Y.: Princeton, N.J: Princeton Architectural Press; Princeton University School of Architecture, 2003), 294.

[81] Ven, *Space in Architecture,* 242.

[82] Ven, *Space in Architecture,* 242.

2.2. Modernist Composition and "Universal Space"

Despite the formal aesthetic of modernist architecture, "universal space" of modernism should not be understood as the universal space of Euclidean geometry being an abstract mathematical construct, but rather space, in which the compositional hierarchy is eliminated and the differences between interior and exterior spaces are abolished, thus creating continuous and fluid space of the unified character. This occurred through fundamental changes of the spatial composition in comparison to traditional architecture that was primarily geared towards enclosing space. The breaking of the box that Moholy-Nagy sketched out *The New Vision* (1938) meant rejection of the Semperian tradition of volumetric spaces. By detaching the constructive elements, the interior space connects with the outside in a continuous, fluid manner. Under the sketch, Moholy-Nagy remarked: "Volume and space relationships. If the sidewalls of a volume are scattered in different directions, spatial relationship originates." Further, in the book Moholy-Nagy wrote, "…architecture will be understood, not as a complex of inner spaces, not merely as a shelter from the cold and danger, nor as a fixed enclosure, as an unalterable arrangement of rooms, but as an organic component in living, as a creation in the mastery of space experience."[83] Thus, the rejection of the idea of space as a volume and breaking of box-like traditional spaces was aimed toward enhancing the experience of space, and, thus, architecture.

[83] Moholy-Nagy, *The New Vision,* 60.

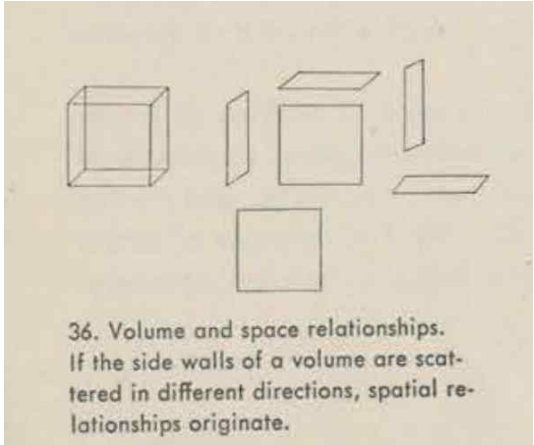

Figure 2. *László Moholy-Nagy, volume and space relationship, 1938.*
Source: *László Moholy-Nagy, The New Vision, (1947), 58.*

More than a decade before Moholy-Nagy published his book, the same idea was explored by Teo Van Doesburg in his *Counter Constructions.* In series of his sketches that look as if they are floating in isotropic space, the constructive elements were detached, and houses were represented without a façade, which further eliminated differences between inside and outside. Van Doesburg referred to such architecture as "anti-cubic" because between the rectangular panels there are no angles and therefore no formations of rooms;[84] interior spaces develop eccentrically without clear boundaries between them. Van Doesburg further connected the idea of the open plan with the "universal space," which meant that in such composition every space is equivalent to another, and, thus, the compositional hierarchy (characteristic of traditional architecture) is eliminated.[85]

[84]Lucan, *Composition, Non-Composition,* 389.
[85]Lucan, *Composition, Non-Composition,* 387.

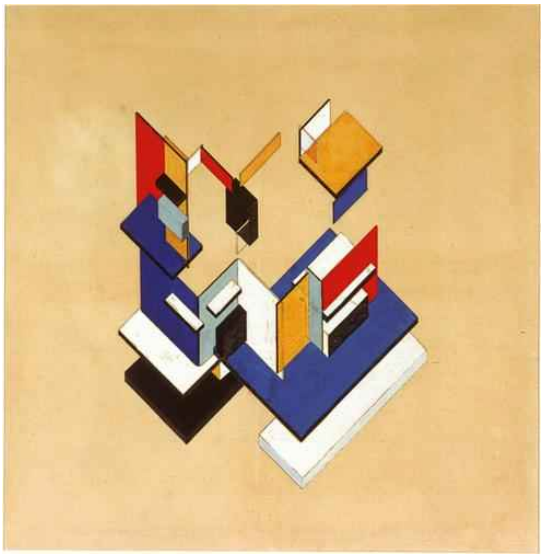

Figure 3. *Theo van Doesburg, Counter-Construction, Axonometric, Private House, 1923.*
Source: *https://commons.wikimedia.org/wiki/File:Theo_van_Doesburg_191.jpg*

Likewise, *free plan,* of which iconic symbol is Le Corbusier's Dom-Ino structure, eliminates hierarchy by narrowing the structural frame to six thin reinforced concrete columns which support horizontal concrete slabs. The structure eliminates the necessity for load-bearing walls and enables a *free* inner organization that is not aligned with "room" or "volume" in the traditional sense. At the same time, the grid, as an underlying geometry of the structural supportive system, implies *striation* of space as geometric order, to which quasi-free organization has to conform in design by the measure of the load-bearing elements. Horizontal slabs are dominant in their immutability and imply infinite extension. They cut off the space hampering vertical extension, thus creating what Peter Eisenman refers to as a "sandwich-like quality of space."[86]

[86] Peter Eisenman,"Aspects of Modernism," in *Eisenman inside out: Selected Writings, 1963-1988* (New Haven, CT: Yale University Press, 2004), 118.

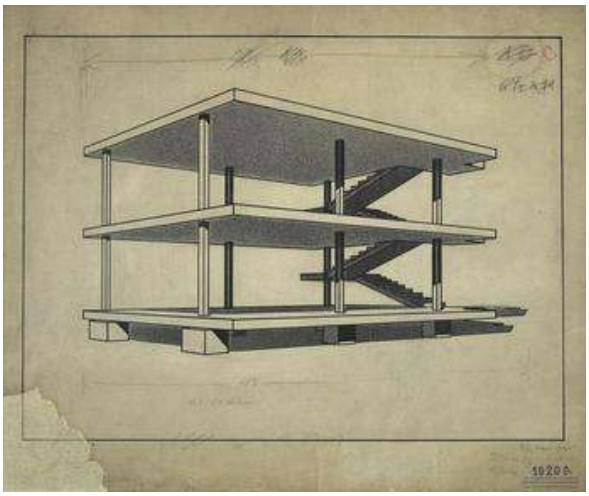

Figure 4. Charles-Édouard Jeanneret (Le Corbusier), Dom-Ino structure, 1914-15.
Source: *https://en.wikipedia.org/wiki/File:Charles-%C3%89douard_Jeanneret_(Le_Corbusier),_1914-15,_Maison_Dom-Ino.jpg*

The Dom-Ino structure could be understood as a diagram of the *free plan*. However, appropriating these features to all modernist buildings would be a rough extrapolation that does not acknowledge individual projects qualities. Yet, it could be suggested that principles of composition employed in the Dom-Ino, similarly to Van Doesburg's *Counter Constructions*, contribute to the homogenization by erasing differences between spaces and bounding inner volumes into a continuous whole. The elimination of sectional hierarchy, present in both of these spatial concepts (one of the aspects of modernism that distinguishes it from the traditional building), additionally contributes to abolishing the differences between individual spaces. Thus, comparing Palladio's *Villa Foscari* and Le Corbusier's *Villa Stein in Garches* Colin Rowe noticed that, unlike in section of the Renaissance villa where there is an obvious hierarchy of the section, in *Villa*

Stein, the equidistance between the ceiling and the floor eliminates such hierarchy and gives equal importance to all "parts of the volume."[87]

The "universal space" of modernism is not the universal space of Euclidean geometry, but rather the space, in which the compositional hierarchy is eliminated and the differences between interior and exterior spaces are abolished. Indeed, the homogeneity of modernist space could be understood in terms of the spatial composition and definition of boundaries rather than orthogonal forms or embodiment of mathematical concepts. Continuous and fluid spaces without hierarchy do not provide the possibility for difference and, therefore, impair diversity. In the case of the Dom-Ino, the grid as an underlying system of organization plays an important role in this process of homogenization. However, this does not happen through flat geometry, right angles, or rendering space measurable; it embodies the structure that eliminates horizontal and vertical hierarchy and erases differences between the inside and the outside by allowing the replacement of walls with sheets of glass.

It is important to note that these ideas do not represent modernist architecture in its entirety. For example, the concept of *Raumplan*, which Adolf Loos developed in the same historical period, contrary to previous spatial concepts, embraces the idea of space as a volume and sectional hierarchy of spaces. However, these volumes have a peculiar and innovative arrangement encompassing a continuity of movement (an aspect of composition also important to space-time conception). As Loos himself explained: "My architecture is not conceived in plans, but in spaces (cubes).

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[87] Colin Rowe, *The Mathematics of the Ideal Villa, and Other Essays* (Cambridge, Mass: MIT Press, 1976), 12.

I do not design floor plans, facades, sections. I design spaces. For me, there is no ground floor, first floor, etc… For me, there are only contagious, continual spaces, rooms, anterooms, terraces, etc. Stories merge, and spaces relate to each other. Every space requires a different height… To join these spaces in such a way that the rise and tall are not only unobservable but also practical, in this I see what is for others the great secret, although is for me a great matter of course… Coming back to your question, it is just this spatial interaction and spatial austerity that thus far I have best been able to realize in Dr. Muller's house."[88] Loos' idea of continuous movement brings together spaces of different qualities and gives spaces different importance by changing the height. Thus, modernist architecture does not equal eternity to abolishing hierarchy and creating a "universal space." Yet, universality understood as equality and homogeneity became a dominant understanding of modernist architecture through functionalist doctrine and urban planning.

Similar compositional inversion happened in Modernist urbanism, with the shift from *concave space* of traditional cities, with public spaced streets and squares closely articulated by the surrounding buildings, to *convex spaces*, where buildings are laid out as isolated sculptures in the urban field.[89] Abandonment of corridor streets, courtyards, and squares bordered by the buildings, which create distinct, intimate atmospheres in urban space, resulted in ultimate openness that denies the possibility of diversity as the whole city exists in the void of unified character. Just like in

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[88]Adolf Loos, shorthand record of a conversation in Plzeň, 1930, quoted in Maria Grazia Sandri, "Talking about the space. Searching the Image," in *The Visual Language of Technique*, ed. Luigi Cocchiarella (New York: Springer, 2014), 99.

[89] Lucan, *Composition, Non-Composition,* 382-3.

inner spaces, continuity and lack of enclosure are principal factors that lead to the absence of diversity in the sense of the atmosphere or the character of the urban space.

2.3. The Critique of Abstract Space and Euclidean Geometry

Criticism focused on the homogeneity of space in modernist architecture and urbanism is often ambiguous regarding different meanings that the word “homogeneity” carries, usually with a negative connotation. The adjective “homogeneous,” meaning of unified quality or lack of variation, has been used in different contexts to describe qualities that vary from austere formal aesthetic, design based on the grid, simplified open plan, and borderless space, continuity between inside and outside. The context, in which Modernist space is commonly described as homogenous, is concerning CIAM urban strategies: abolishing the hierarchy of industrial cities, creating new cites with segregated functions using a strategy of erasure and replacement, and typical planning that did not acknowledge local differences. All these functionalist strategies contributed to homogenization in the sense of lacking diversity in the urban space and the overall uniform appearance of cities without identity.

In the context of critique, homogeneity of modernist architecture is often assimilated with Euclidian geometry and quantification of spatial experience embodied through compositional and formal aspects of modernist architecture. In phenomenological critique, the concepts of space, around which modernist architecture evolved, were deemed for neglecting the qualities of lived space. Introducing the idea of existential space that involves human experience and subjectivity, Christian Norberg-Schulz deemed Zevi's account of space (*Architecture as Space*) as "naively realistic" where "space is a uniformly extended 'material' which can be 'modeled' in various ways."[90] This means that space is a chunk of Euclidian space – a volume without defined qualities. He also regarded Giedion's spatial conceptions defined in Space-Time and Architecture as "naively realistic." However, Norberg-Schulz acknowledged that Giedion approached the idea of existential space by recognizing the importance of visual perception and the relationship of the subject with the environment as well as the interaction between inside and outside.[91] This, according to Norberg-Schulz, implies that Giedion "leaves the idea of a mechanistic combination of units in Euclidean space behind, and attempts to describe qualitative differences."[92]

In *The Language of Postmodern Architecture,* Charles Jencks also pointed out that Modernist architecture has been focused on the articulation of abstract space as a "content of the form." He distinguishes two traditions of space in modernism. The first relates to early German aesthetic theories where space was understood as the essence of architectural creation. Giedion's account of space in *Space, Time*

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[90] Norberg-Schulz, *Existance, Space & Architecture*, 12.
[91] Norberg-Schulz, *Existance, Space & Architecture*, 12.
[92] Norberg-Schulz, *Existance, Space & Architecture*, 12.

Architecture, falls in this category, culminating with the "space-time" perception concept realized in Villa Savoye and Barcelona Pavilion.[93] The second tradition of modernist space, according to Jencks, comes from the development of the Chicago School's steel frame through Le Corbusier's Dom-Ino block. Jencks describes this space as "isotropic, homogeneous in every direction, although layered in grids at right angles to the frontal plane and front lines."[94] The end development of this kind of approach is warehouse space that appears in Mies van der Rohe's design of vast empty halls.[95] In both of these traditions, space is seen as an abstract matter without qualities and relates to Euclidean geometry through the grid and geometry.

Homogeneity is also associated with the order based on a grid. Demetry Porphyrios wrote that the "moralist of modernism conceived of order as geometrical austerity of a severe and homogeneous syntax."[96] He referred to Hitchcock's and Johnson's account of modernist architecture in the 1932 edition of *The International Style:* "A geometrical web of imaginary lines on plan and elevation composes the diverse parts and harmonizes the various elements into a single whole."[97] This kind of order is evident in the work of Mies van der Rohe and Le Corbusier. Porphyrios noticed that this kind of underlining grid is the tool of homogenization and referred to this

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[93] Charles Jencks, *The Language of Post-Modern Architecture*, (New York: Rizzoli, 1991), 96.
[94] Jencks, *The Language of Post-Modern Architecture*, 96.
[95] Jencks, *The Language of Post-Modern Architecture*, 96.
[96] Demetri Porphyrios, " *Heterotopia*: a study in the *ordering sensibility* of the work of *Alvar Aalto*," in *Alvar Aalto*, eds. Demetri Porphyrios, Raija-LiisaHeinonen, and Steven Groák (Architectural Monographs 4. London : New York: Academy Editions ; St. Martin's Press, 1984.), 8.
[97] Henry-Russel Hitchcock and Philip Johnson, *The international style* (1932), as quoted in Porphyrios, "*Heterotopia*," 18.

modernist ordering sensibility (at the same time ethical and constructional) as "homotopia" or "kingdom of sameness."[98]

In the accounts that characterize modernist architecture, there is an association of the Euclidean space and geometrical grid with a lack of diversity in the urban setting or buildings' interior. Used in this context, "homogeneity" has a different meaning than the homogeneity of Euclidian space as an abstract mathematical construct. This ambiguity relates to the duality of concept and experience of space, two different entities incompatible for comparison, which are here ostensibly aligned.[99]

The accounts of critique of Modernist space associate and use interchangeably homogeneity of the mathematical concept and homogeneity of the experience through the notion of abstraction of space in the design. *Abstract space* as geometrically defined, measurable void, barren of all qualities, was Lefebvre's contribution to the critique of modernist architecture and urbanism. In his book *Production of Space* (1974), Lefebvre pointed out how abstract space, upon which architects operate, neglecting and reducing the lived reality of space to the scientific and philosophical concept, "asphyxiates whatever is conceived within it" and

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[98] Porphyrios, "*Heterotopia*," 9.

[99] The paradox between the concepts of space and the experience of space is Bernard Tschumi's idea. It reflects in "the impossibility of questioning the nature of space and at the same time experiencing a spatial practice." Within the historical context, architecture enters this self-paradox because it is at the same time a "thing of a mind, as a dematerialized or conceptual discipline" and a practice interested in the "empirical research that consternates on the senses." See: Bernard Tschumi, "The Architectural Paradox," in *Architecture Theory since 1968*, edited by Michael K. Hays, (Cambridge, Mass: The MIT Press, 1998), 214-228.

imposes abstract homogeneity.[100] This idea was embedded in a number of revisions of the modernist movement in 1960.[101] As Lukasz Stanek writes, Lefebvre's arguments served the revisionist to question the space as a property of architecture. Thus, the modernist space has been discussed in the context of politics, democracy, economy, etc. However, in later revisions, it was acknowledged that what Lefebvre thought was the "modernist concept of space" did not account for the multiplicity of spatial ideas in early modernism – Semper's idea of enclosed space, Loos' *Raumplan*, Le Corbusier's *plan libre*, etc.[102] Lefebvre's ideas of modernist space are rather applicable to CIAM's principles of *The Functional City* that proposed solution of found social problems by strict spatial segregation of functions and providing homes in tall widely-spaced apartment blocks, and urban problems caused by rebuilding cities after WWII with the implementation of these ideas. Regardless of this, in both early modernist concepts of space and the consequent critique, there is a constant entwining of abstract concepts of space and the actual qualities of space that can be experienced. As these concepts are understood as embodied through formal aspects of architecture, heterogeneity has been sought predominantly through formal and not compositional aspects of architecture in later movements.

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[100] Henri Lefebvre, *The Production of Space* (Oxford, OX, UK ; Cambridge, Mass., USA: Blackwell, 1991), 370.
[101] Lukasz Stanek, "Architecture as Space, Again? Notes on the 'Spatial Turn'," *Spéciale'Z,* no. 4 (2012): 49-50.
[102] Lukasz Stanek, "Architecture as Space, Again?, " 49-50.

2.4. Conclusion

The early modernist concepts of space represent a multiplicity of ideas concerned with creating a new, modern architecture that can be grouped in three categories: *space as a continuum, space as an enclosure,* and *space as an extension of a body*. These three categories, however, encompass a number of design concepts that often used scientific (and philosophical) references for substantiation. Nevertheless, their relationship with science was superficial. One of the most pervasive compositional ideas of modernism was the *open plan* that breaks with the traditional room-like spaces, creating a "universal space" where compositional hierarchy is eliminated. Le Corbusier's Dom-Ino structure creates universal space between two horizontal slabs through the constant section. Continuity, openness, and elimination of hierarchy can be understood as homogenizators of the space, as they create a fluid and continuous space that does not account for differences. However, other modernist compositional ideas, such as Loos' Raumplan, did not refuse the idea of space as an enclosure. Through the publication of Giedion's *Time, Space, Architecture,* space as an important category of architecture became commonplace, and architecture was commonly understood as "art of space." Through functionalist planning and doctrine, the early modernist concepts of space that were both aesthetic and functional became predominantly functional. The functionalist ideas have been implemented to rebuild the cities after WWII. However, the poor understanding of concepts and economic building led to the homogenization of urban space through functional segregation and typical planning. At the beginning of the 1960s,

space as the primary substance of modernist architecture became a subject of extensive critique. Modernist spatial strategies were condemned because of their narrowed understanding of space as an abstraction. In the context of critique, these design ideas are often aligned with Euclidean geometry and absolute space. The critique of modernist concepts, as well as their relationship with science, encompasses ambiguity in the use of abstract scientific concepts of space (that are mental constructs) and effects in space. This problem relates to what Tschumi calls the *architectural paradox* – concepts of space and experience of space are different entities without the cause-effect relationships between them. Arguably, as a consequence of understanding the homogeneity of modernist space through the grid and Euclidean geometry, later movements predominantly sought heterogeneity through formal aspects of architecture.

3. Approaches toward Heterogeneity

3.1. The Heterogeneity of Space as Scientific and Philosophical Problem

Starting with postmodernism in the 1960s, several architectural movements attempted to overcome the problems inherited in modernist architecture and urban design. Both design-oriented and theoretical approaches attempted to resolve the problem of homogeneity through the creation of complex formal systems or by bringing forward the complexity of human perception and inhabitation of space. One of the issues embedded in these approaches is borrowing the concepts from other disciplines concerned with space, most often science and philosophy. For this reason, this chapter will introduce some of the scientific and philosophical ideas regarding spatial homogeneity/heterogeneity and discuss how they are used in architecture.

The question of spatial heterogeneity as a philosophical and scientific problem persisted throughout the history of science in the tension between two contrasting theories of space – space as a place, and space as

a continuum/container.[103] The former concept presumes space as the positional quality of the objects and cannot be conceived without material objects. In the latter concept, material objects exist inside space, which is independent and, therefore, superior to the material world.[104] During the sixteenth century, with discoveries made by Copernicus and Galileo, the theory of place and the finite universe that denied the possibility of "empty space" began to collapse.[105] When Newton formulated the concept of *absolute space* in *Principia* in the late seventeenth century, the second definition, which presumes space as infinite and homogeneous, became the central concept of space in science.[106] This kind of space cannot be perceived by human senses, yet it was a necessary assumption for physics to prove the laws of inertia. Newton himself understood the problem of this assumption. He opposed the *absolute* to *relative space,* which is a small portion of *absolute space* perceivable by senses. Leibniz and Huygens rejected the idea of *absolute space* and supported only the concept of *relative space*. Leibniz thought of space as a set of relationships between things, however, he did not have strong scientific arguments for his theory. Thus, Newton's *absolute space* persisted as the main concept in science till it was downplayed by the discoveries of non-Euclidean geometries and Faraday's and Maxwell's contribution to the development of the concept of the field. These discoveries rendered the concept of independent, *absolute*

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[103] Albert Einstein, "Foreword," in *Concepts of Space: The History of Theories of Space in Physics*, Max Jammer (New York: Dover Publications, 1993), XV.
[104] Albert Einstein, "Foreword," XV.
[105] Ven, *Space in Architecture,* 29-30.
[106] Ven, *Space in Architecture,* 30.

space unnecessary to prove the laws of inertia.[107] Leibniz's ideas were rehabilitated only after Einstein formalized his theory of relativity and the special theory of relativity, and the third concept of space – the space-time continuum– was introduced.

Following these discoveries, the ideas of physical space also changed. Having no alternatives, Newton assumed that physical space was Euclidean.[108] However, with the discoveries of non-Euclidean geometries in the nineteenth century, modern physics came to the alternative to formulate the concept of space upon Riemann's idea of the n-dimensional manifold.[109] From here follows the duality of homogeneous space aligned with Newton's infinite, isotropic *absolute space*, and Cartesian geometry on one hand, and heterogeneous space aligned with non-Euclidean geometries on the other hand. The former being metric and measurable, while in the latter, the notion of distance is irrelevant.

The philosophical counterpart of this opposition, equally involved in architectural theories, is Deleuze's and Guattari's concept of *smooth and striated* space formulated in *A Thousand Plateaus: Capitalism and Schizophrenia.* The mathematical model of this dichotomy rests upon the difference between the striated and measurable Euclidean space and the smooth Riemannian manifold (as they describe it as a patchwork of "multi-mapped and multi-connected" spaces, which locally appear as Euclidean, measurable, spaces, but overall cannot be measured or striated).[110]

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[107] Einstein, "Foreword," XV.
[108] Max Jammer, *Concepts of Space: The History of Theories of Space in Physics* (New York: Dover Publications, 1993), 145.
[109] Jammer, *Concepts of Space,* 145.
[110] Gilles Deleuze and Félix Guattari, *A Thousand Plateaus: Capitalism and Schizophrenia* (Minneapolis: University of Minnesota Press, 1987), 485.

However, this opposition can be placed across a number of phenomena. *Striated space* is not only metric, homogeneous, space of visual qualities and arborescent structure, but it is also space of state apparatus, social hierarchy, and order; smooth space is non-metric, heterogeneous, of qualitative features, rhizomatic structure, haptic rather than visual, space of "war machine" and chaos. The notion of *striated* implies logic and reason but also constraints. *Smooth space*, which is characterized by variability and impermanence, is preferred over striation and causality. Yet, in nature, these two phenomena always exist in mixtures and change from one to another. The smooth becomes striated by applying measure, border, order, or hierarchy over it, and when space is completely satiated in all directions becomes homogeneous.[111] According to Deleuze and Guattari, "homogeneity is the limit-form of a space striated everywhere and in all directions."[112]

The qualities of space that modern science assumes are not available to human perception as they result from the constant process of abstraction ever since the beginning of primitive thought.[113] However, in *Space in Architecture*, Cornelis Van de Ven notices how the three main ideas about the nature of space in architecture are parallel to those in natural sciences. Namely, the three understandings of space in physics that Albert Einstein described in the 1953 essay[114] correspond to the main interpretations of physical space in architecture. These are (1) space as a place, (2) three-dimensional absolute space, and (3) four-dimensional

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[111] Deleuze and Guattari, *A Thousand Plateaus,* 474-500.
[112] Deleuze and Guattari, *A Thousand Plateaus,* 488.
[113] Jammer, *Concepts of Space,* 7.
[114] Einstein, "Foreword."

relative space.[115] Nevertheless, Van de Ven notices these are not posterior ideas borrowed from science; they appeared in architecture independently and were rather aesthetic ideas and often contradictory to scientific ones in their interpretations of space.[116]

Conversely, in the context of the critique of modernist space, scientific ideas of space are often equated with architectural space. Parallels with mathematical concepts of Euclidean and non-Euclidean spaces, homogeneous and heterogeneous, are primarily drawn through the geometry of architectural form. Yet, these mathematical conceptions of space are equally abstract, devoid of qualities, and unavailable to human perception. At the same time, the duality of *smooth and satiated* appears to be more tangible in the context of architecture, as they are not related only to space/form but operate in the broader context as two different logics of the world. Thus, in the context of architecture, they can be related to a number of other subject matters. *Striation* is implied through the spatial hierarchy, creating borders, applying a measure over space. The concept of *smooth* is used as theoretical support of generative design, where the form is found by the definition of the relationship between the entities and the variation of parameters, which define these relationships, and not by the definitive measure. Thus, this duality used in architecture is more concrete than scientific concepts regarding physical space unavailable to human perception. The *striated* and *smooth* are also related to the political dimension of the architecture, where the striated space is understood as a space of control, and social hierarchy, while smooth space is a space of

[115] Ven, *Space in Architecture,* 242.
[116] Ven, *Space in Architecture,* 242-3.

liberty and free-acting agents. In actual building space, these abstract concepts are embodied through spatial configurations. In *Digital Hadid: Landscape in Motion,* Patrik Schumacher explains that under complex curvatures of ZHA's buildings "the inhabitant of such spaces no longer orients by the means of prominent figures, axis, edges, and clearly bounded realms. Instead, the distribution of densities, directional bias, scalar grains, and gradient vectors of transformation constitute the new ontology defining what it means to be somewhere."[117] Here, the opposition between axis and edges on one hand and scalar grains and gradient vectors infer the opposition between the striated and smooth, controlled and spontaneous.

3.2. Homogeneity of Geometrical Space, Heterogeneity of Perceptual Space

Homogeneity of space as a philosophical question was initially raised by Ernst Cassirer[118] and entered architectural (and art) discourse by Erwin Panofsky in *Perspective as Symbolic Form.*[119] The definition that Panofsky adopted from Cassirer had two conditions of homogeneity. The first is that in homogenous space all the points in space are mere positions devoid of any content except the relationships between them. The second condition

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[117] Patrik Schumacher, *Digital Hadid: Landscapes in Motion* (Birkhäuser, Basel, 2003), 19.

[118] Ernst Cassirer, *The Philosophy of Symbolic Forms. Volume Two: Mythical Thought* (New Haven: Yale Universty Press; London: Geoffrey Cumberlege, Oxford University Press, 1955), 83-4.

[119] BrankoMitrović, "Leon Battista Alberti and the Homogeneity of Space," *Journal of the Society of Architectural Historians* 63, no. 4 (2004): 424.

dictates that it is possible to draw identical figures from each point of space. Cassirer argued that these postulates of homogeneity could be fulfilled only in geometrical space, a mathematical construct, and do not exist a priori. As the points of geometrical space of Euclidean geometry have no content other than their position, the possibility of diversity and heterogeneity must be excluded. On the contrary, in immediate human perception, infinity cannot exist. Both visual and tactile spaces are anisotropic and inhomogeneous.[120] Panofsky argued that the construction of perspective abstracted and transformed the psychophysiological space of human perception into an infinite and homogeneous mathematical construct.[121] The argument Panofsky used in the book was aimed toward disclosing when in history the understanding of space as homogeneous came about, as, according to him, it had important consequences on the development of Renaissance architecture. [122]

With similar motivation, Branko Mitrović used Cassirer's definition to prove that the understanding of space as a homogenous entity existed prior to Renaissance and that such comprehension enabled the development of perspective, which Alberti described for the first time in his treatise *De Pictura.* Mitrović's argument was grounded on thinking that Renaissance architects would not be able to reproduce elements of Roman architecture, nor would they produce working drawings in the way they did, if they believed that space was not homogenous. If space were not homogenous, then the same objects would have the same dimensions seen from different

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[120] Cassirer, *The Philosophy of Symbolic Forms,* 84.
[121] Panofsky, Erwin, *Perspective as Symbolic Form* (New York, NY: Zone Books, 1991), 30-31.
[122]Mitrović, "Leon Battista Alberti and the Homogeneity of Space,"424.

sides, and therefore, drawing plans and sections, in the way Palladio and Vignola did, would not be possible.[123] Examining closely Alberti's writing, Mitrović had found that the notion of *spatium* presumed by Alberti in *De Re Aedificatoria* represented space that could be rendered independently from bodies in it. Furthermore, all spatial relationships within the *spatium* can be measured and geometrically defined.[124] This definition of space conformed to Cassirer's postulates of homogenous space. Thus, Mitrović proved that understanding space as homogeneous existed before the Renaissance and, therefore, before Newton formulated *absolute space* in *Principia*.

The arguments of the authors mentioned above were directed toward examining the history of the perspective and how the understanding of space as a homogeneous influenced the representation of architecture. In view of this, the discourse on the homogeneity of space that they introduce is relevant from a historical point of view. However, these accounts also infer that homogeneous Euclidean space is a mathematical construct, or a "thing of a mind" that cannot be experienced, while the "lived space" – a space of human experience – is always heterogeneous. Thus, the relationship between geometrical, homogeneous, and perceptual heterogeneous space equates to Tschumi's idea of the duality of concepts and experience of space that he puts forward in "The Architectural Paradox."[125] Tschumi referrers to artistic concepts of space as a "thing of a mind" that gives value to architecture as an intellectual discipline. These

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[123]Mitrović, "Leon Battista Alberti and the Homogeneity of Space," 425.
[124]Mitrović, "Leon Battista Alberti and the Homogeneity of Space," 435.
[125] Bernard Tschumi, "The Architectural Paradox," in *Architecture Theory since 1968*, ed. Michael K. Hays (Cambridge, Mass: The MIT Press, 1998).

intellectual constructs do not share the cause-effect relationship with the experience of space. Thus, there is a difference between understanding (or thinking of space) as homogeneous and experiencing homogenous space (as a lack of diversity in lived space). Therefore, the homogeneity of modernist architecture cannot be directly linked to Euclidean space or understood in the same manner. It can instead be interpreted as a space of low diversity in the built surrounding.

3.3. From Abstract to Lived Space

In the postmodern critique, centralizing space in the modernist architectural agenda was claimed to be "realistically naïve"[126] in the sense of neglecting the very complexity of the lived space.[127] In 1960, the phenomenological project in architecture attempted to approach this problem by bringing forward the complexity of space and human perception and inhabitation through renovation or development of the concept of place. Thus, architectural theory commenced importing ideas of Heidegger, Bachelard, etc. It was pointed out that the space in which we live is not an empty void

[126] For example Christian Norberg-Schulz refers to Giedion's conceptions of space in *Space, Time Architecture*, as well as Bruno Zevi's account of space in *Architecture as Space* as "realistically naïve." Norberg-Schulz, *Existance, Space & Architecture*, 12.

[127] The idea of the "lived space" was for the first time brought forward by Lefebvre. It denotes the space of human experience and subjectivity, as opposed to abstract space deprived of all qualities: "The user's space is lived - not represented (or conceived). When compared with the abstract space of the experts (architects, urbanists, planners), the space of the everyday activities of users is a concrete one, which is to say, subjective." Lefebvre, *Production of Space*, 362.

but saturated with different qualities. Thus, it cannot be addressed as an abstract scientific concept.

These ideas contributed to replacing the term space with the idea of *place* that implies subjectivity. Thus, Aldo Van Eyck wrote: "In order to be included – to help our homecoming – we must be gathered into their meaning (we are the subject as well as the object of architecture). Whatever space and time mean, place and occasion mean more. For space in our image is place, and time in our image is occasion."[128] Cristian Norberg Schulz further developed these ideas in his books *Existence, Space and Architecture* (1971), *Genius Loci* (1980), and *The Concept of Dwelling* (1985) that together constitute the trilogy of the phenomenological project in architecture.[129] In these books, he developed a theory of space as a part of human existence ("being in the world") through interpretations of Heidegger's ideas. These theories, backed with phenomenological ideas, brought forward the importance of subjectivity space (on a perceptive and emotional level) in the context of architectural space. However, bringing the qualities of the human experience of space (that phenomenology focuses on) into the context of a critique of modernist space constitutes the same illogicality that Tschumi disclosed in *The Architectural Paradox*. Namely, neglecting the qualitative properties of space in the quantitative mathematical concepts on the one hand and the quality-rich human experience of space on the other seem to be different entities with a vague

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[128] Aldo van Eyck, "There is a Garden in her Face," in in *Aldo van Eyck: Writings vol. 2,* eds. Vincent Ligtelijn and Francis Strauven (Amsterdam: SUN, 2008), 293.

[129] Elie Haddad, "Christian Norberg-Schulz's Phenomenological Project in architecture," *Architectural Theory Review* 15, no.1 (2010): 90.

relationship. Thus, the phenomenological approach toward heterogeneity represents a shift of focus from a concept of space to the experience. To approach the heterogeneity of space as a problem in architecture then raises questions of how understanding space as an abstracted matter would influence the reduction of qualities in the design of a lived surrounding, and, at the same time, how acknowledging the complexity of the lived space would contribute to the design of space with diverse qualities.

3.4. Formal Approaches toward Heterogeneity

In architectural design, the search for heterogeneity that followed the modernist period was not primarily focused on space. The postmodern turn was characterized by a formalist approach. As the "homogeneity" modernist built surrounding was (in the context of critique) aligned with Euclidean geometry and design based on the grid, dominant approaches toward heterogeneity sought to reverse the effects by breaking the "order" and employing complex geometries that contrast austere modernist aesthetic. In *The Language of Postmodern Architecture,* Charles Jencks points out that postmodern space was intentionally ambiguous and unambitious compared to modernist space.[130] At the same time, architecture inclined toward flatness and amplification of the image.[131]

In *Complexity and Contradiction in Architecture* (1966), Robert Venturi wrote about the problem of openness and fluidity of Modernist

[130] Jencks, *The Language of Postmodern Architecture,* 96; Forty, *Words and Buildings*, 268-69.
[131] Forty, *Words and Buildings*, 269.

compositions. He noted that the purpose of the architecture is “to enclose rather than direct space, and to separate the inside from the outside.”[132] Venturi considered continuity between inside and outside to be the “boldest contribution” of Modernist architecture. Therefore, the complexity Venturi advocated was not meant to contrast only the purity of the modernist aesthetic but also to bring forward the importance of composition, layering, and nesting spaces in the plan.[133] One of the first projects of postmodernist architecture where Robert Venturi applied his ideas from the book is Vanna Venturi House in Philadelphia (1964). In this project, Venturi rejected simplicity and emphasized complexity as a reaction against modernism. The complexity employed in this project was not only formal. The organization of interior spaces in plan and section is “complex and distorted in their shapes and interrelationships.”[134]

Venturi’s ideas had a great impact on the development of architecture. However, dominant approaches toward complexity (and heterogeneity), which followed the *Complexity and Contradiction in Architecture*, had fallen into the citation of the combination of historical references and creating complex forms that oppose modernism’s aesthetic simplicity.

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[132] Robert Venturi, *Complexity and Contradiction in Architecture*. 2d ed. (The Museum of Modern Art Papers on Architecture. New York : Boston: Museum of Modern Art ; distributed by New York Graphic Society, 1977), 70.
[133] Venturi, *Complexity and Contradiction,* 71.
[134] Venturi, *Complexity and Contradiction,* 118.

Figure 5. *Robert Venturi, Vanna Venturi House, Philadelphia, 1964.*
Source: *https://www.dezeen.com/2015/08/12/postmodernism-architecture-vanna-venturi-house-philadelphia-robert-venturi-denise-scott-brown/*

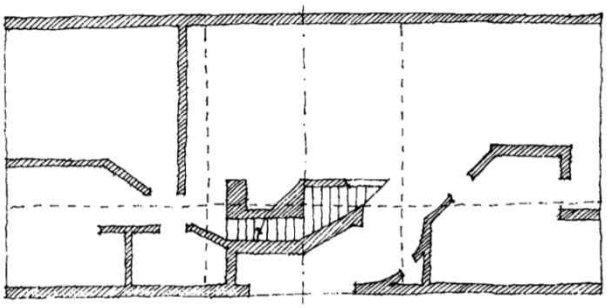

Figure 6. *Simon Unwin, Plan sketch of Vanna Venturi House.*
Source: *Simon Unwin, Analysing Architecture (New York: Routledge, 2014), 287.*

This trend was followed by the attempts of Deconstruction architects in the 1980s to create heterogeneity by applying strategies of opposition, juxtaposition, fragmentation, and discontinuity.[135] The distorted surfaces, fragmented forms, and asymmetry that these architectures embraced contrasted postmodern historicism and radically stepped away from

[135] Di Cristina, "The Topological Tendency in Architecture," 7.

modernist orthogonal aesthetic and order based on the grid. This kind of design approach was meant to produce heterogeneous and fragmented forms to express the conflicting logic of the surrounding.[136] In the case of Peter Eisenman's Wexner Art Center in Columbus (one of the most notable Deconstruction projects), this happens through the collision of the two geometers present in the site: the internal grid of the campus and the external grid of the city.[137]

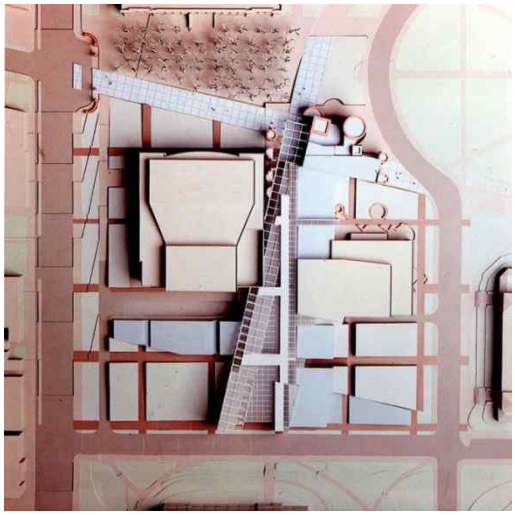

Figure 7. *Eisenman Architects, Wexner Center for the Visual Arts and Fine Arts Library, Columbus, Ohio – model, 1989.*

Source: *Eisenman Architects, https://eisenmanarchitects.com/Wexner-Center-for-the-Visual-Arts-and-Fine-Arts-Library-1989.*

[136] Picon, *Digital Culture in Architecture,* 63.

[137] Eisenman Architects, "WEXNER CENTER FOR THE VISUAL ARTS AND FINE ARTS LIBRARY," *EISENMAN ARCHITECTS*, accessed May 18, 2021. https://eisenmanarchitects.com/Wexner-Center-for-the-Visual-Arts-and-Fine-Arts-Library-1989.

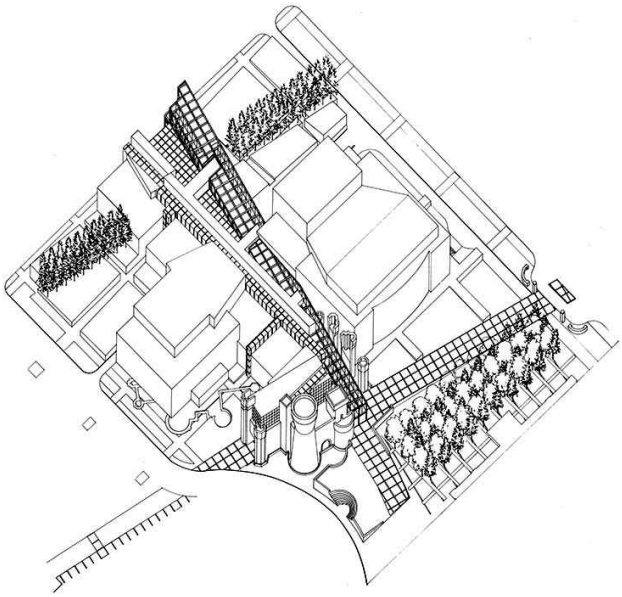

Figure 8. *Eisenman Architects, Wexner Center for the Visual Arts and Fine Arts Library, Columbus, Ohio – drawing, 1989.*
Source: *Eisenman Architects, https://eisenmanarchitects.com/Wexner-Center-for-the-Visual-Arts-and-Fine-Arts-Library-1989.*

3.5. Topological Tendency in Architecture

Although still focused on the form as a means of heterogeneity, the most radical change was introduced in the 1990s with the rise of digital architecture, through the fashion of complex curvatures termed "topological tendency in architecture."[138] This is an umbrella term that Giuseppa di Christina uses in the publication *Architecture and Science* to refer to several design ideas that appeared during the 1990s, empowered by the advancements and digital tools for design and fabrication. The term "topology" was adopted from mathematics in the sense of non-linear

[138] Di Cristina, "The Topological Tendency in Architecture," 7.

complex curvature.[139] These architectures used dynamic properties of topology as both conceptual resource (opposing Euclidian geometry) and design process methodology[140] (bending, twisting, and distorting the surface). Their formal innovation in the shape of fluid and adaptable forms was a reaction against Deconstruction architecture's strategies of fragmentation and confrontation, as well as the postmodern strategy of *collage*.[141]

These pliant architectures drew inspiration and theoretical substantiation from several scientific and philosophical references. The most prominent of these was René Thom's *catastrophe theory* and Deleuze's concept of *fold.*[142] Deleuze's ideas that "the multiple is not only what has many parts, but what is folded in many ways"[143] and that the word "complexity" etymologically embodies the word *pli (*plexus, fold), and thus "complex," implies something that is folded in many ways were the key concepts. They served the architects to recognize in these pliant forms the complexity and multiplicity they had been seeking.

However, these forms were not intended to exemplify a theory or philosophy.[144] Topology, interpreted as a continuous deformation of the form, allowed architects to create new architectural effects by escaping flat geometry and orthogonality – characteristics of modernist architecture. The

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[139] Di Cristina, "The Topological Tendency in Architecture," 7.
[140] Di Cristina, "The Topological Tendency in Architecture," 7.
[141] Pstmodern collage refers here to the urban design strategy of bricolage that Colin Row and *Fred Koetter* developed in *Collage City*, but also tendency of postmodern architects to cite and use historical references in a form design.
[142] Di Cristina, "The Topological Tendency in Architecture," 8.
[143] John Rajchman, *"Out* of the *Fold,"* in *AD: Architecture and Science*, ed. Giuseppa Di Cristina (Chichester: Wiley-Academy, 2001), 35.
[144] Kipnis, "Towards a New Architecture," 60.

manipulation and deformation of continuous forms provide the possibility to adjust to programmatic and structural needs.[145]The structure smoothes the differences, creating fluid, continuous but differentiated spaces. Thus, instead of making a difference by contradicting and conflicting forms or collage, heterogeneity is achieved under a pliant, flexible structure in a coherent and cohesive manner. As a continuous whole with a complex program, such a building would blend into the urban context. In this manner, it would avoid homogenization present in Modernist treatment of urban space as a *tabula rasa*, as well as the fragmentation and discontinuity of the postmodern collage.[146] Therefore, the idea behind this approach aimed not only to contrast modernism but also to overcome formal strategies of postmodernism and Deconstruction.[147] An example of such urban intervention is Greg Lynn's project for Sears Tower in Chicago (1992) that attempts to create harmony and unite the tower and the city through diversity.[148] Lynn's ideas oppose the production of "heterogeneous, fragmented and conflicting formal systems" that came with postmodern and Deconstruction's agendas.

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[145] Kipnis, "Towards a New Architecture," 60.

[146] The idea of creating an urban collage is proposed by Colin Rowe and Fred Koetter in Collage City where authors argue that the aesthetically most successful cities are not the result of total planning but rather superimposing and collaging pieces. See: Colin Rowe and Fred Koetter, *Collage City* (Cambridge, Mass.: MIT Pr, 1983).

[147] Greg Lynn, "Architectural Curvilinearity: The Folded, The Pliant and The Supple," in *AD: Architecture and Science*, ed. Giuseppa Di Cristina (Chichester: Wiley-Academy, 2001), 31.

[148] Kenneth Powel, "Unfolding Folding," in *AD: Architecture and Science*, ed. Giuseppa Di Cristina (Chichester: Wiley-Academy, 2001), 15.

