

TOBB UNIVERSITY OF ECONOMICS & TECHNOLOGY
GRADUATE SCHOOL OF NATURAL AND APPLIED SCIENCES

**FROM PROJECTIVE METHODS TO REAL-TIME DIGITAL
CONSTRUCTION OF ARCHITECTURAL SPACE IN FIRST-YEAR
ARCHITECTURAL EDUCATION**



MASTER OF ARCHITECTURE

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AUGUST 2024

DECLARATION OF THE THESIS

I hereby declare that all information in this document has been obtained and presented in accordance with academic rules and ethical conduct. I also declare that, as required by these rules and conduct, I have fully cited and referenced all material and results that not original to this work. Also, this document has prepared in accordance with the thesis writing rules of TOBB ETU Graduate School of Natural and Applied Sciences.

Elif Sultan KAYA

TEZ BİLDİRİMİ

Tez içindeki bütün bilgilerin etik davranış ve akademik kurallar çerçevesinde elde edilerek sunulduğunu, alıntı yapılan kaynaklara eksiksiz atıf yapıldığını, referansların tam olarak belirtildiğini ve ayrıca bu tezin TOBB ETÜ Fen Bilimleri Enstitüsü tez yazım kurallarına uygun olarak hazırlandığını bildiririm.

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ABSTRACT

Master of Science

FROM PROJECTIVE METHODS TO REAL-TIME DIGITAL CONSTRUCTION OF ARCHITECTURAL SPACE IN FIRST-YEAR ARCHITECTURAL EDUCATION

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Architecture inherently possesses a four-dimensional dynamic structure. However, architecture has been discussed using two-dimensional representation and design tools for centuries. This thesis explores whether the four-dimensional nature of architecture can be revealed through embodied cognition in terms of spatial representation, comprehension, and understanding. It questions whether the four-dimensional dynamic structure of architecture can be better explored and experienced through the tools used to produce it and the body's involvement.

In this thesis, the historical origins of architectural drawing have been investigated, tracing its evolution from primitive cave drawings to complex orthographic projections and addressing ongoing debates surrounding traditional methods. A critical point is why the methodologies that became systematic in the 18th century have remained prevalent in contemporary architectural education and practice.

The theory of embodied cognition posits that cognitive processes are deeply rooted in the body's interactions with the physical world and that the mind-body connection

fundamentally shapes thoughts and cognition. In this context, the research discusses the potential implications of spatial learning through the lens of embodied cognition.

In the scope of this thesis, first-year architecture students at TOBB University of Economics and Technology were observed interacting with artificial intelligence and virtual reality tools such as Skybox AI, Open Brush, and Arkio in their Basic Design courses, and the impact of these digital tools on the students' spatial understanding and design processes was evaluated. Based on this research, the limitations and future of traditional orthographic projection in understanding and exploring spatial representation were discussed, especially when compared to new methods like collaborative spatial production in VR.

In summary, this thesis questions the possibilities of a comprehensive architectural education that integrates traditional drawing methods as the conventional means of architectural representation and production with innovative pedagogical strategies supported by cutting-edge technology and embodied cognition.

Keywords: Architectural education, Embodied cognition, Orthographic projection, Architectural representation, VR technology, Basic design education

ÖZET

Yüksek Lisans Tezi

BİRİNCİ SINIF MİMARLIK EĞİTİMİNDE PROJEKTİF YÖNTEMLERDEN
MİMARİ MEKÂNIN GERÇEK ZAMANLI DİJİTAL İNŞAATINA
Elif Sultan KAYA

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Tarih: Ağustos 2024

Mimarlık doğası gereği dört boyutlu dinamik bir yapıya sahiptir. Ancak mimarlık yüzyıllardır iki boyutlu temsil ve tasarım araçları ile tartışılmaktadır. Bu tez, mimarlığın dört boyutlu doğasını, bedenlenmiş biliş üzerinden mekânsal temsil, kavrayış ve anlayış boyutunda ortaya çıkarılıp çıkarılamayacağını araştırmıştır. Mimarının dört boyutlu dinamik yapısının, onu üretmek için kullanılan araçlar ve beden katılımlarıyla daha iyi keşfedilip deneyimlenip deneyimlenemeyeceğini sorgulamaktadır.

Bu tezde, mimari çizimin tarihsel kökenleri araştırılmış, ilkel mağara çizimlerinden karmaşık ortografik izdüşümlere doğru evrimi izlenmiş ve geleneksel yöntemler hakkındaki devam eden tartışmalara değinilmiştir. 18. yüzyılda sistematikleşen metodolojilerin çağdaş mimarlık eğitimi ve uygulamasında neden yaygın kaldığına dair kritik bir nokta ortaya konmuştur.

Bedenlenmiş biliş teorisi, bilişsel süreçlerin vücudun fiziksel dünyayla olan etkileşimlerinde derinden kök saldığını ve zihin-beden bağlantısının düşünceleri ve biliş temel olarak şekillendirdiğini öne sürer. Bu bağlamda araştırmada, bedenlenmiş biliş merceğinden mekânsal öğrenmenin potansiyel sonuçları tartışılmıştır.

Tez kapsamında, TOBB Ekonomi ve Teknoloji Üniversitesi'ndeki birinci sınıf mimarlık öğrencilerinin Temel Tasarım derslerinde Skybox Ai, Open Brush ve Arkio gibi yapay zekâ ve sanal gerçeklik araçlarıyla etkileşimini gözlemlenmiş, bu dijital araçların öğrencilerin mekânsal anlayışı ve tasarım süreçlerine etkisi değerlendirilmiştir. Bu araştırmaya dayanarak, özellikle VR'daki işbirlikçi mekânsal üretim gibi yeni yöntemlerle karşılaştırıldığında, mekânsal temsili anlama ve keşfetmede geleneksel ortografik projeksiyonun sınırları ve geleceği tartışılmıştır.

Özetle bu tez, mimarlığın temsil ve üretim yöntemi olan geleneksel çizim yöntemlerini, son teknoloji ve bedenlenmiş bilişle desteklenen yenilikçi pedagojik stratejilerle harmanlayan kapsamlı bir mimarlık eğitiminin olanaklarını sorgulamıştır.

Anahtar Kelimeler: Mimarlık eğitimi, Bedensel biliş, Ortografik projeksiyon, Mimari temsil, VR teknolojisi, Temel tasarım eğitimi

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1. INTRODUCTION

Architecture, as a discipline, has been present since the dawn of humanity as a response to the need for shelter (Kostof, 1995). Individuals would select a location to settle and create enclosed spaces with walls to establish their lives there. These spatial constructs were often visualized through drawings, which, akin to writing, served as a form of expression. Among the various methods through which architecture is manifested, such as drawing, writing, construction, and models, drawing has historically been regarded as the cornerstone of architecture (Agrest, 2000). The origins of architectural drawings can be seen in caves, on stones, and later in papyrus drawings. Evidence of this can be seen in prehistoric cave paintings, carvings on rocks, and later in papyrus drawings, such as those found in Deir el-Medina, which date back to 1550-1070 BCE and include detailed plans of tombs and structures (Arnold, 1991). Drawings are crucial in elaborating an idea by depicting conceptual notions and physical attributes (McQuaid, 2002). The roots of architectural drawings can be traced back to the works of Pappus of Alexandria in the 4th century AD, wherein the concept of anamorphic projection was introduced, referencing the results of Apollonius in Perga (Petrescu, 2019). Girard Desargues (1593–1661), a pioneer in projective geometry, began sharing his theorems in the mid-17th century (Andersen, 2007). Projective geometry involves projecting three-dimensional objects onto two-dimensional planes. This development in geometry coincided with advancements in the drawing techniques used by architects. The "Orthographic set," a drawing set commonly used today, started to take shape. Critics often point out that the "conventions" of architectural representation, known as "projections," are centered around the "orthographic set," and this has sparked much debate. Many architects argue that plans, sections, and elevations limit their ability to fully conceptualize designs and objects, given that they are perceived as "parts of a dissected whole relying on syntactic relations" (Pelletier & Perez-Gomez, 1992). Despite emerging in the 18th century, orthographic projection remains a fundamental architectural education and practice technique. Considering the

proliferation of digital technologies and new methods of spatial representation, orthographic projection remains a standard tool in the architect's toolkit.

Nevertheless, why does a technique rooted in centuries-old principles continue to dominate contemporary architectural practice? To answer this question, we can draw a parallel with the story of the ship of Theseus, a thought experiment from ancient Greek philosophy. According to the legend, the Athenians preserved the vessel where Theseus sailed and replaced the old planks with new ones as they decayed. This raises the philosophical question of whether the ship remains fundamentally the same ship (Plutarch, 1914). Similarly, while our tools and methods may evolve in architecture, core principles and techniques, such as orthographic projection, remain fundamental in practice. They are continually renewed and adapted, yet their essence and utility persist through time.

When exploring examples of 20th-century modern architecture, it becomes evident that pursuing innovative design solutions has been an ongoing quest. For instance, Adolf Loos's Raumplan concept emphasized the three-dimensional configuration of spaces to enhance experiential depth, which aligns with VR's immersive qualities (Colomina, 1992). The De Stijl movement, championed by figures like Piet Mondrian, Gerrit Rietveld, Theo van Doesburg and J. J. P. Oud further pushed the boundaries of architectural design by advocating for abstraction, harmony, and the integration of diverse artistic disciplines into cohesive spatial compositions (Jaffe, 1982). Moholy-Nagy's 'Light-Space Modulator' utilized light to create spatial experiences that evolve as an individual moves through the luminous environment. Greg Lynn's pioneering work in digital architecture has redefined spatial and structural paradigms, introducing algorithmic and fluid forms. Deconstructivist architects such as Zaha Hadid and Frank Gehry have challenged traditional notions of form and function, created fragmented and dynamic spaces while encouraged innovative spatial experiences. These approaches are consistent with the fundamental principles of modern architecture while addressing their limitations and increasing their relevance in contemporary design and education. Some questions about establishing and exploring spatial relationships in a representative environment have existed since the 20th century and have deepened as they meet today's technology.

Khine (2016) explains that spatial ability is the skill to see visual images, create mental pictures, and understand how objects relate in space. He describes it as a strong indicator of personal traits and individual differences. Architectural design is a multifaceted discipline requiring diverse abilities, in particular creativity and spatial ability. One of the goals of architectural education is to nurture students' capacity to generate creative solutions. In addition, because architectural design aims to build three-dimensional structures, the ability to read, interpret, and visualize spatial information – spatial ability – is essential (Mckim, 1972). Spatial skills are integral to architectural education. They embody the principle of embodied cognition, which posits that the mind and body are intricately interconnected and influence cognitive processes. This perspective underscores the notion that sensory and motor experiences are not mere by-products of cognition but actively contribute to shaping cognitive functions (Wilson M. , 2002). The sensory encounter of being in a particular place significantly impacts how people perceive and comprehend architecture. Light, sound, and temperature are crucial in understanding the built environment. Educational methods emphasizing experiential learning and practical architectural design projects have significantly improved students' ability to understand space and enhance their design skills. Students develop a nuanced understanding of spatial relationships by actively engaging with architectural concepts through hands-on experiences and immersive design projects and cultivate essential problem-solving and critical thinking skills (Barkowsky, Bilda, & Hölscher, 2007). This approach enables students to apply their knowledge and skills in a real-world context, gaining valuable insights into design, materials, and construction techniques. Furthermore, the study is exploring the impact of virtual technology in modern architectural education, showcasing how it can enhance the learning experience by actively involving the body in the process.

Spatial perception furnishes crucial "what" and "where" information about objects, enabling architects to navigate and manipulate the spatial configurations inherent in their design processes (Waller & Nadel, 2013). As famously expressed by Louis Kahn (1957), architecture is defined as "the thoughtful making of space," emphasizing the importance of spatial cognition in architectural practice. The architectural design process involves manipulating spatial configurations, considering diverse perspectives and scales, and balancing aesthetic and functional aspects in an iterative manner (Rowe P. , 1987). The ability to mentally visualize spatial transformations is particularly

crucial, permeating every stage of architectural conception and execution. Spatial thinking extends beyond architecture, a foundational element of success in various STEM¹ fields (Wai, Lubinski, & Benbow, 2009). Therefore, nurturing spatial intelligence is essential in architectural education, providing students with the cognitive skills to navigate the intricate landscape of design innovation and spatial manipulation.

According to Wilson and Golonka (2013), "Embodied cognition reflects the idea that the mind is not only connected to the body but also influenced by it.". This thesis applies the principles of embodied cognition, which consider cognition as closely linked to bodily experiences and actions. It presents potential positive outcomes of spatial learning from the perspective of embodied cognition. Considering experience, movement, and interaction with the external world through the lens of "learning by doing" can be beneficial within the framework of mind-body integrity.