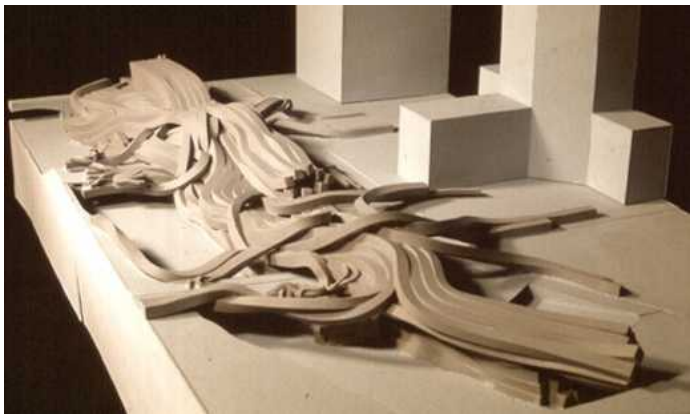

Figure 9. *Greg Lynn, Sears Tower, Chicago– model, 1992.*
Source: *Greg Lynn Form, http://glform.com/buildings/stranded-sears-tower/*

The shift from homogeneous Euclidean space to heterogeneous topological space that these architectures suggested was not only conceptual. The main tool toward the heterogeneity of "topological" architecture is the complex form, yet, propagators of this approach acquired a renewed interest in space and implied that these interventions are primarily spatial. For example, Di Cristina writes that assuming that space is the most important content of architecture, architects have an interest in the "idea of topological space in the sense of a dynamic, heterogeneous and differentiated, as an alternative to the traditional concept of the metric, quantitative, infinite and homogeneous space of Euclidian and Cartesian geometries."[149] Thus, she implies that the space defined by these curved architectures is heterogeneous and diverse in contrast to homogenous spaces of box-like modernist buildings. Elaborating on the possibilities of folded architecture, Greg Lynn puts forward a similar argument: "Folding became a method by which a surface of a large homogeneous volume could

[149] Di Cristina, "The Topological Tendency in Architecture," 7.

be differenced while remaining continuous."[150] Stephen Perella gives a somewhat more complex account regarding the nature of "topological" space: "Architectural topology is the mutation of form, structure, context, and programme into interwoven patterns and complex dynamics…" A curvilinear and pliant form implies dynamic processes and events embedded in the logic of folding.[151] Thus, "topological space" is not an empty container like Cartesian space: it is a dense "filled space" that "imbricates temporal events within a form."[152] Bringing forward event, evolution, and processes, dynamic variation of the form implies movement and, therefore, the dimension of time. Furthermore, the presence of forces that deform the form implies the "energetic density of space."[153] These remarks suggest that the space captured under folded forms is different from quantitative and homogeneous Euclidean (or Cartesian) space. This argument strongly implies the alignment of abstract concepts with spatial effects. Regardless of this, the accounts mentioned above demonstrate that creating heterogeneous space through complex forms was an important issue they attempted to approach. Similar to Deconstruction projects that aimed to express the confliction realities of the surrounding through architectural forms, topological architecture, apart from creating complex formal systems, strived to incorporate complex social and cultural contexts within these systems. Therefore, not only that different programs are blended into a differentiated

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[150] Lynn, "Architectural Curvilinearity," 31.
[151] Stephen Perrella, "Hypersurface Theory: Architecture><Culture," in *AD: Architecture and Science*, ed. GiuseppaDi Cristina (Chichester: Wiley-Academy, 2001), 143.
[152] Perrella, "Hypersurface Theory," 143.
[153] Di Cristina, "The Topological Tendency in Architecture," 9.

continuous whole on the level of architecture, but they also acknowledge the complexity of the surroundings.

However, some authors imply that solely manipulating the envelope is not sufficient to create heterogeneity in space and that some compositional aspects must be addressed too. For instance, Jeff Kipnis in his seminal essay *Toward New Architecture* (1993), identified two (at the time) raising approaches as a possible alternative to homogeneous spatial strategies of modernism, and termed them *InFormation* and *DeFormation. InFormation*approached the problem of heterogeneity by focusing on programs and events, at the same time deemphasizing the importance of form. Therefore, it embraced the simplicity and orthogonal geometry of the modernist forms as a scene for complex programs and events. On the other hand*, DeFormation* was focused on the formal complexity and as means of heterogeneity. *DeFormationist* architects kept the modernist idea of a monolith form but eschewed its geometry of regular solids and Cartesian geometry and moved toward complex geometries.[154] Kipnis' argument implied that the value of such complex monolith forms is in the possibility of creating new, politically relevant architecture without historical references. For this new architecture to attain heterogeneity, composition (specifically sectional composition) is essential. This was suggested in one of the five points he proposed for the new architecture, *vastness*, which in his interpretation "negotiates a middle ground between the homogeneity of infinite or universal space and the fixed hierarchies of closely articulated space."[155] Realizing this kind of composition suggests extending the *free*

[154] Kipnis, "Towards a New Architecture," 59.
[155] Kipnis, "Towards a New Architecture," 59.

plan toward the “free section” by detaching internal organization from the envelope and emphasizing residual over primary spaces. This, Kipnis suggests, could be effectively achieved by “box-within-box” sections where main spaces are designed as floating cubes inside the larger inner space defined by the monolith.[156] An example of such space is Bahram Shirdel’s and Robert Livesey’s 1992 competition project for Nara Convention Hall. The complex monolith structure encompasses three floating theatres within. This kind of composition renders the entrance lobby (the main space) residual.

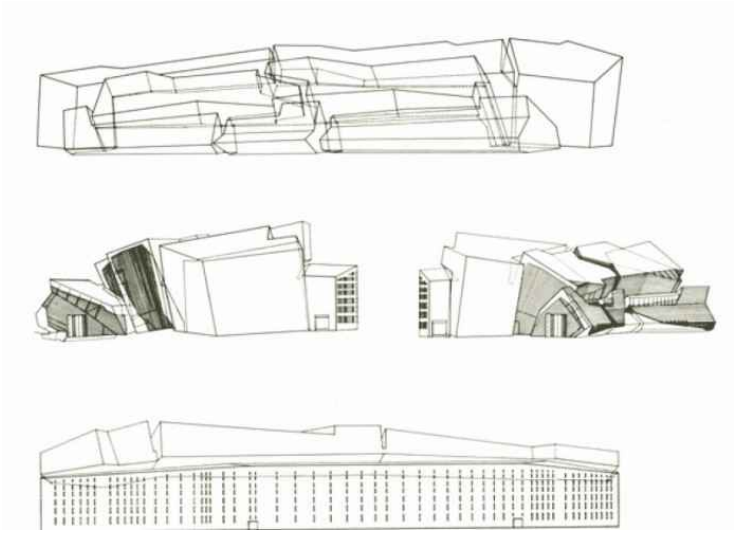

Figure 10. *Bahram Shirdeland and Robert Livesey, Nara Convention Hall - competition project drawings, 1992.*
Source: *Contemporary Architecture of Iran, caoi.ir/en/projects/item/330-nara-convention-hall.html*

[156] Kipnis, “Towards a New Architecture,” 62.

Figure 11. *Bahram Shirdeland and Robert Livesey, Nara Convention Hall - competition project model, 1992.*
Source: *Contemporary Architecture of Iran, caoi.ir/en/projects/item/330-nara-convention-hall.html*

While this kind of sectional composition evidently breaks with traditional hierarchies and modernist "sandwich-like" space, Kipnis does not specify how such a composition attains heterogeneity in terms of quality of space (or in relation to human experience). His account of heterogeneity infers that breaking the continuity and sectional hierarchy creates the differences in space. From the phenomenological point of view, it neglects the same aspects of the spatial reality overlooked in the modernist "realistically naïve" approach to space. In other words, space is treated abstractly, but this time without the underlying grid. It is plausible to say that spaces under such complex structures might have a different character than what Charles Jencks calls a "warehouse space" of box-like modernist halls.[157] However, Kipnis' argument implies that without some compositional

[157] Jencks, *The Language of Post-Modern Architecture*, 96.

properties in section design, these buildings conceived as complex geometries might result in what Eisenman refers to as a "heterogeneous surface with the homogeneous interior." [158] This argument becomes understandable comparing, for example, Glasgow Riverside Museum by Zaha Hadid Architects and the US Post Office building in Chicago by Mies van der Rohe. Despite drastically different geometry of the form, both buildings encompass a simple, vastly open interior.

Figure 12. *Zaha Hadid Architects, Riverside Museum, Glasgow, 2011.*
Source: *https://www.glasgowlife.org.uk/museums/venues/riverside-museum*

Figure 13. *Mies van der Rohe, US Post Office, Chicago, 1960-1974.*
Source: *Michael Dant, https://www.flickr.com/*photos/faasdant/3453070855/in/set-72157617710927185.

Nevertheless, the ideas mentioned above suggest that "topological architectures" were not only a continuation of a series of formal approaches in architecture. Topological architectures had a renewed interest in space that has been neglected in architectural production ever since postmodernism. The search for the heterogeneity in space design involves the questions of the political role and autonomy of architecture. The

[158] Peter Eisenman, "The Problematic of Homogeneous Space," (conversation with Mark Wigley at Columbia GSAPP, August 8, 2013), 25:30. https://www.youtube.com/watch?v=0_b5COTxHuc&t=1185s.

background of this interest goes back to Lefebvre's critique of abstract space and spatial conceptions of modernist architects and later narrative of postmodern geographies where space is understood as a mode of control in society. Lefebvre's book brought forward the problems of multiplicity and diversity of space, however, it did not provide architects with knowledge on how to include these in design concepts.[159] Therefore, from the political standpoint, concerns for heterogeneity in architecture revolve around encompassing the differences [in society] and ensuring freedom from institutionalized control. The debate on how to acknowledge the multiplicity of spaces in the design and whether architecture is in service to society or it can assume an active political role by giving spatial solutions for diversity and multiplicity remains. Several theoretical and design ideas that sought heterogeneity were inspired by these questions. An example of this kind of thinking is Stan Allen's theory of the field where "field could be any formal or spatial matrix capable of unifying diverse elements while respecting the identity of each."[160] The political ideas of multiplicity and diversity are not clearly stated but are inferred in Allan's argument.[161] TERRIOR's concept of *Third Space* extends the political objective of the field. It attempts to create a space outside of the program and, in that manner, gives freedom to the users.[162]

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[159] Hensel, Menges, and Hight, "En route," 23.
[160] Stan Allen, "From Object to Field," in *Space Reader: Heterogeneous Space in Architecture*, ed. Michael Hensel, Achim Menges and Christopher Hight (Chichester, U.K: Wiley, 2009), 120.
[161] John Hong, "Third Space and the Chrisis of the Façade," in Andrew Benjamin, John Hong, Gerard Reinmuth and TERROIR (Firm), *Terroir: Third Spaces* (Melbourne, Australia: Uro Publications, 2019), 11.
[162] John Hong, "Third Space and the Chrisis of the Façade," 11.

The questions of heterogeneity and political relevance have in recent decades been related to the spatial organization within buildings. In recent projects for public buildings, all social space tends to be organized in such an organizational model that allows for flexibility, mobility, and connectivity.[163] This space is "networked," landscaped, borderless and reprogrammable" so that it facilitates the creative industries to mobilize subjects.[164] Just like folded forms have found a conceptual resource in Deleuze's philosophy of *fold*, this kind of spatial organization uses Deleuze's and Guattari's concept of *striated and smooth spaces*. Architects interpreted the *smooth space* as a topological, fluid space in constant variation. It is a heterogeneous setting where a human as an urban nomad moves freely while transforming space itself as modes of use are not predetermined. This kind of spatial organization is opposed to *striated space* – a space of rigid geometry, where movements happen in predetermined lines of the Cartesian grid.[165] Therefore, *striated space* is a space of state control and social hierarchy. Smooth space is preferred over the striated because the constant variations and fluidity are a suitable spatial organization to house the multiplicity of social practices.

These alternative spatial organizations are not only conceptual; they also question the possibilities that such spatial organization has in architectural autonomy and the role of architecture in the society of control. This kind of informal spatial organization along with complex forms is characteristic, among others, for the architecture of Zaha Hadid. In her speech for the Pritzker Prize, Hadid explained that classical architecture

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[163] Spencer, "Architectural Deleuzism," 9.
[164] Spencer, "Architectural Deleuzism," 9.
[165] Spencer, "Architectural Deleuzism," 10.

with platonic forms does provide formal possibilities for articulating the"complexities and dynamism of contemporary life." Thus, her work expands the repertoire that architects and urbanists can use to express the dynamism of society.[166] By this, she took a position that architecture is there to follow developments in the society, not to initiate them. Hadid's partner Patrik Schumacher goes further and states that this kind of spatial organization goes hand in hand with the neoliberal economy and post-Fordist society based on networking. According to him "parametricism aims to deliver the dense, complex, variegated, dynamic, information-rich and legible urban order post-Fordist network society needs to thrive."[167]It is a space where spontaneous interactions between actors happen. However, Luc Boltanski and Eve Chiapellofind that the striving for networked and de-hierarchized organizational strategies is not rooted in the forms of production processes but in a critique of capitalism. Yet, this kind of spatial organization of openness and interaction (ideas originating from May 68) that was originally aimed against capitalism became employed by it.[168]Furthermore, such spatial organization is comparable to Deleuze's Ideas from *Postscript on the Societies of Control*.[169]

These accounts questioning the relationships between the spatial organization and social structure modes of economic production, see heterogeneity in architecture as a social and political problem. Thus,

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[166] Spencer, "Architectural Deleuzism," 12.
[167] Patrik Schumacher, "The Stages of Capitalism and the Styles of Architecture," *Patrik Schumacher.com.* 2016, accessed April 15, 2021. https://www.patrikschumacher.com/Texts/The%20Stages%20of%20Capitalism%20and%20the%20Styles%20of%20Architecture.html.
[168] Luc Boltanski and ÈveChiapello, *The New Spirit of Capitalism* (London: Verso, 2007), 97.
[169] Spencer, "Architectural Deleuzism," 12.

heterogeneity does not refer to the diversity of spatial qualities but the variety of users and activities.

3.6. Conclusion

Several architectural movements, starting with postmodernism, attempted to establish architecture as heterogeneous and autonomous, contrary to the homogeneous building tradition affiliated with the Modern Movement.[170] In revisions of the Modern Movement, the spatial homogeneity is said to be the consequence of a naïve approach to "lived space" as an abstract matter. Through abstraction, lived reality saturated with spatial qualities is neglected and reduced to scientific and philosophical concepts of space.[171] Consequently, the discourse on space in architectural theory attempted to approach the problem by importing philosophical ideas (of Heidegger, Bachelard, etc.) and bringing forward the complexity surrounding the phenomenon of space, human perception of it, and its inhabitation. It was pointed out how the space, in which we live, is not an empty void but saturated with different qualities. These theories give a valuable insight into the human experience of space. However, the space of human perception is

[170] Robert Somol, "Dummy Text," 9.

[171] *Abstract space*—homogeneous, geometrically defined, measurable void, and barren of all qualities—was Lefebvre's critique incorporated in revisions of the Modern Movement in 1960. Such understanding of space, as Lefebvre claimed, "asphyxiates whatever is conceived within it" and imposes "an abstract homogeneity." See: Lefebvre, *The Production of Space*; Stanek, "Architecture as Space, Again?"

inherently complex and heterogeneous and, thus, this knowledge does not impart nor articulate design concepts.

In the context of critique, “homogeneity” as a lack of diversity in the lived space is often equalized and used interchangeably with the homogeneity of abstract scientific constructs—Newton’s “absolute space” and Euclidian and Cartesian Geometries—that indeed presume space as infinite and homogeneous, but are not available to human perception. As these different entities are ostensibly aligned, the abstract Euclidean and Cartesian spaces are, in the context of critique, often understood as embodied through the geometry of form and the subordination of design to an abstract order based on a grid.

Consequently, the dominant design approaches toward heterogeneity sought to reverse the effects of modernist spatial concepts through formal innovations - breaking the “order” and employing complex geometries that contrast the austere modernist aesthetic. Postmodern architecture, following Venturi’s *Complexity and Contradiction in Architecture*, predominantly fell into recombination and citation of historical references. This was followed by attempts of Deconstruction architects to create heterogeneity by opposition and juxtaposition, fragmentation, and discontinuity, breaking the orthogonality and more radically stepping away from the order based on the grid. These form-focused approaches were further followed by a trend of complex curvatures and folded architectures with the rise of digital architecture in the 1990s. These architectures used dynamic features of topological geometry and the idea of continuous transformation as an inspiration for the creation of innovative forms but also as a conceptual resource that denotes spatial heterogeneity. Thus,

employing complex geometries in buildings' form suggests a conceptual shift from Euclidian geometry to topology, i.e., from homogeneous to heterogeneous space. Such parallels with mathematical concepts fall into the realm of architecture "as a dematerialized or conceptual discipline" and respond to the problem of heterogeneity as a "thing of a mind,"[172] a design concept. These concepts are most often embodied through formal aspects of architecture. However, it is implied in many of these approaches that they seek for heterogeneity in the spatial organization, which is now facilitated through curved surfaces of the form. This search for heterogeneity through the spatial organization is closely bound with the questions of the political dimension of architecture and its relationship with the socio-economic conditions.

[172] In "The Architectural Paradox," Tschumi that due to "the impossibility of questioning the nature of space and at the same time experiencing a spatial practice," architecture enters self-paradox, as it is a discipline interested in both intellectual concepts and fashioning experience of space. This study suggests that this kind substantiation of design through the concept of topology is related to the trends that see architecture as a "thing of a mind, as a dematerialized or conceptual discipline" as opposed to architectures interested in sensory experience of space.

PART II - Spatial Heterogeneity: Theoretical Argument and Interpretation through Compositional Properties

4. Theoretical Grounding of the Thesis and Formulation of the Hypothesis

The insight into the theoretical and design ideas regarding modernist spatial concepts (deemed a catalyst of homogenous space), and later design and theoretical aspirations toward heterogeneity gives two main observations. First, the modernist space can indeed be considered homogeneous due to the spatial composition based on openness and fluidity that impairs differences. However, the “homogeneity” of such space cannot be comprehended in terms of Euclidean space, nor is it related to the geometry of formal expression. Lack of enclosure in the open-plan creates a “universal space” where the traditional spatial hierarchy is eliminated and spatial volumes bound into a continuous whole without variation. Of course, this is not something that can be extrapolated to the entire Modern Movement and all the spatial ideas and concepts that appeared at the time. Neither can it be attributed to any building in its entirety. Projects that are entirely built by the principles of openness and fluidity are rare. The second observation is that the aspirations toward heterogeneity that followed the modernist movement were primarily focused on formal aspects of architecture, and on the other hand, anchored in discourses external to

architecture. While these questions are relevant for architecture as a discipline in the broader sense, this study focuses on addressing composition fluidity and continuity that impair diversity as well as relating these to the human dimension of spaces.

Understanding the homogeneity through compositional aspects of modernism prompts an idea to find the principles of compositional design that reverse these effects and generate the diversity of spatial qualities within a building that can be experienced and designed. Experience of space, according to Tschumi, is essentially related to "making space distinct" by determining boundaries.[173] Thus the problem regarding the heterogeneity of space in architecture would be how to reverse these effects through spatial compositions and the definition of boundaries, i.e., how determining boundaries could not only "make space distinct" but also diverse.[174] This study, in the present chapter, establishes the theoretical concept of such a possibility in three steps. Firstly, it uses mathematical topology as a conceptual resource; secondly, it embodies the concept through a compositional strategy of interconnected spaces; finally, it interprets the quality of such settings through the ambiance of space as a denotation of spatial quality.

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[173] Tschumi, "The Architectural Paradox," 219.

[174] Jelena Mandić and Jin Baek. "Compositional Principles of Heterogeneous Spaces: The Topology and Emotional Dimension of Interconnected Spaces," *The International Journal of Architectonic, Spatial, and Environmental Design* 15, no.2 (2021): 2.

4.1. Topology as a Concept of Spatial Relationships

4.1.1. Mathematical Notion of Topology

To interpret topology in architecture in the context of spatial heterogeneity, it is necessary to understand this concept in mathematics. The origin of the idea that underlines topology dates back to Leibniz's *Analysis Situs*. However, as a science, topology developed in the second half of the nineteenth century and the first decades of the twentieth century.[175] The term topology originates from Greek words topos (τόπος), which means "position" or "location," and logos (λόγος) which means "study."[176] Topology is a branch of mathematics that is, like geometry, a science of space. However, there is an essential difference between the two. While classical geometry studies metric spaces (Cartesian and Euclidean space), topology studies topological spaces. Euclidian and Cartesian geometries presume space as an empty homogeneous void where points do not have content other than their position, and the distances between points are fixed and measurable. Therefore, dimensions determine all relations in space. Topology studies topological spaces – a set of points that share an array of properties (called topology) that do not change under continuous deformations (homeomorphisms). In other words, topological properties do not change when an object is gradually stretched, bent, crumpled, or twisted.

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[175] William G. Chinn and Norman E. Steenrod, *First Concepts of Topology: The Geometry of Mappings of Segments, Curves, Circles, and Disks* (Washington: Mathematical Assoc. of America, 1966), 1-2.

[176] Fred H. Croom, *Principles of Topology* (Mineola, New York: Dover Publications, Inc, 2016), 1.

Even if the distances between points do change, the figure remains the same as long as the connection between points is not broken.[177] Suppose the connection between points is broken or a new connection is made. In that case, the body's structure is modified, and, thus, topological properties change. In this sense, a complex curvature is no more topological than a cube or a sphere. In fact, Euclidian space is a special case of topological space, where the topology is the distance between points. Thus, while geometry is focused on measurement and distance between the points, in topology, the notion of distance is irrelevant and replaced with the term *nearness*.[178] Thus, topology is not interested in quantitative properties but rather in qualitative ones such as the structure of space, connections, and the vicinities of points.

In the context of spatial heterogeneity, the mathematical notion of topology is used in architecture as a conceptual counterpart to homogeneous Euclidian geometry. Topological space is indeed heterogeneous (except for the special case of Euclidian space). Still, this mathematical concept is equally as abstract as Euclidian space. It can be related to the human experience only when used metaphorically or as an inspiration for architectural design.

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[177] Arkady Plotnitsky, "Algebras, Geometries, and Topologies of the Fold: Deleuze, Derrida, and Quasi-mathematical Thinking (With Liebniz and Mallarmé)," in *Between Deleuze and Derrida,* eds. Paul Patton and John Protevi, (London ; New York: Continuum, 2003), 99.
[178] Croom, *Principles of Topology,* 4.

4.1.2. Topology in Architecture as the Logic of the Spatial Relationships

Long before topology was used as inspiration and a conceptual recourse for the architecture of complex curvatures in the 1990s, it had been used not only in art but also in architecture. These early ideas were focusing on topology as relationships, i.e., vicinities of points in space. For example, Harry Beck's 1933 *London Tube Map* was not based on the geographic locations of the stops but their connections and relative positions.[179] In his map, the subway lines are shown as straight lines that connect these points, and their actual shape and length are neglected. This kind of map represents the application of topological principles simply because the network's geometrical properties are ignored, and inner relationships are placed in focus.

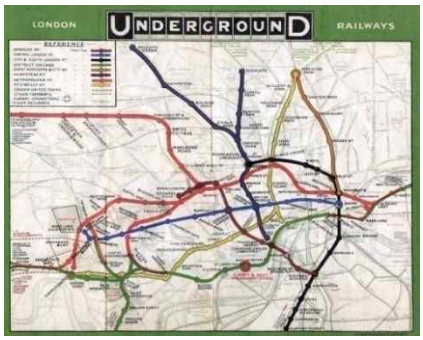

Figure 14. *Map of London's underground lines, 1908.*
Source: *https://www.openculture.com/2018/04/the-genius-of-harry-becks-1933-london-tube-map.html*

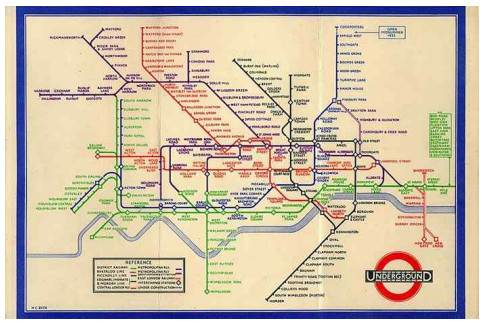

Figure 15. *Harry Beck's London underground map, 1933.*
Source: *https://www.openculture.com/2018/04/the-genius-of-harry-becks-1933-london-tube-map.html*

[179] Tepavčević and Stojaković, "Representation of Non-Metric Concepts of Space," 291.

The idea of topology penetrated architecture at the same time as it appeared in science. Early modernist architects often quoted scientific papers to find substantiation for their ideas. For example, Jean Badovici took over the concept of topology from Henri Poincaré's *Analysis situs.*[180] He saw it as an indication of the change in the sensibility of space: "We can neither speak of 'absolute location,' nor of 'absolute size,' nor of absolute distance between two points;' we can only speak of interrelationships."[181] Thus, his account of this mathematical concept also implies neglecting the geometrical properties and emphasizing the relationships in space.

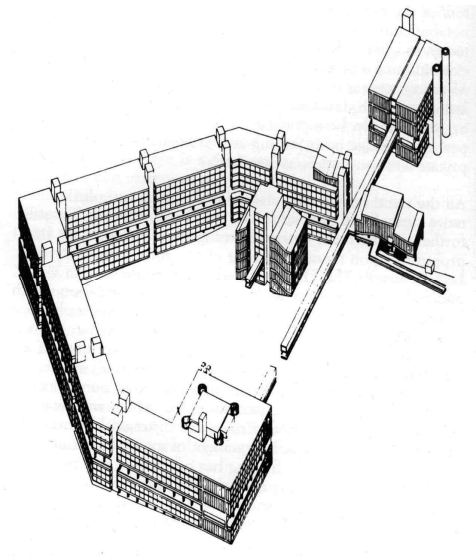

Figure 16. *Alison and Peter Smithson, Sheffield University Extension, 1953.*
Source: *https://archiveofaffinities.tumblr.com/post/38987513743/alison-and-peter-smithson-sheffield-university*

[180] Lucan, *Composition, Non-Composition,* 397.
[181] Jean Badovci, "L'espace et le temps d'après Henri Poincaré," as quoted in Lucan, *Composition, Non-Composition,* 398.

The term “topology” in relation to a building was used for the first time by Reyner Banham to describe the informal spatial organization in Alison and Peter Smithson’s Sheffield University project.[182]In this project, the Smithsons created an unconventional layout where the composition was organized by the logic of program connections, and not the scheme’s geometry like most architectural compositions historically were. Thus, Banham used the term “topology” to describe the organic connection of spaces that did not conform to any abstract geometrical rules. Banham further noted that topology has always been present in architecture (in the sense of circulation, penetration inside, etc.) as a subordinated discipline compared to Platonic geometry. In the Smithsons’ project, the relation was reversed: “The ‘connectivity’ of the circulation routes is flourished on the exterior and no attempt is made to give a geometrical form to the total scheme.”[183] Thus, Banham used the mathematical concept of topology to describe the structure of architectural space in the sense of spatial connections and circulation. Laurent Stalder referred to Banham’s account of topology as purely functionalist and metaphorical[184] that can only be partially aligned with the definition of topology in mathematics. Nevertheless, it is important to note that Banham’s thinking in *New Brutalism* suggests the shift from geometry to topology as a guiding idea in design. This approach represents what many accounts suggest, a shift from homogeneous to

[182] Banham, “The New Brutalism,” 361.
[183] Banham, “The New Brutalism,” 361.
[184] Laurent Stalder, “New Brutalism’, ‘Topology’ and ‘Image’: some remarks on the architectural debates in England around 1950,” *The Journal of Architecture* 22, no.5 (2017): 954

heterogeneous space on a conceptual level.[185] However, for this conceptual shift to have a deeper meaning in the context of the character of architectural space, it is necessary to understand how topological relationships in the composition render architectural space heterogeneous. This is something that Peter Eisenman uncovers upon analyzing the plans of Palladio's villas. His analysis goes beyond the concept and reveals the importance of topological relationships within a building in creating complex, diverse space. To understand Eisenman's idea, it is necessary to explain how he understands the spatial homogeneity to which Palladio's project is opposed.

The problem of homogeneous space that Eisenman addresses is not related to modernist spatial ideas and striated design. He asserts that homogeneous space in architecture was postulated in the fifteenth century by Leon Batista Alberti. Homogeneous space was a part of Alberti's larger metaphysical project for architecture postulated his treatise *De Re Aedificatoria*.[186] Eisenman further interprets architectural history, starting with Bramante and his successors, as a discipline preoccupied with questioning spatial principles and challenging the metaphysical project that originated from here. This was finally achieved in Palladio's villa architecture.[187]

However, Eisenman does not specify in what manner Alberti's theory postulated space as homogeneous. From his argument, the association of Alberti's ideas with homogenous space can be interpreted in several ways.

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[185] This idea appears in Greg Lynn's and Stephen Perella's writings, as well as in Peter Eisenman's *Palladio Virtuel.*
[186] Eisenman and Roman, *Palladio Virtuel*, 10.
[187] Eisenman and Roman, *Palladio Virtuel,* 10.

For example, Branko Mitrović suggests that the construction of perspective, which Alberti for the first time described in his treatise *Da Pintura,* implies that the rules of geometry can describe all spatial relationships and everything in nature.[188]This "quantification of visual experience" was part of a larger "systematic quantification of the subject" that Alberti attempted in his treatises, with the ambition to describe spatial relationships in a reliable manner and, thus, reduce the unreliability of the drawings that were at the time copied by hand.[189] The process of quantification of spatial and visual experience, as Mitrović argues, would not be possible if Alberti did not think of physical space as homogenous. With this argument, Mitrović asserts that the idea of space as homogenous existed long before Newton's definition of *absolute space*, even though it was not the dominant understanding of space.[190] Still, more important than determining how Alberti understood the physical space is how his project of quantification affected architecture.

One such example of the quantification of spatial and visual experiences relevant to architecture is implied in the concept of *concinnitas* by which Alberti defined beauty. The notion of *concinnitas* assumes that beauty is determined by three elements: *number, outline,* and *position,* which refer to nature as a source of perfect harmony and proportions.[191] Thus, Alberti suggested, the establishment of dimensions is not to be done randomly but according to a "harmonic relationship" through definite

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[188] BrankoMitrović, "Leon Battista Alberti and the Homogeneity of Space," *Journal of the Society of Architectural Historians* 63, no. 4 (2004): 431.
[189]Mitrović, "Leon Battista Alberti and the Homogeneity of Space," 432.
[190] Mitrović, "Leon Battista Alberti and the Homogeneity of Space,"435.
[191] Leon Battista Alberti and Joseph Rykwert, *On the Art of Building: In Ten Books* (Cambridge, Mass London: MIT Press, 1997), 302-303.

numbers drawn from the list he provided.[192] This coincides with Eisenman's argument that homogeneity is implied through the emphasis on number, dimension, proportion, and relationship of the whole and the parts – abstract geometrical rules to which architecture conforms. Palladio's villas are still predominately analyzed through numbers and proportions. For example, in a paper published in 2008, Lionel Mach analyses Palladio's Palazzo Antonio plan through numbers and mathematical formulas. [193]

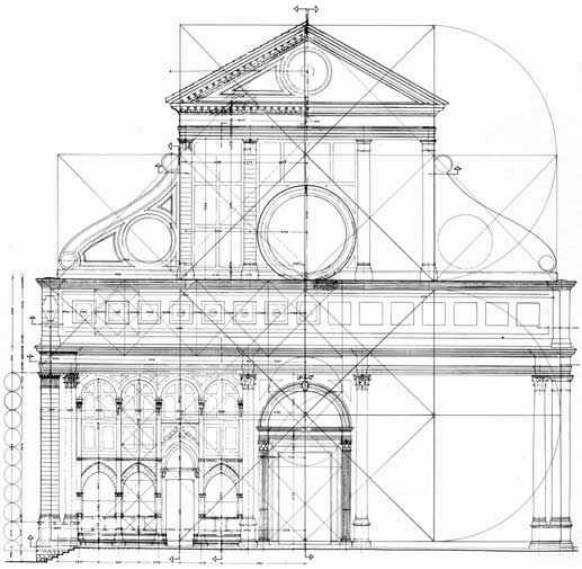

Figure 17. *Leon Battista Alberti, the facade of the church of Santa Maria Novella, mid-1400s.* Source: *https://figuringtheunfigurable.wordpress.com/2014/08/05/santa-maria-novella/*

It is worth noting that the quantification of space through geometrical descriptions and imposing rules of proportion, found in Alberti's ideas, aligns with Deleuze and Guattari's idea of *striation* – imposing a measure and

[192] Alberti, and Rykwert, *On the Art of Building,* 305-307.
[193] Lionel March, "Palladio, Pythagoreanism and Renaissance Mathematics," *Nexus Network Journal* 10, no. 2 (2008): 227-243.

order over space.[194] Furthermore, these effects are comparable to that of the modernist grid that subordinates design to abstract geometry and can also be understood as a tool of striation. In this sense, Eisenman's idea of homogenous space in architecture relates to those of the critics of modernism and suggests that there is an underlying relationship between the subordination of design to geometrical rules and rendering architectural space homogenous. However, with the analysis of Palladio's villas, this relationship between abstract mathematical concepts of space and spatial effects is made more tangible as he explains how topological relationships in the composition render architectural space heterogeneous.

Palladio's villas have been traditionally analyzed through a nine square diagram representing the architectural ideal of a villa plan.[195] This diagram consists of nine squares of equal size, where A-type squares occupy corners, B squares are central edges, and C is a central square (Figure 19). In *Palladio Virtuel,* Eisenman abolishes this kind of geometrical analysis concerned with the dimension and proportions of spaces and applies a topological analysis concerned with the relationships of spaces instead. In his formal analysis A, B, C notations are not based on shape, size, or proportion, but on their role in the villa – portico, transitional space, and central space, respectively. In Eisenman's analytic diagrams, they

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[194] Deleuze and Guattari take the year 1440 for the title of the chapter on smooth and striated, the year when the sea, which is essentially smooth space, was striated by bearings, and the map with meridians and parallels, which defines into a grid. See: Deleuze and Guattari, *A Thousand Plateaus*, 479.

[195] In *Architectural Principles in the Age of Humanism,* Rudolf Wittkower sketched "Schematized Drawing of 11 Palladio's Villas." These drawings can be reduced to a single nine-square scheme. See: Wittkower, *Architectural Principles,* 73.

become spatial notations represented as tri-dimensional volumes losing their original location and meaning (Figure 20, Figure 21). He refers to this analysis as “topological” because, unlike the previous analyses of Palladio’s villas concerned with geometry (size and proportions of individual spaces), his analysis is focused on topological relationships - “adjacency, superposition and overlaps” of spatial volumes.[196] Topological diagrams reveal that spaces within villas are not volumetrically discrete units, but they extend, overlap, and superpose, whereby the differences between them become blurred.[197] Eisenman refers to these overlaps as “space within a space” or “space between spaces.”

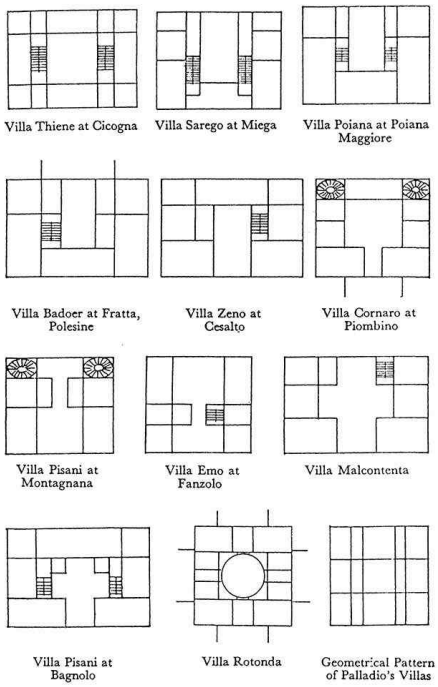

Figure 18. *Rudolf Wittkower, Palladian Villa Types, in Architectural Principles in the Age of Humanism (London, 1952).*

Source: *https://www.pinterest.fr/pin/331507222547715006/*

[196]Eisenman and Roman, *Palladio Virtuel*, 11.
[197]Eisenman and Roman, *Palladio Virtuel*, 21.

The overlapping of spaces and blurring the differences between them showcases the greater importance of the internal relationships of spaces compared to the geometry, shape, and size of individual spaces[198] (which can be understood as the norm given by the *concinnitas*). Through the emphasis on spatial relationships and connections over geometrical order, seen in Palladio's villas, Eisenman sees as a conceptual shift from Cartesian geometry toward topology, i.e., a shift from homogeneous to heterogeneous space.[199] Thus, in heterogeneous space (or space where these overlaps occur), the structure in the sense of the relationship of the parts is more important than the shape and size of individual components.

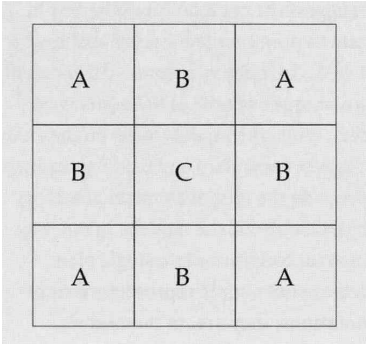

Figure 19. *Peter Eisenman, nine-square diagram, in Palladio Virtuel.*
Source: *Eisenman and Roman, Palladio Virtuel, 27.*

Eisenman suggests that overlapping spaces ("other spaces" or "in-between") have indeterminate characters and are different as well.[200] By this, he creates a tangible relationship between the concept of topology and the character of space. His ideas imply a gradual change of qualities from one

[198]Eisenman and Roman, *Palladio Virtuel*, 21.
[199]Eisenman and Roman, *Palladio Virtuel*, 10
[200] Eisenman and Roman, *Palladio Virtuel*, 10.

space to another over a threshold (overlap) that has the characteristics of both of these spaces.

However, in Eisenman's analysis, spaces are narrowed to abstract volumes, and their overlaps are visible only in diagrams. Furthermore, Eisenman's interpretation of topology does not account for the actual connections of spaces (access from one to another), but rather their position of one toward another. Thus the overlaps do not depict the actual relations of spaces in the villa plan. They are rather graphic representations of the villa's reading. The reading is based on the role that the spaces have in the building and they are classified into three groups: central space, transitional space, and portico. As Eisenman shows in diagrams, the spaces within every villa can be read (classified) in multiple ways. Yet, his observation that the overlaps of two spaces of different characters (in this case, they are distinguished as the three aforementioned types) create a space of an undetermined character. The creation of this space implies heterogeneity and makes a connection between the concept of topology and spatial qualities.

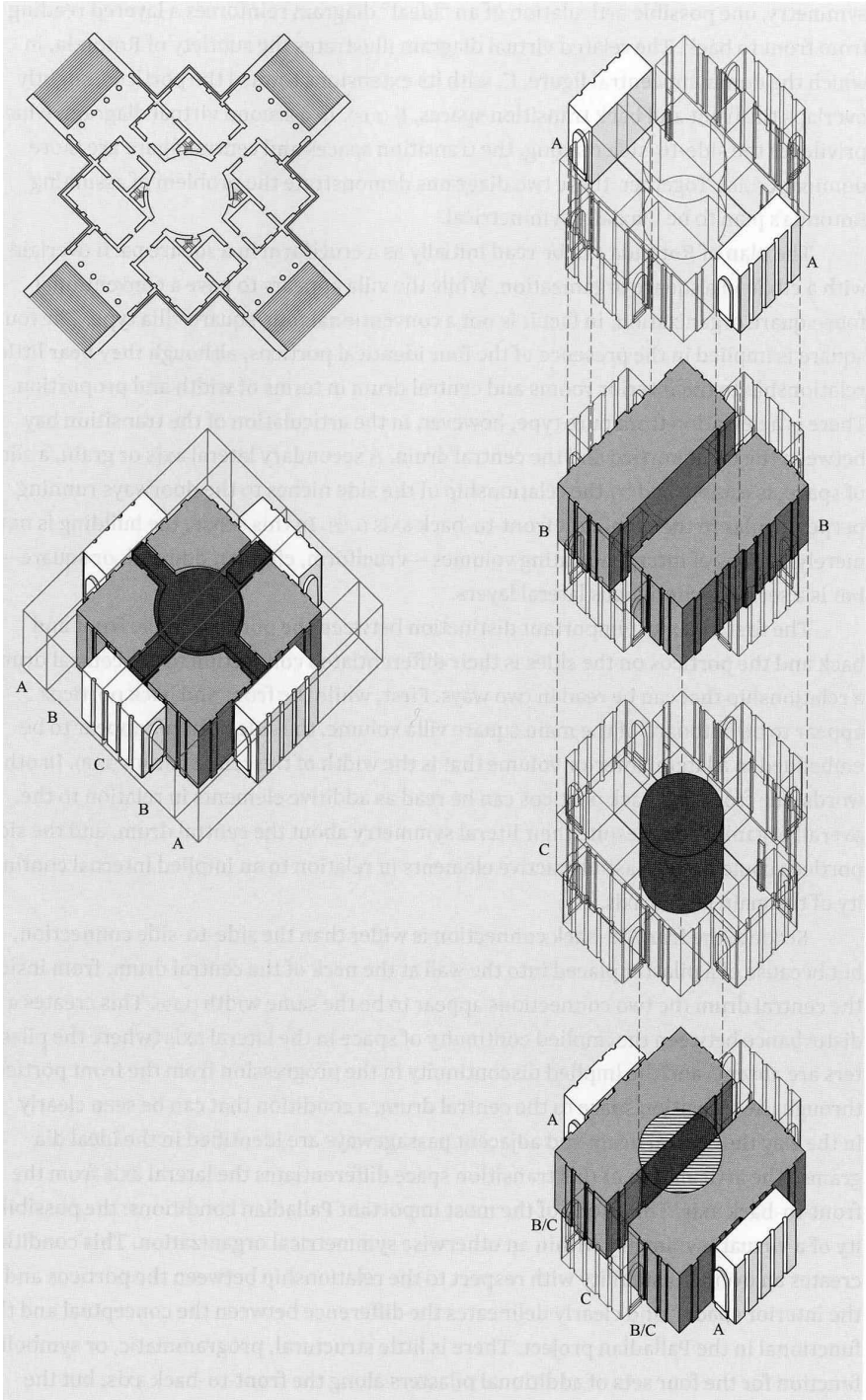

Figure 20. *Peter Eisenman, virtuel diagram of Villa Rotonda.*

Source: *Eisenman and Roman, Palladio Virtuel, 41.*

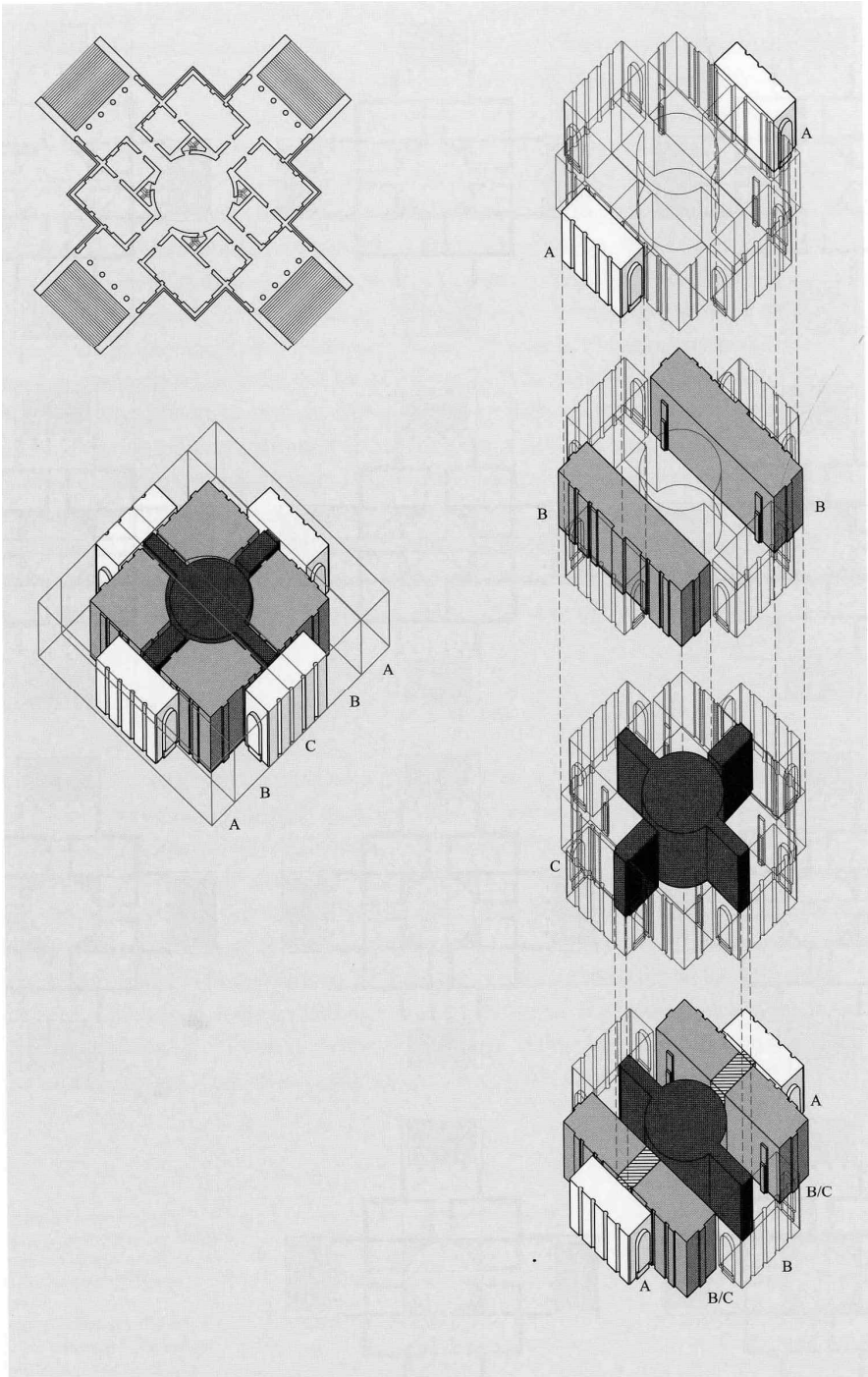

Figure 21. *Peter Eisenman, virtuel diagram of Villa Rotonda.*

Source: *Eisenman and Roman, Palladio Virtuel, 40.*

4.1.3. Concept of Topology and the Character of Space

In Banham's interpretation of topology, the connections of spaces are understood through the circulation in a building. Eisenman's ideas of topology seek to establish a connection to the spatial position and an adjunction with the quality of space. In this sense, Eisenman's ideas are aligned with the efforts of the "topological approach of architecture." In both interpretations, the concept of heterogenous space was grounded on the difference between classical geometry and topology. Both approaches suggested that the conceptual shift from the former to the latter(embodied through the design aspects they suggested)changed the character of space. The proponents of the folded architectures suggested that the actual change in space happens as a homogenous volume, becoming differentiated under the folded structure. In the case of Eisenman's reading, the differences between spaces are generated as the different spaces overlap and superimpose, creating "the other spaces" or "in between." With his interpretation, the conceptual shift from classical geometry to topology as a shift of emphasis from dimension and proportions toward the relationships of spaces becomes more than a metaphor. It implies a change in the quality of spaces and creates a tangible relationship between the abstract mathematical concept and spatial effects.