In architectural education, basic design provides the fundamental foundation upon which advanced architectural concepts are built. This foundational education emphasizes developing critical visual and spatial thinking skills to create functional and aesthetic built environments (Ching, *Architecture: Form, Space & Order*, 2007). On the one hand, John Dewey's approach sees the student as the agent of action, interpreting and reflecting on it as an intellectual activity for future actions (Dewey & Ratner, 1939). From a broader perspective, exploring embodied cognition and learning in architectural design and education is important for increasing the understanding and representation of space in 2D and 3D using traditional and innovative methods. The research questions the extent to which applied learning and physical interaction can change the understanding of spatial concepts and design principles.

The study questions new environments where students actively use and control their bodies in architectural fields. It aims to evaluate the ability to develop spatial

¹ STEM is an educational program developed to prepare primary and secondary students for college, graduate study and careers in the fields of science, technology, engineering and mathematics (STEM). October 2023. <https://www.techtarget.com/whatis/definition/STEM-science-technology-engineering-and-mathematics>

understanding and representation in virtual environments with today's technology. When the computer produces a virtual environment, the user interaction creates an immersive visual and sensory experience (Youshuang, Xianglong, & Fei, 2004). This technology gives architects and designers a powerful tool to visualize and manipulate three-dimensional areas. It allows students to experience their designs more immersively and realistically, helping them understand spatial relationships and scale. For this reason, the thesis examines the approaches of virtual environments that today's technology allows.

This research is conducting phenomenological research in the basic design course of TOBB ETU architecture undergraduate students in order to test the thesis claims. This study questions new environments where basic design students in architecture actively use and control their bodies. In this research, a qualitative method model that concludes scientific thought was determined as a method (Kaptanoğlu, 2013). Qualitative research is research in which different qualitative data creation methods such as observation, interview and document analysis are used, and a qualitative process is followed to reveal perspectives, perceptions and events realistically and holistically in a natural environment (Yıldırım & Şimşek, 2016, s. 41). It is indicated that there are differences in the ways qualitative research methods are used and that it would be more appropriate to use qualitative techniques that are appropriate to the nature of human behavior (Yıldırım & Şimşek, 2016, s. 42-48). Phenomenology aims to understand human experience (Van Manen, 2007, s. 12-28). Phenomenology emerged from a philosophical movement trying to make sense of lived experience since the beginning of the twentieth century (Wilson A. , 2015, s. 38-43). It is a qualitative research method used to describe how people experience a phenomenon or concept and express their understanding, feelings, perspectives, and perceptions (Rose , Beeby, & Parker , 1995, s. 1123–1129).

In its most comprehensive sense, phenomenology refers to the totality of lived experiences belonging to a single person (Giorgi, 1997, s. 236). Phenomenology focuses on phenomena we know but need a detailed and deep understanding. These phenomena, which appear in different forms such as events, experiences, perceptions or situations, can be encountered differently daily (Tekindal & Uğuz Arsu, 2020, s. 153-182). However, this does not mean the phenomena must still be fully understood.

Therefore, phenomenology is used for studies that aim to investigate phenomena that are frequently encountered daily, are not foreign to us but whose full meaning is not understood and creates a suitable research ground (Yıldırım & Şimşek, 2016, s. 69).

The research is focused on specific questions and hypotheses designed to evaluate the potential advantages of using different tools in developing spatial understanding and design skills within the scope of Basic Design courses of nine first-year architecture students at TOBB ETU. These students shared their experiences using AI and VR tools such as Skybox Ai, Open Brush, and Arkio in their design projects. The final part of the thesis will analyze the differences and similarities that emerge from the results of this phenomenological research. In summary, this thesis explores the possibilities of a comprehensive architectural education that blends traditional techniques with innovative pedagogical strategies supported by cutting-edge technology and embodied cognition. By promoting a comprehensive understanding of spatial representation and understanding in an embodied approach, architectural education can prepare students with the skills and knowledge required to navigate the complexities of contemporary design practices.

1.1 Research Questions and Objectives

Starting from the discussion that traditional orthographic projection techniques may have limitations in architectural representation, comprehension and spatial exploration, this thesis explores possible future developments using new tools.

The thesis begins by investigating why projective methods from the 18th century continue to be used in architectural education. Despite significant technological advances in architectural representation, the field still relies heavily on orthographic projection. This technique emerged in the 18th century. In 21st-century design methods, strategies that include the student's subjective experience and enable them to understand and find space by representing it with their own body should be examined. As architectural education develops, questions about the adequacy of traditional methods arise in light of new technologies that offer innovative ways of conceptualizing and interacting with space.

Architecture, by its very nature, is dynamic. However, it has been discussed and represented with 2D tools for centuries. This thesis explores whether these dynamic

features can be unveiled by integrating bodily cognition into spatial representation, comprehension, and person. This leads to the central question of the thesis: Can the dynamic four-dimensional structure of architecture be better explored and experienced with the tools we use to produce it and with the participation of the body? Or are two-dimensional representation tools sufficient in this regard? Phenomenological research was conducted within the scope of the thesis to answer these questions.

To address these questions, a phenomenological study was conducted as part of this thesis. The research sought to understand the impact of various tools and environments on first-year architecture students by observing their transitions between different media and environments and the resulting changes in the forms and materials they use. Based on this research discusses the limits and future of traditional orthographic projection in understanding and exploring spatial representation, especially when compared to new methods such as collaborative spatial production in VR.

The thesis emphasizes the principles of embodied cognition, which highlight the pivotal role of physical interaction in learning. It examines the level to which integrating work in virtual reality through embodied cognition into architectural education is integrated into the design and to what extent the designer is integrated into virtual reality, in this case, through phenomenological research.

1.2 Methodology

This research examines embodied cognition in architectural education through the lens of a phenomenological study. The study examines the experiences of undergraduate architecture students when interacting with VR tools. The research investigates whether traditional projective drawing methods require greater capacity to represent, grasp and explore architectural space adequately. In contrast, incorporating embodied cognition, which examines the interaction between mind and body in the cognitive process, can significantly enhance the educational experience of architecture students.

There are multiple research approaches under the title of qualitative methods, such as theory formation, ethnography, case study, and phenomenology. The basis of phenomenology, one of these approaches, is based on the works of philosopher Edmund Husserl in the twentieth century (Oktem, 2005, s. 28) Brown et al.'s (2006)

study exemplifies all stages of a phenomenological analysis, and the authors illustrate many key aspects of this research approach.

Initially, the researchers developed a topic and basic research area, subsequently identifying a problem related to a gap or deficiency in the existing literature. They then reviewed the relevant literature concerning the identified problem. The authors provided a brief overview of the philosophical roots of phenomenology and related philosophical discussions ((refer to "Phenomenological Approach" under the title (Brown, Sorrell, McClaren, & Creswell, 2006, s. 122)). The study investigated a specific phenomenon. Data were generated through interviews with individuals who had experienced the phenomenon at a large Midwestern university. During the data analysis, the researchers systematically utilized key expressions, meanings, themes, and detailed explanations of the phenomenon's essence by adhering to the steps recommended by Moustakas (1994). In the findings and discussion section, the authors crafted a textural description of the experience, detailing how the phenomenon was lived through themes derived from significant expressions and meaning units. They also offered a structural and textural explanation with imaginative variation. The research culminated in explaining the essence of several individuals' experiences and the process they underwent related to the phenomenon, concluding with a comprehensive elucidation.

Phenomenology allows for an in-depth examination of the expressions of several people who have experienced the same phenomenon. Knowing the common experiences of individuals regarding the phenomenon under consideration is valuable for the study (Yalçın, 2022). Those who engage in phenomenology try to find commonalities in how people perceive and interpret similar experiences. The commonality in these perspectives can be expressed as the essence of the experiences (Fraenkel, Wallen, & Hyun, 2012). Like other qualitative research designs, phenomenological research depends on the researcher's interpretation of the data obtained. Therefore, the most important limitation of phenomenological research is

that the results of the research cannot be generalized, and their accuracy cannot be fully determined (Yıldırım & Şimşek, 2016, s. 72).

The phenomenological research method was chosen for this thesis because, in addition to its descriptive features, some of its features are related to the qualitative research process (data sources, data creation process, data analysis, etc.). Qualitative research includes the feature of “flexibility in research design” and the selection of appropriate methods or methods for the research, that is, the use of multiple methods (Patton, 2018).

Although qualitative research is a cyclical process, as Creswell (2020, s. 51) stated, it is thought that qualitative research is included in the scientific method process with the common stages required by every research. In this respect, the first stage in a qualitative research process is generally determining the problem related to the gap or deficiency in the literature after a topic and a basic research area are created. In the following stages, the researcher examines the literature related to the problem, asks questions, creates data, analyzes them, and writes the report. However, since there is a flexible approach in qualitative research besides this general process, it can be reshaped repeatedly according to new situations and analyses encountered during the research process (Tekindal & Uğuz Arsu, 2020).

1.3 Structure of the Thesis

This thesis consists of four main sections. It starts with a short introduction and is followed by the first section, which emphasizes the definition, aims and importance of the problem at hand.

The second chapter focuses on the role of learning by doing and bodily cognition in spatial relations in design. At this point, it delves into historical research by going to the recent history of spatial searches, following the evolution of orthographic drawing from Gaspard Monge's descriptive geometry to the present day, discussing the perspectives of Alberto Perez-Gomez and Louis Pelletier.

In the continuance, research investigates some architects and manifestos from the 20th century, which can be called modern architecture. Examining early modern architectural examples such as Raumplan and De Stijl emphasizes that orthographic

drawing is used as a design tool rather than merely a means of representation. Starting from this context, the thesis began to examine traditional orthographic projection's inherent limitations and possibilities in representing, comprehending and exploring space, especially considering approaches such as collaborative spatial production in VR environments. Here, the role of learning by doing and bodily cognition in spatial relations in design and the potential of VR headsets are examined. Special emphasis is given to the experiments and results of various academics and researchers. Considering the limitations of projective methods in understanding, representing and exploring space in the current educational environment, it is necessary to consider the potential enrichment created by alternative work environments. The research examines whether immersing students in this digital space and engaging them in design activities based on bodily cognition can integrate their spatial design abilities.

The third chapter presents a comprehensive overview and course content of the core design studio conducted by Aktan Acar, which has been meticulously studied over time. This section serves as a thorough introduction to the context of the phenomenological research, which will be the focus of the thesis, demonstrating the depth and rigor of the study. After explaining the content of the course in previous semesters and the content of the summer semester course that this thesis will examine, the details of the phenomenological research will be discussed. The thesis will conduct phenomenological research by observing undergraduate students who took the summer retake of the Basic Design course at TOBB ETU.

The conclusion chapter will then meticulously analyze, categorize, and list the differences and similarities that emerged from the research results, thereby highlighting the value and potential impact of the research findings.

2. SPATIAL RELATIONSHIPS IN DESIGN: FROM SKETCH TO BUILDING

Pallasmaa (2009) says that architectural ideas arise from existential intuitions, not 'biologically' conceptualized and lived, rather than from intellectual analysis and theories. According to him, all sensory systems 'think' when structuring relationships with the world. Even in the case of learning skills, the complex sequence of movements and spatiotemporal relationships is experienced and embodied internally, unconsciously, rather than being understood and remembered intellectually. Psychologist Howard Gardner proposed seven categories of human intelligence: linguistic, logical-mathematical, musical, bodily-kinesthetic, spatial, interpersonal, and intrapersonal intelligence. He later considered three more categories: naturalistic, spiritual, and existential intelligence, and even discussed the possibility of a moral category of intelligence (Gardner, 1999). This theoretical framework emphasizes that sensory and motor experiences actively shape cognitive functions rather than being passive byproducts of them (Gallese & Lakoff, 2005). Gaston Bachelard writes about the imagination: 'Even the hand has its dreams and assumptions. It helps us understand the innermost essence of matter. It also helps us imagine [forms of] matter' (Bachelard, 1982, s. 107). Pallasmaa (2009) describes this concept as follows: The capacity to imagine and liberate oneself from the limits of matter, place, and time must be regarded as the most human and essential of all our qualities. Creative capacity, as well as ethical judgment, calls for imagination. It is evident, however, that the capacity of imagination does not hide in our brains alone, as our entire bodily constitution has its fantasies, desires and dreams. Some philosophers, such as Alva Noë (2009), have recently questioned the self-evidently assumed location of human consciousness in the brain. For these thinkers, consciousness is a co-product of our brain or neural systems, embodied beings, and the world.

Embodied cognition asserts that cognitive processes are closely linked to physical experiences and sensorimotor interactions, implying that engaging with spatial environments can significantly influence architectural comprehension and design

skills (Wilson M. , 2002). Embodied cognition is a crucial theoretical framework for understanding the architectural domain's complexities of learning and comprehension. Proponents of this perspective argue that abstract representations and symbolic processes are closely connected to sensory-motor systems, highlighting the link between the mind and body in cognitive function (Mutlu & Soylu, 2018). Rooted in the phenomenological tradition, which emphasizes the importance of bodily movement and the unity of body and mind, embodied cognition provides a nuanced perspective for grasping the intellectual foundations of architectural education (Gallagher, 2014). While this perspective emphasizes the profound relationship between individuals and their environments, knowledge acquisition is enhanced through fluid, experiential interactions with architectural space. Ulubay and Önal (2020) emphasized that adopting the principles of embodied cognition allows architectural education to move beyond traditional teaching methods. This adoption encourages a deeper understanding of spatial exploration and design innovation through comprehensive experiential learning. These spatial abilities provide a valuable perspective for comprehending the intricate relationship between the mind, body, and environment within architectural education. By incorporating the principles of embodied cognition into architectural teaching, educators can enable students to utilize their physical experiences and bodily sensations as essential assets for exploring space and enhancing design innovation (Dancing Minds, Embodied Whispers: A Deep Dive into Embodied Cognition., 2024). This comprehensive approach encourages a deeper connection between students and their architectural environment, fostering a more intuitive and embodied grasp of spatial relationships, ultimately enriching the effectiveness and depth of architectural education.

In architectural education, embodied cognition provides a crucial perspective for understanding the complex relationship between perceptual-motor skills and spatial intelligence. As Tschacher (2015) emphasized, executive functions necessitate continuous interaction between mind and body, perception and movement, and cognition and social context, underscoring the inseparability of mental and physical phenomena. Cheung, Shen, and Meadan (2022) also explain that movement, social-emotional, and cognitive skills form a multifaceted structure that unfolds as individuals engage with their environment. This viewpoint underscores the holistic nature of cognitive processes, where the body is a conduit for realizing cognitive functions within lived experiences. Embracing the principles of embodied cognition in

architectural education provides a comprehensive framework for nurturing students' spatial intelligence and design skills, leading to a deeper understanding of the interplay between the mind, body, and architectural environment. Consequently, integrating embodied cognition theory into architectural methodology presents a comprehensive approach to architectural education, enabling students to navigate the intricate realm of design thinking and spatial manipulation with greater insight and effectiveness.

In architectural design studios, the principles of embodied cognition align with Donald Schön's (1987) influential concepts of reflection in action, reflection on action, and knowing for action. These concepts shed light on the iterative nature of design processes, in which designers continuously experiment, reflect, and adapt as they navigate the complexities of spatial creation. Furthermore, discussions about embodied cognition extend beyond design theory to explore its tangible effects on the creative design process. Scholars like Sinnamon and Miller (2022) delve into the intricate intersections between embodied cognition and architectural practice, enriching our understanding of the embodied nature of design cognition through investigations into perceptual-motor skills and somatic awareness in architectural design and education. Embodied cognition has significant architectural implications, providing valuable insights into how physical experiences and cognitive processes interact within spatial environments. It suggests that the sensory experiences within a space profoundly impact our cognition and understanding, with elements like light, sound, and temperature playing a crucial role in shaping our perception and emotional response to architectural environments.

Drawing from the foundational principles of embodied cognition, architectural education increasingly embraces experiential learning methodologies, emphasizing the concept of 'learning by doing.' This educational approach acknowledges the inherent value of hands-on, immersive experiences in promoting profound learning and skill development. Through active involvement in design exercises, prototyping, and physical model-making, educators enable students to transform theoretical knowledge into practical application, effectively bridging the divide between conceptual comprehension and tangible design outcomes (Schön, 1987). The learning-by-doing approach fosters technical expertise and cultivates critical thinking, problem-solving, and spatial reasoning abilities—essential attributes for aspiring architects (Cuff, 1992). Additionally, this hands-on approach cultivates a strong understanding of the iterative nature of the design process, teaching students to persist through

challenges and view failure as an opportunity for growth (Kolb, 1984). Engaging in the continual cycle of creating, reflecting, and refining, students gain a profound comprehension of design principles and a natural understanding of the practical aspects of architectural practice. Experiential learning becomes a fundamental aspect of architectural education, providing students with the practical skills and flexible mindset needed to succeed in today's ever-evolving field of architecture.

Learning by doing is a teaching approach where students learn through hands-on experience and practice rather than passively receiving information through lectures or textbooks. Salama says in *Spatial Design Education* (2012) that this method is based on the belief that students learn best when actively involved in learning and can apply what they have learned. It is effective for various subjects, including technical skills, problem-solving, and critical thinking. Additionally, it encourages students to take ownership of their learning, fostering self-motivation and independence. Considering "learning by doing" in the context of mind-body integration in experience, movement, and interaction with the outside world is beneficial. The core effectiveness of 'learning by doing' lies in its alignment with the comprehensive framework of integrating mind and body, where cognitive processes are intricately connected with sensory experiences and physical actions. Drawing from the philosophical foundations established by John Dewey, this approach suggests that mental activity cannot be separated from physical engagement, as learners actively create meaning through their interactions with the surrounding environment (Dewey & Ratner, 1939). Educators strive to cultivate a dynamic learning environment that promotes critical thinking, problem-solving, and self-directed learning by involving students in hands-on learning activities that encourage exploration, experimentation, and reflection. Furthermore, 'learning by doing' fosters students' sense of control and responsibility, enabling them to steer their learning journey and develop the resilience and adaptability necessary for success in architectural practice.

The "learning by doing" technique is a highly effective strategy in architecture education that promotes the actual application of academic information and skill gain. This experiential learning approach encompasses a range of activities, from designing and constructing small-scale structures to creating architectural models and engaging in immersive site visits to observe real-world construction processes. Through active participation in these hands-on experiences, students gain firsthand insights into various aspects of architecture, including design principles, material exploration, and

construction methodologies. Additionally, the iterative nature of "learning by doing" fosters the development of problem-solving abilities and critical thinking skills among students, which are essential for navigating the complexities of architectural practice (Schön, 1987). This immersive educational approach deepens students' comprehension of architectural concepts and cultivates a comprehensive skill set, preparing them for success in architecture's dynamic and multifaceted field.

The thesis investigates basic design courses as a component of first-year architecture education. It will initially delve into the history of orthographic drawing to address its inquiries. Subsequent sections will explore methods for integrating embodied cognition into spatial studies using contemporary technologies.

2.1 Orthographic Drawing and Projective Methods

As Norman Foster says in his book (2015), 'As an architect, you design for the present, with an awareness of the past, for a future which is essentially unknown.' Architecture is a constantly evolving art form that reflects values and creativity. Architectural drawing reflects this dynamic relationship between imagination and realization. Humans have developed their exploration, communication, and expression tools throughout history. Drawing is one of them. From primitive floor plans in ancient civilizations to the construction drawings used today, architectural drawings have evolved over thousands of years. Architecture as a discipline goes beyond mere functionality. From primitive sketches carved on papyrus by ancient Egyptians to intricately detailed drawings of modern skyscrapers, it symbolizes its time's cultural ethos, social aspirations, and technological prowess. The history of architectural drawing describes humanity's quest for spatial expression and structural innovation (Yuzhu, Mariane, & Mokhtar, 2024). As Robin Evans says in *Projective Cast* (1995), "Drawing... is not just a representation but an active agent in the construction of architectural meaning." In other words, drawing is a form of representation and a practical tool that reflects cultural, technological and artistic influences, creating a versatile history.

Investigating the origins of architectural drawing involves analyzing the evolution of construction techniques and changes in human perception and creativity across cultures. This research reveals the essence of architecture's visual language, which speaks volumes about collective aspirations, creativity and cultural identity. Despite

thousands of years of human existence on Earth, hundreds of people have studied the ongoing mystery surrounding the practice of drawing. Since investigating why drawing is taught in its simplest form today is one of the questions this thesis asks, this research can be started by questioning the mystery of the unsolved origins of drawing. Translating three-dimensional space into a two-dimensional drawing is a creative feat that architects must master. This process requires them to forge an innovative connection between a drawing and its corresponding building. This challenge underscores the complexity and artistry of architectural drawing. Drawing has been a form of expression since early human history, with early humans using drawings on caves and stones to express their basic needs (Gombrich, 1950). Based on this discourse, architectural drawing has always been integral to the built environment, from rough sketches etched on cave walls to the complex plans of today's skyscrapers. Nevertheless, one may wonder why the first architects chose to paint. For the ancestors, drawing was more than just a technical necessity; it served as a means of storytelling and transmitting knowledge and culture across generations (Mazzoli, Morganti, & Bartolomei, 2022). Examining drawing as a bridge between different aspects of architectural practice, Edward Robbins (1994) distinguished between the cultural and social use of drawing in building production, and although the social use of drawing has institutional, political and economic constraints, the artistic use of drawing preserves the unrestricted representation of the architectural imagination. Design emerges in this space of imagination between concept and drawing, allowing the idea and its visual manifestation to exist autonomously. Drawing serves as a training ground for architects to conceptualize visually. Through the act of drawing, architects learn how structures attain significance. As they refine their drawing skills, architects grasp the mechanics of representation and intimately understand the dynamic interplay between an idea and its visual depiction (Pallasmaa, 2009). Consequently, buildings conceived in this manner embody the architect's ideas. While the medium of a building differs significantly from that of a drawing, both mediums serve as vessels for materializing abstract concepts into tangible forms.

Architecture has gone beyond its initial task of providing shelter. It has become a tool for expressing and concretizing cultural values worldwide (Ballantyne, 2002). Since architecture reflects the evolution of its function in society and physical manifestations, it can also reflect changing aspects of human existence over time. The transformation of architectural ideas from imagination to reality occurs through

drawing tools as tools of discovery, understanding and representation. It is unclear how long architects have used drawing tools (Ching, *Architectural Graphics*, 2015). However, various archaeological discoveries have shed light on the first examples of architectural representation. However, various archaeological discoveries have shed light on early instances of architectural representation. One such example is in present-day Anatolia, where archaeologists unearthed architectural artifacts at Çatalhöyük, an ancient settlement dating back to 6200 BC. They discovered various reliefs and structural remains at the site. 1950 British archaeologist James Mellaart (1967) examined these findings and uncovered evidence of a sophisticated urban design. Approximately 40 dwellings or sacred structures were arranged in neat clusters separated by streets, indicating a well-planned layout.

The architectural discoveries at Catalhoyuk, focusing on the 56th building (Figure 2.1), have revealed fascinating insights into ancient building practices. The wall reliefs within the building (Figure 2.2) are of particular interest, providing a glimpse into the architectural techniques of the time. One of the most remarkable discoveries is a wall relief that dates to 6200 BC. Scholars believe this relief represents a "village plan," showcasing the early attempts to visually represent architectural layouts and urban organization. Although open to interpretation, these findings shed light on ancient civilizations' innovative and creative nature (Tasheva, 2012).



Figure 2. 1: View of Building 56, Catalhoyuk Excavation. Accessed February 18, 2024. Retrieved from <http://www.catalhoyuk.com/>.



Figure 2.2: Bas-relief found in James Mellaart excavation. Accessed February 18, 2024. Retrieved from <http://makingmaps.net/2024/02/18/cartocacoethes-why-the-worlds-oldest-map-isnt-a-map/>.

The sense of relief derived from the consistent urban design attributes at Çatalhöyük evidence this. Figure 2.3 depicts the use of rectangular shapes, the careful division of corridor spaces, the intentional proportions in settlement planning, and a volcanic symbol within the village nestled beneath the mountain. A wide array of building elements, urban landscapes, and interior scenes spanning diverse ancient cultures adorn various surfaces, serving as symbolic indicators and visual reflections integral to the surrounding environment despite lacking architectural utility.

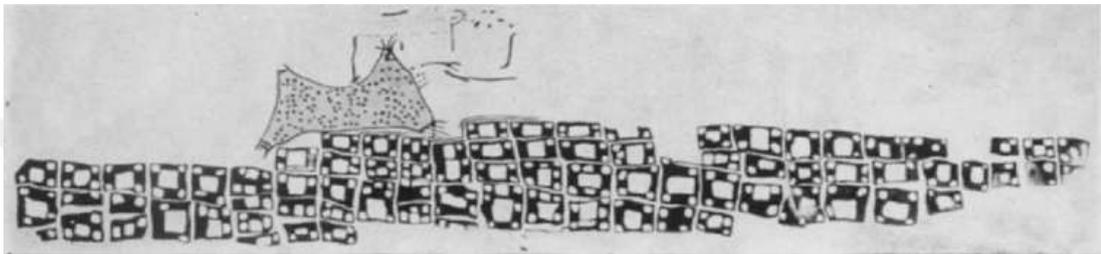


Figure 2.3: Wall relief reconstruction, according to James Mollart. Accessed February 18, 2024. Adapted from James Mollart, *CatalHoyuk: A Neolithic Town in Anatolia*, 1967.

Architectural drawings have been very important in human civilization since ancient times, as evidenced by their use in the Egyptian and Mesopotamian civilizations (Moffett, Fazio, & Wodehouse, 2003). Over time, the importance of historical drawing practices continues, and information about this heritage continues to be learned through works such as the Gudea Statue (Figure 2.4). This artifact, originating from a distinct historical epoch, is a testament to the continued utilization and significance of drawing practices in societal contexts beyond the Neolithic era. Originating around 2200 BC, this statue is a remarkable example of early architectural representation in Mesopotamia, which provides evidence of patronage in the field (Langdon, 1927). The sculpture portrays Gudea, the ruler of Lagash, holding a detailed architectural plan in his lap, which symbolizes his involvement in constructing significant structures under his patronage. The architectural design of the Building in Lagash is an ancient masterpiece widely recognized as the earliest example of an architectural writing system. This fact is apparent in Figure 2.5, where one can observe two cylinders near a statue bearing cuneiform inscriptions that elaborate on the temple's various functions, construction details, and intended purposes.