However, to understand the generation of differences in space through topological relationships, it is necessary to understand how virtual spatial overlaps, i.e., "spaces within spaces," change their character and the experience of space. This is something that Eisenman suggests in *Palladio Virtuel*. Nevertheless, his analysis is not focused on actual spaces and their

connections, but what he refers to as “virtual spaces” that can be seen only through volumetric readings of the villas. To make these ideas more tangible, it is necessary to develop the idea of “spaces within spaces” in relation to the spatial composition since the composition allows for “adjacency, superposition, and overlaps” to happen.

4.2. The Composition as Embodiment of Topology

This section develops the concept of topological relationships through the compositional aspects of a building. The idea of “spaces within spaces,” introduced in the previous chapter is elaborated through ideas from literature and buildings’ examples.

4.2.1. Spaces within Spaces

The concept of “spaces within spaces,” as a denotation of spatial complexity, is not solely Eisenman’s idea – it appears in other authors’ writings, too. However, the phrase does not always carry the same meaning concerning the architectural composition. For example, Eliel Saarinen defined architecture as the “art of space in space.” He explained: “The building is an organization of space in space. So is the community. So is the city.”[201]Using Saarinen’s argument, Robert Venturi, in *Complexity and Contradiction in*

[201] Eliel Saarinen, *Search for Form:A Fundamental Approach to Art* (New York: Reinhold Publishing Corporation, 1948), 254.

Architecture, brought forward the idea of nested interior spaces within a critique on modernist, flowing, borderless space. He was interested in the spatial complexity that comes from layering and nesting spaces in the interior and how these complex interiors contrast the envelope.[202] Venturi supported this argument with several historical examples of buildings where spaces are layered horizontally, like in Egyptian temples, and vertically, as in multiple Baroque domes.[203] However, this does not mean that the complexity of the interior is achieved only by arranging spaces in sequences. In the St. Basel church in Moscow, the concept of spaces within spaces is implied in nesting a series of smaller churches inside the interior.[204] Maritime theatre in Hadrian's Villa in Tivoli is composed as a series of concentric spaces, of which none is completely enclosed so that the view extends from the outside toward the center of the atrium. The simplest example of space inside another space is *baldacchino* –a canopy inside the church – where the difference between a larger church space and the one defined by a canopy is only blandly implied, yet present.[205]

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[202] Venturi, *Complexity and Contradiction,* 70-71.
[203] Venturi, *Complexity and Contradiction*,74 -77.
[204] Venturi, *Complexity and Contradiction,*79-80.
[205] Venturi, *Complexity and Contradiction,* 70.

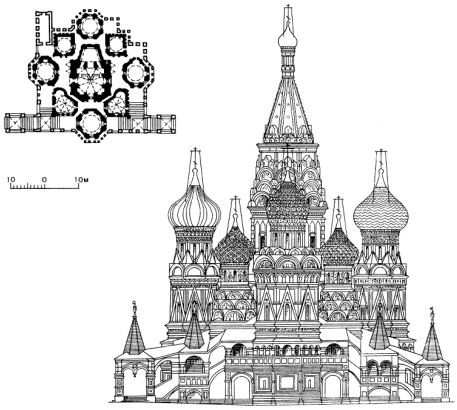


Figure 22. *Saint Basil's Cathedral, Moscow, 1561.*
Source: *https://www.pinterest.ch/pin/101190322857184420/*

Figure 23. *Baldacchino di San Pietro, St. Peter's Basilica in Vatican City.*
Source: *Robert Wash, https://www.flickr.com/photos/robertwash/33097311885*

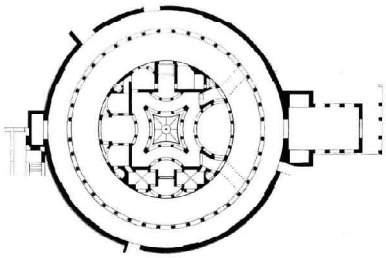


Figure 24. *Maritime Theater, Hadrian's Villa, Tivoli. Plan.*
Source: *https://archiveofaffinities.tumblr.com/post/93113030091/circular-casino-hadrains-villa-plan-tivoli*

Figure 25. *Maritime Theater, Hadrian's Villa, Tivoli. Reconstruction.*
Source: *https://i.pinimg.com/originals/b4/3d/59/b43d59383e5e0c1826cbc0cafbba5a54.jpg*

The concept of "space within a space" is also implied in Jeffrey Kipnis' idea of a "box inside box" section that he suggested as a means for heterogeneity in the seminal essay *Toward New Architecture*. One of the five points he proposed for the new and heterogeneous architecture was *vastness* that, in his interpretation, "negotiates a middle ground between the homogeneity of infinite or universal space and the fixed hierarchies of closely articulated space."[206] This kind of composition suggests extending the *free plan* toward the "free section" by detaching the internal organization from the envelope and emphasizing residual over primary spaces.[207] This, he suggests, could be effectively achieved by "box-within-box" sections where main spaces are designed as floating cubes inside a larger inner space defined by the monolith form.[208] With this idea, Kipnis, like Venturi, emphasized the importance of the detachment of the interior from the envelope as a means of creating a complex space in the interior as opposed to the modernist spatial simplicity and fluidity. Furthermore, this sectional composition breaks up the spaces with dominant horizontal planes that create a "sandwich-like quality of space." An example of a "box-within-box" sectional composition is Bahram Shirdel's and Robert Livesey's 1992 competition project for the Nara Convention Hall. In this project, the architects designed three theatres floating in the section within the main space, and thus the main space is concurrently a residual space between

[206] Kipnis,"Towards a New Architecture," 59. Kipnis acquired the five points for the new architecture from a 1990 lecture that Roberto Mangeiberra Unger gave at ANYONE conference in Los Angeles. However, in this essay, Kipnis gave his own interpretation of each of the points in relation to the creation of a new and heterogeneous architecture.
[207] Kipnis, "Towards a New Architecture," 59.
[208] Kipnis, "Towards a New Architecture," 62.

the floating theatres. This example of composition, in the context of the "space-within-space" concept, is similar to some examples of complex spaces that Venturi used to exemplify his ideas. For example, the St. Basel church in Moscow where the interior becomes a labyrinth of residual space between the smaller churches inside creates the same effects in the plan as the Nara project in the section. The difference is that in the Moscow church these residual spaces are formed in the plan while in the Nara competition project they exist in the section as well.

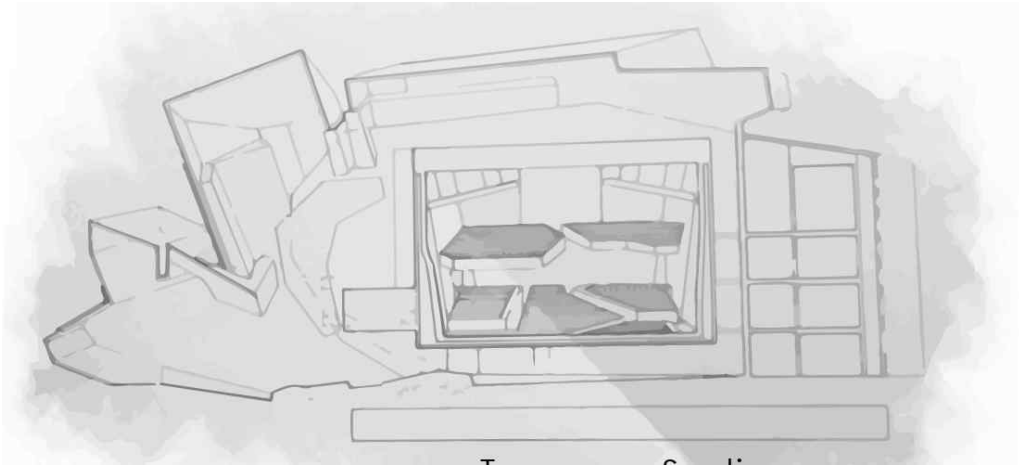
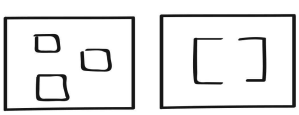
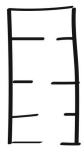


Figure 26. *Bahram Shirdel and Robert Livesey, Nara Convention Hall, competition project - transversal section, 1992.*
Source: *Contemporary Architecture of Iran, caoi.ir/en/projects/item/330-nara-convention-hall.html*

The function and scale of the many projects that Venturi gives as examples, as well as the project that Kipnis introduces, are different. One cannot assume that any of these compositional ideas can be universally applied. However, these projects share the idea of achieving spatial complexity by layering and nesting spaces in plan or section. These spatial

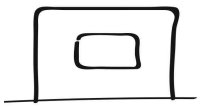
ideas open a number of possibilities to create a complex space with different types of complex compositions. The spaces in the plan can be arranged in sequences or concentrically. Several spaces can be layered vertically. The section can be “free” of horizontal layering if the smaller spatial volumes/boxes are hung in the main space. Each of these compositions would create spatial overlaps, i.e., spaces-within-spaces or spaces-between-spaces.

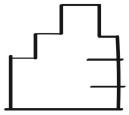




Nested spaces in plan: several spaces inside a larger space

Layered spaces in plan





Nested spaces in section

Layered spaces in section

Figure 27. *Diagram of nested and layered spaces.*

4.2.2. Connections of Spaces

These concepts give a more tangible idea of overlapping spatial volumes concerning spatial composition than Eisenman’s virtual diagrams. However, it is worth noting an essential difference between the spatial idea of nested

spaces defined by *baldacchino*, and the “box-within-box” section. In the case of *baldacchino,* the boundaries between spatial volumes are only implied, and, therefore, it forms a virtual space within a space. This kind of composition creates a change of spatial quality without apparent boundaries between spaces. Even though it implies spatial complexity, the “box-within-box” strategy (as in the Nara Convention Hall project) does not allow for the connection of nested spaces and creates different effects. Layering and nesting spaces have to be emphasized by their connections to allow for the virtual overlaps of spatial volumes and the heterogeneity that they suggest. Without connections, the overlaps of spaces are not visible, and they are experienced as separate, discrete volumes. This idea points back to the composition that negotiates between the openness and fluidity of modernist spaces and the enclosed traditional spaces.

a) Box-inside-box section *b) Space implied by baldacchino*

Figure 28. *Diagrams of nested spaces.*

4.2.3. Heterogeneous System and Diversity through Difference

The importance of connections to create a space of diverse qualities is rooted in the very essence of the notion of diversity. As Deleuze pointed out, diversity is given by the differences: “Difference is not diversity. Diversity is

given, but the difference is that by which the given is given, that by which the given is given as diverse."[209] When this kind of thinking is applied to architectural space, it becomes evident that it is necessary to bring together the differences between the individual parts of the space in order to establish a diverse character. However, the differences of individual spaces can be apparent only once connections between spaces have been established in a way that allows for their individual character to persist, without blending them into a continuous whole. Brought together, different characters confirm each other's qualities through oppositions. Thus, the overall space becomes diverse through the differences between the individual parts. In this context, the composition of the plan and section and the connections between spaces play an essential role in allowing spatial volumes to overlap and mix whilst keeping their individual character.

Thus, heterogeneous space, defined as a quality of diversity within a spatial whole, is neither conceived as a complete enclosure nor aims toward openness, as the former concept suggests isolation and the latter singularity of the spatial quality. The heterogeneity is achieved by avoiding rigid boundaries of spatial volumes. In such design, volumes of spaces are not detached as homogeneous entities and discrete parts but overlap and extend, blurring the differences between them. As they are not entirely separated from one another, the overall space is rendered diverse through the differences of the individual parts of the spatial volume. This kind of composition creates a gradual change of spatial qualities from inside to outside, from dark to light, etc.

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[209] Gilles Deleuze, *Difference and Repetition*, translated by Paul Patton (New York: Columbia University Press, 1994), 222.

Figure 29. *Xavier Corbero, Barcelona Residence– courtyard.*
Source: *Carl Hansen & Søn,*
https://plainmagazine.com/carl-hansen-and-son-xavier-corbero/

This is why the idea of “spaces within spaces” as a denotation of spatial complexity needs to be extended towards the communication and connections of spaces within the composition to become a paradigm of spatial diversity. These connections allow the actual spaces to overlap and mix. Xavier Corbero’s house, for instance, creates layers of interiority and exteriority through a series of arcades that separate and define spaces whilst simultaneously connecting them. Despite the similarity in formal aspects, the quality of space changes from one layer to another. The problem remains how to explain these differences and the character of space.

4.2.4. Compositional Principles of Heterogeneous Spaces

The effects of overlapping spatial volumes are achieved through the connections of spaces. These connections can be achieved through:

1) Open access from one room to another through a cased opening, but also a line of arcades, etc;
2) A visual connection that does not allow for access from one space to another but links them visually through a window-like opening. This kind of connection also exists between the volumes of space that are separated through a sectional movement – elevating one part of the section.

This said, it is evident that certain types of spatial compositions are advantageous for creating interactions between spatial volumes. In theoretical arguments presented above that discuss the possibility of creating "spaces-within-spaces," there are already several such compositional types implied:

1) Spaces-between-spaces can be created by layering spaces. These can be layered horizontally or vertically;
2) Nesting spaces – when several smaller spaces are placed within a larger space. This spatial strategy can also be applied horizontally (nesting spaces in plan), or vertically (box-within-box section). In such a spatial setting, the main spaces are divided into smaller bits by the nested volumes;
3) Sectional movement or free section is a spatial idea that can be interpreted in various manners. Still, the principal concept is breaking the dominance of the horizontal slabs that hamper the extension of

space vertically. Furthermore, the manipulation of sectional slabs creates a possibility of visually linking spaces that are not at the same level.

4.3. The Atmosphere as Denotation of Spatial Character

The idea of interconnected spatial volumes seemingly approaches the problem of diversity at a conceptual level where spaces are understood as abstract, empty, geometrical volumes without qualitative properties. Nonetheless, this study attempts to approach and define qualities of space through the notion of architectural atmosphere. The quality of space that is usually referred to as character or ambiance (atmosphere) is a property of any place or setting. This quality of space is difficult to define but it is immediately perceptible in any space.[210] The atmosphere is usually understood as "a setting's perceptible character or mood,"[211] which is not comprehended intellectually but rather emotionally.[212] Such quality is determined by several factors – the characteristics of the setting, the historical and cultural context, and the sentiments of the observer.[213] This

[210] David Leatherbarrow,. "Atmospheric Conditions," in *Phenomenologies of the City: Studies in the History and Philosophy of Architecture*, eds. Henriette Steiner and Maximilian Sternberg (Ashgate Studies in Architecture. Farnham Surrey, England ; Burlington, VT: Ashgate, 2015), 85.

[211] Leatherbarrow, "Atmospheric Conditions," 85.

[212] Juhani Pallasmaa, "Space, Place and Atmosphere. Emotion and Peripherical Perception in Architectural Experience," *Lebenswelt. Aesthetics and Philosophy of Experience* 4, no. 1 (2014): 242.

[213] Leatherbarrow, "Atmospheric Conditions," 85. See also Gernot Böhme,"Urban Atmospheres: Charting New Directions For Architecture and Urban Planning," in *Architectural Atmospheres: On the Experience*

makes it difficult to define, yet it is an essential aspect of any architectural (and urban) space. Furthermore, it can be a subject of design, i.e., the setting (a building or urban space) can be staged so it affects the way people perceive the surroundings [214] and to create desired "moods." Adolf Loos suggested that the effect that an architect wishes to "exert upon a spectator" (or the atmosphere he wants to produce) in interior spaces "are produced by both materials and the form of the space."[215] This idea has been an essential theme of the investigation of the phenomenological approach in architecture. In his book *Atmospheres*, Peter Zumpthor, an architect interested in "atmospheric" design, introduces several factors that influence the atmosphere, including sound, light, materiality, etc. On top of Zumthor's list is "the body of architecture." "The body of architecture" represents the "material presence" of architecture.[216] It delimits and defines the space. The boundaries that define space define the atmosphere inside. This idea is important in this study as it deals with the qualities of spaces delimited within the composition and their interaction. Each of the individual spaces has its own character that depends on a number of factors.

This study argues that what actually occurs through communicational and visual connections is that distinct atmospheres of individual spaces are brought together and that through their differences, diversity in space is attained. If the boundaries completely close the space, its character is rendered homogeneous; both closely articulated and open

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and Politics of Architecture, eds. Gernot Böhme, Ólafur Elíasson, Juhani Pallasmaa and Christian Borch (Basel: Birkhäuser, 2014), 43.

[214] Böhme, "Urban Atmospheres,"45.

[215] Adolf Loos, *Spoken Into the Void. Collected Essays 1897-1900,* ed. Aldo Rossi (Cambridge, Mass: MIT Press, 1982), 66.

[216] Peter Zumthor, *Atmospheres* (Berlin: Birkhäuser Architecture, 2006), 21.

spaces do not provide the possibility for change. To create diversity, at least two spaces of different characters must be brought together. The compositions of interconnected spaces embody diversity as they bring differences together and allow them to coexist. Overall diversity is achieved as the differences between spaces become evident, as they are not separated from one another but interact through communications. As the boundaries between spaces are not clear, a gradual change of spatial quality occurs. In this way, the topological relationships of the spaces (in the sense of their connectivity and position) create effects of heterogeneity by variations in the space.

For this reason, the suggested spatial composition based on interconnected volumes, where individual spaces are both articulated and open, constitutes the setting where the character of space is rendered heterogeneous. The interactions of spatial volumes do not create virtual spatial overlaps but rather the field in which the visible change in atmosphere happens. Through communicational and visual connections that can be established through open access, windows, or perforated walls, the differences between individual volumes are brought together and thus render the overall space diverse. The character or the mood of the space changes from one space to another, and these can be either small changes or more abrupt ones. It can be an encounter between a more intimate and more public space, or a more illuminated and a darker space, inside and outside, or between furnished and empty rooms. The heterogeneity of space comes from changing the atmosphere across a continuous spatial volume, parts of which have their own characters. Thus it is hidden in the complexity of spatial relations.

Figure 30. *Xavier Corbero, Barcelona Residence.*
Source: *Openhouse magazine, https://openhouse-magazine.com/xavier-corbero/*

An example of such variable ambiance is Xavier Corbero's house where, from the sunny yard, one steps into the shade of the porch and then through another arcade deeper inside the house. These boundaries are not obvious. The individual spaces between the series of arcades are essentially different one from another; however, they do not create a distinct atmosphere. On the contrary, the whole space, with series of arcades arranged in layers, radiates with a unique but variable atmosphere.

Thus, there are overlaps of the atmospheres in the spaces that are completely enclosed by the boundaries but connect to other spaces. These spaces cannot be observed separately but as one heterogeneous ambiance.

Since the manifestation of the atmosphere is not only related to the setting, but our sentiments play an important role in this process as well,[217] the atmosphere is a quasi-objective phenomenon –a manifestation of co-

[217] Leatherbarrow, "Atmospheric Conditions," 85.

presence of subject and object.[218] For this reason, the atmosphere allows us to relate the setting based on spatial communications and virtual overlaps of spaces with the experience of the inhabitant.

4.4. Spatial Heterogeneity Interpreted through Topology and Atmosphere of Space

In summary, through communicational and visual connections, different spaces meet and produce a variable atmosphere within a building, thus, rendering the space heterogeneous. For this reason, the system of spatial relations becomes important to create a complex heterogeneous space. These relationships can be understood in terms of topology. However, in this context, the idea of topological relationships within the composition (that Eisenman describes as the "adjacency, superposition and overlaps" of spatial volumes) can be reinterpreted as connections between the space that allow different spaces to come together. With this, the topology of space can be understood not only as circulation within a building (how Rayner Banham described it) but as any kind of connection between spatial volumes that is not necessarily related to patterns of movement through the building. The idea of topological relationships needs to be extended toward visual connections as they play an important role in creating spatial overlaps. This interpretation of topology would mean that the spatial relationships described by the concept do not denote only functional connections but also the character of space, i.e. that through the spatial connections of enclosed

[218] Böhme, "Urban Atmospheres," 43.

yet open spaces, the overall ambiance becomes diverse. That is why the heterogeneity of space is closely related to the idea of topology as a spatial configuration. Moreover, with establishing new connections and removing the existing ones, space changes its quality.

Accordingly, it is possible to interpret the heterogeneity of space through the compositional aspects of a building using the concept of topology as a spatial configuration that defines spatial ambient wholes within a building. This interpretation brings forward the next assumptions:

1) The heterogeneity of space can be understood as the diversity of ambiance produced by creating spatial overlaps and blending different atmospheres into a continuous, changeable spatial whole.
2) These effects are enabled by a system of relations: compositional aspects (design of the plan and section) and connections of spaces.
3) The network of spaces and spatial connections within a building can be described in terms of topology. Partially defined spaces in this parallel can be understood as vertices and connection edges. According to this, the connected spaces are understood as near vertices.
4) The connections of spaces refer to the openings that allow for visual links between spaces and overlaps of ambiances instead of the access (through a door) from one space to another.
5) As the diversity of the ambiance is dependent on these elements of spatial composition, there is a direct correlation between the topology of space and the heterogeneity (diversity) of the ambiance. For example, if the spaces have a simple topological structure (such as discrete, traditionally enclosed volumes) they are qualitatively

homogeneous. In contrast, the spaces with complex topological structures (which means that there are several interconnected volumes) are rendered heterogeneous.

6) Changing any of these contacts between spaces (adding new connections or eliminating existing ones) changes the character of space.

4.5. Conclusion

Chapter 4 constitutes theoretical grounding for the interpretation of spatial heterogeneity through the compositional properties of a building. This interpretation has used the concept of topology as a denotation of spatial complexity and quality. The most common interpretations of topology in architecture understand this mathematical concept through geometrical properties or circulation patterns in the building. However, in *Palladio Virtuel,* Peter Eisenman connects this mathematical concept with the quality of space. He defines topology not as a network of relations but as the "adjacency, superposition and overlaps" of spaces. He finds these aspects of design more important than the proportions of Palladio's villas. He, therefore, considers it a shift of focus from geometry toward topology, i.e., from homogenous to heterogeneous space.

Using Eisenman's idea of spatial overlaps or "spaces within spaces" and examining this idea in other authors' writings and projects, compositional properties that allow for this kind of effect have been identified. Topological relationships have been redefined as actual physical connections in the closely defined spaces, in contrast to Eisenman's

abstract diagrammatic schemes. Thus, the topology of space has been redefined from an abstract concept to a spatial configuration of interconnected spaces. Moreover, the abstract idea of overlapping spatial volumes has been interpreted in terms of architectural atmosphere or ambiance. Spatial heterogeneity is then understood as a changeable atmosphere within the composition of spaces that are simultaneously closed and open. Thus, the homogeneity/heterogeneity of space can be understood through its topological structure.

5. Case Studies Analysis

5.1. Case Study Selection

In this section, the theory that was formulated in the previous chapter will be assessed through case studies. The case studies were selected concerning their relevance for the study. The principal goal of the analysis is to examine whether and how the connectivity of spaces changes the character and creates heterogeneous space, as well as to interpret this propriety in terms of topology. The concept under investigation assumes that contact between spaces occurs through open connections that allow ambiances to interact. In this regard, this interpretation of heterogeneity/topology can be applied to any plan or part of a plan. However, in the theory formulated in the previous section, some types of composition were deemed advantageous for establishing these connections and creating spatial overlaps. Thus, the criteria for the selection were formulated as follows:

1. **Relevance to the study/ compositional properties**

   The selected case studies encompass compositional properties or a combination of compositional properties that provide interesting data and results. The compositional properties advantageous for creating

spatial overlaps are interconnecting of spaces, nesting, layering, and free section. However, these are applied hierarchically:

a) **Interconnection of spaces;**

This is an essential element for the idea of topology. Selecting case studies where the spaces are not interconnected would not give valuable results. Therefore, all selected case studies encompass spaces interconnected through open access or visually. They are chosen over examples with other preferable qualities (such as the nesting of spaces) where there is no connection.

b) **Level of the enclosure of spaces;**

Case studies have different levels of enclosure. This is an aspect of the selection that gives relevant results because different levels of the enclosure create levels in the degree of interaction of spaces rendering them more or less as a unique whole. However, none of the case studies is composed strictly of entirely open or wholly enclosed spaces. This is because the former case does not generate differences, and the latter excludes any interaction between spaces.

c) **Nesting, layering of spaces, and free section;**

These are not primary but secondary criteria because these can create opportunities for spaces to interconnect in different manners but do not necessarily do so. Thus, examples of architecture encompassing free section or

nesting spaces, where the spaces are not interconnected, are not considered for the analysis.

2. **Historical period;**

   The study is not a historical account of architecture, and the presented idea of topology and heterogeneity can be analyzed in any building. However, the study focuses on the design and theoretical ideas starting with early modernism till today. For this reason, case studies are selected from this historical period. The historical buildings from the earlier period have not been considered even if they encompass the compositional properties that are suitable for the study.

3. **Valuable design or theoretical idea;**

   Each case study is a significant project that holds a theoretical and design concept or aspect important in the context of this study.

4. **Size of the study;**

   Another criterion considered in the selection is the size of the building. While the same logic can be applied to any space, some of the buildings of greater scale would be difficult to illustrate through diagrams or analyze in detail. For this reason, smaller or medium-sized projects were chosen for the analysis. In addition, some of the projects were analyzed only partially.

5. **Availability of material;**

   The selected case studies are notable projects with published materials that were used in the analysis. The case studies that are suitable for the study, but do not have published available materials were eliminated from the selection.

It is also important to acknowledge that the composition of the building often depends on the necessity of intimacy or publicity, i.e., from the function of the building. However, the analysis at this point is only focused on compositional properties and interpreting topology in the context of heterogeneous ambiance.

Through literature analysis and review of historically significant buildings, six case studies were selected that meet the criteria for the case studies and are representative of ideas important for this study:

1. **Villa Moller in Vienna by Adolf Loos (1927-1928)**

   This is one of the two case studies that are examples of Adolf Loos' *Raumplan*houses. These houses were selected because in the interior of *Raumplan* based houses spaces are arranged on multiple levels that interlock and connect through stairs. Such organization enables individual rooms to remain clearly defined while remaining connected. Access from one space to another is not established through doors, and thus the spaces meet one another in an unaffected manner allowing for continuous movement throughout the house. In the case of Villa Moller, two significant compositional aspects are considered for this study: interconnecting spaces through cased openings and elevating part of the floor to create a different space that is at the same connected and separated from the main volume.

2. **Villa Müller in Prague by Adolf Loos (1928-1930).**

   The second case study – Villa Müller – is a more prominent example of *Raumplan*. It repeats the idea of connecting spaces on different levels through stairs, open access, and elevating a

portion of space so that a smaller and more intimate area is created within a larger space. An element that appears here but does not appear in the Moller House is the window-like opening. There are several “windows” in the interior of the villa between the living and the dining area and between the dining area and the staircase. This idea appeared previously in some other projects (House Rufus in Vienna and Tristan Tzara House in Paris), and it is a purely visual connection of the two spaces. Additionally, in Villa Müller, every room has distinguished materiality of the interior of each space, which emphasizes the differences between spaces.

3. **Philips Exeter Library in Exeter by Louis Kahn (1972).**

   This building encompasses the compositional idea of layering spaces. The central “atrium,” the book area surrounding it, and the reading area along the entire outer edge of the building, are nested one within another. However, these spaces are not composed as discrete units. Immense window-like openings bind functionally distinct parts of the building. This theme appears in several other Khan’s projects, including the Bangladesh Parliament building. While both buildings encompass similar spatial ideas and compositional properties, the Exeter Library was selected over the Parliament building for the analysis due to its smaller size. Additionally, in this project, the differences between different spaces are emphasized through different materiality and type of illumination.

4. **Hurva Synagogue in Jerusalem (unbuilt) by Louis Kahn (1961).**

   The fourth case study is an example of a different nesting of spaces where several smaller spaces are nested within a greater whole. Although unbuilt, this project, revived in 3D, provides the opportunity to examine the following spatial ideas: 1) nesting a series of smaller spaces within one larger space rendering the main spaces residual; 2) sectional movement (formation of galleries) that allows for communication between different levels. This building is chosen over other cases where the spaces are nested because there is a significant interconnection between the smaller spatial units through openings in walls and galleries.

5. **Jussieu – Two Libraries in Paris (unbuilt) by OMA (1992-93).**

   The fifth case study represents a ground-breaking project that challenges ideas of the datum and horizontally stacked section. An uninterrupted folded plane that extends from the lowest to the highest level incorporating the extensive program of two libraries. While previous case studies encompass a sectional movement that plays a role in the definition of spatial units, Jussieu Library is an example of an entirely free section. This case study is also significant because it encompasses a grid-like structure, where most of the spaces are open or defined without vertical divisions. The differences in space are achieved through the movement of planes or changes in program/arrangement in the space.

6. **Vagelos Education Center at Columbia University in New York by Diller Scofidio + Renfro (2013-2016).**

   This building also encompasses the idea of a free section. The free section has many interpretations, where the main idea is to break the layers of horizontal slabs. In this building, a part of the elevation is “decomposed” so that the spaces became a part of the extended staircase – the “Study Cascade.” The design resembles a vertical *promenade architectural*. In this aspect, it is similar to the Jussieu library. However, in Vagelos Education Center, there is no large programmatic diversity and depth of space. Comparing these two case studies might demonstrate to what extent the sectional movement plays a role in the differentiation of spaces.

In summary, while the six case studies encompass interconnected spaces, they can be divided into three groups (Figure 31). Villa Moller and Villa Müller constitute the first group. While the rooms inside villas are interconnected and form a kind of a path inside the house, the spaces are well articulated and can be described in the terms of volumes. The second group consists of Exeter Library and Hurva Synagogue. These two projects represent examples of layered and nested spaces. Lastly, Vagelos Education Center and Jussieu library are projects that encompass a free section. With this, the selected case studies cover all compositional properties suggested in Chapter 4. The compositional properties of each case study are summarized in Table 3.

It is important to note that the selected case studies display a variety in the level of spatial articulation and enclosure: from volumetric spaces to those where vertical partitions of the spaces gradually disappear and the boundaries are only vaguely implied (Figure 32).

Figure 31. *Diagram of the compositional properties of the six case studies.*

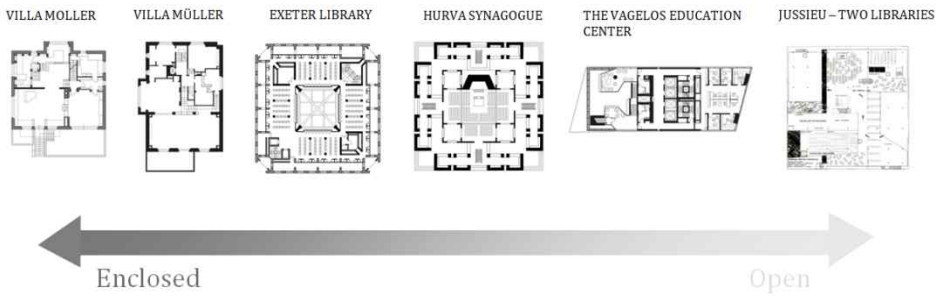

Figure 32. *Diagram of the levels of enclosure of the six case studies.*

Table 3. *Relevant compositional properties of case studies.*

Case study	Relevant compositional properties
Villa Moller, Vienna 1927-1928 Adolf Loos	• Interconnecting spaces (open access); • Sectional movement (elevated part of a section);
Villa Müller, Prague 1928-1930 Adolf Loos	• Interconnecting spaces (open access, visual connections); • Sectional movement (interconnecting spaces of different height;
Exeter Library, Exeter 1972 Louis Kahn	• The concentric layering of spaces; • Interconnected spaces: open access and visual connections (window-like openings);
Hurva Synagogue, Jerusalem, 1968-74 (unbuilt) Louis Kahn	• Nesting smaller spaces within larger space; • Interconnecting the spaces through open access; • Sectional movement – formation of the galleries;
Jussieu - Two Libraries, Paris 1992-93 (unbuilt) OMA/ Rem Koolhaas	• Free section (development of a folded plane from the lowest to • Interconnection spaces through cuts horizontal/tilted slabs.
The Vagelos Education Center at Columbia University, New York, 2016 Diller Scofidio + Renfro	• Free section (partially)- spaces are not stacked in horizontal layers but open one toward another; • Interconnecting spaces (open access, visual connections);

5.2. Design of the Analysis

The analysis was designed following the hypothesis formulated in the previous chapter that assumes the relationship between the connectivity of spaces and the quality (heterogeneity) of space. The connectivity of space and the network of spatial connections that bring different spaces together were interpreted in the terms of topology. The topology of architectural space is not understood as a pattern of circulation within a building but rather as a network of spaces where connections create overlaps through visual joints. These relationships can be understood in the context of the function, patterns of use of the space, social circumstances, culture, and the historical context. However, these aspects are not the focus of the investigation. The analysis conducted in this study focuses on how these joints change the ambiance within a building and render space heterogeneous. The spaces within each case study need to be classified and the topological connections between them analyzed. By this reasoning, the "heterogeneity" would increase with the complexity of connections. The problematic of this approach lays in the fact that the quality of space cannot be accurately depicted. To overcome this, the notion of the atmosphere is used to describe the quality of space and to identify spatial wholes. The notion of the atmosphere is used in architecture to denote the "setting's perceptible character or mood."[219] This quality of space is difficult to define as it is perceived emotionally before it is comprehended intellectually.[220] Several conditions influence the atmosphere of a setting. Sensing

[219] Leatherbarrow, "Atmospheric Conditions," 85.
[220] Leatherbarrow, "Atmospheric Conditions," 85.

atmospheres is not purely visual – all senses participate in the process, as well as the subject's feelings. For this reason, atmospheres are difficult to define. Nevertheless, the interest of this study is not to define the atmosphere but to identify the spatial and ambiance wholes within buildings and to learn how they interact through connections of spaces. Thus, this study focuses on those aspects of atmospheres that can be a subject of design. Peter Zumthor is one of the most notable architects who uses the "atmospheric approach" in their design. In his book *Atmospheres*, Zumthor defined nine features of the building important for creating atmospheres.[221] These include the body of architecture, material compatibility, the sound of space, the temperature of space, surrounding objects, between composure and seduction, the tension between interior and the exterior, levels of intimacy, light on things.[222] These properties are explained in Table 4.

However, as some of these properties are difficult to identify through plans, photos, and analytical diagrams. For this reason, these nine criteria, for the purpose of the analysis were narrowed to four: function, frame, materiality, and light.[223] Individual spaces are distinguished primarily based on their "frame," which usually coincides with the use of the space, and then materiality, illumination, and other qualities. In some projects, these differences are more obvious than in others. The volumetric spaces give a clear idea of an atmospheric whole, while in open spaces different ambiances are only vaguely implied. The full list of the criteria with the

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[221] Zumthor, *Atmospheres,* 21-61.
[222] Zumthor, *Atmospheres,* 21-61.
[223] Jelena Mandić and Jin Baek, "A Study on Relationship of Architectural Atmosphere, and 'The Body of Architecuture'," *Jounal of the Korean Insititute of Cultura Architecture*, no. 72 (2020): 281.

description and the explanation for narrowing are given in Table 4. The narrowed criteria are presented in Table 5.

Table 4. *Elements of architectural atmosphere according to Peter Zumthor, and narrowing the list of elements for the analysis.*[224]

Elements of architectural atmosphere	**Description according to Zumthor**	**Narrowed criteria**
The Body of Architecture	Architectural elements that define and enclose space.	Frame;
Material Compatibility	Materials in space, their mutual reactions, and composition.	Materiality;
The Sound of Space	Sounds in the interior and their amplification.	Materiality, frame, and functional zones; These features are generated concerning the shape and materials of the space and the activities performed in a room.
The Temperature of Space	Each building has a temperature, not only physical but also psychological concerning materials applied.	Materiality; The physical and psychological temperature of a space depends on the materials in the space.
Surrounding Objects	Objects and things in the room (including furniture, books, instruments, etc.) create a sense of home.	Function; The objects in the room are primarily related to the use of the room.
Between Composure and Seduction	Involvement of the movement in architecture; how people	Frame;

[224] Mandić and Baek, "A Study on Relationship of Architectural Atmosphere, and 'The Body of Architecuture'," 282.

	are directed to move inside a building; bringing different parts of the building together to stage and direct the experience of space.	The movement of the users is essentially related to the definition and enclosure of spaces, and how the individual spaces are connected.
Tension Between Interior and Exterior	Enclosure, thresholds, crossings, doors, the transition from outside to inside.	Frame; This relationship is primarily dependent on the envelope of the building and its composition.
Levels of Intimacy	These relate to the scale, proximity, distance, and relationship of the body scale and the room.	Function, frame; The level of intimacy of space primarily depends on how this space is used and whether it is open or enclosed.
The Light on Things	Illumination of space and staging the light effects.	Light;

Table 5. *Criteria for identifying ambient zones.*[225]

Criteria for identifying ambient zones	Description
Frame	Defines a zone within boundaries (walls, ceilings, panels, windows, change of height, etc. These can be clear or unclear.
Functional zones	Classification following patterns of use. These are related to the scale, levels of intimacy, object in the interior, sounds, and human habitation.
Materiality	Materials in the interior. These are also related to the sound and temperature of a place.
Light	Artificial and natural illumination.

The analysis of each case study consists of the following steps:

1) Identifying the type of composition (plan and section) and the main spatial idea. The types of compositions were determined according to Table 6.
2) Identifying basic spatial units. Different spatial units are determined based on the criteria given in Table 5. A space defined within the boundaries constitutes a unique whole; it has a certain function, materialization, or type of illumination, etc. that clearly distinguishes it from the surrounding spaces.

[225] Mandić and Baek, "A Study on Relationship of Architectural Atmosphere, and 'The Body of Architecuture'," 282.

3) Identifying and classifying the type of connections between the spatial units: access, open access, and visual connections. The classification is given in Table 7. The differentiation between these three types of connection is essential for the analysis conducted in this thesis. When despite openness, the shape and position of the connection do not allow for a significant interaction between the spatial volumes they are neglected in the analysis.
4) Creating a diagram that depicts topological relationships. In topological diagrams, individual spaces are seen as vertices (nodes) and connections between them as edges. After excluding the connections that assume access through a door (which means that spaces are essentially separated) topological diagrams reveal discrete (homogenous) and complex (heterogeneous) spaces.
5) Discussing how these connections influence the atmosphere of space.

Table 6. *Elements and types of architectural composition.*[226]

Elements of Composition	Type		Description
Pan	Articulated spaces		Spaces are completely enclosed
	Open plan		The interior space is not divided by constructive elements. Zones are determined by furniture or panel divisions.
	Combined		Individual spaces within a building are not completely enclosed, nor open, but negotiate between; Or part of the building is open space and part articulated.
Section	Simple	Extrusion	The plan is directly extruded to a certain height
		Stack	Floors are layered vertically (repetition of extrusion)
		Shape	Space is defined under deformed horizontal or vertical surfaces (usually curved)
	Complex	Shear	Vertical or horizontal cut through the building creating a rift.
		Hole	Penetration through a slab causes a loss of a part of the floor area.
		Incline	Floor surfaces are sloped and connect different levels (the plan is tilted into the section)
		Nest	Nesting and overlapping of spatial volumes
		Hybrids	Combination of two or more different types

[226] Mandic, and Baek, "A Study on Relationship of Architectural Atmosphere, and "The Body of Architecuture," 282.

Table 7. *Types of connections between spaces.*

Type of connection between spaces	Access	Open access	Visual connection
Picture (example)	 Adolf Loos - Hugo Semler's Apartment, Pilsen, 1930.	 Adolf Loos – Villa Moller, Vienna, 1928.	 Louis Kahn, Bangladesh Parlament, Dakha, const.1961-1982.
Description	Two spaces are connected through doors. This kind of connection allows for access from one space to another and it is important for circulation within a building but does not allow	Two spaces are connected through a cased opening that at the same time allows access from one space to another and enables visual connections. The two spaces can be read as the two parts of the same whole.	Two spaces are connected through a window-like opening that does not give of possibility of access from one space to another but creates a visual connection.

5.3. Case Studies Analysis

5.3.1. Case Study 1 – Villa Moller, Vienna

CASE STUDY INFORMATION	TYPE OF SPATIAL COMPOSITION	ELEMENTS OF TOPOLOGY
 VILLA MOLLER YEAR 1927-1928 PLACE Vienna, Austria ARCHITECT Adolf Loos	**Section:** Stacked + shear; horizontal slabs are moved so that adjoined spaces have different heights. **Plan:** combined of articulated spaces and spaces that are neither enclosed nor open.	Multiple spaces (music room, dining room, and living room with elevated interconnected by two basic types of connection: 1) cased openings and 2) sectional movement (elevating smaller sitting area); visual and communicational connections.

Loos' buildings have been a subject of extensive interest and investigation regarding architect's spatial ideas, interior materiality, and exterior aesthetic deprived of ornaments. One of the most famous accounts on Loos' architecture is *Raumplan versus Plan Libre* – a book where the domestic architecture of Adolf Loos is examined parallelly with Le Corbusier's open plan houses.[227] The comparison of the two design philosophies is significant in the context of this study because it parallels two different approaches to

[227] Max Risselada and Johan van de Beek, eds. *Raumplan versus Plan Libre: Adolf Loos/Le Corbusier (* Rotterdam: 010 Publishers, 2008).

space. While Loos' idea of the Raumplan falls into those modernist designs that focus on enclosing space, *plan libre* tends to break with the enclosure. However, both *Raumplan*and the *open plan* are oriented toward the experience of space. Raumplan assumes that architecture is not conceived through plans and sections, but spatial volumes that expand both horizontally and vertically.[228] In the interior of Loos' houses, spaces are arranged on multiple levels that interlock and connect through stairs. Such organization enabled individual rooms to remain clearly defined whilst being connected. It also allows continuous movement through the house. Beatriz Colomina (among others) examined Loos' villas in the context of modernity and media arguing that modern architecture changes the relationship between private and public by changing the experience of space.[229] Loos villas represent an interesting example of such a change because of the levels of domestic privacy that Loos achieved through spatial composition. Christopher Long and Wolfgang Thaler extend this idea by analyzing Loos houses in terms of the movement through the house, which was meant to enhance the experience of the users. They analyzed the house plans of three Viennese architects (Adolf Loos, Josef Frank, and Oscar Strnad), and related their projects to Schmarsow's ideas on space as "the essence of architectural creation."[230] They concluded that pioneers of Viennese modern architecture (amongst whom Adolf Loos) were influenced by these aesthetic

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[228]Adolf Loos, shorthand record of a conversation in Plzeň, 1930, quoted in Maria Grazia Sandri, "Talking about the space. Searching the Image," in *The Visual Language of Technique*, ed. Luigi Cocchiarella (New York: Springer, 2014), 99.

[229] Beatriz Colomina, *Privacy and Publicity: Modern Architecture as Mass Media* (Cambridge, Mass: MIT Press, 1994).

[230] Schmarsow, "The Essence of Architectural Creation."

theories and attempted to translate the theory into built forms fashioning the spatial experience of an inhabitant.[231] In the spatial composition of house interiors, they abandoned the definition of rooms as closed cubes and developed an interest in spatial sequences and the movement of the body. Ergo, Joseph Frank suggested that a four-cornered room is the least suitable for living and that a house should be organized like a city – with several places and paths that connect them.[232] These ideas suggest opening up spatial volumes and establishing connections between them as a means to enhance the experience, and in this sense are similar to what Loos' achieved with *Raumplan* compositions. Long and Thaler's book encompasses developed drawings of the Loos' houses where they are seen as series of paths and places. From Long's analysis of Loos' houses, it is evident that the connections of spaces in *Raumplan* did not come solely from the economy of space, as Kulka suggested.[233] The configuration of the spaces and their peculiar connections are directly related to the "experience of space through movement" and engaging the psyche of the participant.[234]

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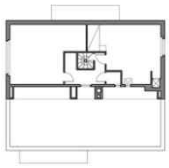
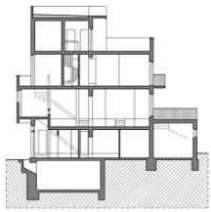
[231] Long and Thaler, *The New Space.*
[232] Josef Frank, "The House as Path and Place (1931)," in Long and Thaler, *The New Space,* 224-5.
[233] Herinrich Kulka, "Der Raumplan (1931)," in Long and Thaler, *The New Space,* 223-4.
[234] Long and Thaler, *The New Space.,* XIII.

1) Identifying the Type of Composition

Table 8. *Villa Moller – identifying the type of composition.*

				
Level 1 plan	Level 2 plan	Level 3 plan	Level 4 plan	Longitudinal section
Articulated spaces; Spaces in this level are closely articulated and connected through a system of corridors.	**Combined;** Spaces are articulated, however, they are not completely enclosed. Main spaces are connected through cased openings.	**Articulated spaces;** Spaces are articulated and completely enclosed. The connections are established through a corridor.	**Articulated spaces;** Spaces are completely enclosed and connected through a corridor.	**Hybrid section: stack+ shear;** Horizontal slabs are "broken" and shifted to create spaces of different heights at the same level. This is visible in levels 1 and level 2.

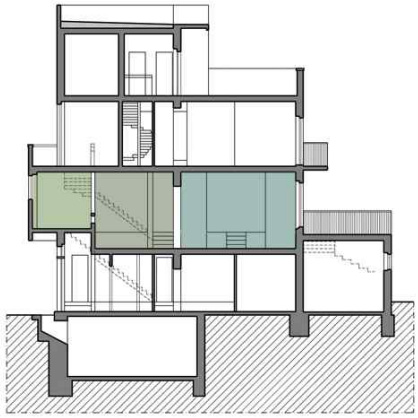
House of Hans and Anny Moller in Vienna, built between 1927 and 1928, is one of the most completed Raumplan houses, where Loos not only manipulated the volumes but also inserted a "path" in the plan. Additionally, he punctuated the walls with openings [235] enhancing the visual experience along the path. The peculiarity of this plan is the most noticeable on the first floor (level 2). The music room is the largest room that opens toward two other adjoined spaces. On one side, it is connected with the dining room, on the other, with the central hall where Lady's alcove is placed. This sitting

[235] Long and Thaler, *The New Space,* 114-118.

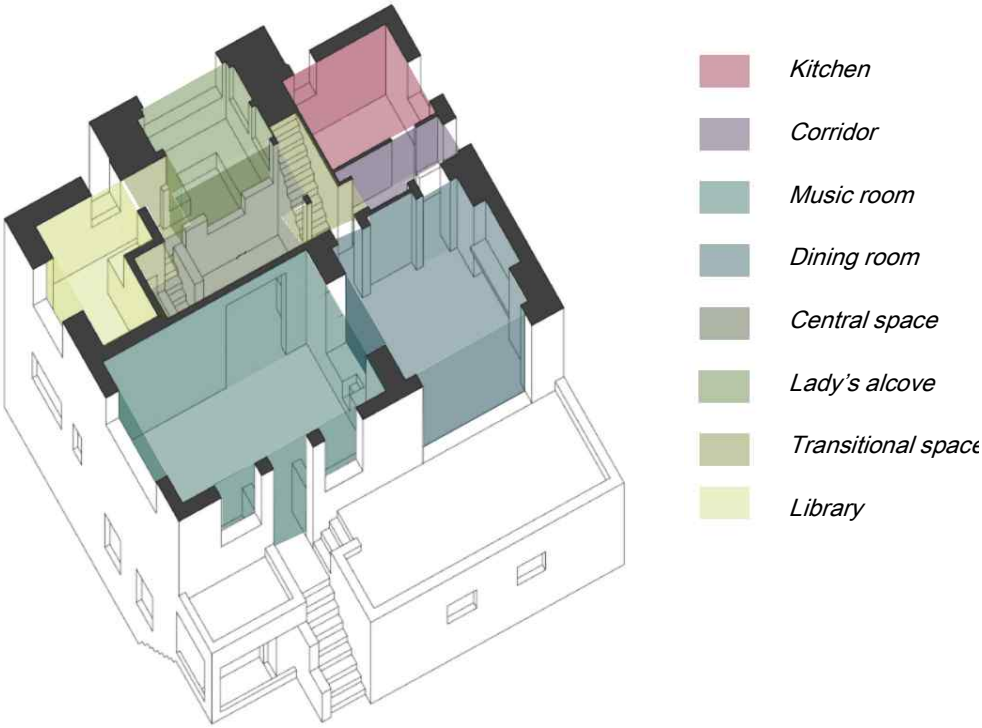
area, as well as the dining room, is elevated above the level of the central space. Although the height differences are not extreme, the section of the villa can be defined as a hybrid – a combination of stacked levels with elements of a shear section. Similarly, in the planar composition, the spaces of the house are mostly traditionally enclosed spaces except on the second level where the main living spaces negotiate between enclosure and openness, as they are interconnected. The analysis conducted in this study is focused on the second level where most of these peculiar spatial relationships occur.

2) Identifying Basic Spatial Units

a) Level 2 plan



b) Longitudinal section



c) Axonometric view of level 2

Figure 33. *Villa Moller – identifying spatial zones.*

Table 9. *Villa Moller - defining main spatial zones.*

Kitchen	*Corridor*	*Music room*	*Dining room*
Kitchen space is a discrete space that connects to the rest of the building only through a door, and over a corridor. It is defined as a unique ambient zone based on the clearly defined frame and as a functionally separate space. The information about the materiality and other qualities is not available.	The corridor is a discrete space that connects the dining area with the kitchen. It is defined as a separate spatial unit based on the clearly defined frame that completely encloses the space.	The music room is a clearly defined, traditionally framed space. Based on this, and its clear function it is defined as a separate spatial unit. This space opens toward the dining room. The connection is not so prominent as to merge the spaces into a unique whole.	The dining room is a framed, discrete space. It is defined as a separate zone based on the frame and function. Space opens toward the music room, but these spaces are functionally and physically separate wholes.
Central space	*Lady's Alcove*	*Transitional spaces*	*Library*
Central space is passing spaces that connect all other rooms on the second floor, as well as the second level and level 1 and level 3. The lady's alcove, and the staircases that lead to the next level, are immediately linked to this space. These can be understood as a part of the central space, or as separate spatial units.	Lady's alcove is an elevated sitting area in the central space. Although it can be read as an integral part of the central space, it is defined as a separate spatial zone. Despite being largely open toward the central space its border is defined by elevating the floor and creating a railing between them. By this, it is not only separately framed but it also became a more intimate sitting space.	Transitional spaces are defined as separated categories, as they are not completely part of the main living space, but are neither a separate spatial unit. They usually represent a transition between the spatial units and for this reason they can also be understood as a type of connection between main spaces.	The library is a discrete, clearly defined space It is classified as a separate zone based on the frame and the function. The information about the materiality and other qualities is not available.

The spatial units/ambiance zones were identified based on the criteria given in Table 5. As each of the rooms has a relatively strictly defined volume, the spatial zones coincide with the volumes. The graphic representation of the zones is given in Figure 33. The explanation for each zone is given in Table 9.

3) Identifying Types of Connections

The classification of the connections between spaces is based on the criteria given in Table 7. In the analysis of the Villa Moller, apart from the three basic types of connections, transitional spaces are marked on the villa plan. These spaces can be read as both a connection and a part of the living space.

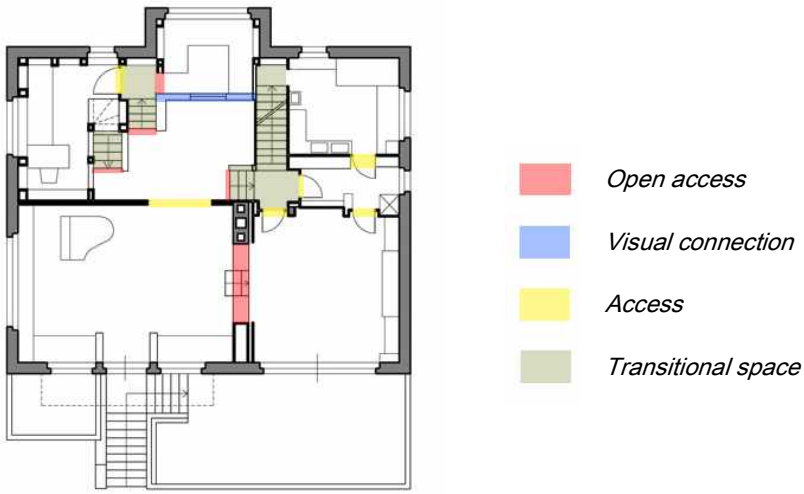


Figure 34. *Villa Moller - identifying types of connections.*

The *open access* type of connection occurs between adjoined spaces where a large cased opening is created to link them. In Villa Moller, the cased opening appears between the main spaces of the villa's second level – the music room and dining room (picture).

Visual connection occurs between the adjoined rooms when one space opens toward another visually. This link between the spaces does not allow for access from one room to another. In Villa Moller, this kind of connection appears between the elevated sitting area and the central space separated by a low wall and railing.

Transitional spaces are the spaces that connect other spaces in the plan and can be understood as a part of a larger space, or as a connection. In Villa Moller, such transitions appear in the central space. These connect the central space with the Lady's alcove and the library on one hand and with the kitchen and the dining area on the other, as well as with the other levels of the villa.

Access assumes habitual connections of spaces through a door. In the Moller house plan, it occurs between the central space and the music room, between the kitchen and the corridor, and the corridor with the rest of the living spaces. The library is also separated from the rest of the floor.

a)

b)

c)

d)

Figure 35. *Types of connectons in Villa Moller: a) open acess; b) visual connection; c) transitional space; 4) access.*

Sources: *a) The Albertina Museum, Vienna;*

b), c), d) https://en.wikiarquitectura.com/building/villa-moller/

4) Creating a Topological Diagram

The topological diagram of Villa Moller is created concerning the types of connections. In the diagram, each of the spaces represents a vertex, and the connections between them are graphically shown as edges that connect them.

The topological relationships in the diagram denote spatial wholes, of which some are complex and consist of several smaller interconnected

spaces, while others are discrete. This is important in the context of heterogeneity because the ambiance of the complex spaces is rendered diverse due to spatial interactions.

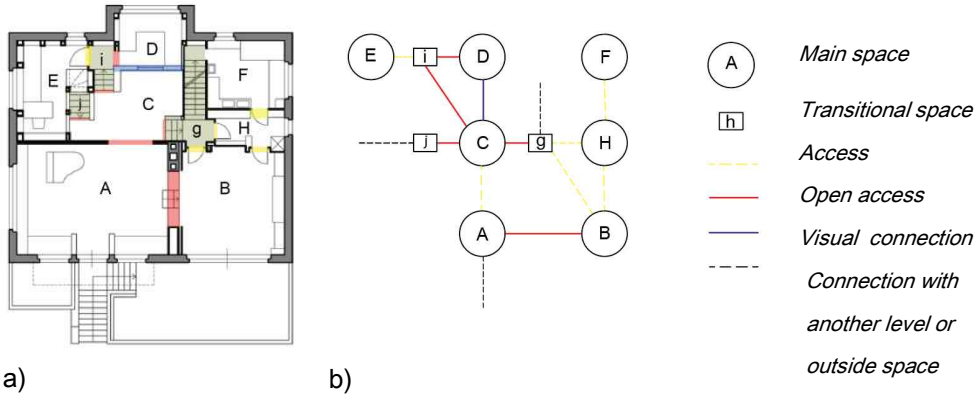


Figure 36. *Villa Moller - creating topological diagram; a) identifying spatial units and connections; b) graphic representation of the space.*

When the connections that mark the “access,” i.e. the connections between spaces that are established over a door are removed from the diagram (because these connections are functional but do not create any kind of interaction of spatial volumes), the discrete spaces of the kitchen, corridor and the library lose their connection to the main space. These spaces can be understood as single spaces, simple spaces, or homogenous spatial units. At the same time, the central space of the villa is a complex or heterogeneous space that consists of several different adjoining spaces, that when combined create a spatial whole.

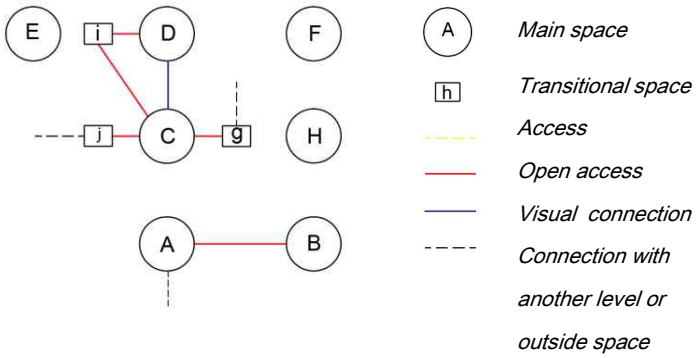


Figure 37. *Villa Moller - topological diagram of complex and discrete spaces.*

5) Examining spatial connections in the context of the atmosphere

The importance of these connections is not only in the functional aspects of a space. Loos and other Viennese architects were exploring these ideas concerning the human experience of space and its emotional dimension.[236] The question this study attempts to answer is how these relationships reflect on the spatial ambiance.

Looking at the peculiar relationship between the music room and the dining room it is clear that despite being widely open one toward another these are separated spaces. This is emphasized by elevating the dining room floor. The staircase that leads to the dining room is placed directly in the cased opening. Owing to this, the opening resembles a window with a view toward the dining room (Figure 38). However, despite each of these spaces being clearly defined they form a heterogeneous whole.

[236] Long and Thaler, *The New Space,* XIII-XIV.

Figure 38. *Villa Moller - view from the music hall into the dining room.*
Source: *The Albertina Museum, Vienna.*

On the other side, the music room connects to the central hall (Figure 40) that links all the spaces on the floor. From this space, a short staircase leads to an elevated sitting area – a lady's alcove (Figure 39). This small and intimate area is in this way open toward more open and public spaces in the house with an open vista through the central hall and the music room to the balcony door. The emphasis on visual connections is evident in the design of walls that border the staircase punctured with window-like openings. By connecting spaces through cased openings and separating them through elevations Loos created a variated ambiance in this villa: spaces of a different atmosphere, use, and illumination are bonded in a continuous whole, which qualities are changing gradually.

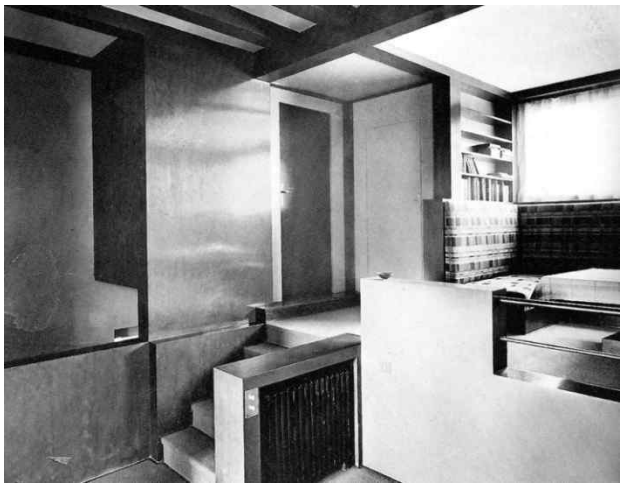


Figure 39. *Villa Moller - Lady´s alcove.*

Source: *https://en.wikiarquitectura.com/building/villa-moller/*

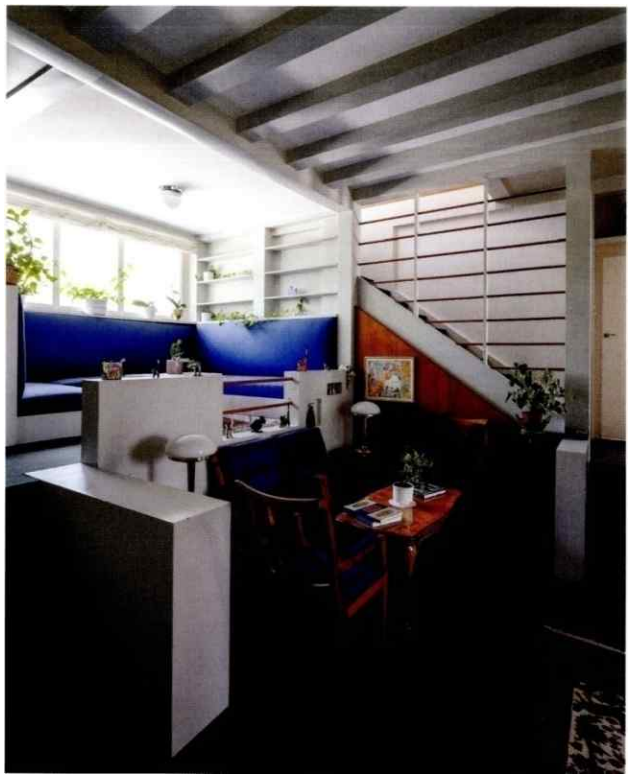


Figure 40. *Villa Moller - view of the central hall with alcove.*

Source: Long and Thaler, *The New Space, 121.*

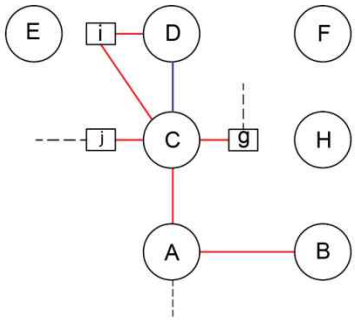
The significance of these relationships in the ambiance of space is obvious when one assumes a change of the topological structure of space (Figure 41). By enclosing these connections, the interior obtains a different character: it becomes smaller and less illuminated, but it also loses the variability it has. The connections allow the different levels of intimacy, illuminations, and different materiality to bend into a whole.

a)

b)

Figure 41. *Changing the topological structure of space; a) closing the opening between the dining room and the music room; b) removing the visual connection between lady's alcove and the central space.*

On the other hand, by opening the sliding door between the central space and the music room a new topological connection is formed and the two heterogeneous spaces are bonded into a larger heterogeneous whole (Figure 42).



a)

b)

Figure 42. *Villa Moller - Changing the topological structure of space - opening the side door between the central space and the music room: a) topological diagram; b) view from the alcove to the music room.*

Source: *b) https://en.wikiarquitectura.com/building/villa-moller/*

5.3.2. Case Study 2 – Villa Müller, Prague

CASE STUDY INFORMATION	TYPE OF SPATIAL COMPOSITION	ELEMENTS OF TOPOLOGY
 VILLA MÜLLER YEAR 1928-1930 PLACE Prague, Czech Republic ARCHITECT Adolf Loos	Section: *shear;* horizontal slabs are moved so that adjoined spaces have different heights). Plan: combined (spaces within are neither enclosed like traditional spaces nor completely open and fluid.	Multiple spaces interlocked and linked through visual and communicational connections: cased opening, interior windows; elevated sitting area creating "space within space."

Villa Müller built in Prague between 1928 and 1930 is one of the most important Loos' works where the concept of *Raumplan* is fully developed. Loos himself believed that in this house he achieved the purest design of spaces in cubes (*Raumplan*).[237] The house was a subject of several interpretations, usually seen as one of the volume-generated houses. However, CynthiaJara points out that the unfolding of the volumes (how Münz previously described it [238]) demonstrates a spatial interaction in the plan, and thus cannot be observed only in the sense of volumes.[239] In her interpretation, the connections that exist between spaces suggest a "free

[237]Adolf Loos, shorthand record of a conversation in Plzeň, 1930, quoted in Maria Grazia Sandri, "Talking about the space. Searching the Image,"99.
[238] Ludwig Münz and Gustave Künstler, *Adolf Loos, Pioneer of Modern Architecture* (New York: Praeger, 1966).
[239] Cynthia Jara, "Adolf Loos's 'Raumplan' Theory," *Journal of Architectural Education* 48, no. 3 (1995): 193.

plan" where, at the same time, the hierarchy of spaces is present.[240] The living room is the largest of the cubes in the majority of *Raumplan* houses. The next most important room – the dining room – is usually adjoined and connected to the living room through open access. As the dining room is elevated one has to access it through stairs. The living room is then at the same time self-contained and extends through an open plan.[241] Seen in the light of the "place and the path" idea, each room has a double reading – as an individual room (a place) and as a part of a path through the house. The ideas of movement and experience that Long noticed in Villa Moller exist in this house, too.

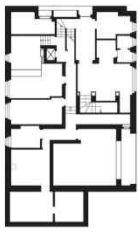
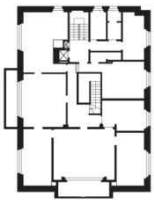
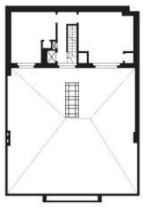
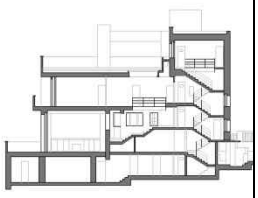
1) Identifying the Type of Composition

In the composition of Villa Müller, most of the spaces are clearly defined and at the same time peculiarly interconnected. On the first level, which consists mostly of service spaces, all rooms are clearly defined and connected through the hall. The floor level oscillates, but as the spaces are discrete, this does not create significant effects in the interior. The most important spaces are placed on the second level. The living room is the largest and the highest of all second-level spaces. It connects to the central staircase and the dining room, both elevated from the living room level. Lady's boudoir contains two smaller sitting areas that can be defined as separated spaces. This area connects to the living room through a staircase and a

[240] Jara, "Adolf Loos's 'Raumplan' Theory,"199.
[241] Jara, "Adolf Loos's 'Raumplan' Theory,"199.

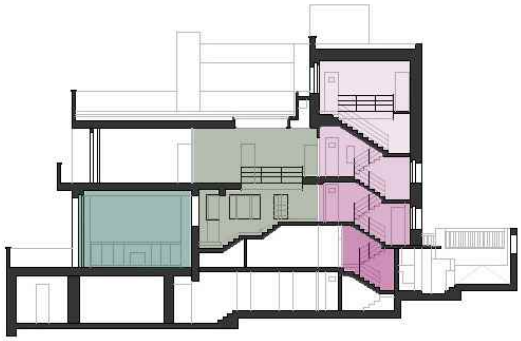
window-like opening. Overall, in the plan, spaces are mostly articulated and interconnected, and the section is a combination of the stack and shear composition. The analysis in this study focuses on the second level where most of these interesting connections and relationships between spaces happen.

Table 100. *Villa Müller – Identifying the type of composition.*

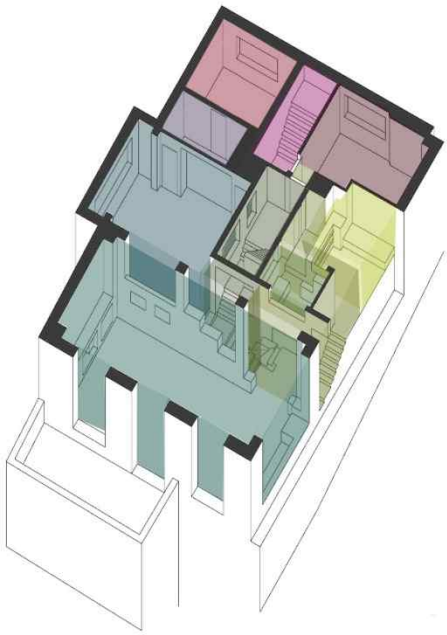
				
Level 1 plan	Level 2 plan	Level 3 plan	Level 4 plan	Longitudinal section
Articulated spaces; Spaces are closely articulated and connected through a system of corridors.	**Combined;** Spaces are articulated, but not completely enclosed. Main spaces are connected through window-like openings.	**Articulated spaces;** Spaces are articulated and enclosed. The connections with the main space are established through a gallery.	**Articulated spaces;** Spaces are completely enclosed and connected through a corridor/stairc ase.	**Hybrid section: stack+ shear;** Horizontal slabs are shifted to create spaces of different heights and at the same time connect spaces at different levels.

2) Identifying Basic Spatial Units

a)



b)



Library

Back staircase

Kitchen

Kitchen 2

Living room

Dining room

Main staircase

Lady's boudoir

Transitional space

Lady's boudoir 2

c)

Figure 43. *Villa Müller – identifying spatial zones: a) level 2 plan; b) longitudinal section; c) axonometric view.*

Table 11. Villa Müller - defining main spatial zones.

Library	*Back staircase*	*Kitchen*	*Kitchen 2*
Library space is a discrete space that connects to the rest of the building only through a small transitional staircase. It is defined as a unique ambient zone based on the clearly defined frame and as a functionally separate space. Additionally, it has a unique designed enterer.	A service staircase is a discrete space that connects all the levels in the house. It is defined as a separate spatial unit based on the clearly defined frame that completely encloses the space.	The kitchen space is clearly defined, traditionally framed. Based on its clear function, frame, and distinguished interior it is defined as a unique space. It connects to the staircase and a second kitchen room.	This space represents a transitional space between the kitchen and the dining room. It is defined as a separate whole as it has clearly defined boundaries.
Living room	*Dining room*	*Main staircase*	*Lady's boudoir*
The living room is the largest in the house. It also has the highest ceiling by which it is clearly distinguished from any other room. It constitutes two separated sitting arrangements, however, it is volumetrically and by materiality a unique whole. Through open access and window-like opening, it is visually connected to the dining room and the main staircase.	The dining room is a clearly articulated space with distinguished materiality of the interior. However, it opens through a window-like opening toward the living room and the main staircase.	The central staircase extends through three levels. Vertically it connects the living room with the dining room and the library and further extends to form a gallery that leads to all the rooms on the third level. It is defined as a unique space based on its function and materiality, as well as its frame.	Lady's boudoir is a clearly articulated elevated sitting area that on one side opens toward the larger area in front of it and on the other overlooks the living room through a small "window." By frame, function, and materiality represents a unique micro ambiance.

Transitional space	*Lady's boudoir* 2
Transitional spaces are defined as separated categories, as they are not completely part of the main living space, but are neither a separate spatial unit. They usually represent a transition between the spatial units and for this reason they can also be understood as a type of connection between main spaces.	The second sitting area in the lady's boudoir is framed by the sitting arrangement, but it is open toward a larger space in front of it. Space is defined as a separate whole by its frame, function, and materiality.

In Villa Müller, despite the interconnection, the spaces are mainly volumetrically defined. Moreover, Loos applied unique decoration and materials in every interior space, by which it is distinguished from other rooms. For this reason, different ambiance zones match the spaces defined by interior walls. In several cases, the boundaries between the two spaces are ambiguous, and these areas are defined as transitional zones. The definition of individual zones with explanations is given in Table 11.

3) Identifying Types of Connections

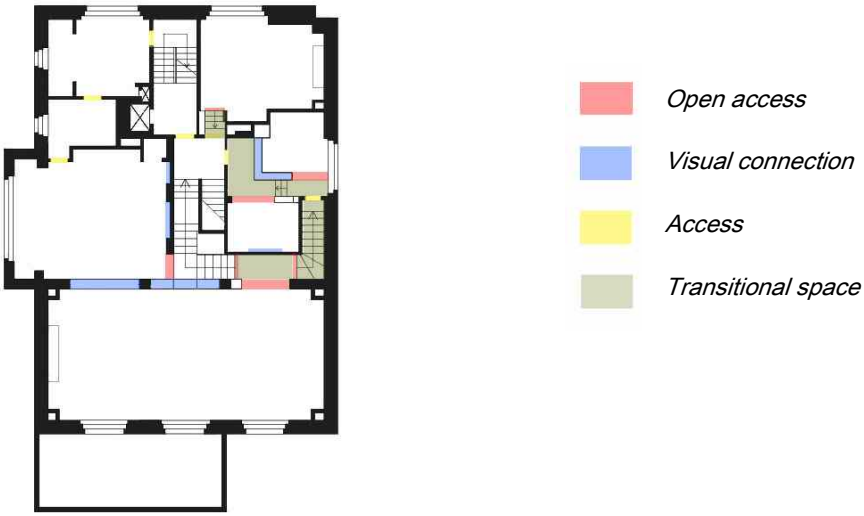


Figure 44. *Villa Müller - identifying types of connections.*

The *open access* type of connection occurs between the stairs and the living room, the main staircase, and the dining room. The entrance to the living room is framed between massive columns but allows a visual connection to the stairs that lead from the lower level. Open access connects the two separated sitting areas in the lady's boudoir with the transitional space between them (Figure 45 a).

Visual connections In Villa Müller are established between the living room and the staircase and the dining room (Figure 45 b), as well as between the dining room and the stairs through the window-like opening (Figure 50). A different type of visual connection exists between the sitting area in the lady's boudoir and the larger space in front of it.

Transitional spaces that are both a connection and a part of the space occur between the living room and the three stair entrances (Figure 45 d). This space is a part of the living room and at the same time a part of the communication. *Transitional space* appears between the two sitting areas in the lady's boudoir and the exit of the library (Figure 45 a). This space is a part of the library and at the same time marks the exit as a separate spatial unit.

The *access* type of connection links the main space with the kitchen, library, and service staircase. Doors also separate the lady's boudoir from the main stairs on one side and the little staircase that leads down to the living room on the other side.

a)

b)

c)

d)

Figure 45. *Types of connections in Villa Müller: a) open-access; b) visual connections; c) access through a door; d) transitional space.*
Source: *https://en.wikiarquitectura.com/building/villa-mueller/*

4) Creating a Topological Diagram

The topological diagram is generated by identifying the main spaces and the transitional spaces in the house as vertices and the three types of connections between them are interpreted as edges. The diagram below (Figure18) describes the structure of the villa space.

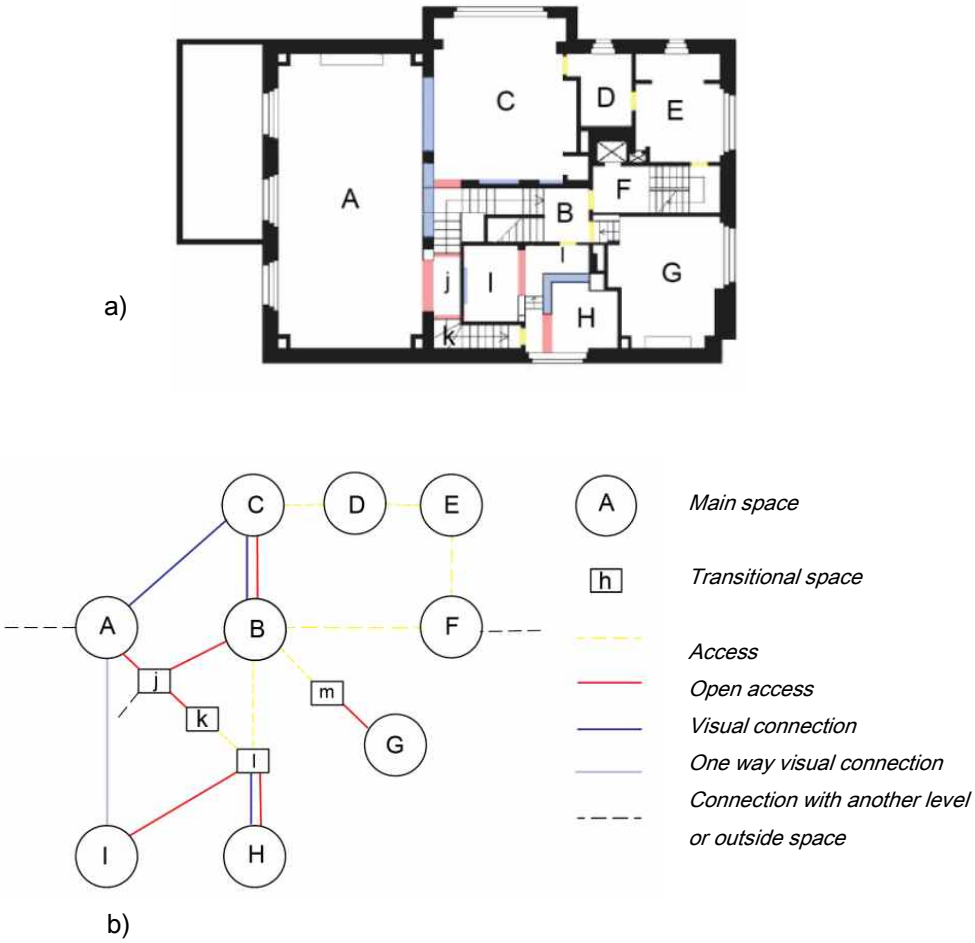


Figure 46. *Villa Müller- creating topological diagram; a) identifying spatial units and connections; b) graphic representation of the space.*

When the connections that represent traditional access to a room through a door are removed from the diagram, complex (heterogeneous) and discrete (homogenous) spaces are reviled (Figure 47).

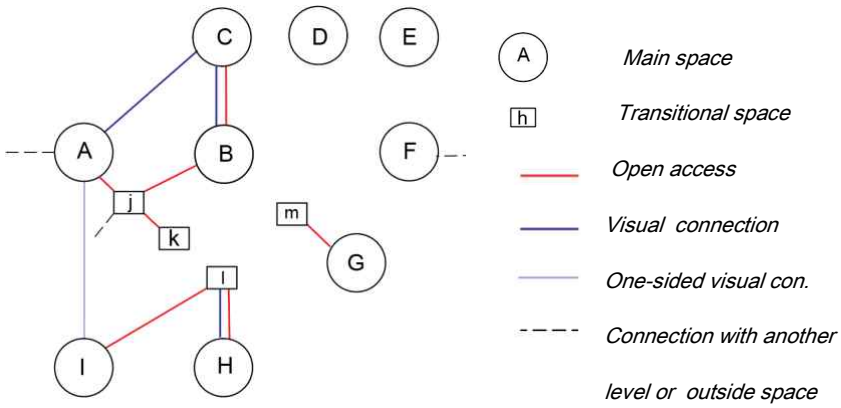


Figure 47. *Villa Müller - topological diagram of complex and discrete spaces*

Topological diagrams reveal two heterogeneous wholes. One consists of the living room, the dining room, and the main staircase (Figure 47). The other includes the transitional space and the two sitting areas in the lady's boudoir (Figure 49). These two spaces are connected by a visual connection – a window in the elevated sitting area that overlooks the living room. However, this connection is not as strong as to mingle the two ambiances into one. A third, rather insignificant, complex space constitutes the library with the small stairway at the entrance. Kitchen spaces are discrete units without connection to the rest of the floor.

5) Examining spatial connections in the context of the atmosphere

Through the connections and the disposition of spatial volumes, Loos created interiors that embody the diversity of spatial qualities that Adam Caruso describes in Villa Müller: "you are aware of moving from one atmosphere to another, from an intimate and fragile setting to a grand and representational one."[242] However, the connections that allow for open access and continuous movement through the house are not only a part of the composition that allows for this effect. The walls between the rooms that are punctured with window-like openings visually connecting spaces, also play a role as they bind functionally distinct parts of the villa into a spatial unity with a differentiated character, such as the wall between the living room and dining room or between the dining area and the stairs. Similarly, the elevated sitting area in the lady's boudoir in this house is closely articulated yet opens toward the larger space in front of it. Changing the topological structure of the space by closing any of these connections would drastically change the interior of the villa (Figure 50).

As the images show, the visual connections in the villa play an essential role in the atmosphere of space, while their function in the sense of movement and circulation is less significant. Replacing the opening with impermeable walls the atmosphere in space essentially changes (Figure 52).

[242] Adam Caruso, *Gardens of Experience* (Amsterdam: SUN, 2010), 39.

Figure 48. *Villa Müller - Work by Architect Adolf Loos, Living Room.*

Source: *@The Prague City Museum.*

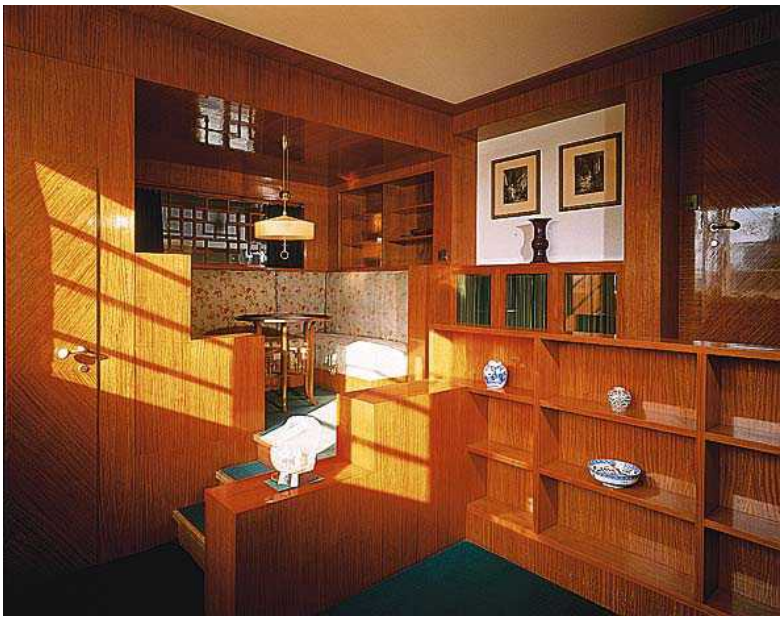


Figure 49. *Villa Müller - Work by Architect Adolf Loos, Lady's boudoire.*

Source: *@The Prague City Museum.*

Figure 50. *Villa Müller - staircase.*

Source: *https://en.wikiarquitectura.com/building/villa-mueller/*

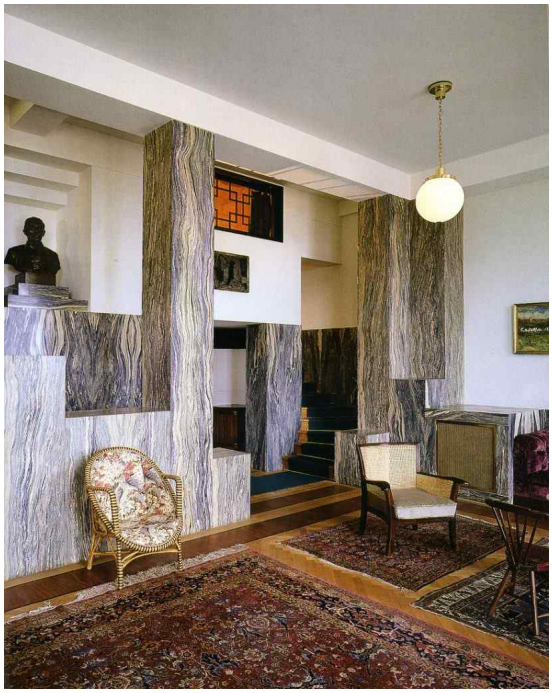


Figure 51. *Villa Müller - living room.*

Source: *https://en.wikiarquitectura.com/building/villa-mueller/*

a)

b)

c)

Figure 52. Villa Müller - changing the topological structure of space; a) closing the opening between the dining room and living room; b) removing the visual connection between lady's boudoir and the living room, open access to the living room; c) closing the "windows" between the dining room and the living room and the staircase.
Source: a) @The Prague City Museum; b) https://en.wikiarquitectura.com/building/villa-mueller/

5.3.3. Case study 3 – Philips Exeter Library, Exeter

CASE STUDY INFORMATION	TYPE OF SPATIAL COMPOSITION	ELEMENTS OF TOPOLOGY
 PHILLIPS EXETER LIBRARY YEAR 1972 PLACE Exeter, New Hampshire, USA ARCHITECT Louis Kahn	Section: a combination of the stack and hole section Plan: open plan except for few articulated spaces.	Three functionally different spaces are nested one within another. Boundaries between the layers are only implied. Open access to all library spaces. Visual connections from one section of the library to others through window-like openings.

One of the projects where Kahn used the strategy of layering space is Exeter Library commissioned by the Phillips Exeter Academy in 1965. The composition of the library, although simple, creates complex spatial relationships. Kahn designed the building so that the three different spaces are nested inside one another: the reading rooms, the book area, and the atrium in the middle. These are all three separate functional units with different patterns of use. The central hall penetrates the building to the roof. Its sides are perforated by a large circular opening that visually connects the central area with the book and reading spaces. Creating this type of composition, Khan inverted inside out the traditional library where the reading areas are placed in the middle and surrounded by book stacks on the periphery. [243] In this manner, the reading seats can have natural light,

[243] Robert McCarter, *Louis I. Kahn* (London ; New York: Phaidon, 2005), 306.

while the books are protected from it.[244] The differences between these three rings are emphasized by different materiality: the external layer of space with a brick structure, and the internal structure with concrete. The outer edge of the reading spaces is emphasized by lining up small reading carrels made of wood. Thus, “building-within-building” is clearly separated through materiality.[245]

The design of the library consisting of three rings was a subject of numerous interpretations in terms of composition, design process, light, and symbolism. Vincent Scully interpreted the library as Kahn's inspiration by Roman ruins[246] because the walls do not meet nor form corners. Much is said about the central hall, the cross on the ceiling, and the light that comes from above. John Lobell makes an observation regarding the hierarchy of spaces within the library that is interesting in the context of this study. He finds in the Exeter library a building example where the hierarchy of spaces is not incompatible with democracy. In traditional (neoclassical and classical) buildings, the importance of central spaces was more emphasized over the periphery and their importance in the structure of the building coincides with certain people or functions. In Exeter library, according to him, these differences can be “internalized into each person” bringing the richness of human complexity to the architecture.[247]

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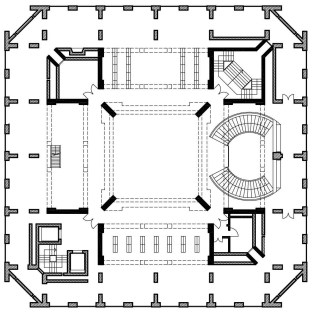
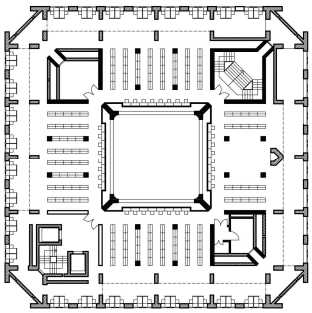
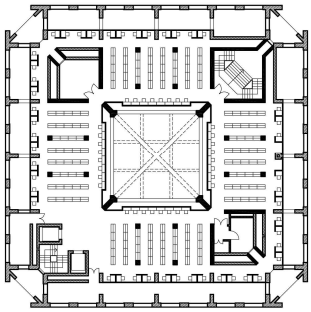
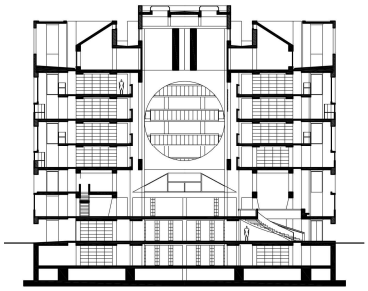
[244] McCarter, *Louis I. Kahn,* 306.
[245] McCarter, *Louis I. Kahn,* 316.
[246] Vincent Scully, “Louis I. Kahn and the Ruins of Rome,” *Engineering & Science* (1993):12.
[247] John Lobell and Louis I. Kahn, *Between Silence and Light: Spirit in the Architecture of Louis I. Kahn* (Boulder: Shambhala : distributed in the U.S. by Random House, 1979), 100.

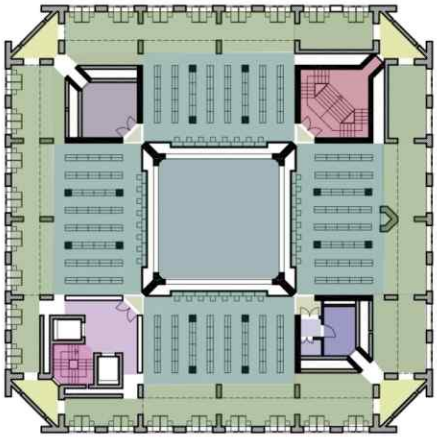
1) Identifying the Type of Composition

Table 11. *Exeter Library - Identifying the type of composition.*

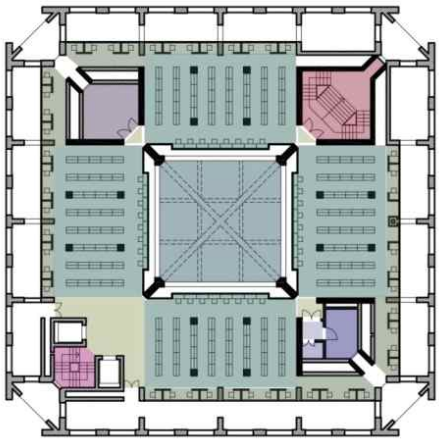
	
Level 1	Level 3, 5
Combined plan; The space of the floor is predominantly open with enclosed service spaces inside four concrete cores.	**Combined plan;** The floor is open with enclosed service spaces. The central area of the floor is penetrated vertical cut.
	