A remarkable Sumerian inscription spans the fabric of the statue and the nine columns of its throne. The inscription is a veritable treasure trove of information about the temple's construction, including divine guidance, construction materials and intended purposes (Frankfort, 1978). What is particularly noteworthy about the inscription is that it contains a scale line that provides precise dimensions for the architectural elements depicted, underscoring the primary function of the plan as a means of conveying architectural information (Tasheva, 2012). This blueprint affords viewers a wealth of detailed insights into the architectural features, configurations and groupings of the structures depicted, revealing the meticulous planning and execution that went into ancient architectural projects. The blueprint not only categorizes the architectural features, such as walls, buttresses, and towers, but also provides precise measurements, configurations, and groupings, ultimately revealing the architectural intent with utmost clarity and precision. The Gudea Statue is a tangible reminder of ancient architectural practices and the legacy of architectural representation throughout human history. With the detailed Study and interpretation of such artifacts, researchers have been able to unravel the complexities of ancient civilizations and their architectural accomplishments.

Architectural drawing has evolved alongside human civilization (Jokilehto, 1999). Over the centuries, it has played a vital role in shaping residences, urban landscapes, and environmental areas. Like written languages, the architectural lexicon has continually transformed and is closely connected to cultural, technological, and geographical influences.



Figure 2.4: Gudea, Prince of Lagash C.2120 B.C. A statue dedicated to the god Ningirsu, called ‘Architect with Plans.’ Accessed February 18, 2024. Retrieved from <https://www.metmuseum.org/art/collection/search/329072>

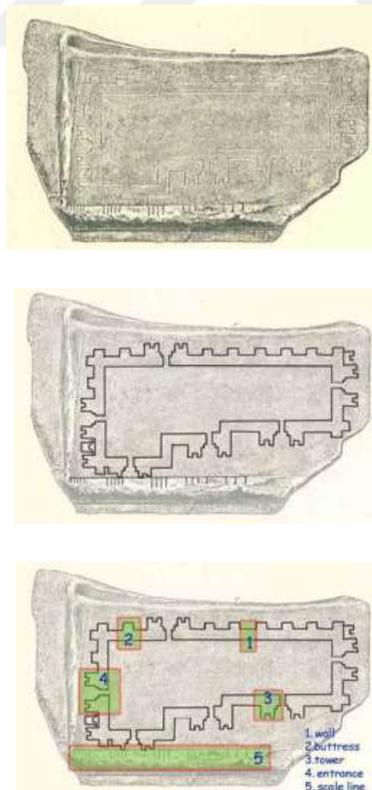


Figure 2.5: Sketch of the plate in the statue's lap. Accessed February 18, 2024. Adapted from <https://www.gutenberg.org/files/17323/17323-h/17323-h.htm>

Throughout its evolution, architectural drawing has experienced many important turning points that, as Yee (2012) mentions, have led it to its contemporary manifestation. The ancient civilizations of Egypt and Greece established the basic principles and traditions of architectural drawing, thus standardizing drawing practices and marking these important milestones. These innovative cultures form the basis of a coherent framework within which individuals can converge on standardized conventions and methodologies to represent architectural elements accurately. The art of drawing has been deeply embedded in human history since ancient times and has served as a means of expression (Dissanayake, 1988). Early civilizations utilized cave paintings and inscriptions on stones to convey their basic needs and cultural stories (Gombrich, 1950). However, drawing plays a crucial role in architecture that surpasses its communicative function, becoming an essential tool for architectural practice. The development of architectural drawing from basic sketches to refined and intricate visual communication is a tribute to the collaborative efforts of architects, artisans, and scholars throughout different historical periods. Over time, architectural drawing has progressed and evolved, surpassing its original utilitarian purpose to encompass various artistic, technical, and theoretical aspects (Pevsner, 1963). While architects analyze the intricacies of spatial design, drawing is a channel to bring these spaces to life. It enables abstract concepts to take shape in concrete forms. The architectural drawing principles of ancient Egyptian and Greek civilizations have had a profound and lasting impact on the course of architectural history. Their contributions have made a mark and established a foundational framework that has guided subsequent architectural endeavors (Robins, 2008). The fact that examples of architectural drawings from Ancient Egypt can still be read and are by architects today indicates their mastery of drawing techniques. It shows the universal language created (Dieter, 2003). The works they left behind show that the architects of that period displayed remarkable talent in designing, planning and constructing monumental structures. Egyptian architects documented their architectural designs using various tools, including papyrus scrolls. They produced detailed plans and renderings of temples, pyramids, and other architectural marvels. The innovative use of papyrus and a reed pen with ink deserves recognition for revolutionizing the documentation and preservation of architectural knowledge (Badaway, 1968).

The ancient Egyptians' use of papyrus to record architectural designs highlights their impressive technological advancements. This versatile material was used for ink production and was a reliable medium for documenting intricate architectural plans (Wilkinson, 1992). This interdependence between material technology and architectural documentation underscores the vital link between innovation and practice in ancient Egyptian culture (Kemp, 2006). The architectural drawings created by the ancient Egyptians were detailed plans that provided a blueprint for the construction process, enabling precision and accuracy in building complex structures. The skill of the Egyptian architects is evident in their ability to navigate the principles of scale and drawing, as demonstrated by their construction of monumental structures such as pyramids, temples, and tombs with unparalleled precision and meticulousness (Badaway, 1968). Egyptian architectural drawing is characterized by its meticulous use of grid systems and proportional scaling techniques, reflecting a dedication to achieving coherence and uniformity in architectural compositions. Architects and artisans employed these methods to ensure precision and alignment when translating designs from papyrus sketches to monumental structures. Using grids and standardized measurements exemplifies this commitment to meticulous planning, facilitating the precise delineation of building layouts and proportions (Wilkinson, 2000).

The architectural process was also augmented through scale models and prototypes, providing architects with valuable tools to assess spatial relationships, proportions, and aesthetic qualities before embarking on large-scale construction projects. By leveraging scale models, architects could refine their designs and anticipate potential challenges, thereby improving the overall efficiency and effectiveness of the architectural process. The human figure was traditionally depicted as 18 squares high until a transition occurred, likely during the Twenty-fifth Dynasty, to a different grid system (Figure 2.6). In this new system, the human figure measured 21 squares from the upper eyelid to the upper eyelid, demonstrating an evolved understanding of proportion and composition (Rossi, 2003). This evolution reflects the meticulous attention to detail of Egyptian architectural drawing practices. Egyptian artists accurately portrayed perspective and depth in architectural drawings and reliefs. They expertly utilized techniques such as foreshortening and superimposition, creating compelling illusions of three-dimensional space on two-dimensional surfaces. Their mastery of perspective imbued architectural drawings and reliefs with a sense of

realism and dynamism, elevating the visual impact of these representations (Nyord, 2013). This situation, in turn, underscores the sophistication of Egyptian artistic and architectural achievements. The use of the T-square is an essential aspect of ancient Egyptian architectural drawing, as it is a fundamental tool in technical drawing and drafting that remains indispensable for hand drawing despite its contemporary usage having waned. The T-square consists of a straight edge and a perpendicular crosspiece, shaped like the letter T. Scholars debate the precise historical genesis of this tool. However, they attribute its origins to ancient Egypt. The T-square perspective gained prominence during the Renaissance period, coinciding with the development of axonometric and projective methods, which played a pivotal role in the precise preparation of architectural and engineering plans (Habraken, 1996). Even though the exact inventor of the T-square remains elusive, its evolution and widespread adoption represent humanity's enduring pursuit of precision and efficiency in technical drawing and drafting practices (Kubovy, 1986).

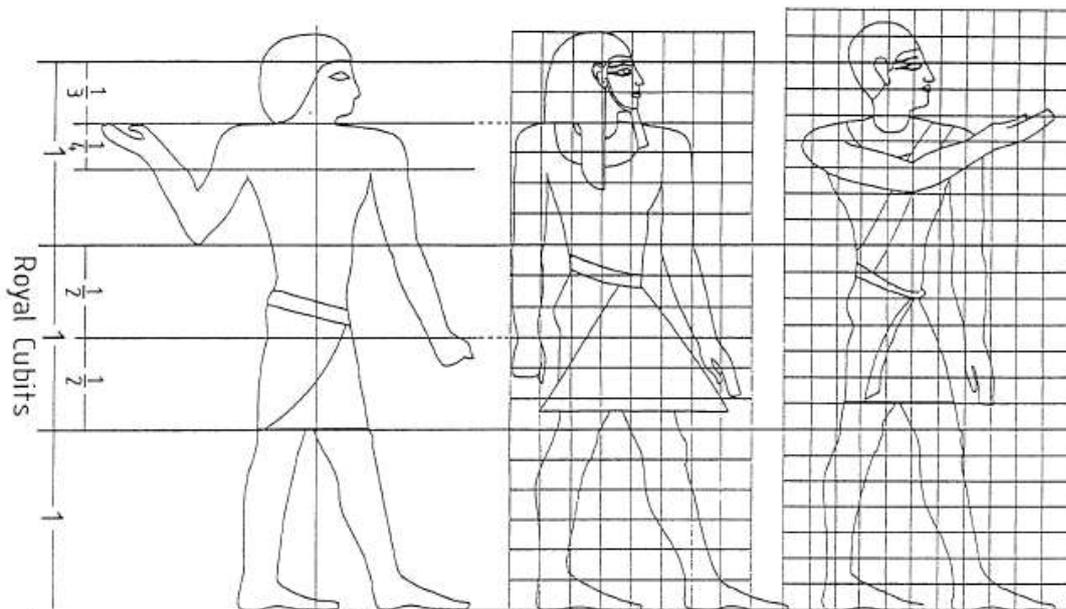


Figure 2.6: The development of the square grid system according to Legon. Accessed February 19, 2024. Adapted from (Rossi, 2003)

An architect must know how to draw and readily make sketches to show the appearance of his proposed work.

(Vitruvius/Morgan, 1st century BC/1914, bk I, ch.1, para. 4)

Orthographic projections are essential in architectural drawing and technical illustration, representing a critical turn in visual representation and engineering history. Its roots trace back to ancient civilizations like Egypt and Greece, where people used it to render three-dimensional objects into two-dimensional representations visually. This method uses parallel lines to project an object's key features onto a plane, ensuring that its dimensions, contours, and spatial configuration are accurately depicted without distortion or perspective aberration (Woodward & Harley, 1987). Thanks to the contributions of artists and architects, the Renaissance era saw the refinement and codification of orthographic projection methodologies. Driven by a desire to create structured frameworks for articulating spatial relationships and architectural compositions, these luminaries formalized and refined the precision of orthographic projection (Edgerton Jr, 1976). As a universal language of graphical communication, orthographic projection fostered an environment conducive to collaboration and intellectual exchange among architects, engineers, and clients, thus transforming architectural and engineering praxis.

The roots of architectural drawings trace back to the meticulous efforts of ancient civilizations, particularly the Greeks, known for their intricate designs and architectural marvels like the Parthenon. Using wax tablets as their preferred medium, Greek architects meticulously crafted initial sketches later transcribed onto parchment paper, thus marking the early stages of architectural representation (Woodford, 2004). There was an evolution in architectural drawing with the contributions of the Roman architect Vitruvius. Best known for his masterwork "De Architectura," Vitruvius left behind a comprehensive architectural treatise that contained detailed directions on building design and construction materials (Yasuoka, 2017). He strongly advocated for systematic planning and meticulous documentation, emphasizing the importance of standardized measurements, intricate specifications, and unambiguous representations of architectural elements in drawings. At the heart of his discourse was the notion that proportion, harmony, and aesthetic appeal were central to architectural design, with drawings as the principal means of achieving these goals. Vitruvius's treatise continues to influence architecture education and practice profoundly. His clear explanations of drafting techniques, design principles, and construction methods gave architects and builders invaluable insights, ushering in a new era of architectural discourse

(Vitruvius, Pollio, & Morgan, 1914). "De Architectura" evolved architectural education, influencing the fabric of architectural practice within the Roman Empire and across the globe. The evolution of architectural drawings finds its roots in the meticulous endeavors of ancient civilizations, notably the Greeks, who exhibited a penchant for intricate designs exemplified by architectural marvels like the Parthenon. Greek architects, wielding wax tablets as their medium of choice, painstakingly crafted initial sketches. They subsequently transcribed onto parchment paper, thereby delineating the nascent stages of architectural representation (McEwen, 2004). In his book, Vitruvius explicitly advocated methodical planning and comprehensive documentation. He espoused the indispensability of standardized measurements, complex specifications, and clear representations of architectural elements in drawings. Central to his discourse was the priority of proportion, harmony, and aesthetic allure in architectural design, with withdrawing as the principal conduit for realizing these imperatives. Indeed, "De Architectura" emerged as the enduring legacy of Vitruvius's treatise, profoundly influencing architectural education and praxis across epochs. His lucid explanations of drawing techniques, design paradigms and construction methodologies inspired ideas among architects and builders. They led to a change of method in architectural discourse (Lefos, 2000).