Level 4,6	Section
Combined plan; The main spaces are open with the enclosed service spaces. The central floor area is penetrated by the central hall that extends from level 1. The exterior edges recede from the exterior wall and form a gallery.	**Hybrid section: Stack + Hole;** The horizontal slabs are regular. The central hall extends from the first floor through the entire elevation of the building causing a loss of the central floor area on higher levels. There are no full-height vertical partitions except toward the outside and four cores.

Exeter library interior space can be understood as mainly open space. The only enclosed areas in the plan are service spaces placed in four vertical concrete cores. The section of the villa also displays a simple composition of stacked layers punctured with an atrium. Yet, the important compositional aspects of this building are nesting spaces and their interconnections. The effects of this type of composition are visible on levels 3-6 that are connected with the central hall through colossal circular openings. For this reason, the analysis conducted in this study focuses on floors 3-6, their mutual relationship, as well as their relationship with the central hall, with which they are connected through the circular opening.

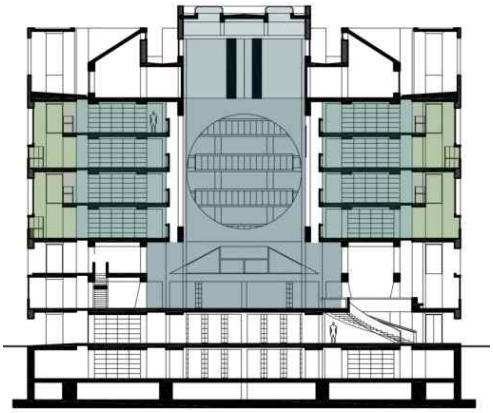
2) Identifying Basic Spatial Units



a)



b)



c)

Central hall
Bookshelves
Gallery reading area
Reading area
Corner terraces
Transitional spaces
Service spaces
Service spaces
Staircase foyer
Staircase
Staircase

Figure 53. *Phillips Exeter Academy Library - identifying basic spatial units; levels 3 and 5; b) levels 4 and 6; c) section.*

Table 12. *Exeter Library - defining main spatial zones.*

Central hall	*Bookshelves*	*Reading area*	*Gallery reading area*
The central hall is the most dominant space in the library. It extends from the first floor through the entire elevation of the building. Its boundaries are in space are clear despite this space being connected to all surrounding spaces in the building.	The bookshelves area is defined as a separate space based on its function and therefore the object in space, as the entire space is filled with book stacks. This area is only partially determined by the frame. The border between this area and adjoined reading area is only implied by the change of use and height of the ceiling, as well as the natural illumination.	The reading area is placed on the outer edge of each floor. It is marked as a single unit based on its function and spatial arrangement although it can be divided into several sub-zones. The boundaries between the reading area and the books stalks are only impaled by the way space is used as well as the height of the ceiling.	The gallery reading area represents a thin line, the edge of the book stacks. It can be interpreted as an integrated part of these spaces. However, it is defined as a separate spatial unit because of the specific use and atmosphere it attains from the natural light and the relationships it has with the lower-level reading area.
Transitional spaces	*Corner terraces*	*Staircases*	*Service spaces*
Transitional spaces in Exeter library are marked as a point of joining the three different spatial units: two book stack areas and service/staircase zones.	These are exterior spaces places on the corners of the building and connected to the reading areas.	Staircases are defined as separate spatial units as they are closely framed within concrete cores. They are discrete spaces with distinguished functions and extend through the entire height of the building.	Service spaces are placed in n the concrete cores and moved to the periphery. They are defined as separate spatial units based on their function and frame.

The analysis of interior spatial units shows that the main spaces mainly coincide with the three rings of nested spaces. However, the outer rings are divided by vertical cores into smaller spaces. Furthermore, there are differences within each of these spatial units, especially in the arrangement of the reading areas. These differences are neglected in the analysis focused on the relationships between the three rings of the nested spaces and the effects these connections create in the interior atmosphere. The atmospheric wholes, therefore, mostly coincide with the functional zones, in which differences are emphasized through the application of different materials and illumination. The list of the atmospheric wholes within the building together with explanations is given in Table 13.

3) Identifying Types of Connections

In the interior of the library, there are all three types of connections that this study considers. In addition, the spaces that are at the same time a connection and a part of the main spaces are defined as transitional zones.

The *open access* type of connection occurs between the book stacks and the reading areas. It is not framed as a passage or entrance, nor can it be exactly positioned. It is only implied by the change or the use of the place and the height of the ceiling. In this, a smooth transition between spatial qualities can be observed.

The most important and most prominent *visual connections* in the library are established through colossal circular openings that connect the book areas on every floor with the central hall. *Visual connections* also exist between the reading area on the galleries and the lower reading areas. However, this type of visual connection is only one-sided.

Transitional spaces in the library mark the meeting point of the main spaces with the service zone. These are rather small portions of space that do not belong clearly to any of these spaces. Another way to understand them is as patches that connect the four bookstall areas into a continuous ring.

The *access* type of connection appears between the reading areas and the corner balconies, as well as at the entrance of the main spaces. Other spaces within the building are separated by compositional aspects and specific spatial arrangements.

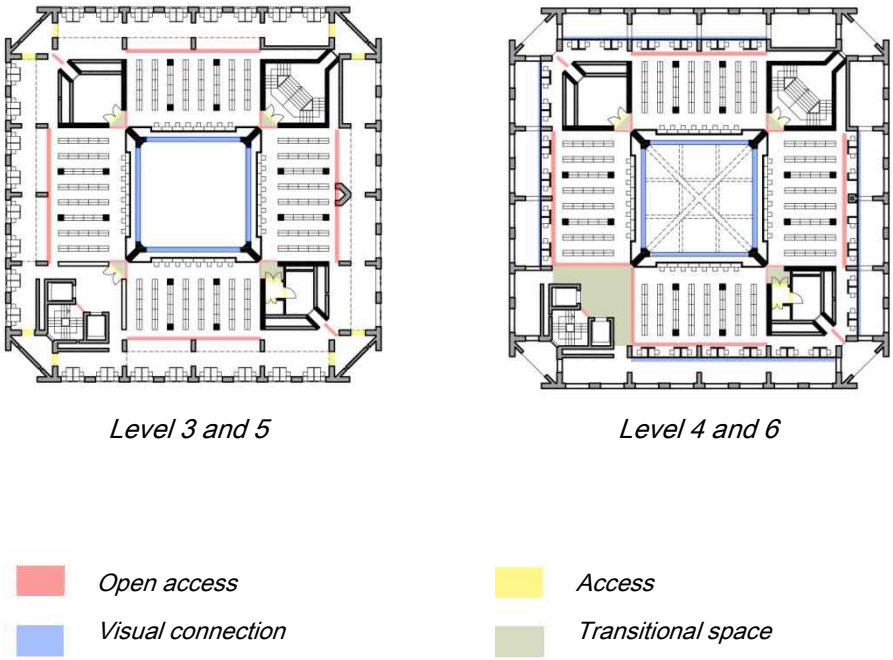


Figure 54. *Exeter Library - identifying spatial connections.*

a)

b)

c)

d)

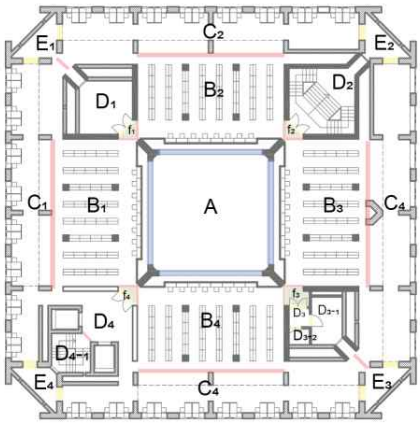
Figure 55. *Types of connections in Exeter Library: a) open access; b) visual connection; c) transitional space; 4) access.*

Sources: *a) The Architectural Review, https://www.architectural-review.com/buildings/library/phillip-exeter-library-in-new-hampshire-usa-by-louis-kahn ; b) http://architecture-history.org/architects/architects/KAHN%202/OBJECTS/1965,%20Phillips%20Exeter%20Academy%20Library,%20New%20Hampshire,%20USA.html.*

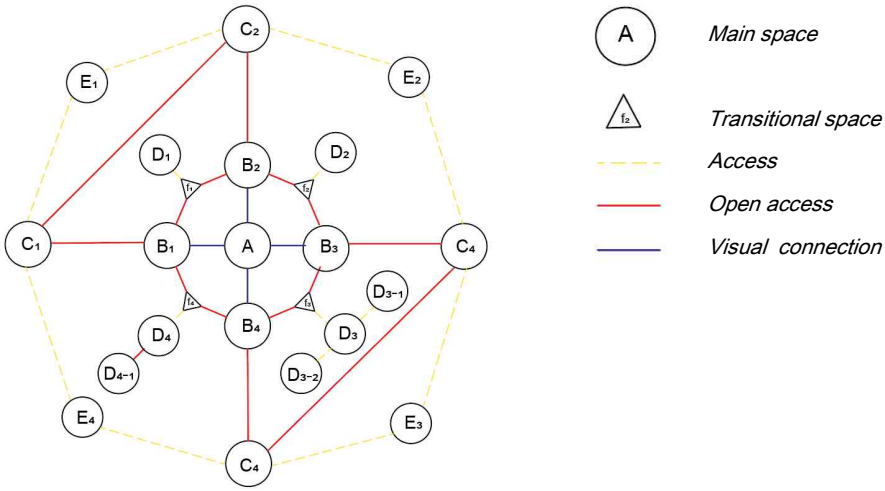
4) Creating Topological Diagrams

Topological diagrams are created in the same manner as in the previous studies – transforming the spaces into nodes and connections into the edges. In addition, a topological diagram of the section was created to depict the vertical relationships between spaces. It is worth noting that in the

plan of the Exeter library only a few spaces are accessed through a closed door, thus, almost the entire building constitutes a complex heterogeneous whole.



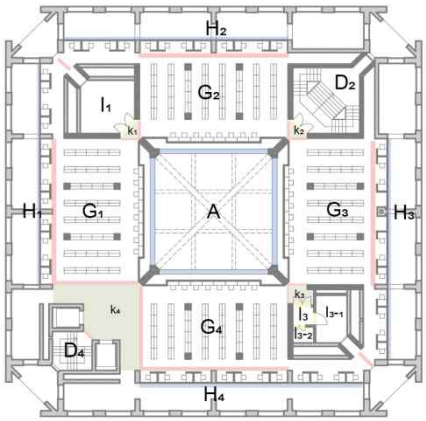
a)



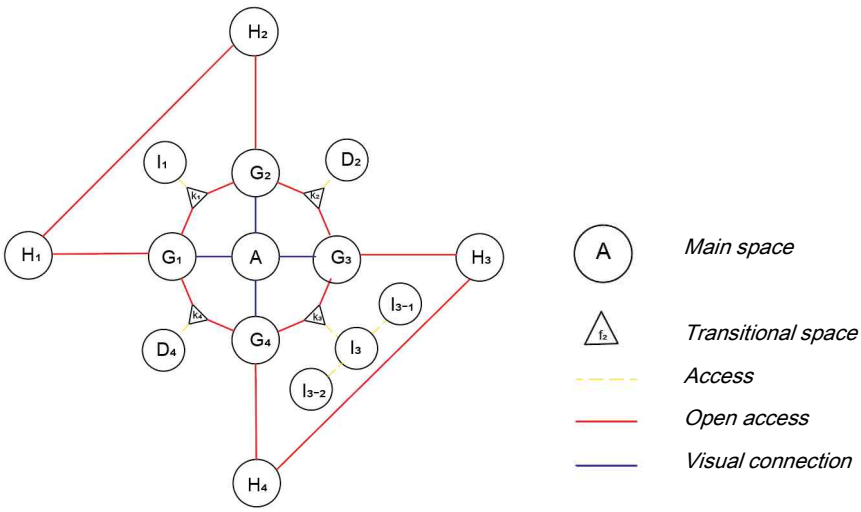
b)

Figure 56. *Exeter Library - creating the topological diagram, levels 3 and 5; a) identifying spatial units and connections; b) graphic representation of the space.*

a)

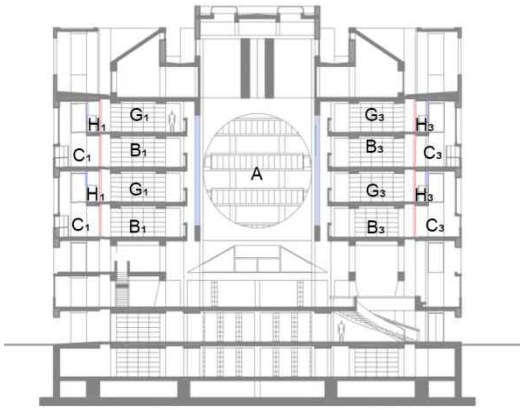


a

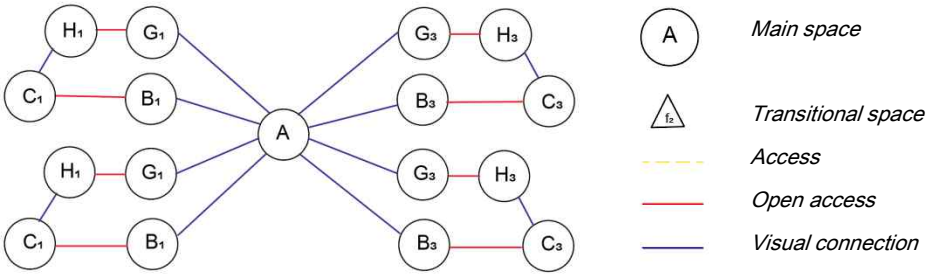


b)

Figure 57. *Exeter Library – creating the topological diagram, level 4 and 6; a) identifying spatial units and connections; b) graphic representation of the space.*

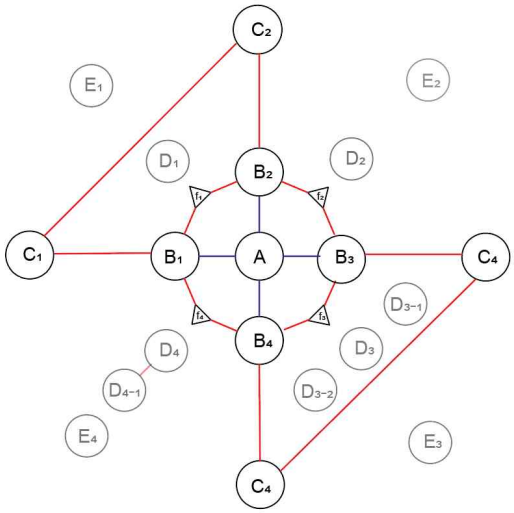


a)

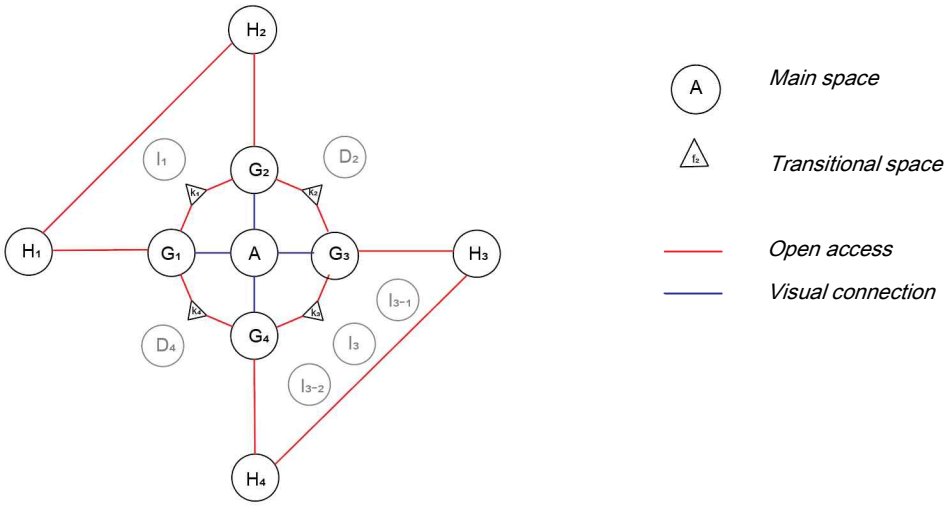


b)

Figure 58. *Exeter Library - creating the topological diagram – section; a) identifying spatial units and connections; b) graphic representation of the space.*



a)



b)

Figure 59. *Exeter Library - topological diagram of complex and discrete spaces; a) Level 3 and 5; b) level 4 and 6.*

5) Examining spatial connections in the context of the atmosphere

The topological diagrams reveal that all the spaces on each floor (apart from the service spaces enclosed in the cores) constitute a heterogeneous whole. The central hall, as well the receding horizontal slabs that form galleries, allow these separated floors to connect. The tools of Kahn's composition that enabled these connections are nesting spaces, sectional movement, and enabling visual connections.

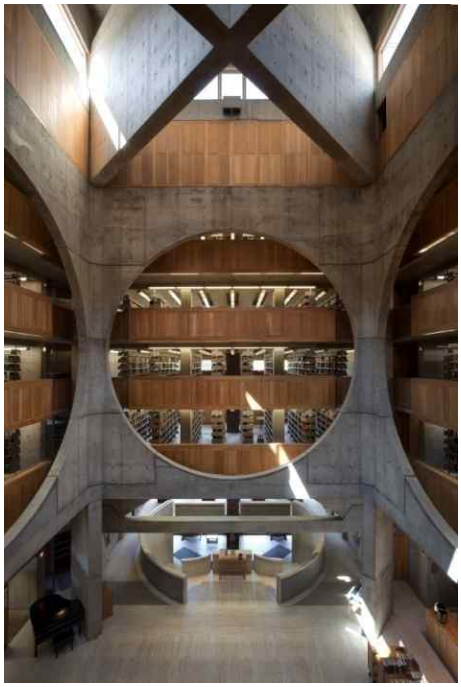


Figure 60. *Exeter Library – central hall.*
Source: *https://commons.wikimedia.org/wiki/File:Exeter_library.jpg*

The question of what kind of impact these connections have on the ambiance of space arises. The sheets of concrete that separate this central area from the book stalks, perforated with large circular openings, have no structural role as they are floating free, detached from the balconies. These

circular openings do not give the possibility of access nor do they play a role in the illumination of the space, yet they unite the different characters of spatial volumes into a heterogeneous whole. Through these connections, smaller and more intimate spaces are visually connected to the more public ones. Hereby, the library interior embodies a single ambiance, which qualities gradually change from one space to another. The importance of these perforated walls – the visual connections – in generating the heterogeneous character of this space is irrefutable. The library interior would have a very different character if these spaces were separated by solid walls. Changing the topological configuration of the space changes the ambiance of the interior. This can be seen in Figure 63, where the photographs of the interior are edited to illustrate the closing of these connections.

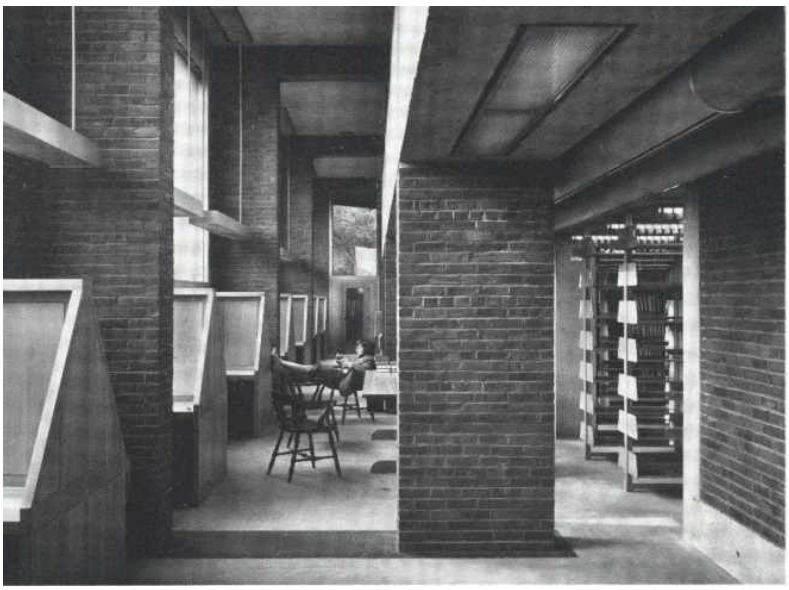
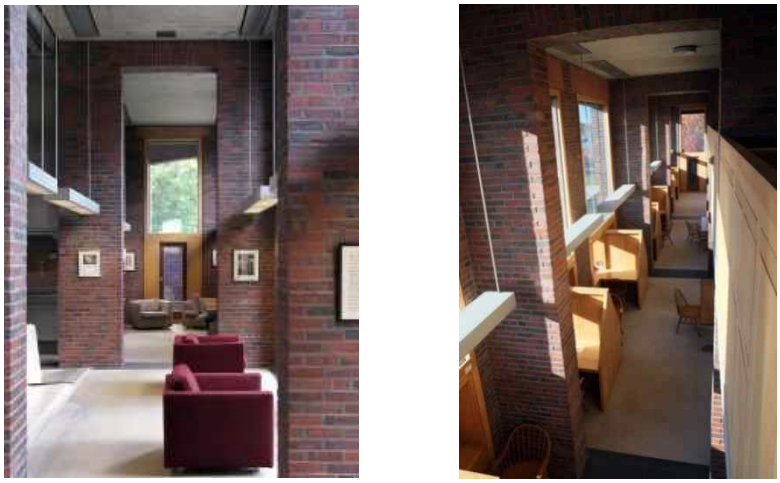


Figure 61. *Exeter Library - reading area.*
Source: *The Architectural Review, https://www.architectural-review.com/buildings/library/phillip-exeter-library-in-new-hampshire-usa-by-louis-kahn*

Another peculiar relationship occurs between the book stacks and the reading area (Figure 61). It is difficult to find the exact boundary between these two zones. They are not separated yet the difference between them is obvious. The composition plays an important role in this peculiar connection (the height of the ceiling changes) as well as the furniture (the way space is used), and the amount of natural light. Several places on this imaginary line that separates these two zones are ambiguous and might be interpreted as a part of either of them. However, they are all part of the same spatial volume where boundaries are only implied, and differences are constant.

It is worth noting that understanding Exeter library building through these three functional rings is still a simplification. Smaller differences that exist in each of these zones were neglected when determining basic spatial units. For example, the reading area can be divided into several sub-zones with different kinds of seats that create a different atmosphere (Figure 62). The quality of the interior space is in constant change.

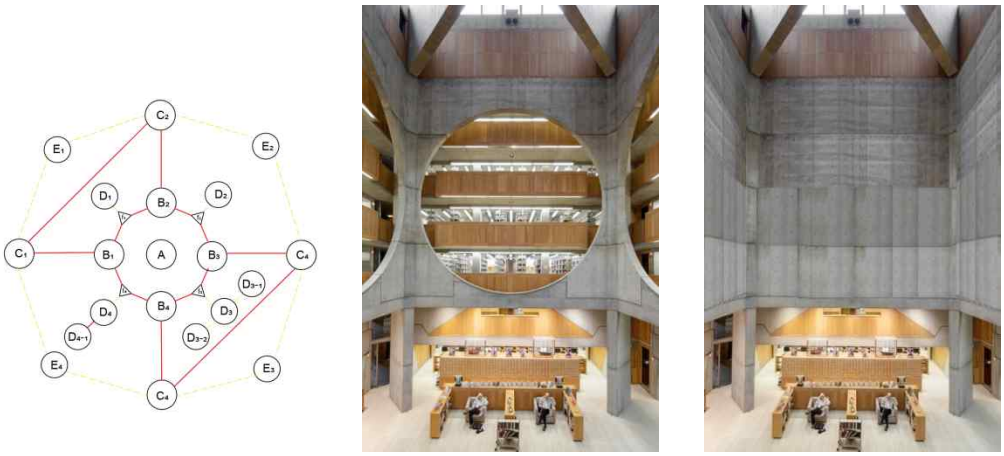


a) b)

Figure 62. *Exeter Library - reading area.*

Source: *a) https://www.flickr.com/photos/wdb3b/6290097923/ ; b) https://commons.wikimedia.org/wiki/File:Phillips_Exeter_Academy_library_carrels_1.jpg*

a)



b)

Figure 63. *Exeter Library - changing the topological structure of space; a) closing the opening between the book stacks and the central hall; b) closing the opening in the central hall.*

Source: *a) http://architecture-history.org/architects/architects/KAHN%202/OBJECTS/1965,%20Phillips%20Exeter%20Academy%20Library,%20New%20Hampshire,%20USA.html*

b) https://www.flickr.com/photos/scottnorsworthy/14208186683

5.3.4. Case Study 4 – Hurva Synagogue, Jerusalem (unbuilt)

CASE STUDY INFORMATION	TYPE OF SPATIAL COMPOSITION	ELEMENTS OF TOPOLOGY
 HURVA SYNAGOGUE YEAR 1968-74 (Unbuilt) PLACE Jerusalem, Israel ARCHITECT Louis Kahn	Section: complex section - shape, and sheer. Plan: spaces are open with some indication of the enclosure.	The spaces between the galleries and the gallery itself create vague differences between the spatial volumes both vertically and horizontally. These volumes are all part of a unified whole.

Hurva Synagogue is one of Kahn's projects that embodies the complexity of spatial relationships, communication, and the nesting of spaces. The project was commissioned from Kahn in 1967 to be built in the place of an older synagogue ruin (Hurva in Hebrew means a ruin). By 1974 he designed three versions of this project, but the building was never realized. Hurva Synagogue was investigated in relation to Kahn's design process, as well as the historical and cultural context. The synagogue design stands out as a building that does not have a common synagogue design for its time, nor is it a completely modern building.[248] The design of the composition as well as the evolution of the design through three different projects were a result of Khan's investigation of the history of Jewish architecture, the synagogue location, and Jewish sacred service.[249] Its value has also been examined in

[248] Dana Margalith *Tradition As Mediation: Louis I. Kahn,: The Dominican Motherhouse and the Hurva Synagogue* (Taylor & Francis Group, 2018), 119.
[249] Margalith, *Tradition As Mediation,* 121.

the context of the formation of the national Jewish style in architecture.[250] Despite its historical and political context, the synagogue design was aimed toward the experience of space.[251] Since the building was never built, it was difficult to discuss its spatial qualities until it was 3D visualized by Kent Larson. Larson published 3D visualizations of the synagogue in his book together with other unbuilt Kahn's works. [252] The visualizations of all three versions of the building testify to Kahn's skillful manipulation of the light. [253]

This study examines the 1968 proposal of the synagogue and its 3D visualization that gives a close idea of how it would have looked if it had been built. In this project, the outer edge of the synagogue is defined by sixteen hollowed pillars. Kahn borrowed the idea of hallowed walls from Scottish medieval castles and previously had used this strategy in some of his projects to place the service spaces. Using hollowed pillars, he created complex "walls" that embody small spaces. These spaces open toward the interior space of the synagogue. Inside the synagogue, there are four more "pillars" that support the balconies and the ceiling. These "pillars" are also hallowed and punctured with openings on all four sides. These openings are large enough to enable circulation through the"pillars." These compositional elements are not necessary in the functional sense, but their use enabled Kahn to closely define smaller portions of space while they remain an open and integral part of the main space interior.

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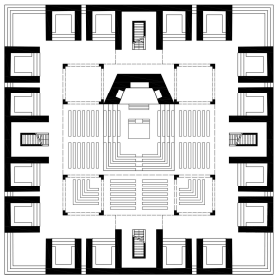
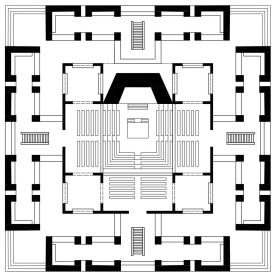
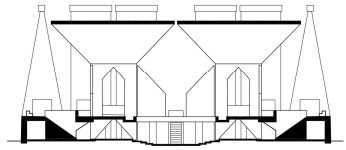
[250] Yasir Mohammed Sakr, *The Subversive Utopia: Louis Kahn and the Question of the National Jewish Style in Jerusalem* (Doktoral disertatio University of Pennsylvania 1996).
[251]AlonaNitzan-Shiftan, "On Concrete and Stone: Shifts and Conflicts in Israeli architecture," *Traditional Dwellings and Settlements Review* (2009):56.
[252] Kent Larson and Louis I. Kahn, *Louis I. Kahn: Unbuilt Masterworks* (New York, NY: Monacelli Press, 2000).
[253] Larson and Kahn. *Unbuilt Masterworks,* 147.

1) Identifying the Type of Composition

Table 13. *Hurva Synagogue - identifying the type of composition.*

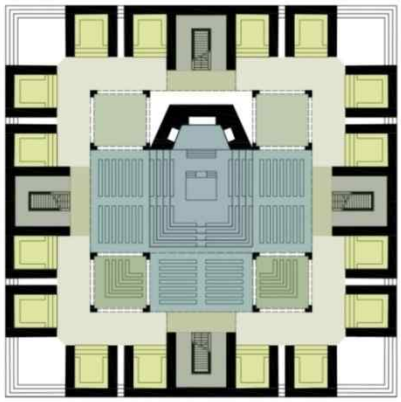
		
Level 1	Level 2	Section
Combined plan; The plan of the synagogue is essentially an open space bordered with sixteen hollowed pylons. These *poché* spaces are only partially enclosed as they open toward the main space.	**Combined plan;** The plan of the second level consists of enclosed spaces inside the pylons that connect with the central gallery. The spaces of the gallery are bordered by four hollow columns and concrete panels, thus despite being widely open toward the main space they negotiate between enclosure and openness.	**Complex section;** The complex sectional composition of the synagogue cannot be placed in any of the typical section categories. However, if the lined up pylons are interpreted as exterior walls, and four hollowed columns as simple columns that carry the ceiling space can be interpreted as a unique volume. The section can be interpreted as a shear section due to the gallery, and a shape section due to a peculiar four-part roof.

The interior of the synagogue consists of a series of smaller spatial units that negotiate between enclosure and openness. The second level consists of galleries that surround the central space and also extend along the external edge of the building. For this reason, the section can be understood as a shear type of section. However, due to the particular shape of the ceiling and the envelope of the building the section is a combination of shear and shape types. As spatial relations that are of interest for this study

(interconnecting and nesting spaces) appear in the whole body of the synagogue, the study will analyze the building in its entirety.

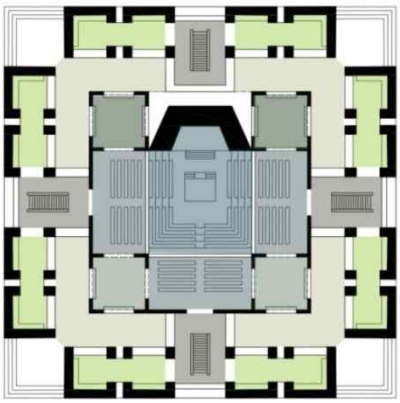
2) Identifying Basic Spatial Units

a)

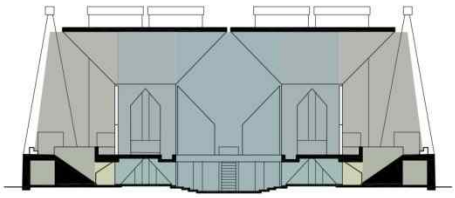


Hollow pylons
Circulation space
Transitional space
Staircase
Hollow columns
Hollow column/ sitting
Sitting area
Central space

b)



Hollow pylons/gallery
Hollow column/gallery
Hollow column/gallery
Gallery sitting
Central space
Staircase



c)

Figure 64. *Hurva Synagogue - identifying basic spatial units; a) level 1; b)level 2; c) section.*

Table 14. *Hurva Synagogue - classification of the spatial units.*

Hollow pylons	*Circulation space*	*Transitional space*	*Staircase*
The spaces inside hollowed pylons are defined as separate units as they are closely defined despite being open toward the main space.	Circulation space is generated between the lined-up pylons and inside columns connected by the galleries.	Transitional space is in the s This space can be interpreted as a part of the staircase, part of the circulation, or a connection between them.	Space between the two middle pylons on all four sides of the synagogue that contains a stairway.
Hollow columns	*Hollow columns /sitting*	*Sitting area*	*Central space*
Spaces inside hollow columns; These spaces are open on all four sides. The columns flank the sitting area.	The space inside the hollow columns that contain sitting benches and connects in this manner connects the three sitting platforms in a continuous whole.	Sitting area refers to the spaces flanked between the wide columns with the sitting arrangement. These spaces are open on all four sides but are clearly framed as they are placed under the gallery.	Central space is the largest space in the synagogue and it extends through the entire elevation. The specific ambiance is produced by its frame, objects in space, as well as the illumination from the ceiling.
Gallery sitting	*Hollow columns gallery*	*Staircase/ gallery*	*Hollow pylons /gallery*
The sitting areas on the gallery are flanked between the wide columns. These spaces open widely toward the central area, while they are separated from the stairway by concrete panels.	Spaces inside hollow columns on the gallery level; These spaces are open on all four sides either as a passage or as a "window."; They connect the three parts of the gallery setting.	These spaces connect the sitting gallery with the spaces inside hollow columns and are the place of stairway upper landing.	On the gallery level, the spaces inside pylons connect into a continuous space extending toward the gallery. These spaces are also overlooking the interior of the synagogue through window-like openings.

The spaces in the synagogue were classified based on their frame and partially on their function. However, it is clear that that they are closely interconnected and that boundaries between them are not sharp, as none of the spaces is entirely enclosed. This creates difficulty to precisely define spaces. For example, the space that connects the sitting area with the staircase can be read as a connection, as a part of the staircase space, or as a part of the circulation space, and for this reason, it is marked as a transitional space. Classification of spatial zones with explanations is given in Table 15.

3) Identifying Types of Connections

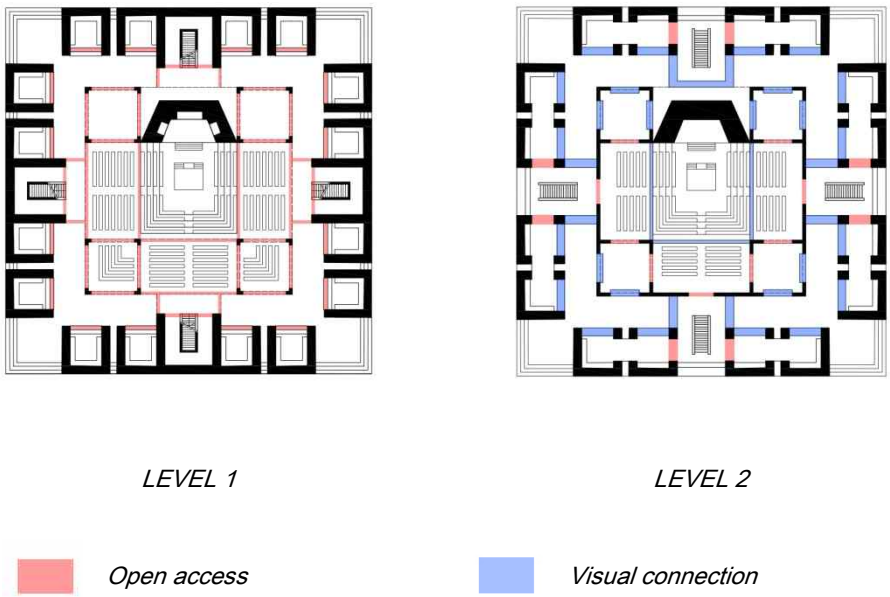


Figure 65. *Hurva Synagogue - identifying types of connections.*

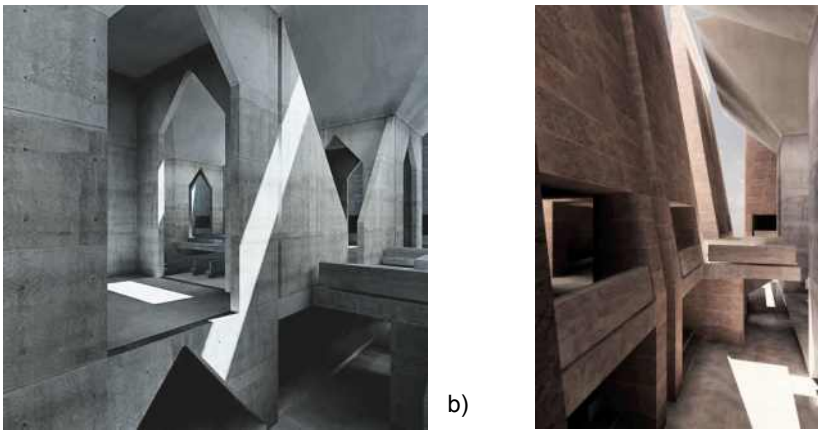
There are no doors in the interior of the synagogue. All spaces are accessed through an open entrée. These have several variations from cased openings that connect the galleries with the interior of the columns to the cuts in concrete panels between the gallery space and the staircase and the triangle-shaped openings that lead inside hollowed columns on the lower level.

Purely visual connections that do not allow for access are present on the hallow pillars on the gallery levels. These “windows” are overlooking the circulation space and extend the view toward the central part of the synagogue. Another type of visual connection appears between the space inside the hollow columns and the surrounding space on the sides of the columns that are not connected to the gallery. The visual connections are marked only if adjoined volumes share such a connection. Open views to non-adjoined spaces are not considered.

a)

b)

Figure 66. *The open access between spaces in Hurva Synagogue: access from the staircase to the gallery; b) the opening between the hollowed column and the gallery.*

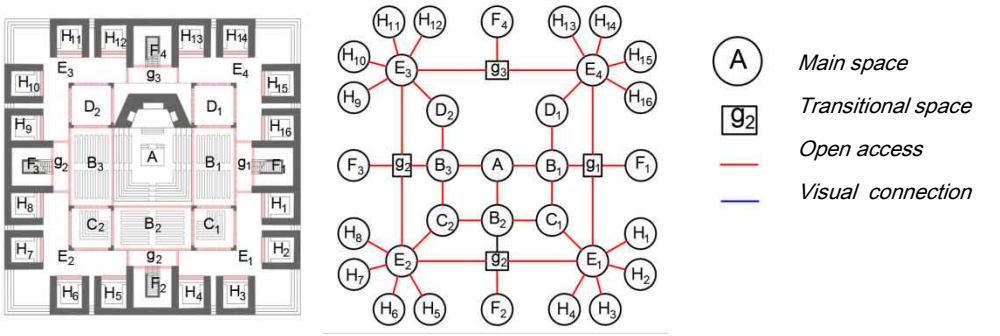


a) b)

Figure 67. *Visual connections in Hurva Synagogue: a) sides of hollow columns opened toward the central space; b) outer pillars open toward circulation area.*

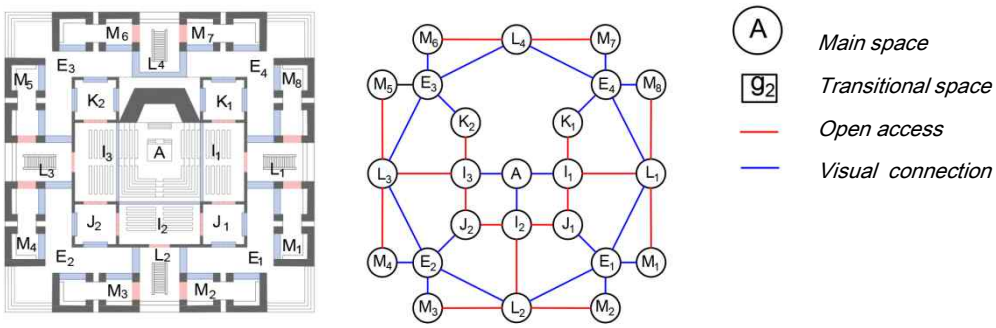
4) Creating Topological Diagrams

In topological diagrams of the synagogue, the spatial units are interpreted as vertices and connections as two types of edges. Apart from the diagrams of the ground plan and the gallery plan, a topological diagram of the section was created. The three diagrams represent an interpretation of spaces in the plan and the section merely for a clear representation of spatial relations. It is possible to create a spatial diagram that includes all the spaces in the building on both levels. The topological diagrams reveal that the interior of the synagogue is a unique complex space that incorporates a number of smaller spaces.



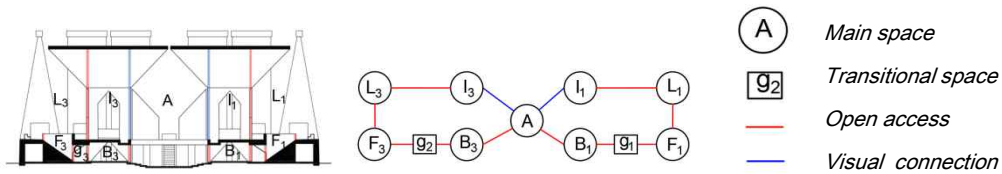
a) b)

Figure 68. *Hurva Synagogue - creating topological diagram LEVEL 1; a) identifying spatial units and connections; b) graphic representation of the space.*



a) b)

Figure 69. *Hurva Synagogue - creating topological diagram LEVEL 2; a) identifying spatial units and connections; b) graphic representation of the space.*



a) b)

Figure 68. *Hurva Synagogue - creating topological diagram SECTION; a) identifying spatial units and connections; b) graphic representation of the space.*

5) Examining spatial connections in the context of the atmosphere

The topological diagrams reveal that the entire body of the synagogue is a heterogeneous whole – a unique space composed of several smaller spaces. This is achieved through visual and access connections in the composition emphasized by the sectional movement. As a consequence, the whole building, as well as its parts, negotiate between enclosure and openness and between inside and outside. Galleries (intended for women who attend the religious service) are a part of the main space, yet they encompass a different ambiance. The connections between spaces are more prominent than they are in the Exeter Library. The interior body of the synagogue is without a doubt a single whole, yet its parts radiate different characters, different quality of light, and levels of intimacy. Thus, despite its unified character, it is far from fluid and open space.

Figure 69. *Hurva Synagogue- model section.*
Source : *http://documenta-akermariano.blogspot.com/2011/03/louis-kahn.html*

What allowed for the creation of these kinds of spatial relationships and effects in spaces is the layout. Although very simple the plan is enriched

by a few simple interventions. This is primarily extending and hollowing of the four central columns in a way that not only a new space is created inside each column, but also the unique volume of the interior is divided into smaller segments. Their size, shape, and disposition define the area of communication on the outside, the central space with bimah on the inside, and the sitting area between them. This type of composition allows creating of divisions without physically dividing space. Vague boundaries between these parts are the main instrument to create a heterogeneous whole.

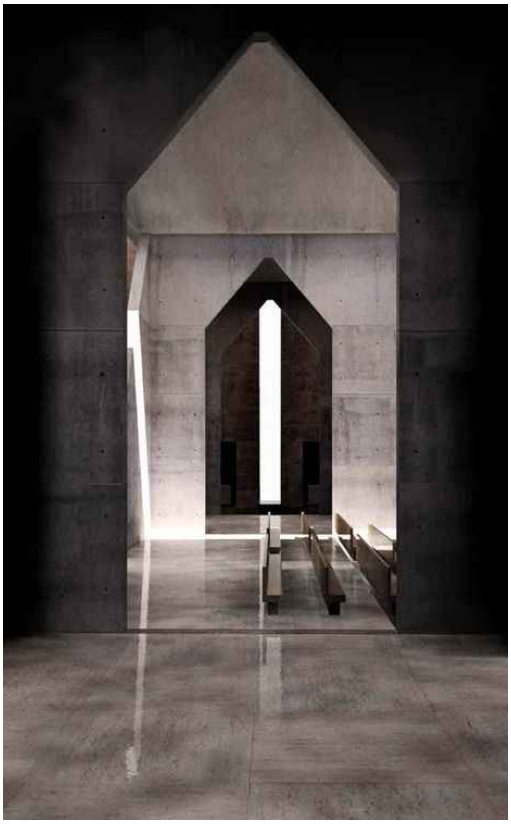


Figure 70. *Hurva Synagogue- gallery (model).*
Source: *https://israel-tourguide.info/2011/01/23/hurva-synagogue/*

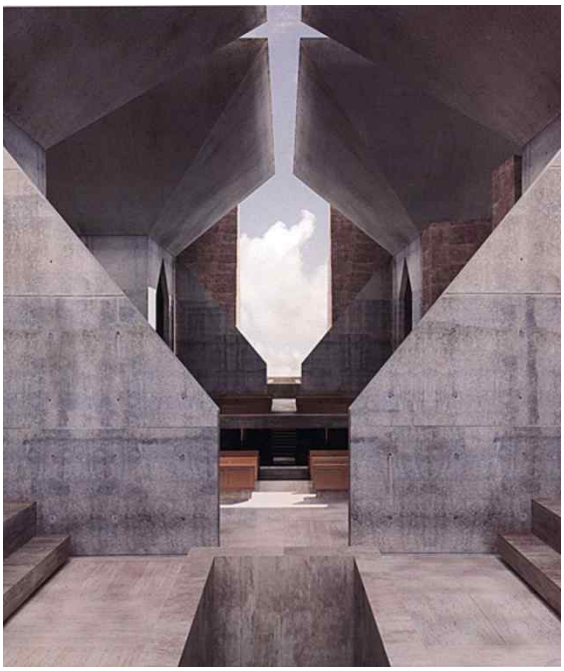


Figure 71. Hurva Synagogue – entrance to the gallery.

Source: *http://documenta-akermariano.blogspot.com/2011/03/louis-kahn.html*

Figure 72. *Hurva Synagogue – staircase exit.*

Source: *https://intarch.ac.uk/journal/issue8/eiteljorg/eit1.html*

Figure 73. *Hurva Synagogue- circulation space with hollow pylons overlooking the central space.*

Source: *https://scandinaviancollectors.com/post/159037311340/louis-kahn-hurva-synagogue-jerusalem-israel*

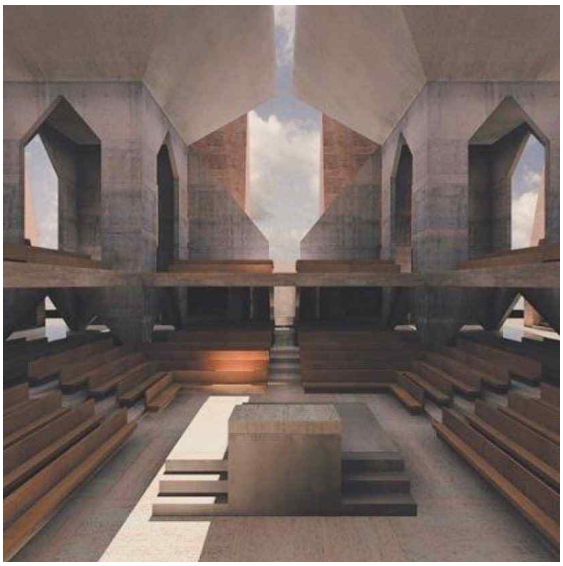


Figure 76. *Hurva Synagogue - central space.*
Source: *https://www.pinterest.es/pin/698550592175315348/*

Figure 77. *Hurva Synagogue - hollow columns.*
Source: *https://israel-tourguide.info/2011/01/23/hurva-synagogue/*

5.3.5. Case Study 5 – Jussieu – Two Libraries, Paris

CASE STUDY INFORMATION

JUSSIEU – TWO LIBRARIES
1992 (unbuilt)
PLACE
Paris, France
ARCHITECT
OMA – Rem Koolhaas

TYPE OF SPATIAL COMPOSITION
Section:
Complex section:
Incline + stack + hole;
Plan: open plan (with a smaller number of articulated spaces).

ELEMENTS OF TOPOLOGY
The building is conceived as a series of spaces that are experienced through a continuous movement from the ground to the top.
There is no vertical division between different spaces – the access is open.
The due to the slits that are consequences of the slabs' inclination and openings in the slabs, visual connection between different levels is enabled.

Jussieu library project by OMA is a 1992 competition-winning project that was never built. The project was designed for Jussieu Campus in Paris. Although unbuilt, it is present in literature as one of the groundbreaking projects. The competition brief predicted the design of two libraries, however, OMA placed both into a single building. Although the library is a vertical project, spaces in the interior are not stalked on horizontal planes but are arranged on a continuous folded plane that extends from the lowest level to the roof. It is the first project where topological geometry was used in the design of the interior. [254]As the slabs of different

[254] Ilka Ruby and Andreas Ruby, *Groundscapes: El Reencuentro Con El SueloEn La ArquitecturaContemporánea ; the Rediscovery of the Ground in Contemporary Architecture* (Land & Scape Series 5. Barcelona: Gustavo Gili, 2006), 26.

levels are manipulated to connect, they form a unique trajectory. This path continues on the urban landscape in the indoor space and creates a sort of "a wrapped interior Boulevard."[255] The spaces inside are designed as urban landscapes as well. Cafes, parks, plazas, and shops arranged along the boulevard constitute an interior urban landscape.[256] This idea renders the Jussieu project a turning point in architecture.[257] The project explores how a university space can become a public space. This idea carries a political dimension as a critique of the modernist architecture of the Jussieu Campus built in the 1960s.[258] The library project demonstrates how a building can be composed using landscape strategies. Design concepts of several contemporary architectural works that encompass a free section can be traced back to this project.[259]

The landscape is not only present in the manipulation of the "multifold floor" but also in the connection of the library with the surrounding streets. OMA's project for the Jussieu library is placed at the intersection of two crossing platforms. OMA originally proposed access to the building on two levels from two different platforms, across partially internal ramps. In this way, the building integrates circulation from the surrounding area on multiple levels losing the datum plane. Moreover, other levels are only vaguely determined as the interior of the library incorporates several

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[255] OMA,"Jussieu Two Libraries," Office of Metropolitan architecture, accessed June 10, 2021, https://www.oma.com/projects/jussieu-two-libraries.
[256] Rem Koolhaas, Bruce Mau, Jennifer Sigler, Hans Werlemann and Office for Metropolitan Architecture, eds. *Small, Medium, Large, Extra-Large: Office for Metropolitan Architecture, Rem Koolhaas, and Bruce Mau*. New York, N.Y: Monacelli Press, 1995), 1326.
[257] Daniel Jauslin, *Landscape Strategies in Architecture* (Delft: BK Books, 2019), 141.
[258] Jauslin, *Landscape Strategies in Architecture* , 142.
[259] Jauslin, *Landscape Strategies in Architecture* , 142.

slopped planes and stepped levels.[260] Due to the distortion of the section created by shafts and ramps, Eisenman interprets OMA's Jussieu project as a critique of the Dom-Ino diagram where the spaces are stacked and suggest a horizontal extension of Cartesian space.[261] The layers of discontinuous horizontal elements that build the Dom-Ino structure, in the Jussieu library project are replaced by a continuous horizontal folded plane with almost no vertical divisions. The plane is malleable, pliable, and unrelated to the ground.[262] OMA started this idea of the folded plane in the project for Convention Center in Agadir and continued in the Jussieu library. According to Eisenman, this project, just like the Très Grande Bibliothèque (OMA's competition project for French national library 1989), uses the strategy of the void. The void here is not created like in Très Grande Bibliothèque, where the spaces are carved out from the solid block, but it is a kind of inverted poché. These voids/slits appear because of the movement of the horizontal slabs.[263] In the competition model, the voids are emphasized as gray solids. These voids enable a voyeuristic gaze between different spaces revealing hidden elements.[264]

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[260] Jauslin, *Landscape Strategies in Architecture* , 150.
[261] Peter Eisenman and Ariane Lourie Harrison, *Ten Canonical Buildings 1950-2000* (New York: Rizzoli : Distributed to the U.S. trade by Random House, 2008), 216-17.
[262] Eisenman and Harrison, *Ten Canonical Buildings,* 205.
[263] Eisenman and Harrison, *Ten Canonical Buildings,* 207.
[264] Eisenman and Harrison, *Ten Canonical Buildings,* 202.

Figure 74. *Jussieu - Two Libraries - exterior – 3D visualization.*
Source: *WAX Architectural Visualizations, https://www.behance.net/gallery/9347955/Jussieu-Two-Libraries*

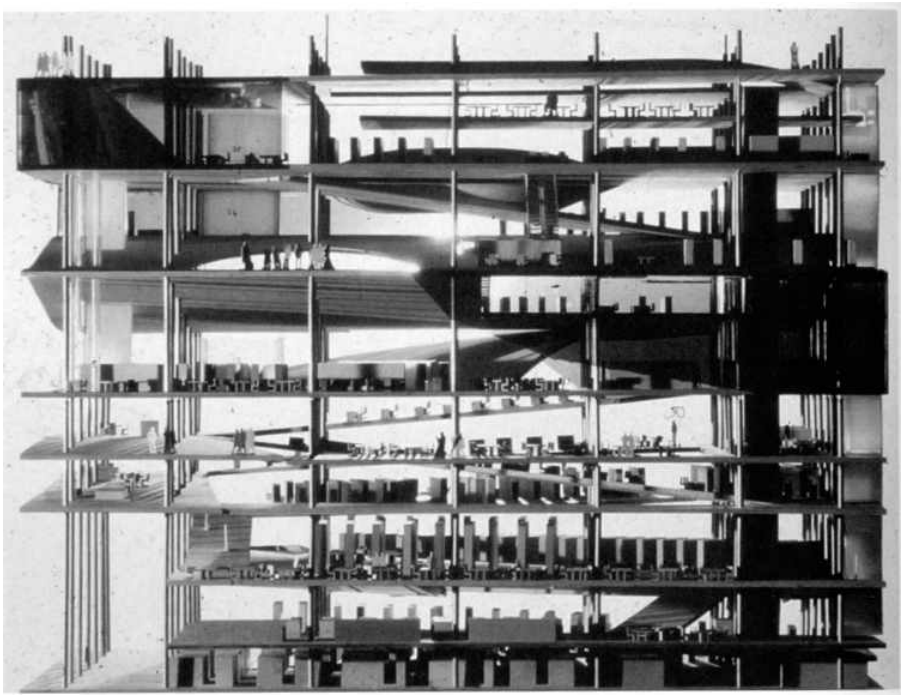
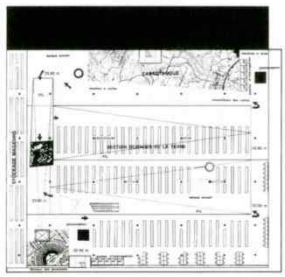
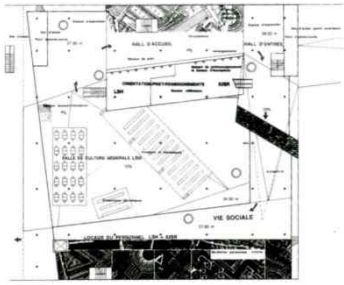
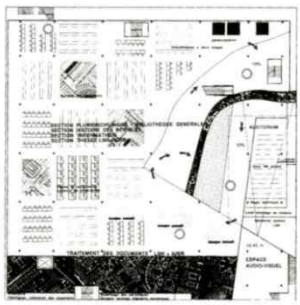
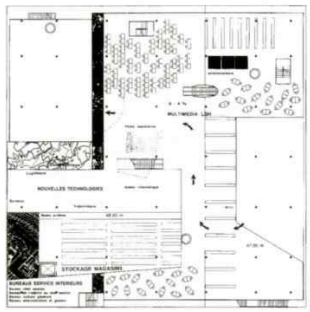


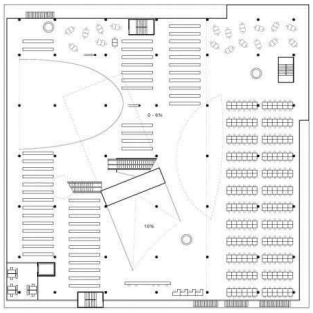
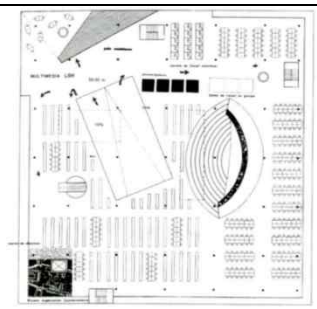
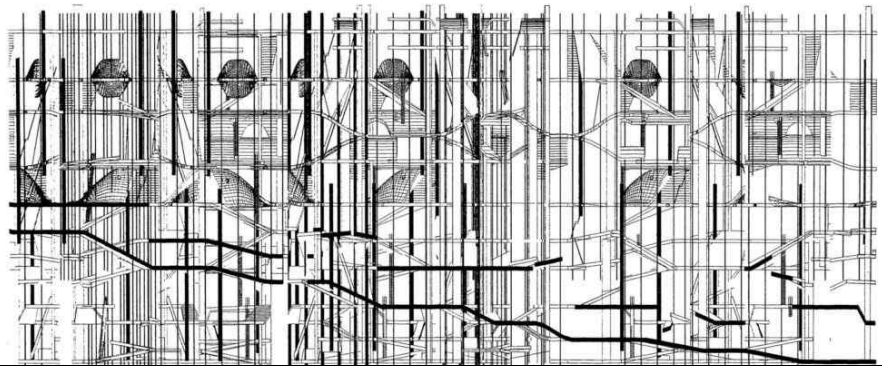
Figure 75. *Jussieu - Two Libraries - competition model.*
Source: *Eisenman and Harrison, Ten Canonical Buildings, 200.*

These visual connections enabled by the overall composition, as well as the sectional movement, make the Jussieu library a relevant case study for the proposed idea of heterogeneous space. This project differs from previous case studies because spaces are almost completely open. There are no vertical divisions between spaces. The focus of the project is the sectional movement that simultaneously creates boundaries and connects spaces.

1) Identifying the Type of Composition

Table 15. *Jussieu Two Libraries - identifying the spatial composition.*

	
Level -2	Level -1
Open plan; The spaces are slopped; Only a small percent of the floor is enclosed; the space overall can be classified as an open plan.	**Open plan;** Apart from elevators and stairs, this space is mainly open.
	
Level 1	Level 2
Open plan;	**Combined plan;**

The space of this level is open;	Space is mainly open with a few articulated enclosed units.
	
Level 3	Level 4
Open plan ; The entire floor is open;	**Open plan;** Only a few smaller enclosed units. The floor is predominantly open;
	
Hybrid section: Incline + Stack + Hole The building section consists mainly of inclined slabs that constitute a continuous path through the library from the ground to the top floor. In the distance, different sectional themes appear, such as cutting a piece of a slab, etc.	

The main element of Jussieu's composition is the continuous folded plane that forms all the floors. The building's plan is mostly open with only a few enclosed spaces (such as group study rooms, or offices). The section is a combination of *incline, stack*, and *hole* types sections.

2) Identifying Basic Spatial Units

As the Jussieu library is an unbuilt project, defining the spatial ambiance units brings difficulties; the differences in the materiality of the space as well as the quality illumination are hard to determine. Furthermore, there are several different versions of the project with a different articulation of certain spaces and the disposition of the ramps. However, in all variations, the main idea remains the same. Unlike the previous projects that were examined, in this case study, the interior spaces are predominantly open, and vertical divisions are nearly nonexistent. The majority of the main spaces are vast, open, and with high ceilings. The openness of the building's plan brings a particular problem to this study. In the previous case studies, the spatial zones were primarily determined based on the frame, which usually coincides with a specific function of the space and often specific materials in the interior. In the Jussieu library, the boundaries between programmatic zones are not clear as different contents – cafes, reading areas, book stacks, multimedia spaces, etc. – continue one after another. For this reason, the spatial zones are primarily defined based on their function. However, these functional zones are often emphasized by the changes in the plane angle or direction. Some of the spatial zones have several subzones that are neglected in the analysis. Conversely, some of the existing zones could be merged into a single zone. These different readings of the spaces, however, do not change the resulting topological diagrams. They demonstrate that the whole body of the library constitutes a single complex space. Additional vertical communications (staircases, escalators, and elevators) were neglected in the analysis focused on the main "path" and adjoined spaces.

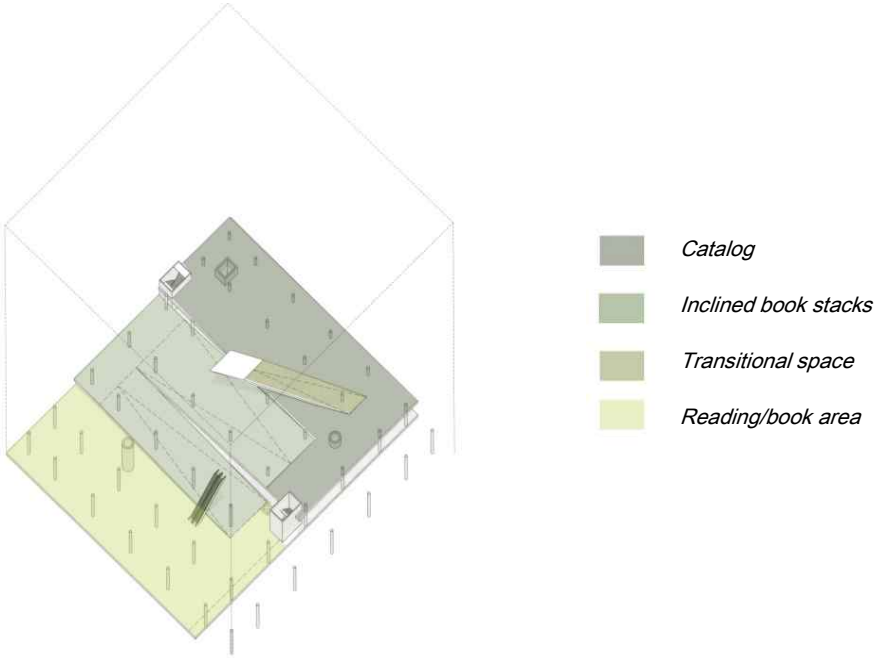


Figure 76. *Jussieu – Two Libraries – identifying spatial zones. THIRD SUBLEVEL.*

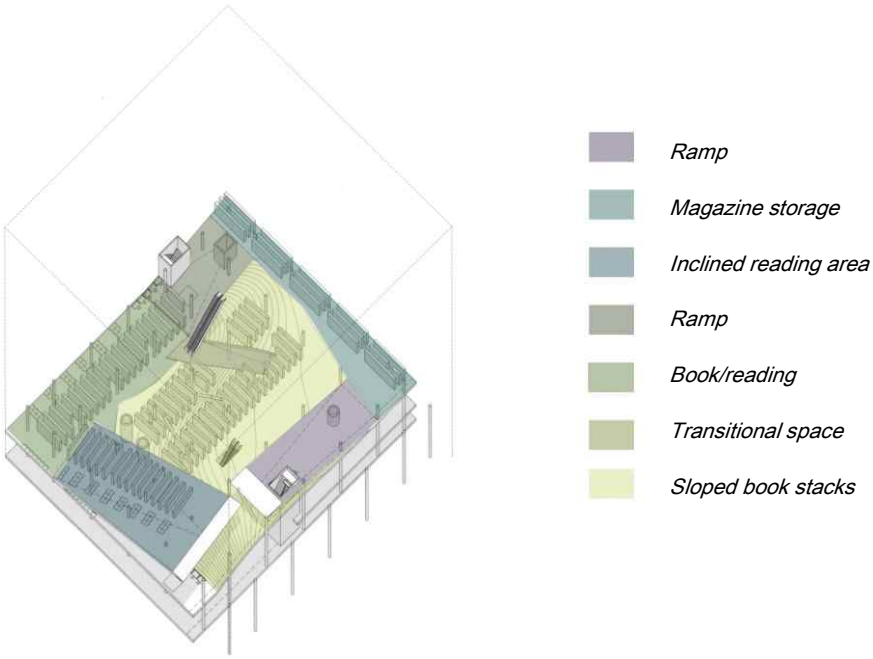


Figure 77. *Jussieu Two Libraries – identifying spatial zones. SECOND SUBLEVEL.*

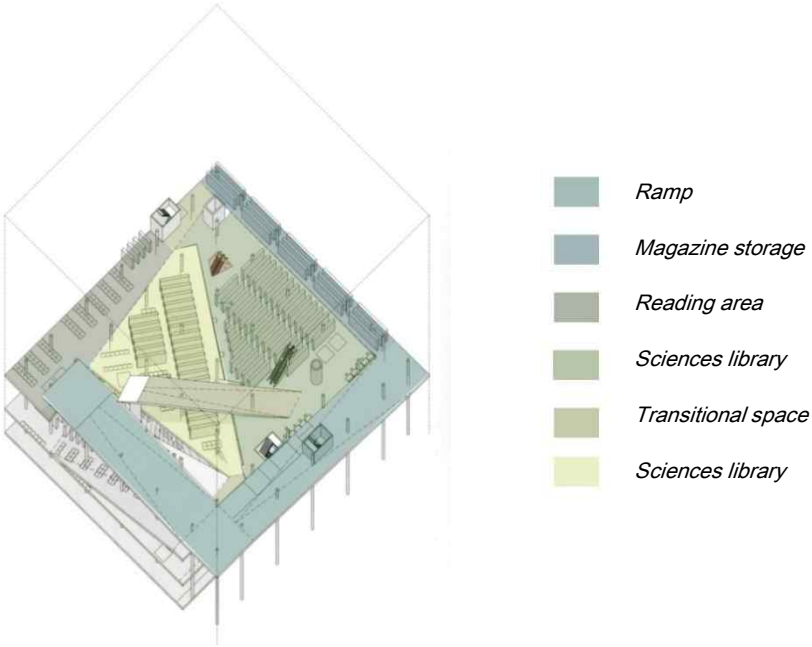


Figure 78. *Jussieu Two Libraries – identifying spatial zones. FIRST SUBLEVEL.*

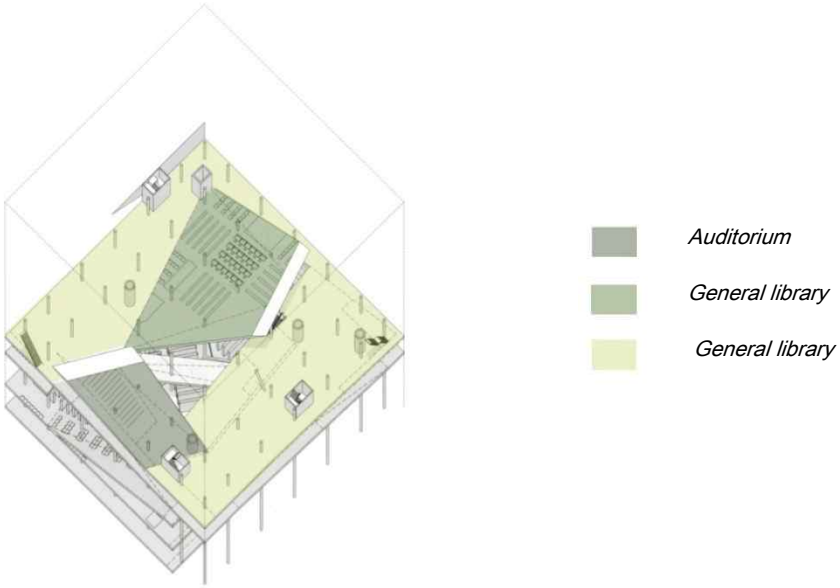


Figure 79. *Jussieu Two Libraries – identifying spatial zones. MEZZANINE ENTRY LEVEL.*

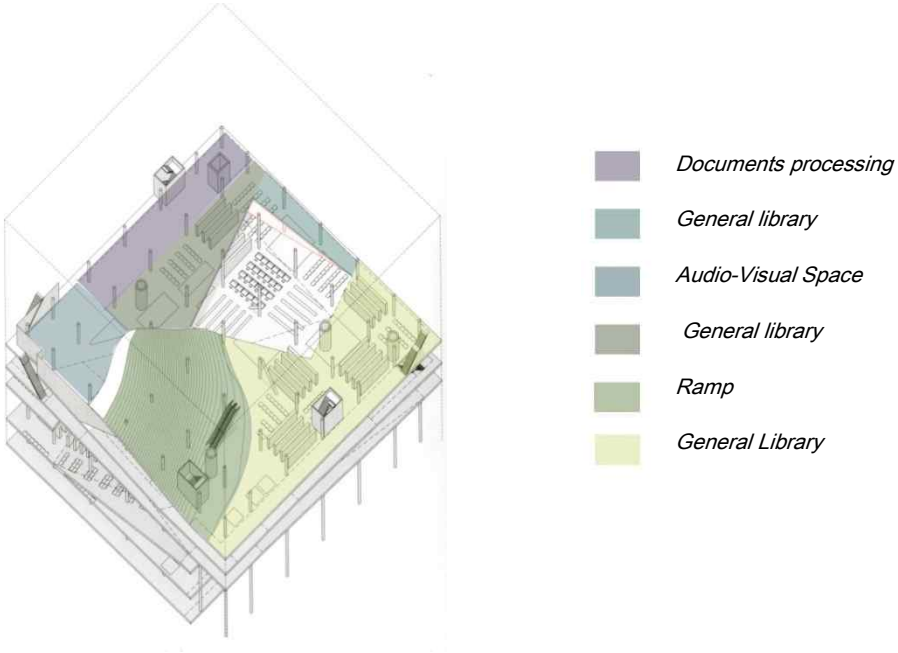


Figure 80. *Jussieu Two Libraries – identifying spatial zones. FIRST FLOOR.*

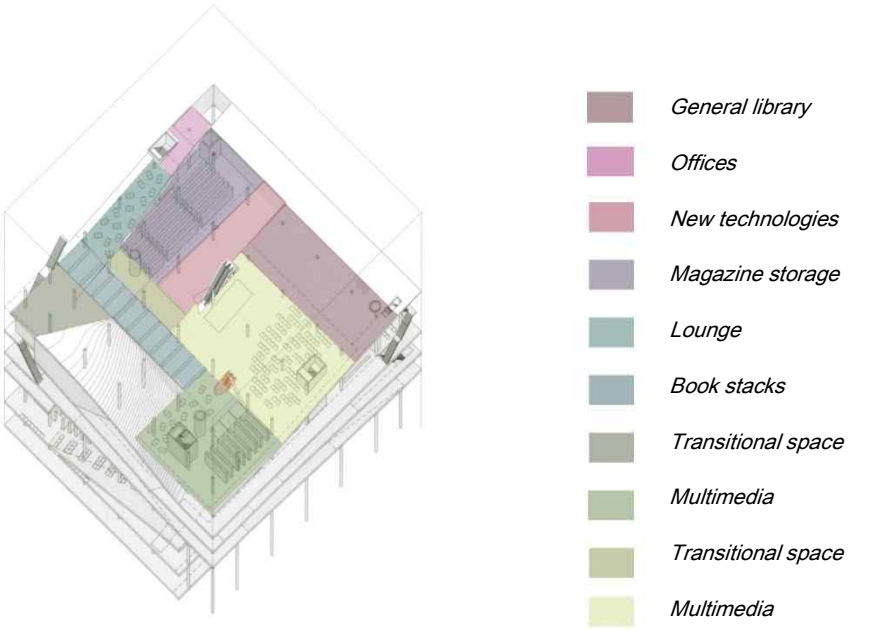


Figure 81. *Jussieu Two Libraries – identifying spatial zones. MEZZANINE ENTRY LEVEL.*

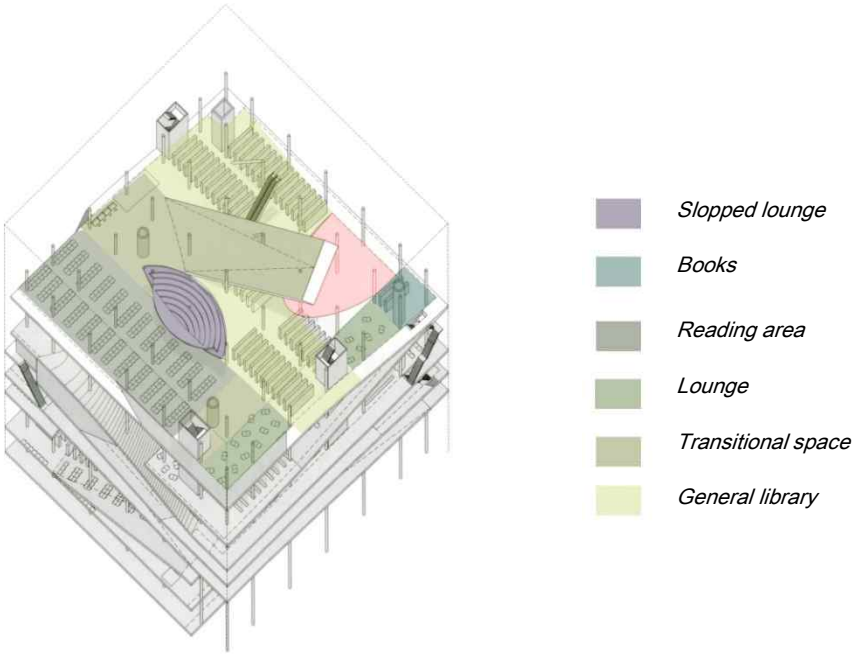


Figure 82. *Jussieu Two Libraries – identifying spatial zones. THIRD FLOOR.*

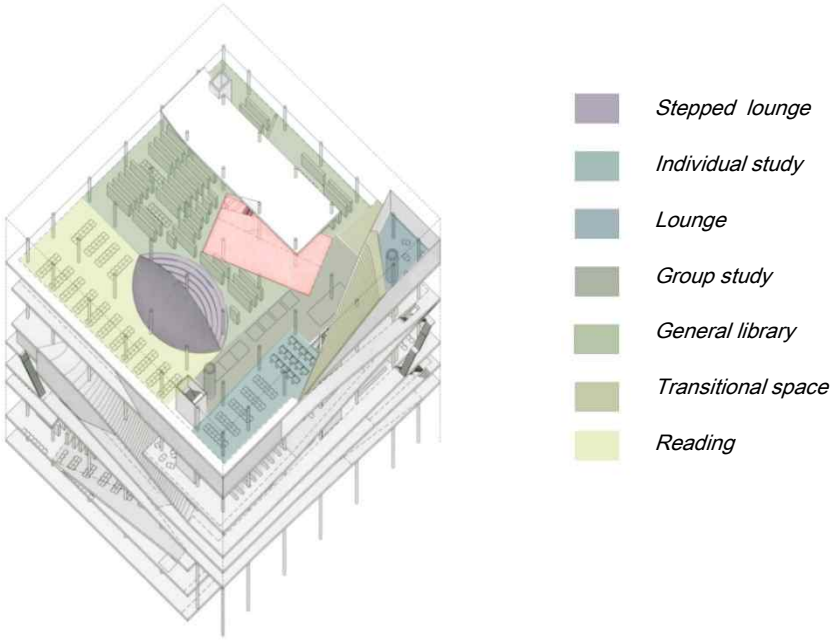
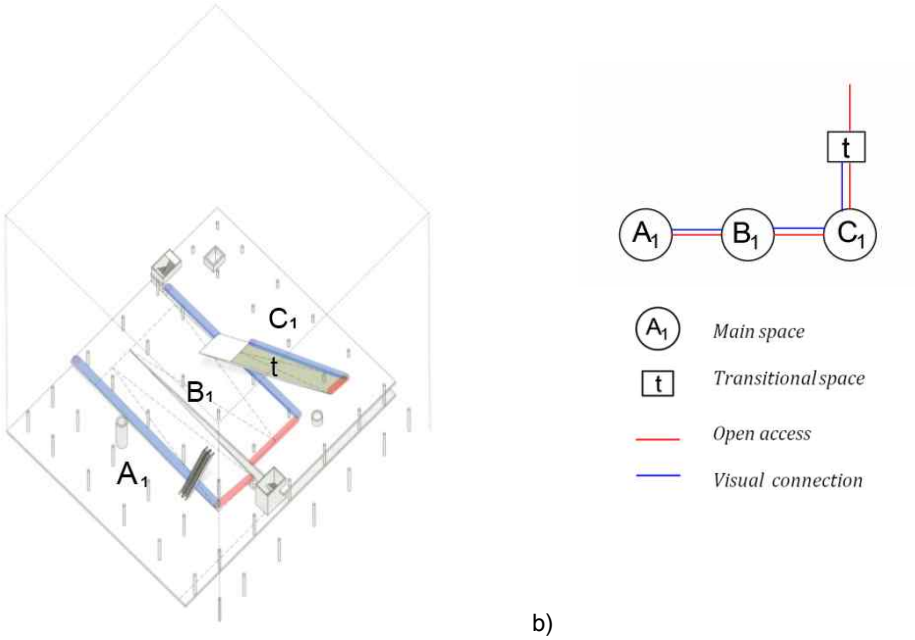


Figure 83. *Jussieu Two Libraries – identifying spatial zones. FOURTH FLOOR.*

3) Identifying Types of Connections and Creating a Topological Diagram

The difficulty in the analysis of the Jussieu library comes from the fact that there is no definitive plan. Thus, in different versions of the project the enclosure of spaces varies. In the variation that this study analyzes, there are almost no enclosed spaces. In the previous case studies, the connections of the spaces are defined through access doors, cased openings or window-like openings that create obvious connections between two spatial volumes. In the Jussieu library, the differences between spaces are vaguer, and, accordingly, the connections are unclear.

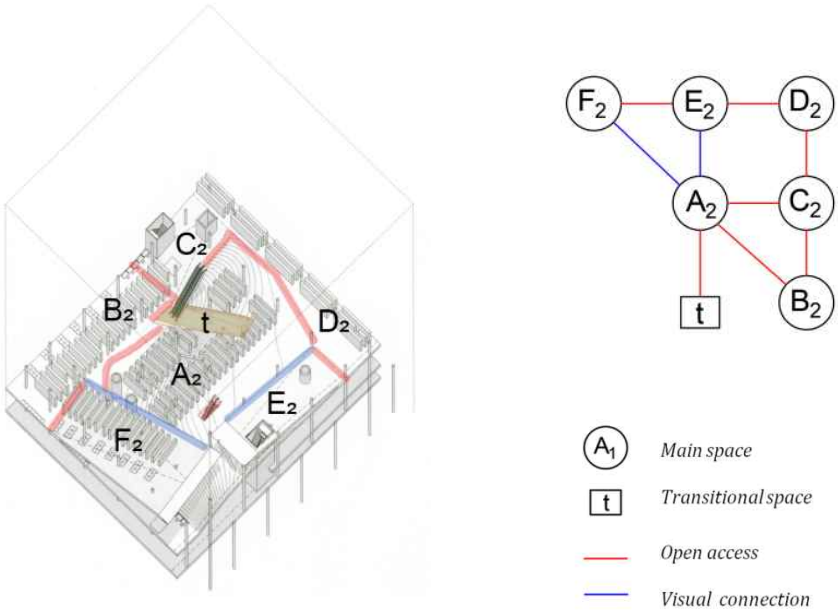
There are two main types of connections: *open access* and *visual connections.* The *open access* type of connections appears when there is no physical obstacle between the spaces. In such a case, boundaries between spaces are unclear and determined approximately due to a change of function. This type of connection is marked as a dividing line between two different spaces. In some cases, it is the beginning of the ramp or a change in the angle of the plane. The *visual connections* appear between spaces that are not physically connected but are positioned in a way that allows a visual connection between them. In the case of the Jussieu library, visual connections are generated by sloping and shafting horizontal planes.



b)

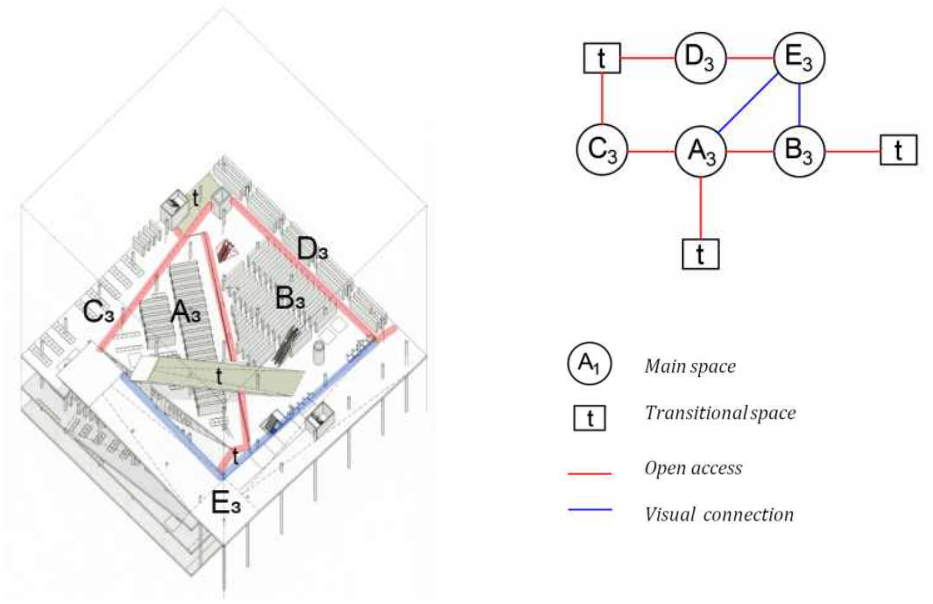
a)

Figure 84. *Jussieu Two Libraries - creating topological diagram THIRD SUBLEVEL; a) identifying spatial units and connections; b) graphic representation of the space.*



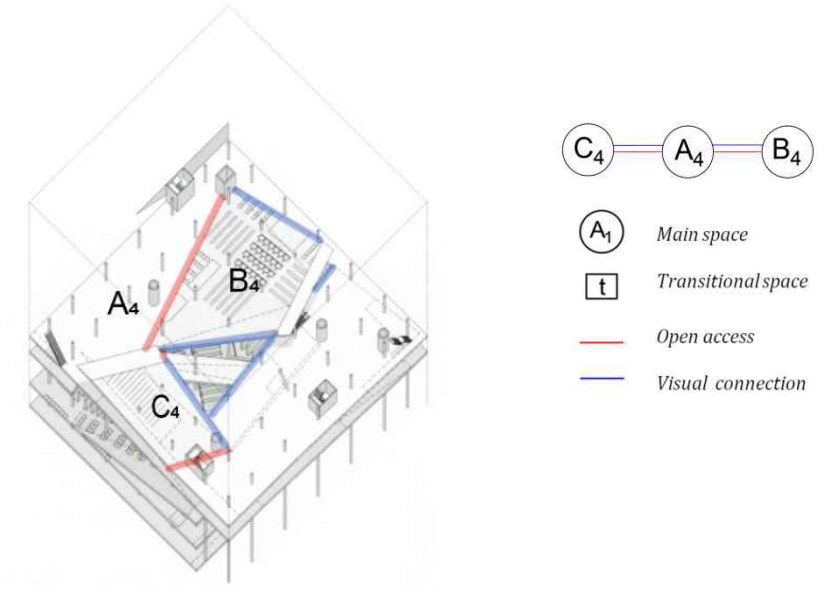
a) b)

Figure 85. *Jussieu Two Libraries - creating topological diagram SECOND SUBLEVEL; a) identifying spatial units and connections; b) graphic representation.*



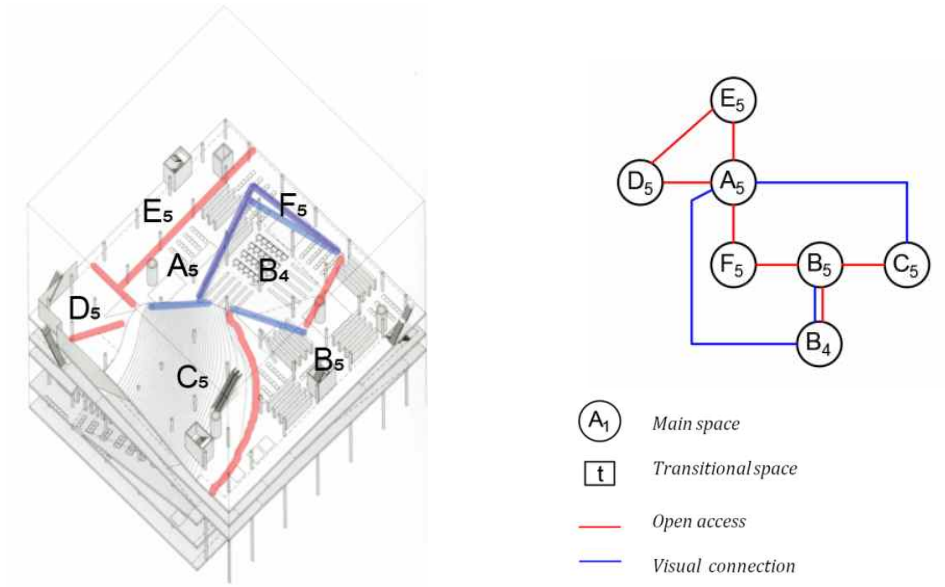
a) b)

Figure 86. *Jussieu Two Libraries - creating topological diagram FIRST SUBLEVEL; a) identifying spatial units and connections; b) graphic representation of the space.*



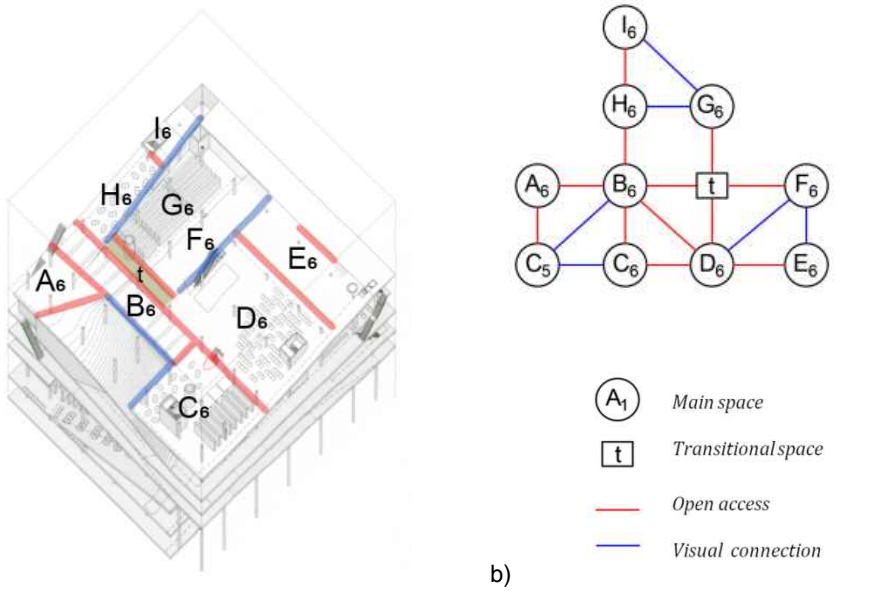
a) b)

Figure 87. *Jussieu Two Libraries - creating topological diagram MEZZANINE ENTRY LEVEL; a) identifying spatial units and connections; b) graphic representation.*



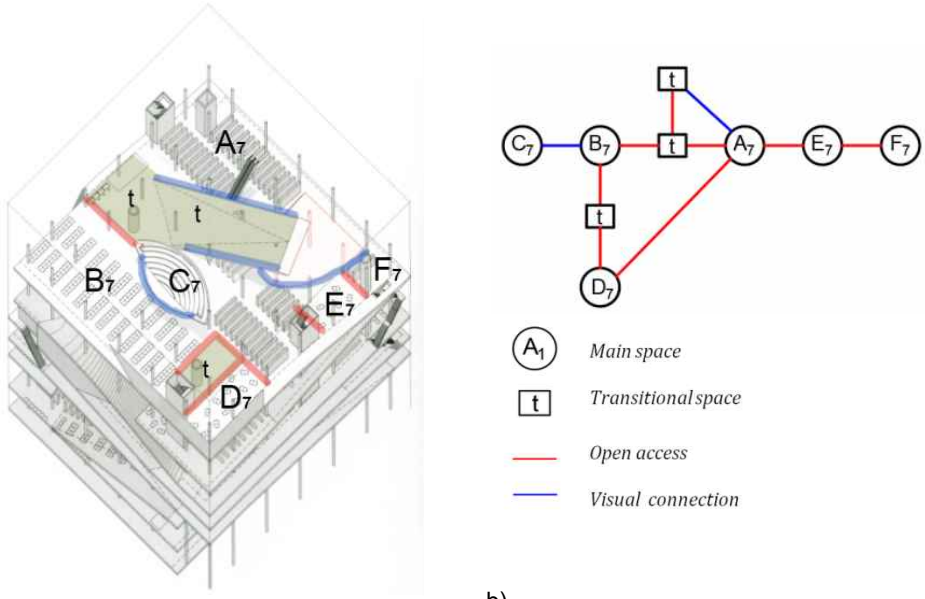
a) b)

Figure 88. *Jussieu Two Libraries - creating topological diagram FIRST FLOOR; a) identifying spatial units and connections; b) graphic representation of the space.*



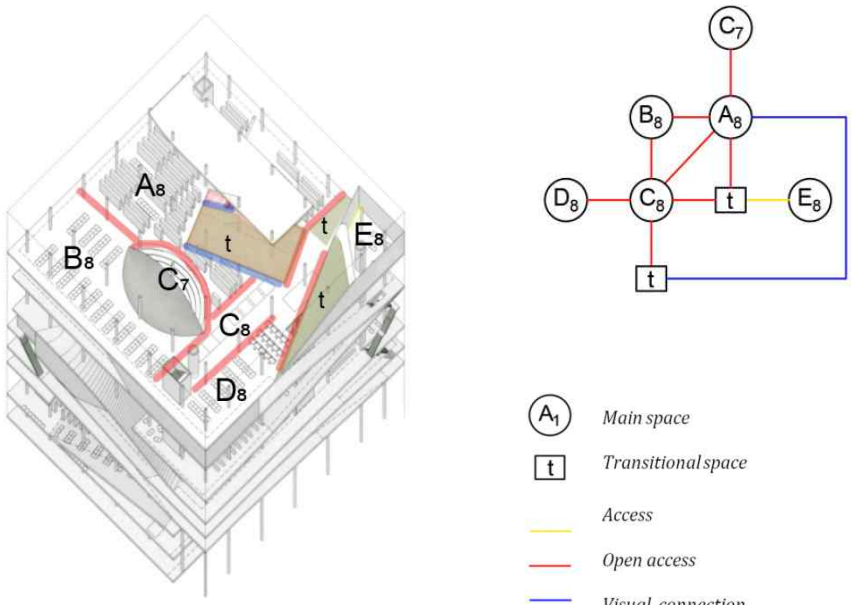
a) b)

Figure 89. *Jussieu Two Libraries - creating topological diagram SECOND FLOOR; a) identifying spatial units and connections; b) graphic representation of the space.*



a) b)

Figure 90. *Jussieu Two Libraries - creating topological diagram THIRD FLOOR; a) identifying spatial units and connections; b) graphic representation of the space.*



a) b)

Figure 91. *Jussieu Two Libraries - creating topological diagram FOURTH FLOOR; a) identifying spatial units and connections; b) graphic representation of the space.*

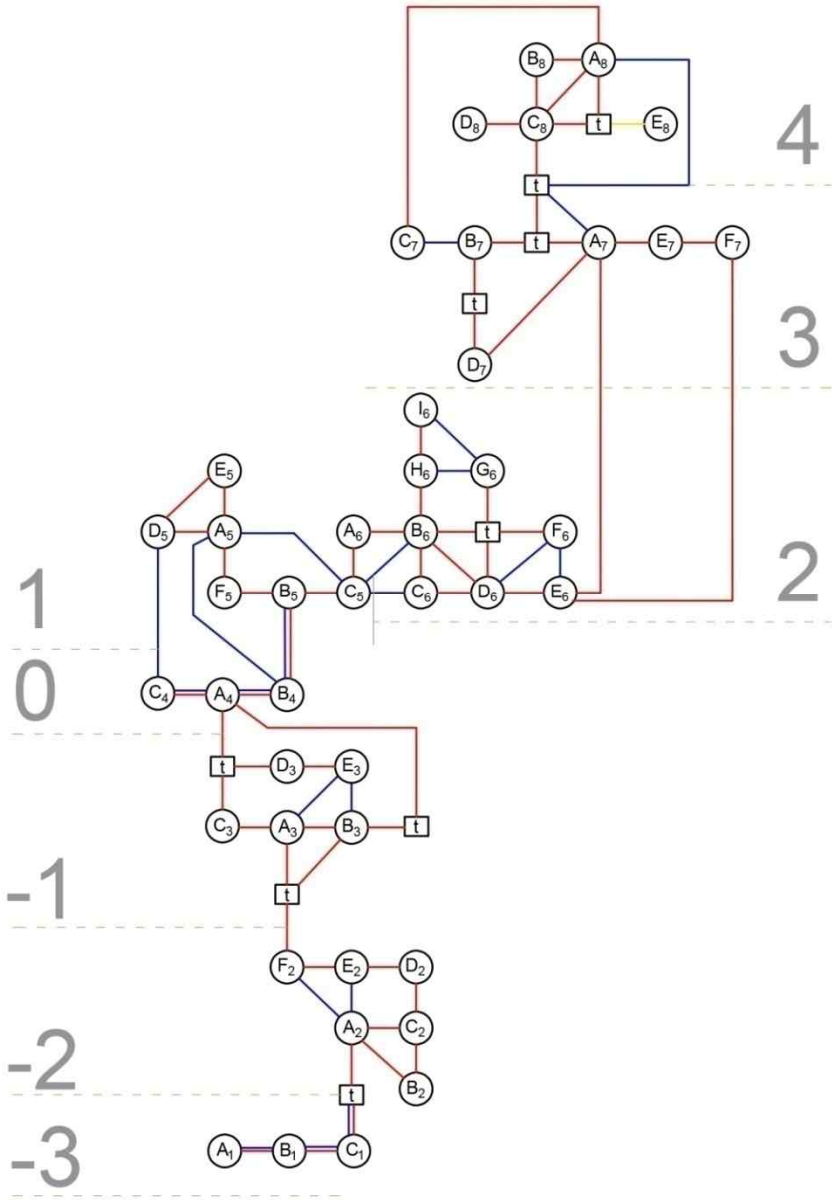


Figure 92. *Jussieu Two Libraries – topological diagram of the building.*

The topological diagrams of each level are formed interpreting spaces as nodes and connections between them as edges. Since all levels are connected in a manner that allows for overlapping of spatial volumes, topological diagrams of individual floors are combined into a topological diagram of the building (Figure 96). This diagram demonstrates that the entire building constitutes a complex spatial whole.