The impact of the ancient Greeks and Vitruvius on architectural drawing can be felt throughout history, as their contributions have instilled the discipline with enduring principles of geometry, proportion, and aesthetics. Their insights have enriched architectural discourse and provided indispensable tools for conceptualizing and bringing design visions to life, cementing the importance of architectural drawing in the built environment. The precise instruments they championed, such as the compass and ruler, have persisted across centuries, serving as conduits for capturing the essence of architectural forms in meticulously crafted drawings (Masterson, 2004). Contemporary discourse on architectural drawing, recognizing the enduring value of projective techniques, has emphasized the need to revisit these methods to convey spatial structures in a universally comprehensible language. With its axiomatic nature and abstraction, orthographic drawing transcends human perceptual constraints to offer architects a standardized framework for depicting plans, sections, and elevations with utmost clarity and precision. The emergence of perspective drawing during the Renaissance era in Europe also underscores the evolution of projective methods.

Innovators like Leon Battista Alberti and Filippo Brunelleschi drove the development and dissemination of perspective drawing, which leverages converging lines to evoke the illusion of depth and spatial relationships. This technique represented a paradigm shift in architectural representation, enriching the visual language of architects and artists alike (Perez-Gomez & Pelletier, 1997).

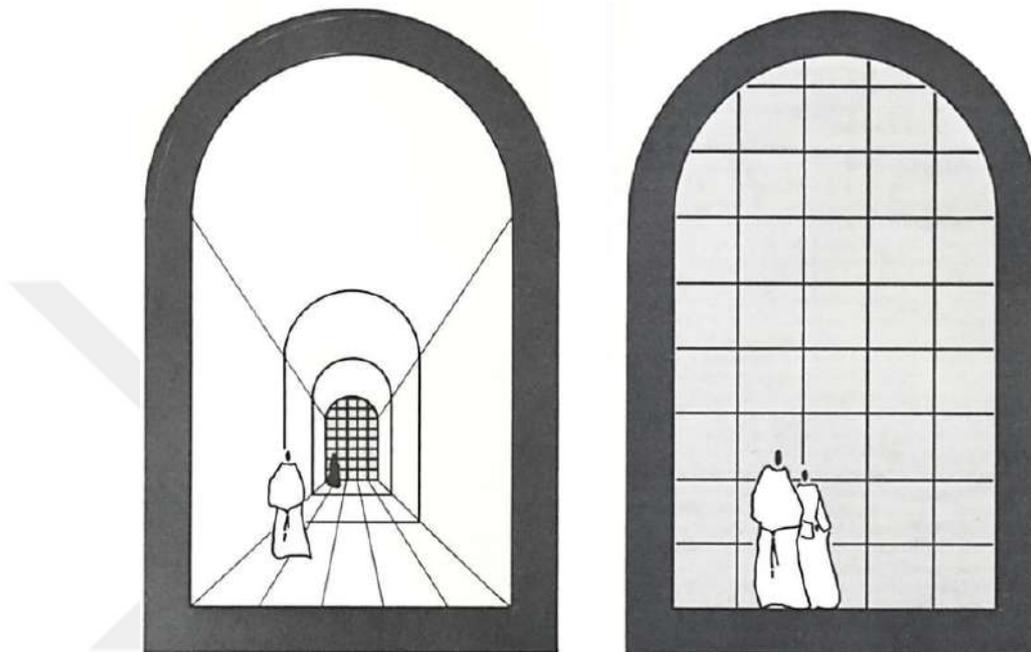


Figure 2.7: Perspective and orthogonal renderings of an interior. Adapted from; Wolfgang Lotz. “The Rendering of the Interior in Architectural Drawings of the Renaissance.” *Studies in Italian Renaissance Architecture*. Cambridge, Mass.: The MIT Press, 1977: 2-3

Orthographic projection possesses a unique advantage in architectural representation as it stays true to preserving the shape and size of structures (Holmes, 1992). This projection method highlights the historical and independent nature of architectural representations like plans, sections, and elevations, which trace their lineage back to prehistoric times and can exist independently or in conjunction with other techniques regardless of the projection method used (Ackerman, 2002). Evans' analysis of representation techniques identifies projection as a supplementary element that cautiously captures the spatial dimensions beyond the two-dimensional drawings. The evolution of traditional tools for architectural representation is significant, given the innovations and reinterpretations during the Renaissance period (Carpo & Lemerle,

2007). Wolfgang Lotz's seminal work, "The Rendering of the Interior in Architectural Drawings of the Renaissance" (1956), thoroughly traces the development of interior representation within projected or executed architectural edifices during the Renaissance (Lotz, 1977). Lotz's analysis highlights the limitations of perspectives in capturing comprehensive views of interior spaces, acknowledging the distorted proportions inherent in singular viewpoints. He delineates two primary methods in Renaissance architectural drawings to render interiors: the perspective section and the orthogonal projection section, which envisages the building bisected by an imaginary plane (Figure 2.7). Lotz's scholarly inquiry emphasizes the dialectical interplay between representation techniques and architectural forms and the crucial role of orthogonal projection in encapsulating the nuanced spatial dimensions of architectural interiors, enriching the discourse surrounding architectural drawing practices.

The creation and continuation of architectural drawings, specifically those crafted using orthographic projection, are inherently linked to the fundamental principles of descriptive geometry. Technical drawing is a tangible representation of the theoretical concepts outlined in descriptive geometry, allowing for the practical application of mathematical principles to create precise depictions of architectural objects. The significance of hand drawing in architectural education is widely acknowledged; it is not just a tool for representation but also a catalyst that initiates cognitive processes (Jones, 2011). The use of standardized rules in technical drawings, guided by principles of consistency and clarity, further emphasizes the importance of adhering to established conventions. These conventions are about communication within the architecture field and students' cognitive development, making hand drawing a crucial part of architectural education. A key driver of contemporary discourse in architectural methodology concerns the enduring relevance and effectiveness of orthographic drawing techniques across different eras. While orthographic drawing remains a venerable tradition in architectural design and representation, its continued use over the centuries raises questions about its impact on students' cognitive understanding of spatial elements in design. Therefore, this study aims to investigate the effect of an unchanging approach over extended periods on students' cognitive grasp of spatial elements in the design.

The mathematical framework of descriptive geometry, essential to representing and elucidating three-dimensional objects within a two-dimensional plane through

projections, can be traced back to the groundbreaking contributions of French mathematician Gaspard Monge in 1798 (Javary, 1881). Monge's pioneering work aimed to create precise representations of spatial entities within a two-dimensional realm, transcending the confines of physical space. Ultimately, the goal of descriptive geometry, as articulated by Monge (1798) himself, is to provide an exact description of the forms and configurations of three-dimensional bodies, allowing for deductions about their spatial attributes and positional relationships. While Monge is undoubtedly a seminal figure in the formalization and dissemination of descriptive geometry, the origins of this mathematical discipline stretch back further than the late 18th century. The history of descriptive geometry reflects a lineage of mathematical inquiry and practical application that predates Monge's seminal treatise. It is essential to trace the historical contours of descriptive geometry to fully comprehend the drawing methodologies prevalent in the contemporary architectural milieu.

Je ne savais pas que je savais la géométrie descriptive!

("I did not know I knew descriptive geometry").

The discourse of Joseph Louis Lagrange, who reassesses Monge's work during the French Revolution (Migliari, 2012)

Albrecht Dürer, an esteemed figure of the Renaissance hailing from Germany, holds an influential position in both the artistic and mathematical realms. His diverse work includes groundbreaking advancements in perspective, proportion, and geometric construction, surpassing the traditional boundaries between creative expression and scientific inquiry. Dürer's magnum opus, "Underweysung der Messung mit dem Zirckel und Richtscheyt" (The Painter's Manual), showcases his unparalleled technical drawing abilities, revolutionizing established practices and cementing his status as a pioneer of geometric construction (Gafney, 1965). Dürer's treatise is a compendium of innovative techniques for achieving accuracy and realism in artistic representation. His meticulous Study of geometry and his penchant for innovation imbued his creative endeavors with a level of precision and fidelity previously unseen, elevating technical drawing to new levels of sophistication and complexity (Dürer, 1977). In a remarkable parallel to Dürer's pioneering efforts, the French mathematician Gaspard Monge emerges as a forerunner of geometric construction in the late eighteenth century.

Despite existing in different temporal and cultural contexts, Dürer and Monge's contributions to geometry and technical drawing demonstrate a shared dedication to precision, accuracy, and innovation. Both luminaries sought to develop systematic methodologies for representing complex forms and spatial relationships, laying the groundwork for modern technical drawing and geometric construction. The convergence of Dürer's artistic genius and Monge's mathematical prowess underscores the symbiotic relationship between art and science, where advancements in one domain fuel progress in the other. Through their respective contributions, Dürer and Monge have indelibly shaped the trajectory of technical drawing, leaving an indelible mark on the annals of human achievement. This example can be seen in Figure 2.8 of Dürer's painting, 'St. Jerome in His Study.' In each case, a point is projected onto several planes rotated to form a right angle (wall and floor) around the ground line. So, the Monge method involves making orthographic projections of an object on two (or possibly more) planes and establishing an exact relationship between the different projections.

It offers a visual representation of Dürer's methodological approach. It exemplifies the strategic projection of points onto planes delineated by a ground line, establishing a harmonious relationship between multiple projections. Similarly, Gaspard Monge's conceptualization of descriptive geometry builds upon the foundational principles espoused by Dürer, albeit within a distinct mathematical framework characterized by systematic projections and geometric constructions (Gafney, 1965). This methodological convergence underscores the enduring legacy of Dürer's artistic ingenuity and Monge's mathematical understanding, wherein the intersection of art and science catalyzes advancements in technical drawing and geometric representation. The historical antecedents of descriptive geometry, as underscored by Vitruvius's treatise "De Architectura," trace back to antiquity, wherein the rudimentary principles of technical drawing found expression within architectural discourse (Cigola, 2016). The enduring relevance of Vitruvius's insights within the broader historical context underscores the symbiotic relationship between architectural theory and technical drawing, wherein advancements in one domain precipitate innovations in the other, culminating in the systematic codification of geometric principles by luminaries such as Monge (Gasca, 2019).

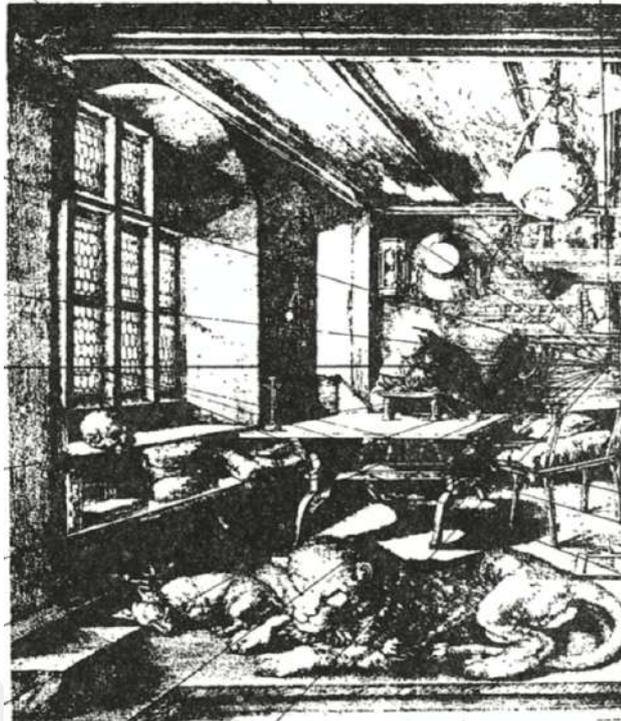


Figure 2.8: St. Jerome in his Study by Albert Dürer. Accessed February 20, 2024. Retrieved from <https://scma.smith.edu/blog/st-jerome-his-study>

Piero della Francesca is widely recognized as a preeminent Italian master of the fifteenth century and occupies a seminal position in artistic and mathematical inquiry annals. This is mainly due to his treatise, "De Prospectiva Pingendi," crafted during the 1470s (Field, 2005). Despite the prevailing historical narratives that often ascribe the systematic Study of perspective to the Renaissance era, Francesca's magnum opus predates this epoch, underscoring his status as a vanguard of artistic and mathematical innovation. As stated in Field's book, Francesca's treatise elucidates a revolutionary approach to perspective drawing, predicated upon the strategic juxtaposition of objects upon a plan and in front of a facade, thereby effectuating a seamless transition from three-dimensional reality to a two-dimensional representation. This innovative technique, which resonates with the fundamental principles of descriptive geometry, found resonance three centuries later in the work of Piero Monge, exemplifying the enduring legacy of Francesca's methodological paradigm. Central to Francesca's treatise is the notion of 'reference lines,' which serve as conduits for establishing the harmonious linkage between the plan and elevation of an object, thereby engendering a cohesive and coherent representation of spatial entities (Ghyka, 1977). By

meticulously delineating the interplay between reference lines and geometric forms, Francesca imbues his drawings with precision and accuracy, transcending the realm of artistic intuition in favor of systematic delineation (Figure 2.9). Figure 2.10, emblematic of Gaspard Monge's endeavors in descriptive geometry, juxtaposes Francesca's methodologies despite the temporal chasm separating the two epochs. Monge's depiction of the intersection curve between two cones underscores the enduring quest for mathematical rigor and geometric exactitude, mirroring Francesca's pursuit of precision in perspective drawing (Monge, 1798). The convergence of Francesca's perspectival techniques and Monge's descriptive geometry epitomizes the continuity of mathematical and artistic investigations across temporal ages united by a common commitment to systematic representation and geometric fidelity. This highlights the critical role of Francesca's treatise in shaping the trajectory of artistic and mathematical research, thus testifying to the enduring legacy of his innovative approach to perspective drawing.

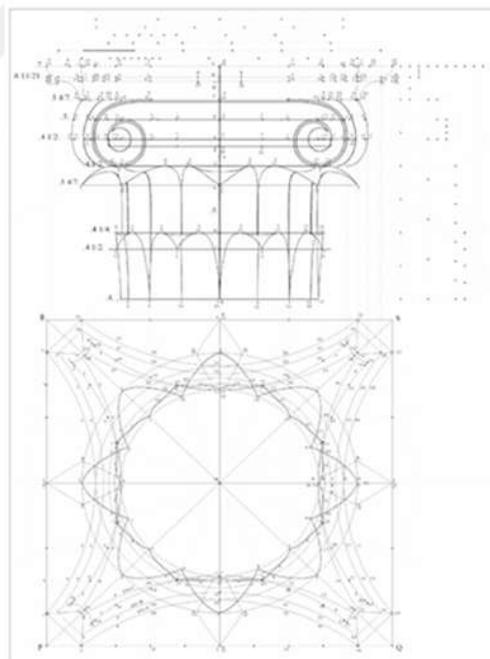


Figure 2.9: This drawing, which is readable only in in-folio format, Represents the graphic transcription of operations related to the construction of the capital, meticulously described by Piero. From fol. 49v to fol. 52r of the manuscript preserved.

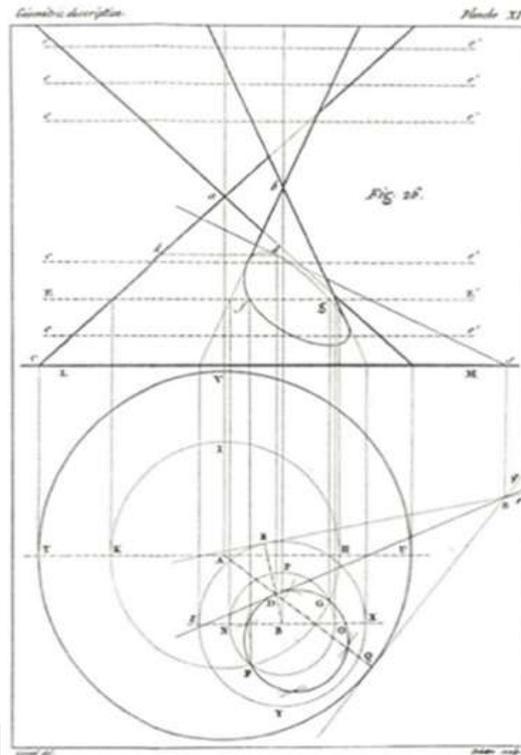


Figure 2.10: Plate XI, from Monge's *Géométrie Descriptive*, 1795, shows the method used for determining the curve of the intersection of two cones.

They are describing a three-dimensional object in a novel space. As Piero used in his experiment, the geometric body and its construction phase are simultaneous in descriptive geometry. The designer imagines the object in his head, and when he molds it, the object takes shape. Piero Della Francesca applied descriptive geometry logic to perspective centuries before Monge (Migliari, 2012). Gaspard Monge's goal was to build an autonomous three-dimensional ideal space. The abstracted space would absorb the information coming from the "object" of the representation; that is, it would take the object's projection on its surfaces and present it in two dimensions. Its descriptive geometry was a science of representation' through the 'objectification of space,' regardless of the shape, size, or orientation of the 'object' to be represented. Pérez-Gómez and Pelletier (1997) argue that descriptive geometry is the precise link between a representation and its corresponding object. Monge's descriptive geometry is essential because it distinguishes spatial configurations from orthographic projection. It uses orthographic projection but two fixed and perpendicular "reference planes." According to Evans (1995), descriptive geometry is concerned with determining the relationships between mathematically specified bodies and surfaces

rather than describing the look of objects. Monge proved this could be accomplished only with points and lines, making everything clear. As a result, we need only two projection planes, and using two points on two surfaces, we can calculate a third distinct point in space from which they are projected.

For this reason, the fundamental set of drawings in descriptive geometry differs from that of architectural drawing. Monge demonstrated that descriptive geometry can accurately represent three-dimensional objects using points, lines, and two projection planes. Descriptive geometry is the foundation for teaching descriptive geometry in architectural education, where students learn about the production of geometric shapes, projections, and image construction through these essential elements. When combined, descriptive geometry is related to space elements such as points, lines, and planes, representing diverse three-dimensional structures and forms. In architectural education, courses teach descriptive geometry through fundamentals of geometry formation, orthogonal and other projections, and image construction. The modified design-analog method connects teaching with educational and professional architectural practice. These classes aim to improve three-dimensional design thinking and connect art and architecture through observation, analysis, and composition. Alberto Pérez-Gómez and Louise Pelletier think that descriptive geometry, the fundamental core subject, allowed for the first time to systematically reduce three-dimensional objects to two dimensions, making the control and precision demanded by the Industrial Revolution possible. Without this conceptual tool, our technological world could not have come into existence (Pelletier & Perez-Gomez, 1992). What is more important for this discussion is that "descriptive geometry became the 'assumption' behind all modern architectural endeavors, from the often superficially artistic drawings of the *École des Beaux-Arts* to the functional projects that embodied technological symbolism of the Bauhaus" (Perez-Gomez & Pelletier, 1997).

2.2 Inquiries in Modern Architecture

Historically, it is critical to examine the contributions of scholars and practitioners who have questioned fundamental questions about the representation and perception of space in their own temporal and cultural contexts. These manifestos, authored by influential architects such as Adolf Loos and Le Corbusier and proponents of the *De Stijl* movement, challenged established design paradigms and introduced

groundbreaking ideas that continue to influence our understanding of spatial design. For instance, Adolf Loos's Raumplan advocated for the three-dimensional design of spaces to enhance experiential depth. Similarly, Le Corbusier's Plan Libre revolutionized architectural design by promoting flexible and open floor plans, liberating interior spaces from the constraints of load-bearing walls. The De Stijl movement, led by figures such as Piet Mondrian and Gerrit Rietveld, further advanced architectural design by advocating for abstraction, harmony, and integrating different artistic disciplines into cohesive spatial compositions. Moholy's 'Light-Space Modulator' uses light to generate spatial experiences that transform as one moves within the spatial and luminous environment. He asserts that, similar to the perception of color, the capacity to perceive space is not static but can be honed through deliberate practice and suitable exertion. After discussing these influential movements, it's essential to explore how later 20th-century architects, such as Greg Lynn and the Deconstructivist architects, further redefined architectural space through complex, fluid forms and fragmented compositions, challenging traditional notions of stability and coherence in design.

2.2.1 Loos and Raumplan

In the early 20th century, Adolf Loos revolutionized architectural design with his concept of the Raumplan, which challenged the prevailing conventions of his time. The innovative spatial organization of the Raumplan prioritized the experience of navigating three-dimensional volumes, diverging significantly from the flat, orthographic projections that dominated architectural representation. Today, as it confronts the limitations of traditional methods in capturing the essence of space, we face a similar pivotal moment.

Designing a space by specific qualities is crucial for transforming a physical environment into a conceptual or virtual space with the potential for future realization. Like a deity within these realms, the architect orchestrates this process according to a set of principles or 'rules,' thus guiding an experiential journey. However, what exactly are these rules? What guiding principles do architects employ? Furthermore, how did this entire methodology originate? Architects conceptualize space through physical drawing and a profound cognitive process that forms mental representations beyond those stored in memory. This capacity for imagination, a cornerstone of cognitive

activities such as planning, foresight, and the generation of creative ideas (Abraham, 2016), is what truly defines space in architecture. This imaginative process creates a dynamic relationship between the body and the spatial environment, constituting the act of design.

Adolf Loos, a pivotal figure in modern architecture, introduced the concept of the Raumplan, a revolutionary approach to architectural design that emphasized the three-dimensional structuring of space. Unlike the traditional two-dimensional floor plans that dominated architectural practice, the Raumplan involves a volumetric space organization, where different areas are arranged at varying levels and interconnected continuously and fluidly. This method addresses functional requirements and enhances the experiential quality of moving through the space. According to Panayiotis Tournikiotis (1991), in his comprehensive examination of Loos's work, "Adolf Loos: Architect against Architecture," the Raumplan was conceived as a response to the limitations of flat, horizontal planning, which Loos perceived as insufficient for creating meaningful and dynamic living environments. By manipulating volumes and levels, Loos sought to develop a richer spatial experience that could engage occupants more profoundly (Tournikiotis, 1991). Contemporary theories of embodied cognition, which propose that cognitive processes closely tie to the body's interactions with the environment, further support the Raumplan concept. Lakoff and Johnson (1999) argue that physical involvement and sensory input enrich our comprehension and experience of space. Loos's design philosophy is an antecedent to these modern cognitive theories, emphasizing the significance of creating spaces that address the occupants' physical and psychological requirements.

The Raumplan, with its intricate interrelationship of spatial volumes, signified a fundamental shift in architectural design. It has prompted contemporary critics and architects, including prominent figures like Le Corbusier, to recognize it as a pivotal move towards a new architectural language. As documented by Risselada (2008), this innovative approach underscored a transition in architectural thought, emphasizing the three-dimensional orchestration of space and challenging the conventional two-dimensional floor plans that previously dominated the field (Risselada, et al., 2008).

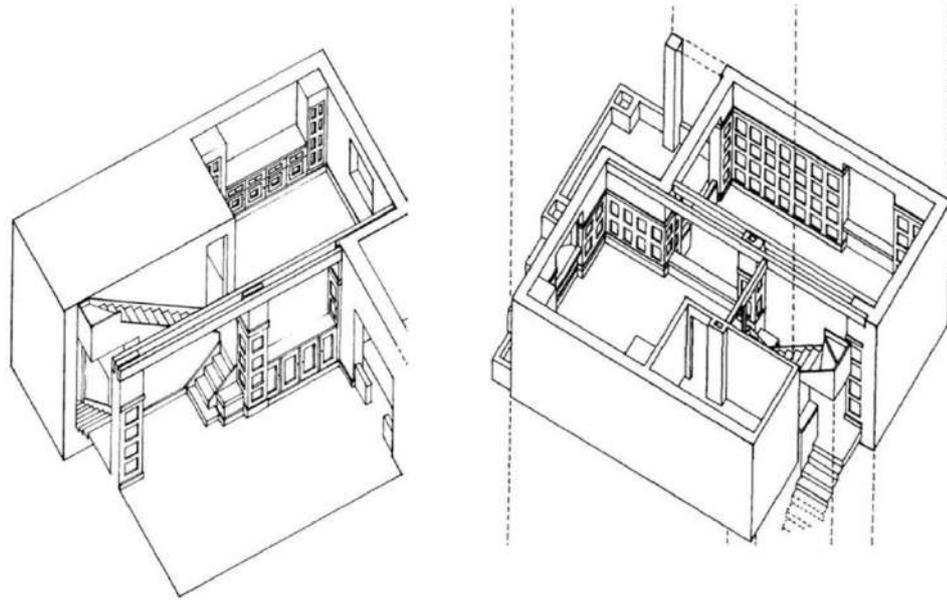


Figure 2.11: An axonometric form of plan expression; Rufer House axonometry.
From, C. Jara. Adolf Loos's Raumplan theory. *Journal of Architectural Education*,
48(3):185–201, 1995.

Raumplan's concern with functional, perceptual, and experiential dimensions of space prefigures current interests in embodied cognition and the phenomenological experience of architecture. It suggests that two-dimensional representations or even three-dimensional models alone cannot fully understand architectural space. It requires an immersive engagement that acknowledges the embodied human experience as central to understanding and appreciating architectural space. In this light, the Raumplan contributes to the historical discourse of architectural theory and provides a valuable framework for considering the future of architectural design and education in an increasingly digitalized and experientially oriented world.