4) Examining spatial connections in the context of the atmosphere

Figure 93. *Jussieu - Two Libraries Paris - the interior of the fourth level – 3D visualisation.* Source: *WAX Architectural Visualizations, https://www.behance.net/gallery/9347955/Jussieu-Two-Libraries*

The spatial analysis of the Jussieu libraries demonstrates what the main compositional idea was – the whole body of the building constitutes a single path. The topological diagrams show a unique space from the underground levels to the very roof. However, it is hard to understand this space in the same way the spaces of Villa Müller or the Exeter Library form a unity. The relationships of the spaces arranged on the ramp with the arbitrary movement are significantly different from the relationships of spaces in Kahn's Library where the central space is a well-defined spatial volume with a strong character. In the Jussieu project, the voids between the ramps are discontinuous and fragmented. The spaces on different levels are not united into the whole in the same manner as the galleries in Hurva Synagogue constitute a part of the whole with the central space. It is difficult to determine what kind of relationships these spaces form through numerous layers, except in the case when spaces are directly attached. The visual connections penetrate through two or three layers, and plausibly, create a significant interaction only with the adjacent space. Furthermore, horizontal slits do not connect the spaces in the same manner as the vertical openings. Vertical openings allow for an open view, or even access, from one space to another. Horizontal shafts allow for visual access but the bounding of space is unconvincing.

A significant problem in the reading of the Jussieu building comes from the definition of spaces. The majority of the spaces (arranged on horizontal and inclined planes) are open. As the project was never built it is not possible to know what percent of spaces on each floor would have been enclosed. Overall, there are almost no vertical divisions. Furthermore, as the library was not built one cannot speak of materiality or even illumination of

space. The differences here are produced in an alternative manner – the shape of the ceiling, the height of space, but also the program and thus arrangement and disposition of the objects in space. The boundaries between spatial wholes are vague, and space can be read and divided in different ways where none is more exact than the other. Moreover, the majority of spaces could have had smaller subdivisions. In the analysis conducted in this study, these differences are neglected due to the size of the library. Such subdivisions do not influence the main argument: the whole of the interior of the library constitutes a unique whole. Yet, there are obvious differences in the space, and one can smoothly move from one space to another.

Figure 94. *Jussieu - Two Libraries Paris - the Interior of the fourth level – 3D visualization.* Source: *WAX Architectural Visualizations, https://www.behance.net/gallery/9347955/Jussieu-Two-Libraries*

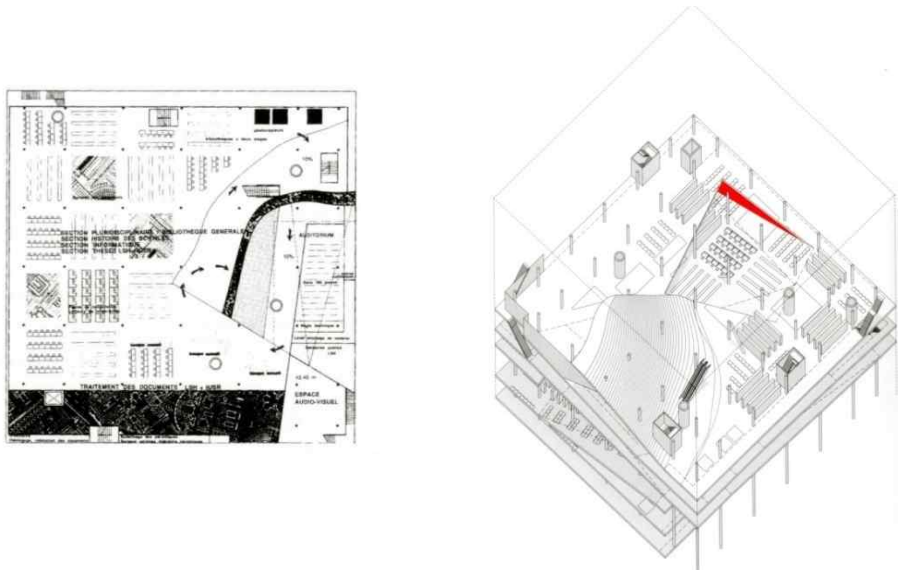
This concept prompts the question of the difference between such space and infinitely extendable horizontal space defined between two horizontal planes (for example, the space inside the Dom-Ino structure). In

such spaces as well, changes could be created by different arrangements and variations of the program on the same plane, without vertical divisions, extended infinitely. Heterogeneity without physical boundaries can be achieved through continuous changes in the program. From this point, the composition seemingly does not have a major role in creating the differences in space. However, in the dynamic interior of the Jussieu, the differences between parts of the volume are more pronounced than they are in buildings with horizontally stacked sections. Even if the program varies, without oscillations in height or quality of the slabs, differences are not pronounced. In other words, space shows a higher level of diversity with constant changes in the frame of each segment. This is visible when the two variations of the first floor of the project– OMA's competition drawing and Eisenman's axonometric drawing – are compared. The former reveals a rather homogenous arrangement despite the changes in the program. The overall space is flat and deep. The stepped area of the floor does not make a significant difference; it can be read as a part of the same or a separate volume with an altered section. However, the variation of the quality is feeble. In the latter plan, a part of a floor is sunk as a ramp, which creates a more significant change. Not only that the sunken area is central to the overall plan, thus dividing the remaining space into smaller segments that are now connected on the edges, but the movement of the slab also creates a slit (void) that connects it with the floor beneath. Eisenman considers these voids an extension of Koolhaas' *strategy of the void* – inverted *poché*.[265] In the context of this study, these voids play a role in connecting

[265] Eisenman and Harrison. *Ten Canonical Buildings 1950-2000*, 201.

the spaces and bringing the differences together where they confirm each other.

The problematic explained above indicates that there are levels of heterogeneity of space. The Jussieu library demonstrates how these differences can become more pronounced with variations in the frame of space. In other words, the composition is the main but not the only generator of the differences. All of the elements of the atmosphere play a role in generating diversity, but compositional aspects can make them more prominent.



a) b)

Figure 95. *Jussieu Two Libraries - first floor; a) plan by OMA; b) axonometric view by Peter Eisenman.*

Source: *Eisenman and Harrison, Ten Canonical Buildings, 210, 223.*

5.3.6. Case Study 5 – The Vagelos Education Center at Columbia University, New York

CASE STUDY INFORMATION

THE VAGELOS EDUCATION CENTER
2016
PLACE
New York, NY, USA
ARCHITECT
Diller Scofidio + Renfro

TYPE OF SPATIAL COMPOSITION
Section:
Hybrid section; Stack + Shear + Hole+ Incline+ Nest
Plan: a combination of open and articulated spaces with a larger part of the building being open.

ELEMENTS OF TOPOLOGY
The layer of loggias on the outside creates an intermediate space – a layer between inside and outside. In the interior vertical cuts (lecture hall and staircase space) enable visual communication and overlaps between spaces

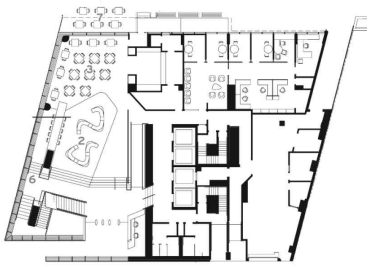
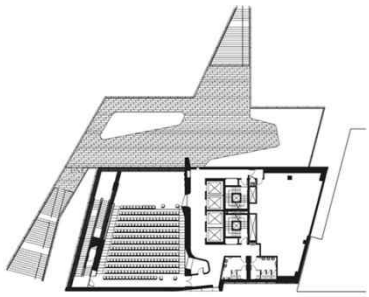
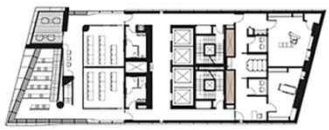
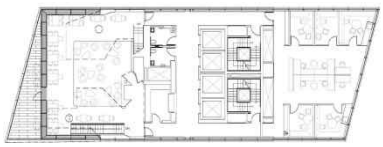
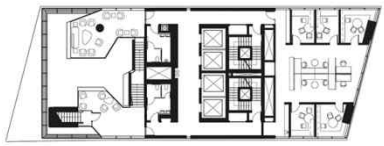
The Vagelos Education Center in New York was constructed between 2013 and 2016, after the 2010 competition. It is a new medical and graduates education building for Columbia University Medical Center. The building is designed as a fourteen-story glass tower that encompasses technologically advanced facilities. Its design responds to the problem of how medicine should be taught and learned today. Vagelos Education Center consists essentially of three areas: public, administration, and study. However, these are not vertically stacked one above the other the way it is common in tall buildings. The specificity of the design is that architects have separated all public activities and arranged them vertically along the south elevation. Thus, the building is functionally divided by a vertical axis and this reflects on its structure. A typical core containing elevators, staircases, and toilets is

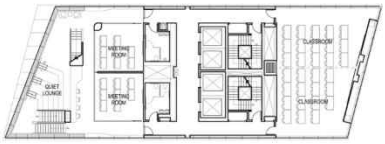
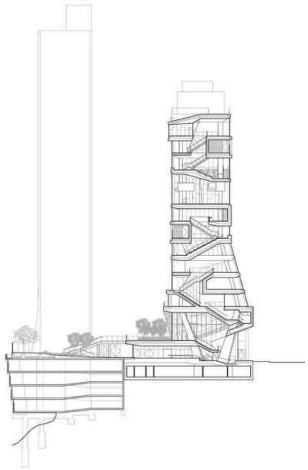
placed in the central area of the tower. The south side, where all public spaces are grouped, constitutes a “Study Cascade” that extends through the entire height of elevation and integrates a number of informal learning spaces. These include oversized and occupiable landings of the cascade staircase, a stepped lounge, and several lounge-style spaces scattered throughout the cascade. The space of the “Study Cascade” places students in an environment designed for collaborative learning. It represents a vertical urban campus. Contrarily, the northern elevation consists of regularly stacked slabs with classrooms and laboratories. The sharp contrast between the structures of the north and the souths side is visible in the longitudinal section of the building.

The DS+R design studio was investigating the possibilities of turning a section of tall buildings design into a path with ramps and stairs in a number of their earlier projects. For example, the McMurtry Building for the Department of Art and Art History at Stanford University and the Museum of Image and Sound In Rio de Janeiro explore this idea.

1) Identifying the Type of Composition

Table 16. *Vagelos Education Center- Identifying the type of composition.*

	
Level 1	Level 2
Combined plan; Several spaces in the plan are enclosed and articulated. The entrance lobby constitutes a large open space. Offices placed on the same floor are predominately articulated.	**Open plan;** Apart from the core with elevators and emergency stairs this floor contains escalated auditorium, hence the space is mainly open.
	
Level 5	Level 8
Open plan; The entire floor, apart from the core, is open and contains several labs.	**Combined plan;** The floor consists mostly of articulated spaces with open space on the south side as a part of the “study cascade.”
	
Level 10	Level 11
Combined plan; The floor consists of articulated offices on one side and the open area on the other.	**Combined plan;** The north side of the floor consists of articulated offices; south of the core two hanging balconies open toward the lower floor.

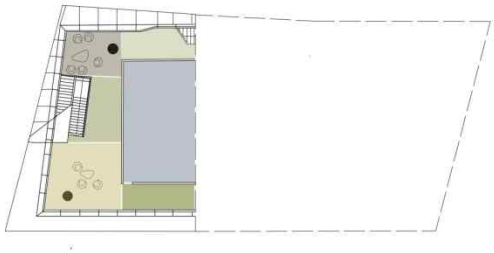
	
Level 12	Level 14
Combined plan ; Spaces on this level are mostly articulated, with an open lounge on the south side.	**Articulated spaces;** The spaces on this floor are closely enclosed.
	
Longitudinal section	Cross-section
Hybrid section; Stack + Shear + Hole+ Incline+ Nest While the north side of the building showcases a stacked section typical for high-rise buildings with the core in the middle, the south side of the building constitutes a “cascade” that uses several compositional strategies to create a series of smaller study spaces placed on the cascade.	

The Vagelos Education Center encompasses several compositional topics. While the spaces in the core are closely articulated, the floors consist of both enclosed and open spaces. The section of the north part of the building consists of regularly stacked slabs. The south side of the building encompasses a free section that combines *shear*, *hole, incline,* and *nest* types of section. This study focuses on the “Study Cascade” because it represents an example of a free section. The analysis is focused on the

composition of the cascade from level six to level fourteen, as it is in this part of the cascade where the significant interaction of the vertical levels occurs.

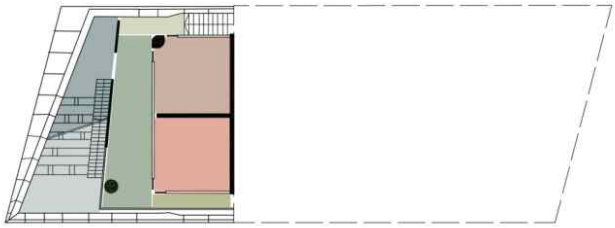
2) Identifying Basic Spatial Units

The individual spaces on the cascade are identified based on the frame and the function. However, the cascade is composed as a vertical promenade (or as a vertical “path and a place”), and most of the spaces are not framed but rather marked with furniture and equipment. This is the case with oversized staircase landings that constitute functional workspaces. Apart from being connected vertically to one another, these spaces connect to the core of the building, and through the core, to the northern side classrooms. As these connections are not separated from lounge spaces, in the analysis, they are defined as transitional spaces. Apart from transitional spaces, vertical communications are also defined as a separate category. Although they represent what is in this study defined as a transitional space, in this project they have a different nature because of the importance of vertical circulation. The borders of the main space with transitional spaces were difficult to determine, and in most cases, they could be divided in several ways. However, determining the exact boundaries between the two spaces is not of essential importance. As they are connected through “open access” they do no create a significant difference in topological diagrams.



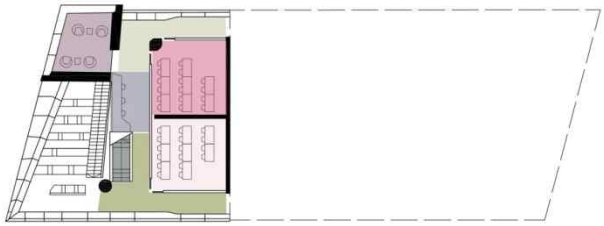
Meeting room
Sitting area
Sitting area
Transitional space
Transitional space
Transitional space

LEVEL 6



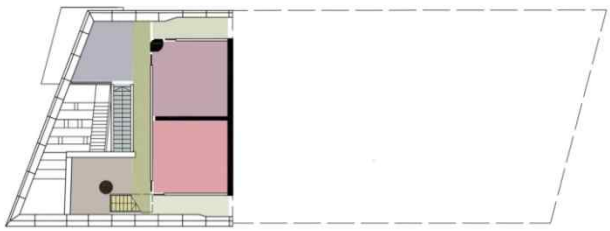
Meeting room
Meeting room
Stepped study lounge
Resting area
Transitional space
Transitional space

LEVEL 7



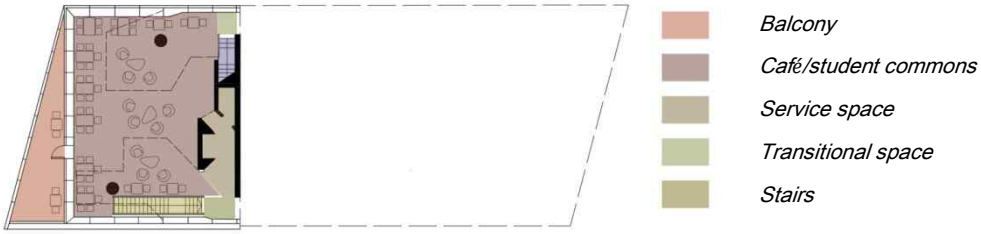
Meeting room
Meeting room
Outdoor room
Computer workspace
Stairs
Transitional space
Transitional space

LEVEL 8



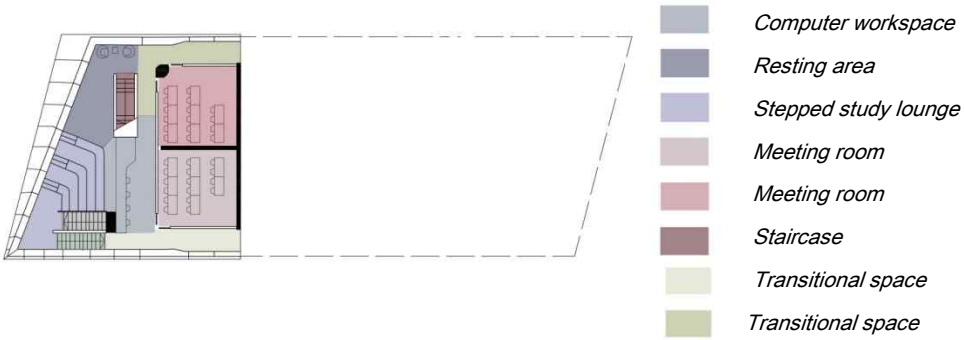
Meeting room
Meeting room
Open gallery
Open gallery
Stairs
Transitional space
Transitional space

LEVEL 9



LEVEL 10

LEVEL 11



LEVEL 12

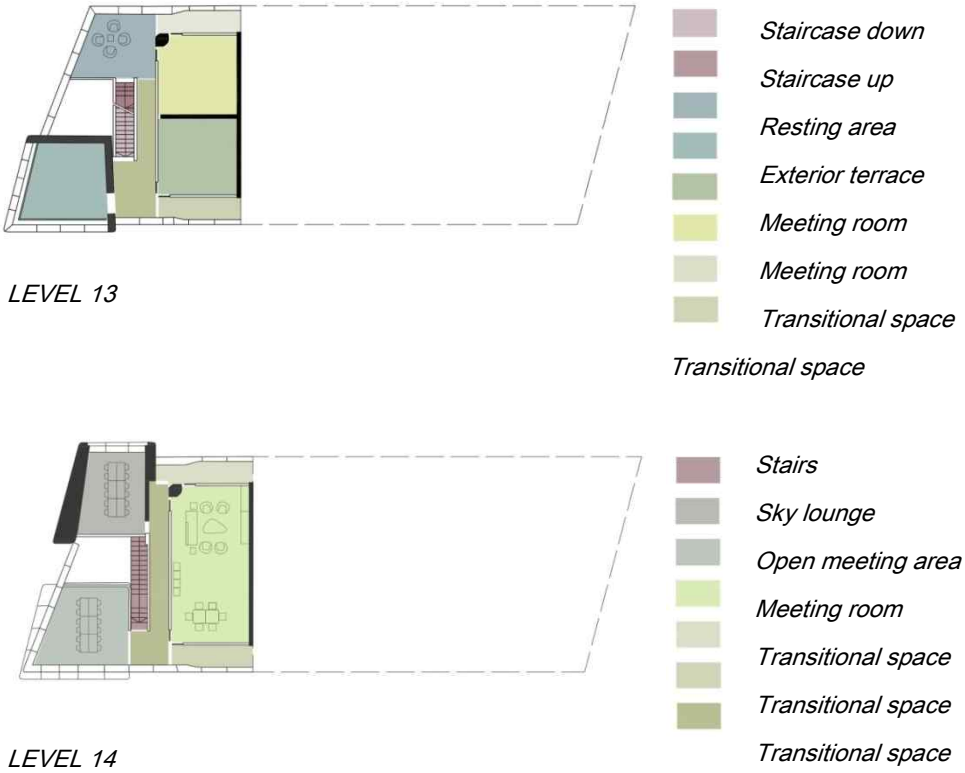


Figure 96. *The Vagelos Education Centre – identifying spatial units – LEVEL 6-14.*

3) Identifying Types of Connections

The boundaries were classified into four groups: *open access, visual connections, transitional spaces, and access*. The distribution of these connections on each plan is shown in Figure 97. Similar to the Jussieu library project, the majority of boundaries between the spaces are vague. The boundary is a gradual change of quality. For example, gradual change from a quiet study space to a corridor.

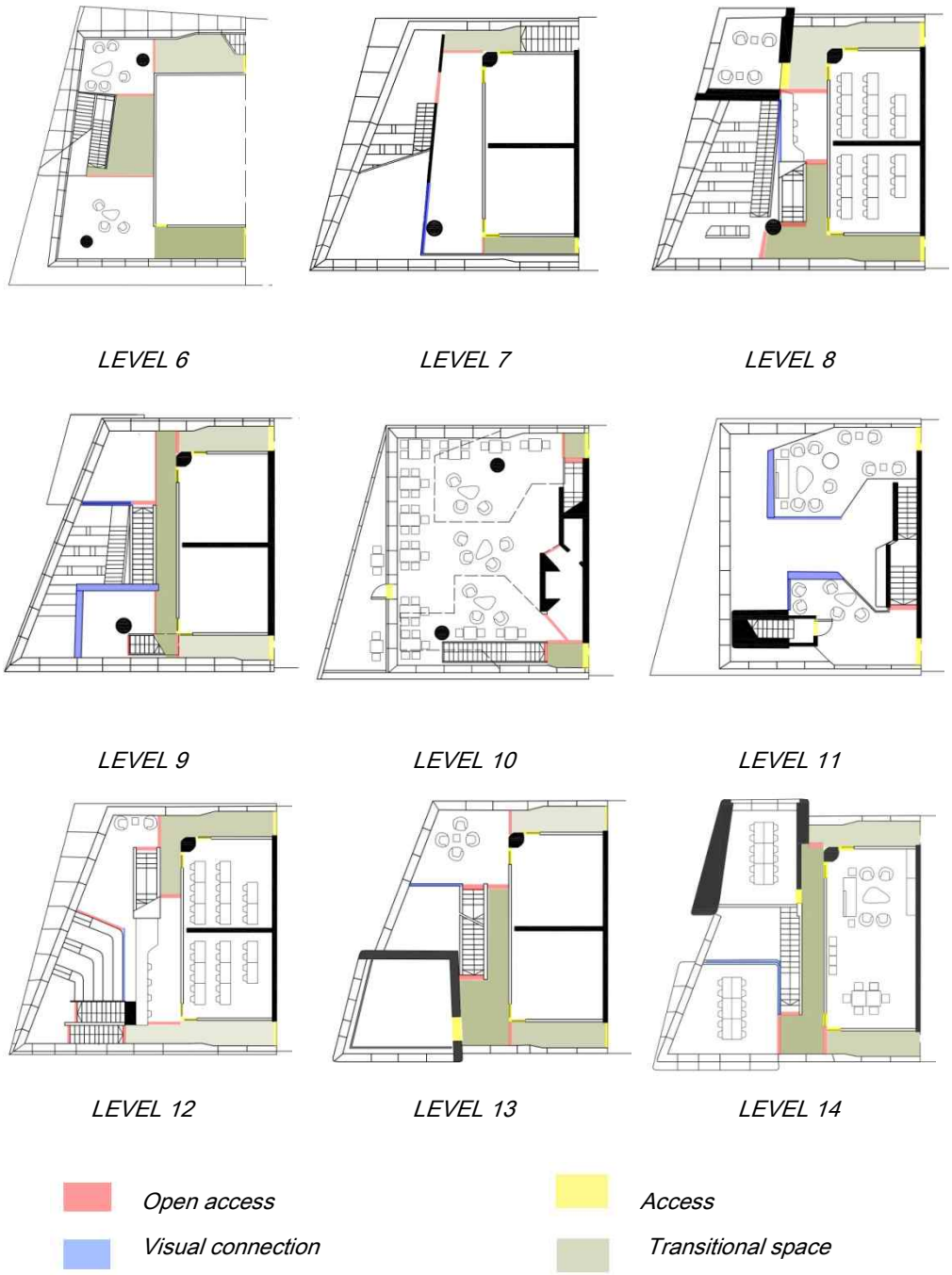


Figure 97. *Vagelos Education Center – identifying types of connections LEVEL 6-14.*

The *open access* type of connection in Vagelos Education center occurs between the study places located on the oversized stairs' landings and transitional spaces or the stairs. These boundaries are only implied by the way the spaces are used and, thus, are different from the *cased opening* type of open connection.

A visual connection is established between the majority of the spaces on the cascade including the meeting rooms and external terraces. However, visual connections established through partitions made of glass are not considered in this study. The reason for this is that these spaces, despite visual connection, represent separated volumes. Their level of interaction is different than between spaces that are directly connected one to another. This type of connection assumes interaction of the sound, smell, and temperature, not only visual connection (although in this study they are called "visual"). In this building, this type of connection occurs between the floors through openings on the horizontal slabs and between the common space and hanging galleries.

The *access* type of connection occurs between the cascade and the meeting rooms, the core, and the external terraces or box-like lounges that stick out of the facade. However, partitions between these spaces are made of transparent material, and, thus the nature of the relationships of these spaces and the atmosphere they create is different from the effect that separating spaces through doors has in previous case studies.

Transitional spaces in the building connect the main spaces with the core and establish communication between the cascade and the core.

Boundaries between transitional and main spaces are only implied by the way space is used, and they can be interpreted as a single volume or space.

a)

b)

c)

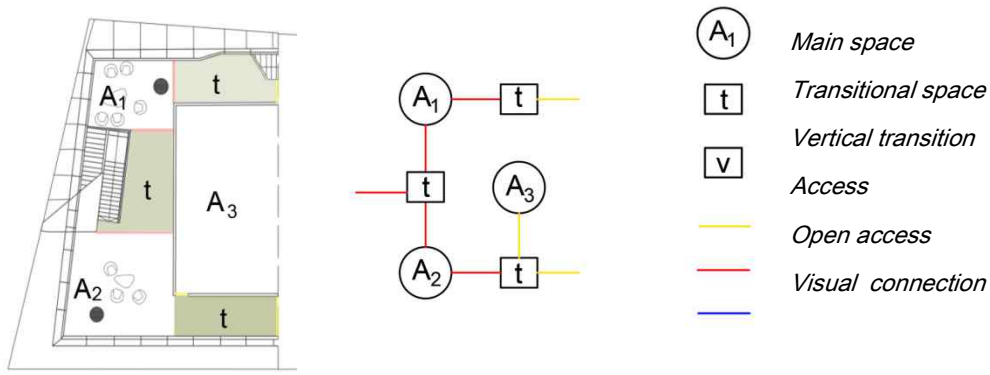
d)

Figure 98. *Types of connections in Vagelos Education Center: a) open access; b) visual connection; c) transitional space; d) access.*

Sources: *https://sciame.com/portfolio/roy-and-diana-vagelos-education-center-columbia-university-medical-center/;*
https://www.facilities.cuimc.columbia.edu/capital-projects/our-projects/roy-and-diana-vagelos-education-center;
http://fieldcondition.com/education/semt3ubei324tpsp6brginnfnjgicc

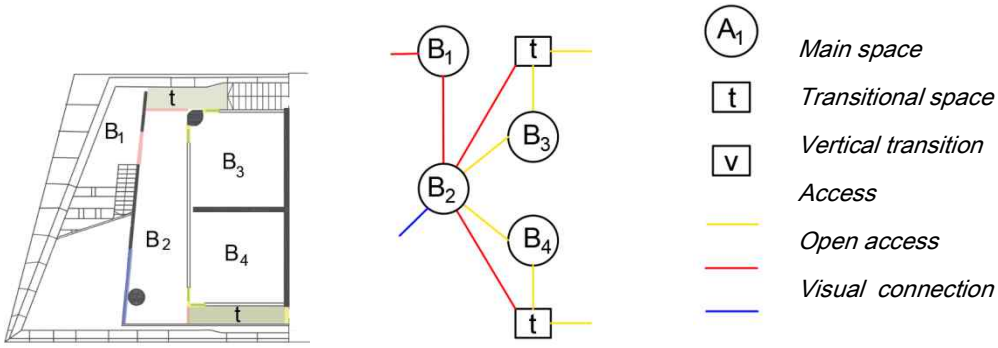
4) Creating Topological Diagrams

In topological diagrams, main and transitional spaces are interpreted as nodes and their connections as vertices. However, due to the specificity of the composition and the importance of vertical communications, vertical spaces are separated as a category of vertices along with transitional spaces. With this, the structure of space is clearer regarding vertical communications. After a diagram of each floor is made separately, they are combined into a vertical diagram that displays both horizontal and vertical relationships between spaces.



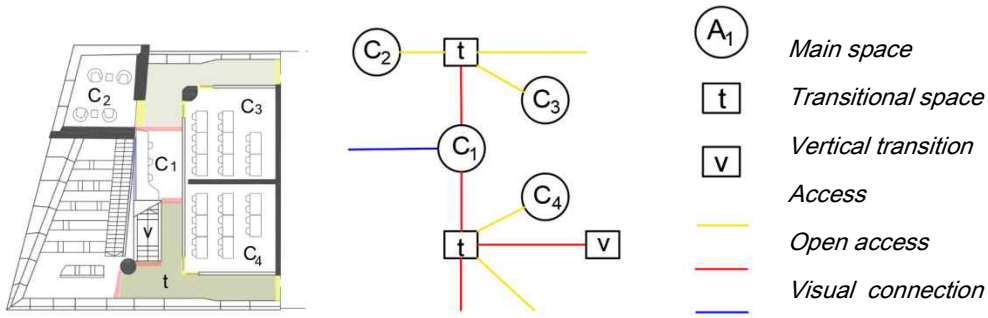
a) b)

Figure 99. *Vagelos Education Center LEVEL 6 – creating topological diagram; a) identifying spatial units and connections; b) graphic representation of the space.*



a) b)

Figure 100. *Vagelos Education Center LEVEL 7 – creating topological diagram; a) identifying spatial units and connections; b) graphic representation of the space.*



a) b)

Figure 101. *Vagelos Education Center LEVEL 8 – creating topological diagram; a) identifying spatial units and connections; b) graphic representation of the space*

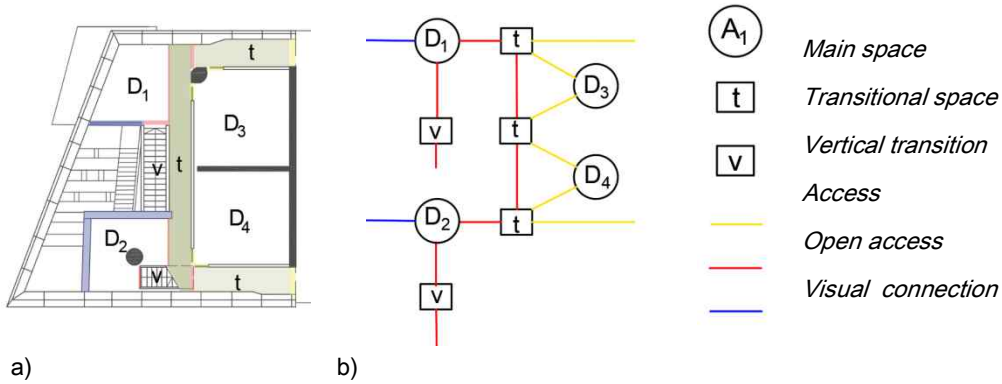


Figure 102. *Vagelos Education Center LEVEL 9 – creating topological diagram; a) identifying spatial units and connections; b) graphic representation of the space.*

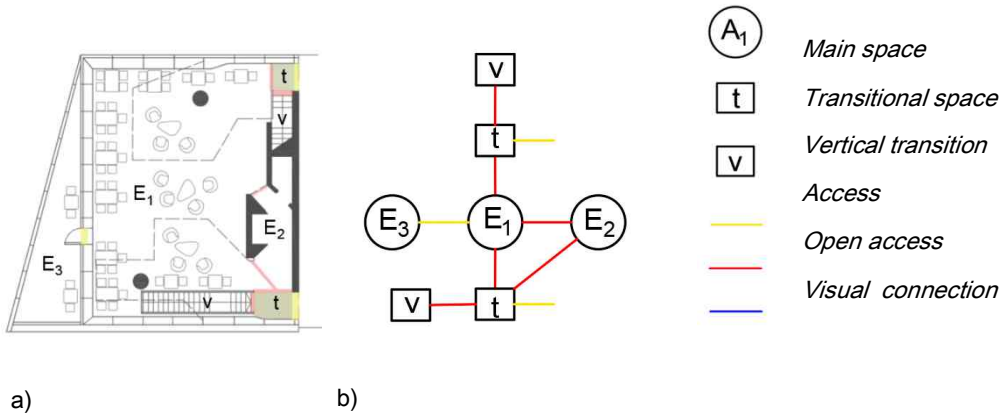


Figure 103. *Vagelos Education Center LEVEL 10 – creating topological diagram;a) identifying spatial units and connections; b) graphic representation of the space.*

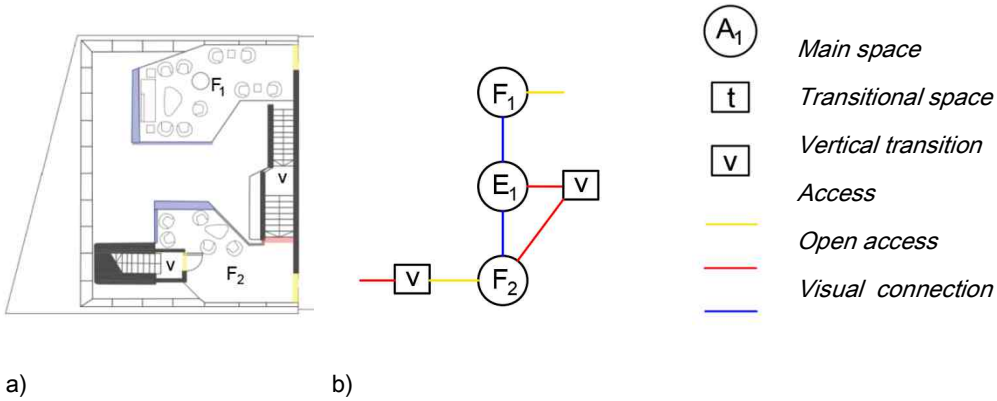


Figure 104. *Vagelos Education Center LEVEL 11 – creating topological diagram; a) identifying spatial units and connections; b) graphic representation of the space.*

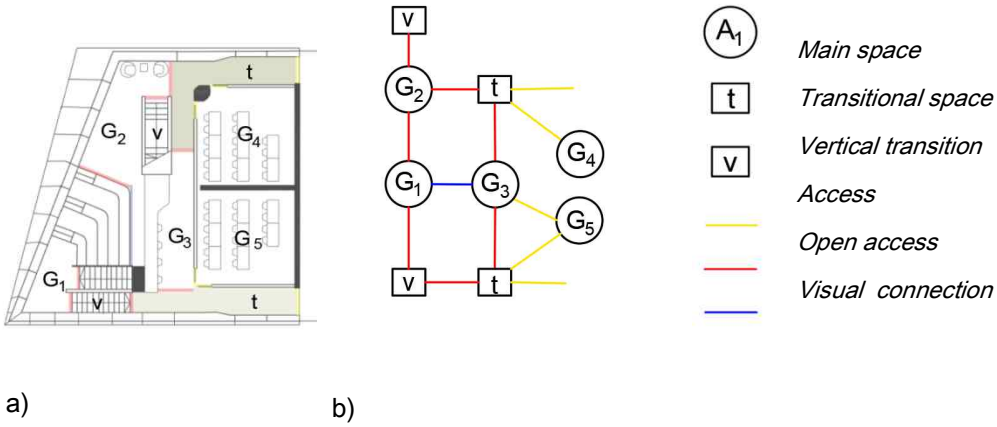
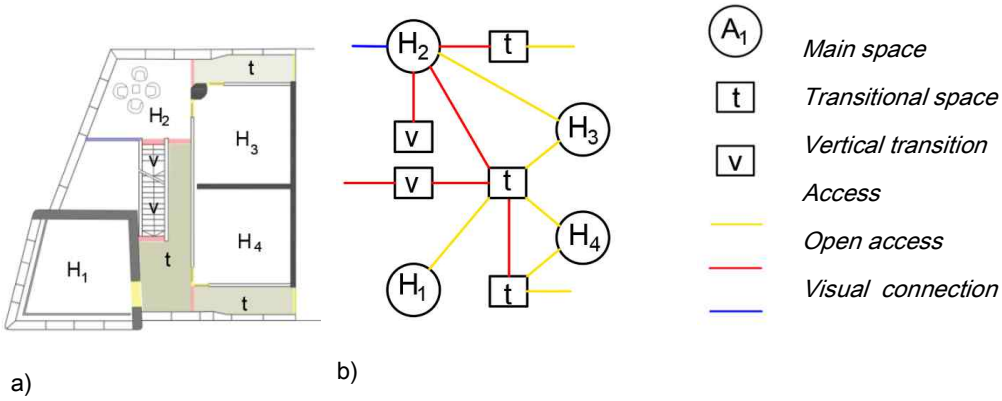
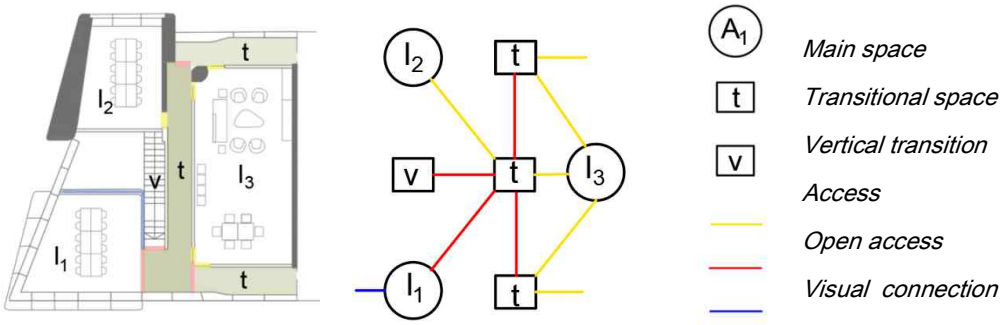


Figure 105. *Vagelos Education Center LEVEL 12 – creating topological diagram; a) identifying spatial units and connections; b) graphic representation of the space.*



a) b)

Figure 106. *Vagelos Education Center LEVEL 13 – creating topological diagram; a) identifying spatial units and connections; b) graphic representation of the space.*



a) b)

Figure 107. *Vagelos Education Center LEVEL 14 – creating topological diagram; a) identifying spatial units and connections; b) graphic representation of the space.*

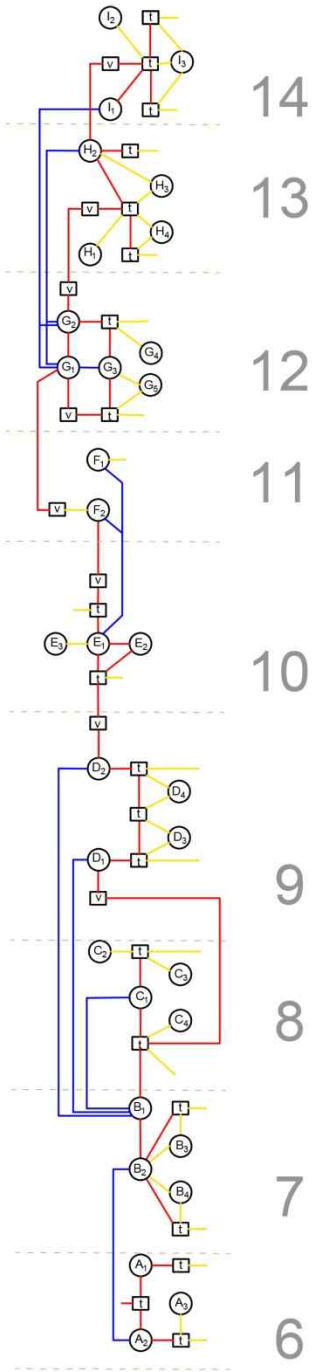


Figure 108. *Vagelos Education Center – topological diagram of the cascade LEVEL 6-14.*

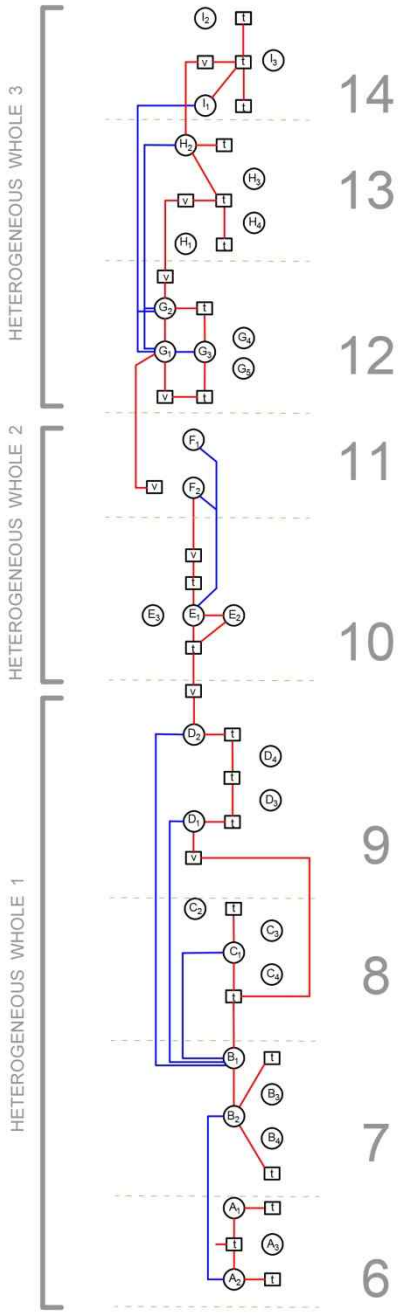


Figure 109. *Vagelos Education Center – identifying heterogeneous wholes.*

5) **Examining spatial connections in the context of the atmosphere**

The topological diagram reveals that there are three heterogeneous spaces on the cascade. The lowest one starts with level six extending to level nine. While the sixth floor is only visually connected to the subsequent level and does not create a strong connection with other levels, the seventh, eighth, and ninth levels create an obvious spatial whole. This happens through gradual movement from one level to the next through the stepped lounge and cutting out a piece of the horizontal slab on the subsequent level. The opening on the horizontal surface is much larger than would be necessary for the stairway. The external terrace placed inside a “box” and the ninth-floor lounge/landing look like they are floating in a space above the stepped study area.