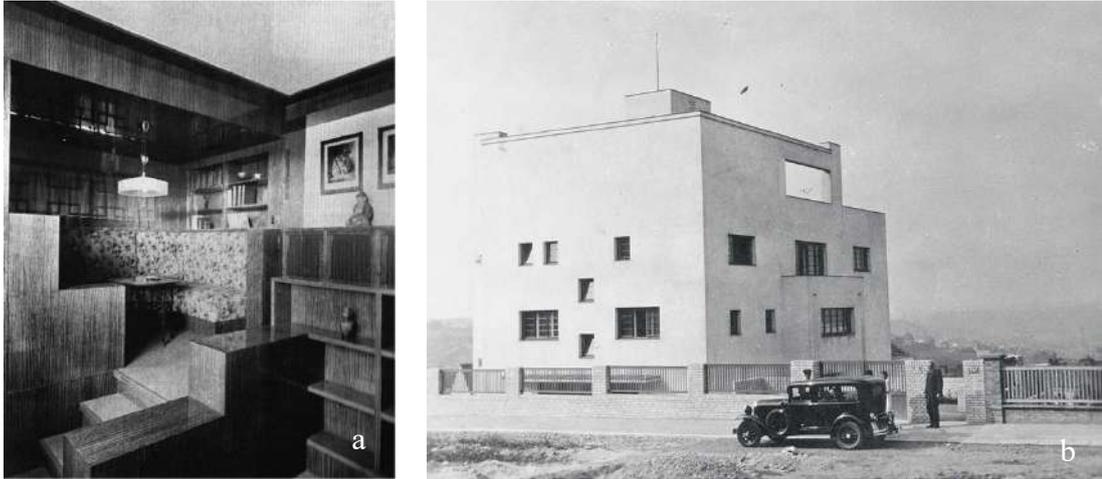


Figure 2.13: (a) Interior of Villa Müller, Praga, 1930. From UPM Archive Prague. En *The Müller Villa in Prague*, City of Prague Museum, 2002. (b) Exterior of Villa Müller, Praga, 1930. From UPM Archive Prague. En *The Müller Villa in Prague*, City of Prague Museum, 2002.

In conclusion, Adolf Loos's Raumplan represents a significant departure from conventional architectural methods, emphasizing a volumetric and experiential approach to space creation. The Raumplan philosophy underscores the importance of three-dimensional spatial planning in architecture. This aspect is vital, considering Loos's critique of the disconnect between architects' and users' lived experiences. Physically engaging with space can enhance comprehension and learning. Raumplan's encouragement of architects to think in three dimensions and consider the user's movement in space is an early example of this concept.

2.2.2 Corbusier and Plan Libre

The concept of Plan Libre, or the free plan, became a defining feature of modern architectural theory, championed by Le Corbusier. This innovative approach to architectural design aims to free up floor space within buildings, offering unprecedented flexibility compared to traditional methods that rely on load-bearing walls. Le Corbusier's pioneering vision not only revolutionized architectural design practices but also profoundly impacted the development of urban spaces. This section of the thesis explores the origins, principles, and manifestations of Plan Libre in Le Corbusier's work, emphasizing its relevance and application in contemporary architecture. The concept of Plan Libre can be traced back to Le Corbusier's

involvement with the avant-garde movement in the early 20th century, where he pursued aesthetic innovation and intersected it with functional considerations. In his influential treatise "Towards an Architecture" (1923), Le Corbusier outlined the five points of new architecture, emphasizing the importance of the free plan. He proposed using columns (pilotis) to raise the structure, eliminating the need for load-bearing walls and creating open interior space (Corbusier L. , 1923). This approach aimed to achieve aesthetic purity and improve living conditions through architectural design. The core principle of Plan Libre revolves around the separation of structural and spatial elements, made possible by reinforced concrete columns (pilotis) supporting the building's weight. This architectural innovation allowed for the independent placement of walls, freeing them from their structural role to serve purely as partitions (Colquhoun, 2002). Le Corbusier's utilization of the open plan and free façade embodies the newfound liberty afforded by modern technology. He wholeheartedly embraced the "aesthetic possibilities inherent in the free plan" (Curtis W. J., 1996), enabling a more dynamic and adaptable use of space. Le Corbusier's theoretical writings elaborate on the concept of the "Plan Libre." In his influential book, "Towards an Architecture," he emphasized the significance of functionalism and advocated for the liberation of architectural form from unnecessary constraints. He argued that the free plan enabled a more rational and efficient use of space, accommodating the evolving needs of inhabitants. This concept was groundbreaking in the early 20th century, challenging the prevailing orthographic projection methods that dominated architectural education and practice (Corbusier L. , 1923).

The L'Esprit Nouveau pavilion, designed by Le Corbusier for the International Exhibition of Modern Industrial and Decorative Arts in Paris in 1925, is a work that demonstrates his architectural philosophy (Corbusier F. L., 1924). The pavilion exemplifies the interplay of movement and space essential to his modernist ideals. The open plan facilitates seamless movement, embodying Le Corbusier's idea that modern living spaces should be adaptable and dynamic. This design approach coincides with the idea that space is not static but is shaped by the movements and activities of its users (Wilson M. , 2002). The pavilion consists of modular units reflecting Le Corbusier's understanding of architectural standardization. This modularity allows flexibility in spatial organization and accommodates different functions and activities within a fluid layout. Using pilotis raises the structure above the ground, creating an open space beneath the building. This design element provides functional support and

increases the flow of movement around and within the pavilion (Benton, 1987). Le Corbusier elevates the pavilion above the pilotis, creating an open ground level that encourages free movement. Thus, it allows users to navigate unhindered in and around the structure, developing an intuitive understanding of spatial relationships and increasing physical interaction with the environment. The free façade, not restricted by load-bearing walls, allows for large horizontal windows. Continuous strip windows enhance the spatial experience by providing a visual connection with the environment and ensuring the user's movement within the pavilion is fluid and expansive. Such movements facilitate an embodied experience of space, where users physically interact with their environment to gain a better spatial understanding.



Figure 2.14: Façade of The L'Esprit Nouveau Pavilion. Accessed May 15, 2024. Retrieved from <https://www.fondationlecorbusier.fr/oeuvre-architecture/realisations-pavillon-de-lesprit-nouveau-paris-france-1924/>

'Architecture is experienced as one roams about in it and walks through it [...] So true is this that architectural works can be divided into dead and living ones depending on whether the law of 'roaming through' has not been observed or whether on the contrary it has been brilliantly obeyed.' (Corbusier L. , 1967).

The promenade architecture - the path through the built space directed at the viewer - is central to Le Corbusier's architectural and urban planning designs. The sequence of images unfolds before the viewer's eyes, who advances step by step. It is the hierarchy of architectural events, the reading instruction -the "inner cycle" of architecture. With the help of the promenade architecture, Le Corbusier created virtuoso interweaving of interior and exterior space. These flowing spaces that open as you move forward. Architecture forms the space of movement sequences (Samuel, 2010). It can be said that Le Corbusier's pavilion exemplifies "learning by doing" by emphasizing movement and interaction within the space.

The design allows users to physically interact with their environment, encouraging them to establish a deeper cognitive connection with the space. This experiential learning approach provides knowledge through active participation. It is consistent with the principles of embodied cognition achieved through sensory interaction. By exploring the pavilion, users develop a spatial understanding beyond static representations. The physical act of moving between and interacting with the different areas of the pavilion provides a holistic understanding of the design and spatial qualities of the building. This dynamic interaction reflects the core ideas of embodied cognition, in which learning is a process based on bodily experience and interaction. Le Corbusier's L'Esprit Nouveau pavilion demonstrates how architectural design can incorporate the principles of embodied cognition and encourage learning by doing. The pavilion's open plan, vertical circulation and multifunctional spaces create an environment where users can physically interact with their surroundings, leading to a deeper and more intuitive understanding of spatial relationships and architectural concepts. This approach enhances the user experience and is compatible with modern strategies emphasizing active, experiential learning.

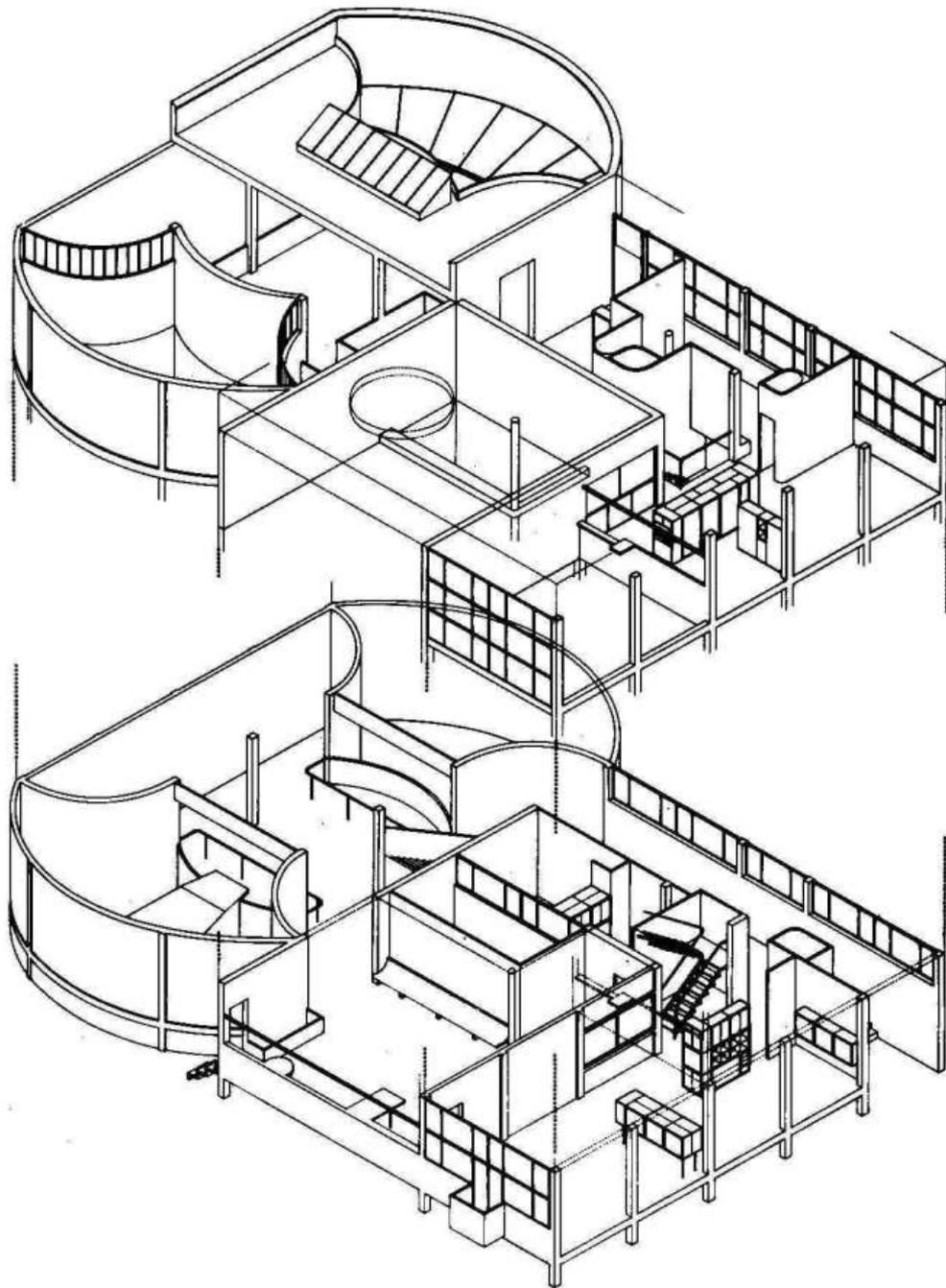


Figure 2.15: Axonometric View of L'Esprit Nouveau Pavilion. Accessed May 26, 2024. Retrieved from <https://visuallexicon.wordpress.com/2017/10/13/esprit-nouveau-pavilion-le-corbusier/>

In summary, Le Corbusier's L'Esprit Nouveau pavilion system is a pioneering example of the spatial exploration and understanding this thesis promotes through VR. While the L'Esprit Nouveau pavilion disrupted conventional architectural practices and representations, it also established the foundation for conceptualizing space as an

experiential instrument. Le Corbusier's approach urged architects to envision and represent space in three dimensions, departing from the two-dimensional constraints of traditional drafting techniques. He recognized the limitations inherent in orthographic projections, asserting that architectural design must encapsulate the volumetric and spatial experiences these representations often fail to convey. He said, "The house is a machine for living in" (Corbusier L., 1923). The design of the L'Esprit Nouveau pavilion illustrates this philosophy through its spatial complexity and fluidity. It opens conversations about the necessity of representing and thinking about architecture in three dimensions.