The second heterogeneous whole consists of the tenth and eleventh level. It encompasses a communal area with two study galleries hanging above it. The tenth level is accessed through an open stairway from the lower level. However, this connection does not create enough interaction between the spatial volumes to consider it a part of the previous heterogeneous whole.

The third heterogeneous whole includes spaces on levels twelve to fourteen. On this part of the cascade, two discrete spaces are placed – exterior terrace, and sky lounge – both in “boxes”

protruding out of the facade. As these are essentially separated spatial units, the cascade unites the stepped lounge on the twelfth floor with the study spaces in the shape of oversized landings on the two higher levels.

Figure 110. *Vagelos Education Center – south facade.*
Source: *https://www.area-arch.it/en/the-roy-and-diana-vagelos-education-center/*

While it is evident that these are the complex spaces that consist of several smaller ambiances, the differences between individual spatial units are not so pronounced as they are, for

example, in Villa Müller (by different use and materials in the interior) or Exeter library (by a different kind of illumination, as well as the materiality). The spatial units in Vagelos Education Center do not display obvious visual contrasts. They are all similarly illuminated from the glass facade; similar colors and materials are used in the interior throughout the entire "Study Cascade" to emphasize its unique concept.

Yet, it is evident that there are differences between the stepped study lounge on level six, the informal sitting lounge on level eight, the commuter workspace on level seven, or the private study on level eight freely hanging over the stepped lounge. These spaces provide different levels of intimacy, generate different kinds of activities, and create different atmospheres or different feelings in space. Thus, together they constitute a heterogeneous whole.

In this case, similarly to the Jussieu library building, it is possible to talk about levels of heterogeneity. These two case studies are examples of a free plan and share the idea of the section as a path, although, in the case of the library, the path is more complex and incorporates a broader program. In both cases, the spaces are articulated by movements of the slabs and cutting out pieces of slabs –compositional strategies that simultaneously connect and separate spaces. Another way of defining spaces in these two projects is simple zoning, i.e., changing the use of space while it remains open. Yet, the spatial composition plays an important role, too, as the

changes in the frame of space suggesting changes of use. However, the openness of such spaces diminishes the differences between them. Such spaces are only conditionally separated into special spatial units on diagrams, based partially on their frame and the manners of use. Thus, these case studies demonstrate that composition is not the only condition of heterogeneity: it depends on materiality, use of light, function, etc. However, the composition gives the possibility to make these differences more pronounced, and, therefore, there are different levels of heterogeneity.

Figure 111. *Vagelos Education Center – stepped lounge level 6- 7.*
Source: *https://www.e-architect.com/new-york/columbia-university-medical-center*

Figure 112. *Vagelos Education Center – stepped lounge on level 12.*
Source: *https://sciame.com/portfolio/roy-and-diana-vagelos-education-center-columbia-university-medical-center/*

Figure 113. *Vagelos Education Center – stepped lounge on level 12.*
Source: *https://www.facilities.cuimc.columbia.edu/capital-projects/our-projects/roy-and-diana-vagelos-education-center*

Figure 114. *Vagelos Education Center- study gallery level 11.*

Source: *https://www.brabbu.com/en/inspiration-and-ideas/interior-design/diller-scofidio-and-renfro-the-secrets-to-urban-architectural-design-excellence*

Figure 115. *Vagelos Education Center – sky lounge level 14.*

Source: *https://www.e-architect.com/new-york/columbia-university-medical-center*

6. Understanding, Implications, and the Value of the Concept of Spatial Heterogeneity

6.1. Understanding Heterogeneity through Spatial Relationships

This study attempted to interpret heterogeneity in architectural space in relation to the spatial composition and the diversity of the spatial atmosphere. This investigation aims to understand how the inner relationships and connections of space influence (or determine) the nature of space, and to further place this idea in a historical context.

The theoretical foundation of this interpretation was developed from Peter Eisenman's reading of topology in *Palladio Virtuel* that establishes a relationship between this abstract mathematical concept and the quality of space. Eisenman does not interpret topology as the communications and circulation within the building, but as the relationships of spatial volumes: their "adjacency, superposition, and overlaps." However, his concept is based on virtual spatial overlaps that are visible only in diagrams. This study attempted to reinterpret and extend Eisenman's idea of topological

relationships toward connections between spaces. This idea is based on thinking that only through actual connections of spatial volumes (where they are at the same time articulated as separate yet connected wholes) can the overlaps and superposition can happen. In this manner, it is possible to create differentiated spaces through the differences of individual spaces. An important aspect of this interpretation is that the connections are not focused on access from one space to another but rather on connections that open one space toward another and allow the volumes to interact. Accordingly, spatial overlaps, “spaces-within-spaces” or “spaces-between-spaces,” are formed through different types of interactions between spatial volumes within the building. This concept emphasizes the importance of the boundaries’ design and both sectional and planar composition to create space that encompasses a changeable ambiance. To examine this concept, six case studies were analyzed. These incorporate such compositions that are probable to create “spaces-within-spaces” and “spaces-between-spaces:” the interconnection of spaces, the nesting and layering of spaces, and the sectional movement.

The six case studies are projects of different scales, created in distinct contexts, with different function and use patterns. Thus, each building demands a different spatial organization as well as the levels of enclosure and intimacy of the main spaces. In general, the interaction of spaces can be understood in terms of the functional, social, and political contexts, etc. However, in the analysis, they were used purely to understand the spatial idea of overlaps and the superposition of individual spaces within a composition as well as their effects on the quality of space. Thus, the case studies provide a solid understanding of how spaces can be designed to

create spatial overlaps. The importance of spatial connections in this process allows for an interpretation of the concept of topology through spatial relationships and the structure of spaces as propriety relevant to spatial qualities.

To clearly define and consolidate this interpretation of heterogeneity, this section begins by elaborating upon compositional properties that form spatial overlaps that display topological relationships of spatial volumes and then discusses the relevance of this interpretation.

6.1.1. Composition, Boundaries, and Connections

COMPOSITION

All case studies examined here encompass compositions of interconnected spaces. However, in each of the buildings, this happens in different ways. The first two case studies – Loos' *Raumplan* based houses – demonstrate how spaces are interconnected and overlapped in an intimate, domestic setting. The spaces are clearly volumetrically defined wholes. Other projects are larger public buildings, and, thus, demand a different level of intimacy and enclosure. While these are essential aspects in the design of the spatial composition, this study has attempted solely to extract compositional and spatial design ideas that result in spatial overlaps or the interaction of spaces regardless of the context.

1) Interconnected spaces

Interconnecting space is an obvious strategy to create an interaction. The interconnecting of spatial volumes can be achieved with diverse compositional strategies. However, it is important to note that the connection between spaces, an essential feature of the composition that embodies spatial overlaps, does not refer solely to access. Indeed, accessibility has a profound impact on the nature of space. Nonetheless, this study considers connections that allow spatial volumes to interact and overlap, which is impossible if the relationship of spaces is established through doors.

Among the case studies that were examined, Villa Moller and Villa Müller are the most obvious examples of interconnecting spaces. Both houses are based on Raumplan and conceived in spatial volumes that are not arranged on horizontal slabs but extend vertically and horizontally, creating spaces of different heights connected through stairs. These volumes are not entirely enclosed, but they open one toward another, thus creating a sort of inner path connecting the “places.” The simplest type of connection is creating a cased opening between two rooms. This connection is often made together with a sectional movement (displacing the slabs and positioning them on different heights) which plays a role in defining the parts of space as separated volumes. In Villa Müller, several window-like openings are created in dividing walls. These openings have no other function than to visually connect the spaces. The third type of visual connection in Raumplan houses is the connection over the low partition, usually enclosing a small elevated sitting area. These seating arrangements create different effects than when the two adjoined spaces are connected

through an opening. Specifically, the lady's alcove in Villa Müller, created by elevating the floor and extending the division in the form of a low wall, represents in the real sense a "space within space" in a similar way that *baldacchino* defines space within the interior of a church. The window-like openings in Exeter library have a different character as they extend through several levels, thus creating a more complex spatial configuration. In addition, the spaces' peculiar connection (or separation) occurs between the book stacks and the reading areas. These are two zones that are functionally and ambiently different. Yet, the boundary between them is not clear.

In the Jussieu library, there are no vertical divisions of spaces. Instead, the spaces are separated by manipulation of the floor plane. In this manner, connections are created between different levels. Furthermore, various programs continue one after another across the tilted planes from the lowest to the highest level in the library. Thus, it is possible to say that they are interconnected, although, in most cases, there is no physical boundary between them. The differences are created through changes in the floors' disposition or by the arrangement of objects in the space. Similarly, in Vagelos Education Center, the boundaries between spaces are created through the movement in the sectional composition or simply implied by the way space is used.

2) Nested and Layered Spaces

Two projects in this study allowed the examination of how the nesting and layering of spaces are advantages for creating complex spaces. In Exeter library, placing the three spaces, one within another, enabled the interconnection of the entire body of the building. Reading areas on each floor constitute a continuous space and connect with book stacks that are also interconnected into a continuous ring on every floor. In Hurva Synagogue, four hollow columns are nested inside the building. Due to their position in the central space, they not only create “space-within-space,” but they also vaguely divide the main space into smaller segments. The corners of the hollow columns mark the corners of the central space whilst their sides flank the sitting area. Circulating space is formed on the outside of the columns along the pylons that mark the exterior wall. This kind of composition allowed for the division of the large volume of the interior into smaller spaces without building walls. Space is also vertically divided by galleries. The difference between the central space and the sitting area is emphasized as the former extends to the roof while the latter is covered with galleries. Thus the space in Hurva Synagogue is differentiated both horizontally and vertically, despite the whole interior practically constituting a single volume. The boundaries between the galleries, central space, lower level sitting area, and the space under the galleries are implied but non-existent. This project demonstrates how manipulating spatial compositions separates and connects the spatial volumes at the same time, creating a continuous yet differentiated space.

These two projects demonstrate clearly how the composition has a role in creating spaces – they are not just divided or added together but form more complex relationships. Nesting and layering do not necessarily result in the effects that these two projects have; however, they enable the creation of more complex spaces in contrast to linear additions or subdivisions within a whole.

3) Free section

All case studies encompass a sectional movement. The manipulation of the horizontal slabs has a vital role in separating spatial volumes as functional units while connecting them visually. Thus, sectional movement (or "free section") becomes an important element for establishing connections (especially visual connections) between functionally and physically disparate spaces. From this follows that the simple types of section (such as the *extrusion, shape,* or *stalk)* are not advantageous to achieving such spatial connections, as they create simple spatial volumes. Contrarily, complex sections as shear, hole, incline, nest, and hybrid types, give the possibility of multiplying visual connections and the overlaps of spatial volumes.

In Raumplan based houses, the manipulation of horizontal slabs contributed to better defining elevated sitting areas as separate spatial units ("space-within-space"), or clearly distinguishing between two interconnected spaces where each of them attains different character by changing the height of the ceiling. In the Exeter library, the floor slabs are layered horizontally. However, the vertical cut of the central hall through them (as

well as the receding outer edge from the exterior wall on every other level) allowed for the creation of diagonal visual connections.

A prominent case of the free section among the case studies is the Jussieu Library building. Here, the entire body of the building consists of one continuous, sloped, and folded plane. This design creates differences, separates, and connects different spaces by manipulating the floor plane. Sloping the parts of the plane creates vertical slits (voids) that allow visual penetration through several layers. A change in the direction or angle of the floor slab marks the boundary between the spaces without vertical division. Furthermore, it allows for a smooth transition from one space to another.

The "Study Cascade" of Vagelos Education Center encompasses several sectional themes: stepping the slabs, cutting a piece of the slab to connect with the spaces vertically, and hanging galleries above the main space. Similar to the Jussieu project, these sectional strategies enabled the interaction of spaces on different levels, typically in tall buildings separated by horizontal slabs.

However, the above argument does not imply that the sectional movement is *sine qua non* condition for spatial volumes to overlap and superimpose. Similar effects can be achieved with the composition of the plan by using different strategies of nesting and layering spaces and creating connections between them. The design of boundaries (perforated walls, stone lattices, etc.) also plays a significant role in interconnecting spaces. Nevertheless, the sectional movement is particularly advantageous for multiplying visual connections, and, thus, giving a more complex structure to space. Thus, we can assert that spatial composition is essential for creating spatial overlaps. Communication between spaces is not limited

solely to plan, but also extends to sectional composition, which forms a spatial composition.

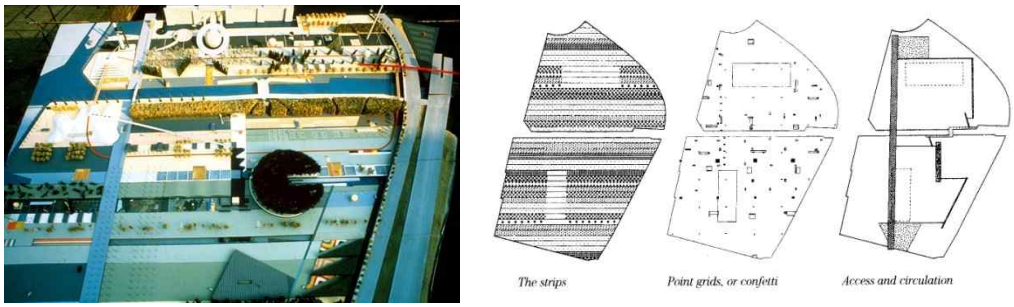
CONNECTIONS AND BOUNDARIES

This study has found that the spatial overlaps, or topological connections, are formed by avoiding the rigid boundaries of spatial volumes both vertically and horizontally. Naturally, it is not possible to apply this kind of spatial idea in designs that require a greater level of intimacy and isolation. However, it demonstrates that it is possible to make a boundary through compositional aspects of a building without building a wall. Hurva Synagogue, where the nesting of spaces divides the interior, is an example of this. A kind of blurred boundary also occurs between the reading and the book area in Exeter Library. The boundary is implied by the difference in the height of the ceiling and the row of structural columns, but the spaces in this area can be understood as either part of the reading area or part of the book area. As this area belongs to both spaces, it can be interpreted as a spatial overlap. The transition from one space to another is smooth and it happens through the change of ambiance. In Vagelos Education on the “Study Cascade”, composed like a vertical promenade or “a path and a place,” there are no boundaries between “paths” and “places;” these are only implied by the way space is used.

The case studies demonstrate that differences between spaces can be more pronounced or vague. In those more pronounced, the spaces are clearly defined by boundaries, and they usually open toward another space through a “window” or cased opening. In vaguer ones, the differences between individual volumes are only implied by, for example, the

manipulation of horizontal slabs. The extreme case is when the new space is created by a simple change in the program or arrangement of objects in space. In such cases, the boundary of two spaces is not any particular kind of element but rather a gradual change of spatial qualities. In such a case, the composition does not play a significant role in creating the differences. However, the composition can amplify the differences by setting clear boundaries and defining spaces more closely, even without vertical divisions. This is visible in two different versions of the Jussieu Library project (Figure 93), where the differences within the deep and vast space of the library are created through the changes of the folded floor plane and constant change in the program. The diversity is more amplified in the version of the project where space is differentiated not only by the programmatic change but also by sinking a part of the slab and connecting it to the lower level.

The idea of heterogeneity through the programmatic diversity without physical boundaries, that OMA explored in the dynamic library plan, was previously applied in OMA's competition project for *Parc de la Villette* (1982-83). This project envisions a park where different programs are organized in lateral stripes, connected by a vertical promenade. While the park is heterogeneous in its content, the park's size and openness do not allow the experience of the diverse contents simultaneously.



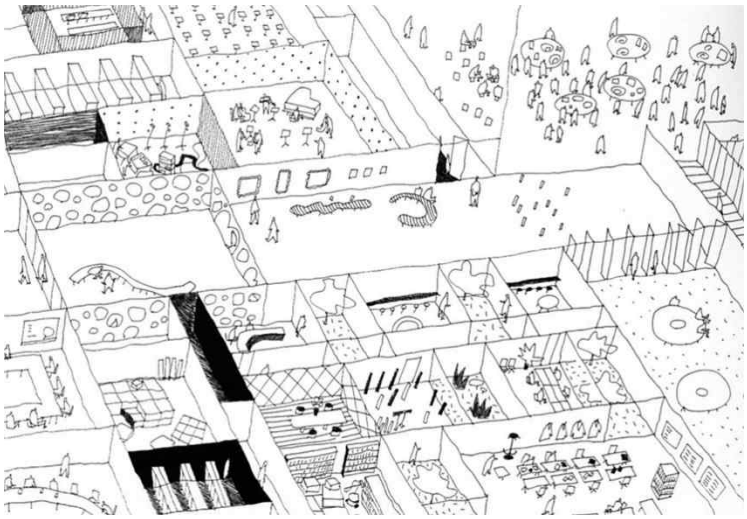
a) b)

Figure 116. *OMA, Parc La Villette, competition project; a) model; b) conceptual drawings.*
Source: *OMA, Parc de la Villette, https://www.oma.com/projects/parc-de-la-villette*

Similarly, in the spaces where diverse contents are contained in enclosed rooms, it is impossible to experience different atmospheres simultaneously, except moving from one space to another. Such examples include SANAA's *Theatre and Arts Centre De Kunstlinie*.

The base of the project is partitioned into rectangle-shaped rooms attached to one another without hierarchy. These spaces are intended for different artistic activities; however, they constitute discrete programmatic units linked through access doors. The strict, impermeable boundaries do not allow for their interaction. While "windows" exist between many of the rooms, they do not allow for enough interaction to create a heterogeneous whole. Regarding levels of heterogeneity, such space is still more heterogeneous than completely enclosed discrete rooms are.

Accordingly, the definition of boundaries is an essential element in rendering the space heterogeneous. Even in cases where the differences in the program create diversity without boundaries, the differences are emphasized through implied boundaries.



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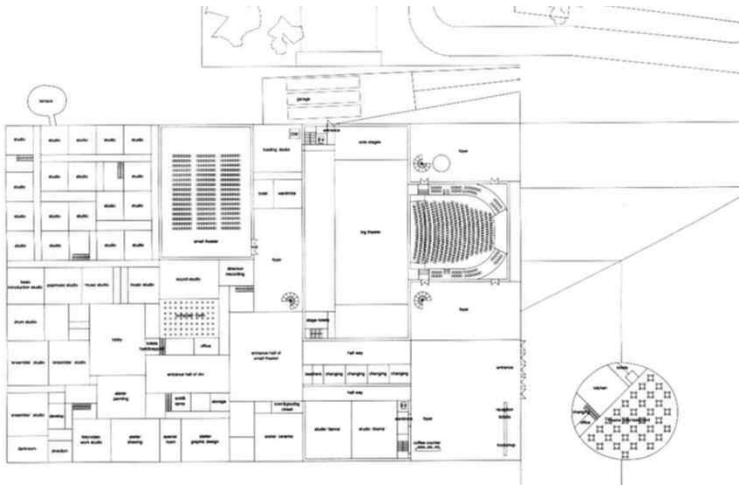

b)

Figure 117. *SANAA, Theatre and Arts Centre De Kunstlinie, Almere,2004-2008; a) sketch; b) floor plan.*

Source: *https://www.archiweb.cz/en/b/de-kunstlinie-mestske-divadlo-a-umelecke-centrum*

6.1.2. The Effects in Space and Interpretation of Heterogeneity

The compositional principles that have been examined through the case studies enable reinterpreting the “adjacency, superposition and overlaps” of spatial volumes as connections between spaces. The overlaps and superposition can happen through actual connections of spatial volumes (where they are at the same time defined as separate yet connected wholes). This study has attempted to actualize the overlaps of spatial volumes through connections between them and denote the quality of these spaces through the concepts of atmosphere or ambiance. Within this interpretation, the idea of overlapping spatial volumes is no longer the overlapping of abstract, empty, geometrical volumes, without qualitative properties and unrelated to the human experience. Instead, the qualities of these spaces and their ambiance become part of the equation. Through connection within a composition, spaces of different ambient qualities are brought together, rendering space diverse.

These kinds of effects are visible in the case studies that have been analyzed. In Loos’ volumetric villas, interiors are designed as paths from one space to another where, as Adam Caruso notices, one is “aware of moving from one atmosphere to another, from an intimate and fragile setting to a grand and representational one.” Villa Müller is an especially prominent example of Loos’ architecture that generates the effects of a heterogeneous atmosphere. The diversity in space is emphasized by the materials in the interior, as each of the spaces within the villa is characterized by specific materiality. From here follows that the effects of interacting ambiances are more prominent if the two spaces that are interconnected are mutually

different in quality. In other words, the differences of individual spaces need to be more pronounced to make this diversity of ambiance more obvious. Thus, the difference in materiality and colors in each interior emphasizes the differences produced by compositional aspects and the specific frame of each space. In Exeter library and Hurva Synagogue, the differences between spaces are emphasized by different illumination qualities and materials. In Vagelos Education Center, these differences are less pronounced as the spaces share similar materiality and are lavishly illuminated through the glass façade. However, the arrangement, the position of spaces, and the levels of intimacy differ. In addition, these spaces accommodate different kinds of activities and, thus, generate a different atmosphere. Thus, experiencing the heterogeneity in the interior is not only related to the differences in visual qualities but also the patterns of use. It is difficult to talk about the atmosphere of the Jussieu library, considering the lack of material on the project. However, the constant change in the frame of space and the program change implies that it would have a variable atmosphere despite the space's openness.

6.1.3. Topology as a Depiction of Spatial Character

In this study, the specific spatial relationships that create a heterogeneous atmosphere in space were interpreted through the concept of topology. After identifying the basic principles that create spatial overlaps in spatial composition, they were interpreted through the topological relationships of vicinity and connection. Each of the case studies was described through

topological diagrams that graphically depict spatial relationships. This was accomplished in several steps. Firstly, each study was divided into individual spatial units and explained how these units are different from other spaces in terms of spatial ambiance. Secondly, the connections between them were examined and classified. Finally, diagrams were generated by turning spaces into vertices (nodes) and connecting them into edges. The critical aspect of these diagrams is that the connections (vertices) were classified into three groups – access, open access, and visual connections. When the type of connections that is irrelevant for the interaction of spaces is excluded from the diagram, the new topological diagram discloses the complex (heterogeneous spaces) that consist of several connected vertices and simple (homogenous spaces) that encompass one discrete spatial unit.

The purpose of topological diagrams is to depict the spatial relationships and make the abstract concept of topology as the structure of space more tangible. Diagrams show that it is necessary to avoid rigid boundaries of spatial volumes to create a complex space (where the superposition and overlaps of spaces occur). However, it is also essential to create enough difference between individual spaces that they do not merge into a continuous whole. In other words, a complex space is neither conceived as a complete enclosure nor does it aim toward openness, as these concepts suggest isolation and singularity; spaces are not cut off as homogeneous entities and discrete parts but overlap and extend, blurring the differences between them. In this kind of space, the boundaries are not necessarily physical obstacles but gradient changes of spatial qualities.

Understanding how the creation of spatial overlaps and connections affects the actual space, and how they differentiate its character indicates

that these relationships and connections embody the nature of space. Thus the topology of space could be understood not only as circulation within a building (how Rayner Banham described it) but as any kind of connection between spatial volumes (that is not necessarily related to patterns of movement through the building). Furthermore, the importance of the sectional composition for the creation of “spaces within spaces” showcases that topological relationships depicting a space do not only extend horizontally through the plan, points of access, and circulation. They also extend vertically and diagonally through visual connections. Since these connections play an important role in the character of space, topology accurately describes the structure of a space and its character. This is why the parallel to the mathematical concept of topology is more than a metaphor. If any of the boundaries were changed, connections broken, or new connections made, the character of the space would change. Thus, the connecting of spaces is not only functional, as it defines the character of space psychologically as well as aesthetically.

Thus, the aforementioned compositional design strategy is not only conceptual (i.e., a “thing of a mind”). The metaphorical correlation of this idea with the mathematical definition of topology is relatively weak. Topological space in mathematics is defined as a set of points that share properties that are not changed under continuous deformation. The properties they share are called topology, and the connection of points is one of these properties. One cannot say that the properties of any space would not change under the continuous deformation of its frame. However, the examples of previously examined spaces demonstrate that the connectivity, number, and nature of connections between the spaces are

much more relevant to architecture. Changing these connections has a profound influence on the nature of space. Thus, topology in architecture could be defined as a structure of space that involves all kinds of spatial connections depicting the character of space. Thus, the correlation of this concept with architecture is stronger because it depicts the character and the diversity of space.

However, the topology of an architectural space defined in this manner is not an exact science. It could be understood as a qualitative property that depends on spatial relationships and changes if the structure of space is changed. Nevertheless, there are no exact guidelines to prescribe for the spatial design of diversity. Any attempt to construct guidelines for such a design would impair creativity. This concept simply explains the role that spatial relationships play in a building and its relationship with the surrounding. The argument presented in this study does not allude that the composition of interconnected spaces is preferred over simple and enclosed ones, nor can interlinking, layering, and the diversity of space be applied in every context. The argument presented here solely suggests that the complexity of spatial quality could be understood through the connections and relationships with other spaces.

6.2. Implications of the Concept in the Context Discourse on Homogenous/Heterogeneous Space

Placing these ideas in the historical context of the development of modernist composition and later quest for heterogeneity presented in Part 1 of this study gives a new perspective to the “homogeneity” of space.

The concept of topology understood as the structure of space is materialized through spatial compositions. To create a complex topological structure, the composition needs to consists of spaces that negotiate between enclosure and openness. The spaces are not entirely open nor enclosed; their characters mix and overlap, generating diverse qualities. However, we cannot talk about interconnected spaces if the spaces are not separated entities. Thus, these effects are impaired in modernist compositions where the lack of enclosure abolishes the differences between spaces binding them and creating a unified atmosphere. On the other hand, in traditional enclosed spaces where the volumes are entirely separated, the connections established through doors cannot generate overlaps. The compositional strategy of connecting spaces counters this problem by providing enough enclosure for individual spaces to keep their distinguished character. Yet, it does not aim to achieve the opposite (i.e., complete enclosure), such as in traditional spaces, which are also homogeneous in their singularity.

Furthermore, the elimination of sectional hierarchy within the modernist composition (discussed in the second chapter) also has an essential role in the homogenization of the ambiance. The space clasped

between two slabs only has the possibility of horizontal extension, thus the possible connection with any space that is not horizontally adjacent is hampered. Contrarily, the compositions that encompass sectional movement suspend the modernist “sandwich-like quality of space,” allowing it to extend vertically and horizontally. The critique of such spaces usually focuses on the political meaning, as well as abolishing the hierarchy present in neoclassical and classical buildings in the name of democracy. However, as the examined case studies show, the hierarchy of spaces does not have to be translated into a hierarchy of social order or to have a political meaning.

Examining the compositional aspects of modernism through topology as a spatial structure, the problem of the “homogeneity” of modernist space relates primarily to some of the compositional ideas brought forward in modernism. These are spatial fluidity and openness (that impair diversity by merging all the spaces into a continuous whole) as well as the lack of sectional movement. In addition, design based on a grid does not allow for any ambiguities in the plan, spatial overlaps, nor blurred boundaries. Space enclosed between the two horizontal slabs renders all spaces equally important and hampers the possibility of any kind of vertical connection between the spaces. These two aspects of composition create a “universal space” that can be infinitely extended horizontally, but not vertically. Such space creates a unified atmosphere without variations. This means that in a topological diagram the entire interior would be rendered as a discrete spatial unit.

The compositional strategies that have been examined in this study (interconnecting, layering, and the nesting of spaces, as well as creating a

“free section”) break such composition and homogeneity of the ambiance. Overall diversity is achieved as the differences between spaces become evident, as they are not separated from one another but allow differences to coexist. For this kind of space, we can say that it is a heterogeneous space as opposed to the homogenous character of modernist space. Of course, it is not possible to talk about absolute homogeneity (except in abstract spatial concepts such as the Euclidean space or absolute space), but rather a low level of diversity. Through multiplying the spatial connections, space becomes more diverse, i.e., heterogeneous.

These concepts become clearer when comparing the interior of Mies Van der Rohe’s New National Gallery in Berlin (an open-plan building where the interior is defined between two horizontal planes) and Kahn’s Bangladesh Parliament building. The former project presents a typical modernist, pure, universal space with minimalistic aesthetics. The horizontal slabs are dominant and do not allow any change of quality in the vertical direction. Horizontally space extends infinitely through glass sheets that only vaguely separate the inside from the outside; there are no significant variations in the quality of space. The latter project is composed of layered spaces connected through window-like openings. Vertical cuts allow for visual communication of different levels, binding different spaces in a unified whole. Of course, these are two projects of different scale, function, and context; however, they demonstrate well the difference of spatial ideas and the effects of homogeneity and heterogeneity.

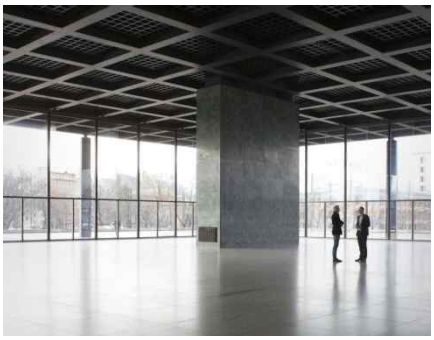

Figure 118. *Mies Van der Rohe, Neue Nationalgalerie, Berlin, 1968.*
Source: *https://www.preussischer-kulturbesitz.de/*

Figure 119. *Louis Kahn Bangadesh Parlament building, 1961-1982.*
Source: *https://mosqpedia.org/en/mosque/302*

It is important to note that only a small number of buildings attain "pure" modernist composition, and thus examples of this kind of purely homogenous space are rare. Instead, we can talk about levels of heterogeneity. The level of heterogeneity increases with the complexity of connections. Furthermore, both Loos' houses and Louis Kahn's projects that have been analyzed in this study historically belong to the modernist period. Thus, the properties of the complexity of space and homogeneity cannot be associated with any style of architecture or historical period, but rather with individual projects.

6.3. The Relevance of the Interpretation

What is important for this interpretation of heterogeneity/homogeneity through the structure of space is that it gives a new perspective on the problematic of “homogeneity” of space, found in revisions of the modern movement. Moreover, it gives an understanding of heterogeneity focused on architectural space as an alternative to formal interpretations.

Through this interpretation of heterogeneity and its significance in the ambiance of space, this study emphasizes the importance of spatial relationships and connections within a building. This becomes important in the context of digital architecture where the focus of creation is the form and the process of manipulating the form.

The logic of relationships and connections does not apply solely to interior spaces, but it can be extended towards the outside, where such connections create layers of interiority and exteriority.

As previously explained, this study does not agitate preference for heterogeneity over homogeneity. It only distinguishes levels of heterogeneity in relation to the complexity of space. Furthermore, the level of complexity of space depends on several contextual conditions, and therefore, the spatial strategy of interconnecting spaces cannot be universally applied.

The idea presented in this study tends to relate to the spatial and compositional concept that embodies heterogeneity to the human experience of space. The ideas of the emotional and psychological relationship between people and space that put space in the center of

architectural creation originate in German aesthetics.[266] According to Long, Loos' (among others) was influenced by these ideas, and his houses were designed to fabricate a certain experience of the users through movement.[267] This idea assumes opening the connections between spaces. This is why his houses encompass a fluidity of movement between the rooms. Experiencing such spaces is different than experiencing completely enclosed rooms.

It is possible to suggest that such a compositional arrangement might have a psychological impact. Venturi's observation that "the function of the house is to protect and provide privacy, psychological as well as psychical is an ancient one" can be extended here. The space that is both open and enclosed negotiates "between our desire for freedom and the need for shelter, between our opposing needs for isolation and socialization; it negotiates between the sense of belonging and the need for a change."[268] In this regard, in Loos' villas, inhabitants have a chance to enjoy privacy and "publicity" at the same time.

With this understanding, the idea of interconnected spaces approaches Aldo van Eyck's concept *in-between*, because in a manner it is a reconciliation between the two opposites, "spatial anti-poles."[269] Through this reconciliation, *space* becomes a *place*, which means that it is not an abstract concept, but includes a man.[270] In the context of heterogeneity,

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[266] Venturi, Complexity and Contradiction, 70.
[267] Long and Thaler, *The New Space*, XIII.
[268] Mandić and Baek, "Compositional Principles of Heterogeneous Spaces," 11.
[269] Aldo van Eyck, "Das Reich des Zwischen" [The In-Between Realm], *Forum,* no. 8 (1959): 268.
[270] Aldo van Eyck, "Interior Art," in *Aldo van Eyck: Writings vol. 2,* eds. Vincent Ligtelijn and Francis Strauven, Amsterdam: SUN. 2008), 296.

spaces negotiate between enclosure and openness. However, the spatial composition of interconnected rooms and overlapping volumes, which this study suggests as a means of creating heterogeneous ambiance, is not an intermediary place or a threshold (although it might include it). It is a whole that is characterized by a gradual change of qualities between the inside and the outside or between one place and another. The whole space is characterized by the gradual change of quality that is possible due to the contradictory nature of each articulated part.

7. Conclusion

The present study assesses the problem of heterogeneous space in architecture and gathers scattered ideas about the subject, making connections between them and identifying the problematic they encompass. It further develops a new interpretation of the heterogeneity of architectural space through the relationship of the structure of space (spatial composition) and the ambiance of space. The problematic that this new interpretation of heterogeneity accesses is twofold: (1) the interpretation of “homogeneity” of modernist space through Euclidean geometry and formal aspects of modernism, and (2) later attempts the reverse these through formal interventions. These include several architectural movements from postmodern collage to “topological architecture” that used topology as a conceptual resource that presumes complexity and fluidity of form as essential for creating a space that embodies diversity and integrates into the urban context.

Accordingly, this study took two steps to establish a new understanding of spatial heterogeneity. Firstly, it examined the broader context of the aforementioned problematic. The theoretical background includes ideas of space in early modernism, the critique of their understanding of space and design strategies, and different approaches

toward heterogeneity that have been animating architectural production since the 1960s in an attempt to reverse these effects. Secondly, the study established theoretical grounds for a new interpretation of spatial heterogeneity through the structure of space. It further examined these ideas through six case studies, finally elaborating on implications of such understanding of the heterogeneity and manifestations it has in architectural space.

The extensive examination of the spatial and design ideas conduced in the first part of the study does not integrate into the study as a historical overview but as a critical reconsideration of these accounts with the purpose to place the study in the context. By thoroughly examining the relevant literature and design ideas, this study attempted to disentangle the different meanings that the word “homogeneity” carries in the relationship to architectural space. It sought to illuminate illogicality and methodological problems embedded within the critique of modernism as well as the later attempts to approach this problematic through the architecture of formal complexity. The most important finding that followed this examination was to recognize that the rift that exists between the concepts of space and the experience of space (that Bernard Tschumi brought forward in *The Architectural Paradox)* persists in the discourse of spatial homogeneity. This paradox animates the critique of modernist “homogenous space” as well as the accounts that were interested in creating the space that embodies diversity by using scientific concepts of space unavailable to the human experience. On the other hand, the ideas of how individuals perceive space, brought into this context, do not build the design knowledge. These problems might not coincide exactly with Tschumi’s theory of

concept/experience duality. However, they do illustrate what Tschumi pointed out that as a conceptual discipline that seeks for a substance and as a discipline concerned with fashioning experience, architecture is necessarily interested in both concepts and experience. Thus, looking into different accounts of how to create a space that embodies diversity, this study found that the concepts irrelevant to experiencing architecture, such as different geometrical models of space (as well as other ideas from science and philosophy) are drawn into the discourse. These ideas fall under the domain of architecture as a conceptual discipline and respond to heterogeneity as a "thing of a mind." Nevertheless, the effects of such designs on the quality of diversity of space and the human experience of it are questionable. In other words, these two entities – concepts and experience – do not have to exclude each other. However, there is no cause-effect relationship between them. Thus, there is no reason to assume that applying a concept that presumes space as heterogeneous will result in a design that embodies differences. Understanding the theoretical background, and the problematic of heterogeneous spaces in this light made it clear that heterogeneity of space has to be formulated as a concept and a design strategy (which effects in space can be experienced) to be relevant to architecture. In this context, this study places the homogeneity of modernist space in the open and fluid composition and unified atmosphere of space it produces. It further attempts to uncover the principles of compositional design that could reverse these effects by generating a diversity of spatial qualities. This idea dwells upon Tschumi's position that the experience of space, as an interest for architecture, is essentially aligned with "making space distinct" by determining boundaries. Thus, the

question of designing a heterogeneous space in architecture (a space that embodies a diverse array of qualities) would involve determining how to reverse these effects through spatial composition and the definition of boundaries. In other words, how determining boundaries could not only "make space distinct," but also render it diverse. The answer to this problem is finding the principles of compositional design that reverse these effects and generate the diversity of spatial qualities within a building.

Following these findings, this study developed a new interpretation of heterogeneity in the context of architectural space that surpasses the formal approaches and shifts focus toward spatial relationships within the architectural composition. To develop this understanding of heterogeneity, a deductive method of study was applied. Through examination of literature, a theoretical argument was developed in three steps. Firstly, the idea of topology that denotes the logic of spatial relationships and the structure of space was borrowed from mathematics and employed as a conceptual resource. The theoretical basis of this interpretation found in previous studies was critically assessed and developed further. Secondly, the abstract concept of topology was embodied through spatial composition becoming a spatial configuration of interconnected spaces that generates a diversity of spatial qualities by allowing for different ambiances to come together. Character, ambiance, or atmosphere is used as a denotation of the spatial quality of spaces. This quality is present in every setting and is fabricated between the place's physical qualities and the subjective feelings of the observer. Thus, spatial heterogeneity is understood as a varying atmosphere that manifests itself through the interactions between the setting (spatial composition within a building) and the inhabitants. This happens in

the compositions where spaces are interconnected so that their individual spaces interact, creating a heterogeneous whole. This strategy directly contradicts both traditionally enclosed spaces and open and fluid spaces.

After establishing the theoretical grounds for understanding the heterogeneity/homogeneity of space through the topological structure of space and spatial ambiance, this study examined the theory through six case studies that encompass the principles of composition presumed to be advantageous for establishing connections relationships between spaces. Through the examination of the case studies, this study demonstrates that visual connections and open access between the spaces play a key role in generating a diversity of spatial qualities, interpreted as spatial heterogeneity. The concept of topology describes the structure of space in terms of complex (heterogeneous) spaces that consist of several interconnected spaces (ambiances) and discrete (homogenous) spaces. Thus, it defines spatial wholes and the levels of complexity of space. This internal topology of interior spaces demonstrates that the more interconnected spaces are, the more complex, heterogeneous ambiance they create. The connections are crucial to this concept as they define the quality of space. Breaking any of these connections essentially changes the character of space. However, to create diversity, differences must exist between interconnected spaces. If the qualitative differences between the spaces are more pronounced, the heterogeneity is more prominent.

This interpretation of heterogeneous spaces has the following implications:

1) The spatial composition of a building plays a key role in generating the diversity of spatial qualities. This happens through topological

relations, i.e., spatial connections. The diversity of spatial qualities comes from interconnected volumes that negotiate between enclosure and openness and thus create change and variations in spatial qualities within a building. These connections are not only established as open access from one room to another but also through visual connections that can be enhanced through sectional movement, perforated walls, and a variety of boundary designs.

2) In the context of the study's background, such spatial arrangement counters the fluidity of space and the continuity of the inside and the outside – hazards of modernist architecture, which render an architectural space homogeneous, whilst concurrently escaping from traditional closed spaces and hierarchies. A new understanding of spatial heterogeneity is achieved through the idea of changeable ambiance that stems from the spatial composition and provides us with the possibility to understand the homogeneity of open and fluid spaces that lack any enclosure – unvarying unified atmosphere.

3) This homogeneity is different from the homogeneity of Euclidean space. The space of our experience and architecture cannot be homogeneous in that sense: it can only have levels of diversity. The concept of heterogeneity of space that this study puts forward is not preferred over homogeneity. It is just meant to illuminate the relationship between spatial arrangements and spatial ambiance. Homogeneity and heterogeneity of space are then not understood as two opposites (Euclidean and topological, rectilinear and curved, ordered and disordered, symmetrical and asymmetrical, etc.). This study gives a nuanced understanding of spatial diversity depending

on the complexity of spatial relationships. According to this understanding of homogeneity/heterogeneity, there has never been a completely homogeneous space in architecture, not even in the entirely open and fluid buildings.

4) The concept of topology understood through spatial relationships does not equal the mathematical discipline that deals with the properties of geometrical bodies that remain under deformations. Yet it does describe the structure of the space through the connections and vicinities of spaces (points). The topology of an architectural space is therefore a structure of spatial relationships that describes the character of space. Interpreted through spatial relationships and connections, the trope of topology as a paradigm of heterogeneity becomes more than just a parallel to the mathematical concept. It accurately describes the quality of space and further relates to the experience of the space through the variations in space spatial qualities. Thus, the said compositional design strategy is conceptual (i.e. “thing of a mind”) and oriented towards the users' experience.

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Abstract

본 연구는 콤포지션을 통한 공간의 다종성 해석에 대한 연구이다. 이러한 아이디어의 배경은 건축과 도시 디자인 모두에서 모더니즘의 공간 전략을 동질적인 공간 효과의 촉매로 여겼던 포스트모던 건축 비평으로 거슬러 올라간다. 디자인을 통해 이러한 공간적 효과를 되돌리려는 시도는 1960년대 초부터 여러 차례에 걸쳐 있었는데, 이 중 “추상적인” 동질성 공간 개념에서는 사람이 공간 체험에 대한 개념을 끌어들이고, 복잡한 공간 형태를 만들어내는 다양한 방법이나 방식을 주목한다. 이질성을 열망했던 많은 접근법들은 과학과 철학에서 차용된 개념을 통해 이론적 확실한 증거를 추구했고, 그 중 건축과의 관계는 종종 표면적이고 명확하게 정의된 인과관계가 없었다. 이러한 방식으로 사용되는 개념 중 하나는 수학에서 차용한 토폴로지의 개념으로, 토폴로지의 동적 특성이 개념 자원으로 채택되고 모더니즘과 관련된 유클리드 기하학에 반대하는 복잡한 형태의 생산에서 설계 프로세스 방법론으로 사용된다.

본 연구는 앞서 언급한 설계 접근방식이 다루는 문제가 되는 “동질성” 공간을 조사하고 비판적으로 접근한다. 모더니즘에 나타난 공간의 “동질성”을 공간 구성의 개방성과 유동성에서 비롯된 낮은 수준의 다양성으로 다시 해석한다. 이러한 관점에서 본 연구는 형식적 접근법을 초월하고, 이러한 공간적 효과를 역전시키는 건축 구성 측면에서 공간의 다종성을 구축하고자 하고 상호 연결된 공간 구성 전략을 제시한다. 또한 이러한 공간 배치에 나타난 공간 분위기를 통해 공간의 다종성을 분석한다.

연구의 논증을 구축하기 위하여 본 연구에는 공간 토폴로지 개념으로부터 건축물에 드러난 공간 상호관계를 통해 공간의 다종성을 해석하고자 한다. 따라서 본 연구는 건축의 형식적인 측면에 초점을 맞추기보다는 토폴로지의 핵심 측면으로서의 공간 관계와 공간의 구조에 초점을 맞춘다. 또한 본 연구에서는 토폴로지 개념을 일종의 조합 전략으로 활용하였다. 즉, 이는 각각 공간의 교류를 통해 특정한 공간 분위기를 창조한다. 공간의 다종성은 개체 공간의 차이를 통해 만들어내는 공간 분위기의 다양성을 의미한다. 즉 공간은 개체가 겹치는 방식으로 연결될 때, 이러한 차이가 나타난다. 또한 공간의 다종성과 토폴로지에는 공간의 대기를 공간의 구성 부분으로써 인간에게 공간을 체험할 수 있게 하는 조건을 만들었다. 본 연구에서 사용된 3단계 논증(위상 - 구성 - 분위기)은 공간 이질성의 이해를 위해서 구성된 이론적 토대이다. 이러한 공간적 효과를 창출하는 데 유리한 건물의 구성 원리를 파악한 후, 이러한 종류의 구성을 아우르는 사례 연구를 분석하고 이론을 테스트하고 결론을 도출한다.

여기에서 언급한 논증을 통해, 본 연구는 동질성과 이질성(공간의 다종성)의 두 가지의 상호 대립 개념(직선과 곡선, 질서와 무질서)에서 공간 관계의 복잡성을 통해 공간의 다양성에 대한 미묘한 이해를 제공하고자 한다. 또한 “사려 깊은 공간 만들기”를 강조하고 난 후 동질성 또는 이질성 중 하나를 선택한다. 토폴로지는 공간 구조와 구성에 대한 방법으로써 공간 구성, 공간 관계, 그리고 공간 경계를 정의함을 통하여 공간의 새로운 의미를 얻는다. 이에 본 연구는 공간적으로 다양한 분위기의 이해와 디자인을 위한 이론적 근거를 마련하고 디자인 지식뿐만 아니라 인간 경험의 의미에서의 가치를 확립한다.

키워드: 공간 토폴로지, 공간의 다종성, 설계 개념, 공간 설계, 건축적 공간, 건축적 콤포지션