2.2.3 De Stijl

The De Stijl movement, also known as "The Style," was a significant artistic and architectural movement that originated in the Netherlands in the early 20th century. It formally began in 1917 with Theo van Doesburg's establishment of the magazine *De Stijl*, which served as the primary platform for disseminating the movement's ideas, principles, and works. Due to the influence of this periodical, the movement rapidly gained prominence within the Netherlands and beyond (Overy, 1991). Key figures who played pivotal roles in the foundation and growth of *De Stijl* include renowned artists and architects such as Piet Mondrian, Gerrit Rietveld, Vilmos Huszár, and Bart van der Leek. Their contributions were instrumental in shaping the principles of *De Stijl*, which emphasized simplicity, abstraction, and a reduction of fundamental elements of form and color (Blotkamp, 1986). In addition to its impact on painting and sculpture, the *De Stijl* movement had profound implications for architectural practice. It notably influenced space design through orthographic methods, including axonometric drawings. This emphasis on fundamental elements and simplicity in design significantly contributed to the evolution of architectural space design during that period (Perez-Gomez & Pelletier, 1997). Piet Mondrian's concept of "Neoplasticism" was particularly influential. Mondrian sought to express a new, refined aesthetic that prioritized essential geometric organization by eliminating the unnecessary (Edwards C., 2015). *De Stijl* members advocated a departure from the individualistic and ornate tendencies of previous artistic and architectural styles through their writings and artworks. Instead, they championed an art form that transcended the individual and could develop into a universal language. Emphasizing abstraction and simplicity, the

movement focused on essential elements such as lines, geometric forms, and primary colors. De Stijl artists and architects endeavored to develop a universal form of expression that could transcend cultural boundaries, employing horizontal and vertical lines and primary colors combined with black and white. This aesthetic aimed to remain objective, devoid of personal emotion in artistic creation. Visionaries like Piet Mondrian and Gerrit Rietveld applied these principles to their architectural works (Troy, 1986).

Rietveld's utilization of axonometric drawings in conceptualizing the Schröder House played a pivotal role in clearly and precisely conveying the spatial relationships and structural details. These drawings, which served as technical tools and expressions of the De Stijl aesthetic, underscored the principles of clarity and abstraction, as Pérez-Gómez and Pelletier (1997) emphasized.

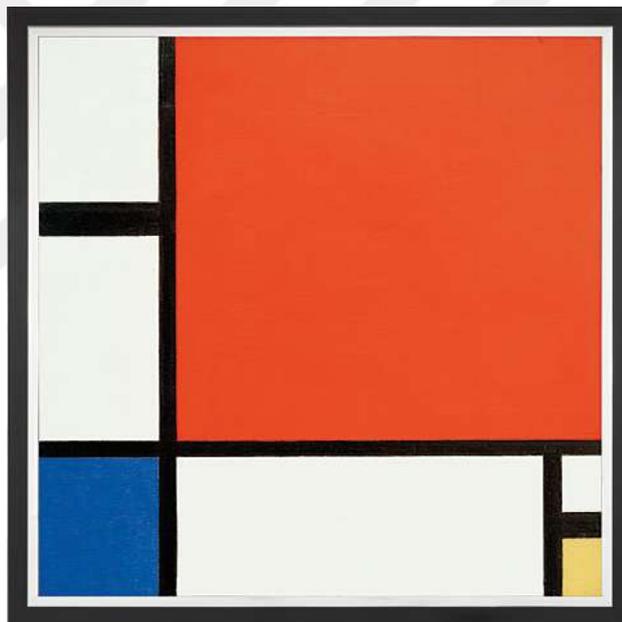


Figure 2.16: Piet Mondrian's work, *Composition*. Accessed June 2, 2024. Retrieved from The MET: <https://www.metmuseum.org/art/collection/search/490012>

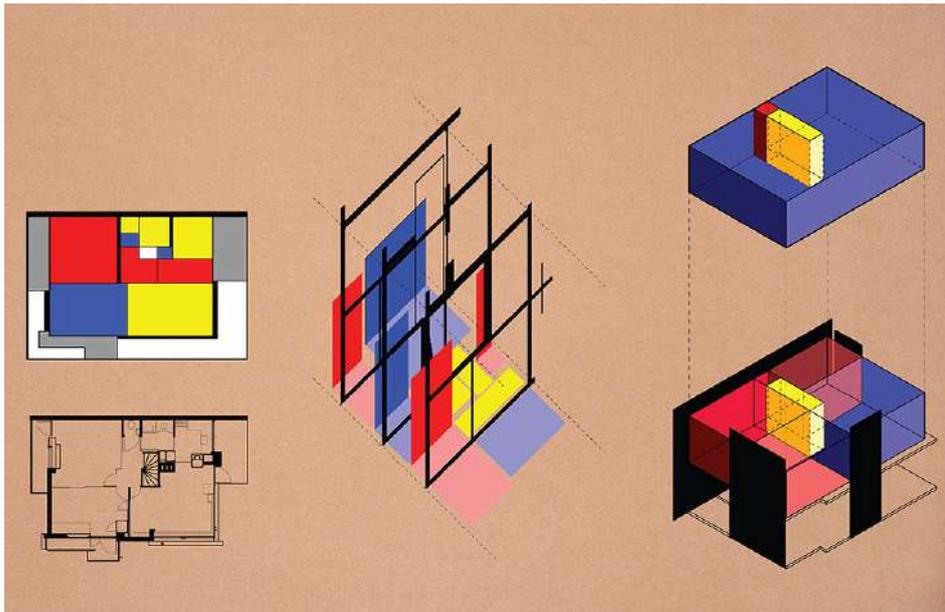


Figure 2.17: Diagrams for Schröder House. Accessed June 3, 2024. Retrieved from https://www.yunfrankzhang.com/?utm_medium=website&utm_source=archdaily.com

Orthographic projection is a time-honored technique for representing three-dimensional objects in two dimensions through plan, elevation, and section views. This essential architectural method has been used for centuries as a standardized way to convey complex spatial information precisely and clearly. While orthographic methods excel in these aspects, they sometimes need help to capture space's experiential and phenomenological elements, leading to a less intuitive understanding of architectural environments (Ching, *Architectural Graphics*, 2015). The advent of axonometric drawings marked a pivotal advancement within the De Stijl movement, as they provided a means to represent three-dimensional structures without the constraints of perspective distortion. Aligned with the movement's dedication to abstraction and precision, this technique enabled architects and designers to swiftly explore and convey intricate spatial relationships, sparking a revolution in architectural representation. The innovative nature of these drawings inspired a new wave of creativity and discovery, ultimately leaving a profound impact on our field (White, 1987). De Stijl artists and architects were renowned for their innovative use of axonometric drawings, which, unlike traditional orthographic projections, represent three-dimensional objects without distortion. These precise and clear drawings provide a more accurate visualization of spatial relationships and structural details, in line with

the movement's principles of clarity and order. For instance, Gerrit Rietveld's axonometric depictions of the Schröder House demonstrate how De Stijl utilized this method to express its architectural ideals, emphasizing the unique contribution of axonometric drawings to the field. Orthographic techniques played a crucial role in the De Stijl movement. Axonometric drawings allowed architects to portray three-dimensional spaces on two-dimensional surfaces with precise, quantifiable relationships between elements.



Figure 2.18: Schröder House, Rietveld Schröderhuis. Accessed June 3, 2024.

Retrieved from Rietveld Schröderhuis.nl:

<https://www.rietveldschroderhuis.nl/de#quote-block-wrapper>

Gerrit Rietveld's axonometric illustrations of the Schröder House display the interior's spatial dynamics and functional adaptability, demonstrating how spaces can be encountered and engaged beyond standard depictions. Axonometric drawings enable a physical comprehension of space, enabling observers to interact with architectural shapes in a way that prioritizes physical engagement and spatial orientation (Fiedler, 2001). Although less restrictive than traditional orthographic methods, Axonometric drawings must be revised to convey the physical and phenomenological experience of space. The limitation lies in the inherent abstraction of such drawings; they provide a "god's eye" view that can distort the occupant's sensory and corporal engagement with architecture. Francesca Hughes (2004) notes, "The axonometric is unable to depict motion, sequence, and spatial relationships that are understood through bodily

movement and perception. The theory of embodied cognition proposes that people's physical interactions with the world influence their understanding. This perspective implies that sensory and motor experiences are intricately linked to cognitive abilities. Consequently, designing environments without taking embodied experience into account can lead to spaces that are not functionally suitable and may be isolating. In the context of De Stijl, the emphasis on strict perpendicularity and the abstract representation of space in axonometric illustrations can be seen as limiting. Although these illustrations were groundbreaking in aiding the communication and construction of intricate forms, they overlooked the embodied perspective – how people engage with, navigate, and experience space at the moment (On De Stijl and Architectural Design, 2016). In addition, the Schröder House's heritage highlights the crucial crossroads between forward-thinking design intentions and the necessity for equally innovative representational methods. Although Rietveld's approaches were revolutionary, modern technologies present new opportunities for more accurately materializing such cutting-edge spatial ideas. The De Stijl movement's reliance on orthographic methods, notably axonometric drawings, signaled a crucial development in the visualization and construction of modern spaces. However, as it moves towards more immersive and embodied design technologies, it is becoming clear that these traditional methods must be updated to encompass the complete range of human experiences within architectural spaces. This evolution from orthographic methods to immersive technologies represents a technological advancement and a paradigm shift towards a more holistic understanding of space in architectural practice (Jencks, 1997).

2.2.4 László Moholy-Nagy and His Works on Space

László Moholy-Nagy, a Hungarian artist and educator, significantly contributed to the Bauhaus movement and modern design and photography. His work and theories, which were ahead of their time, profoundly impacted architecture, particularly in space relations and the integration of technology and art (Kirkpatrick, 1988). Moholy-Nagy's ideas about the spatiotemporal nature of our world served as the foundation for all his mature works. He envisioned a future characterized by a kinetic, spatiotemporal existence, where we become attuned to the forces and relationships that define life, previously unknown to us and lacking precise terminology. Space-time embodies relativity, movement measurement, integration, simultaneous perception of interiors

and exteriors, and structure revelation over the facade. It also introduces a fresh perspective on materials, energies, tensions, and societal implications (Moholy-Nagy, *Vision in Motion*, 1947). According to Moholy, artists would create visual works to educate people about experiencing the world in a new way. Moholy (1937) envisioned that artists would develop a comprehensive system for understanding space relations akin to our current color and sound systems through research. He emphasized the importance of understanding human perception and how we grasp the dimensions of space-time, including our perception of space through sounds, kinesthetic body senses, and visual cues. He noted that kinesthetic experiences come through motion, balance, and various movements. At the same time, visual information is obtained through wide perspectives, intersecting surfaces, moving objects, and layering different space and time levels together (Moholy-Nagy, 1942).

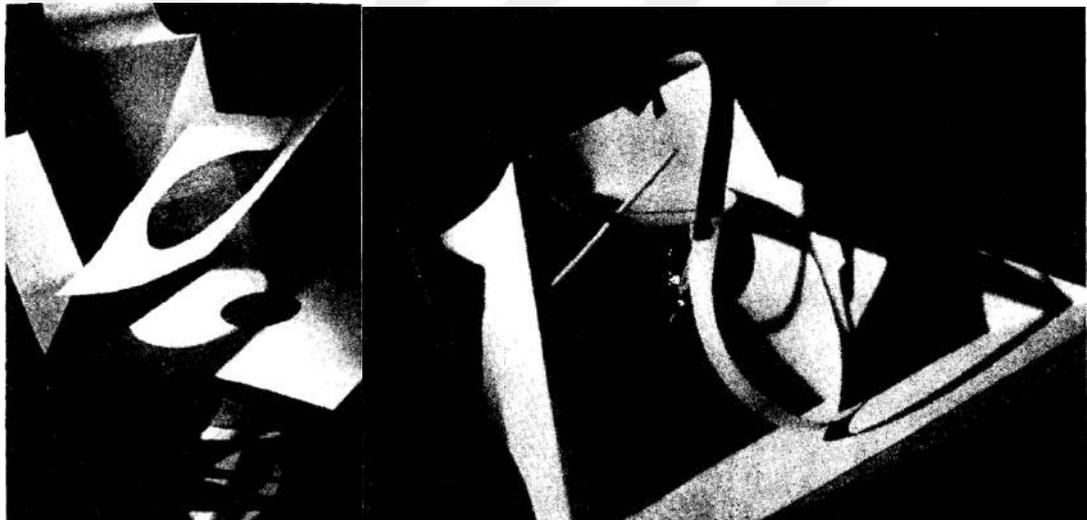


Figure 2.19: Paper Light Modulators as a product of the imagination are as simple as the photographer wishes. By L. Nederkorn. From (Moholy-Nagy, *Moholy-Nagy: an anthology*, 1970).

Moholy (1940) referred to his works as "light modulators." He crafted light modulator paintings, relief paintings, sculptures, and stage sets to explore how light and shadow could convey "vision in motion". For Moholy, photography, or "writing with light," was particularly adept at expressing space-time "vision in motion." True photographic space-time relationships should mirror human perception. The world is inconsistently lit, and objects appear to us with varying degrees of sharpness (Moholy-Nagy, 1947, s. 173-178-252). In these images, he carefully manipulated light passing through and

shadows cast from different objects onto photosensitive paper. The results were two-dimensional images that created the impression of three-dimensional space, a feat achieved through his careful use of compositional techniques in his other abstract works, such as layering, transparency, spatial cues, and chiaroscuro (Kirkpatrick, 1988). Moholy (1947, s. 188-197) believed the photogram was 'a diagrammatic record of the motion of light translated into black and white and grey values [that] can lead to a grasp of the new types of spatial relationships and spatial rendering.'

Moholy describes how people perceive space through various sensory experiences:

1. Visual perception, including wide perspectives, intersecting surfaces, corners, and moving objects with gaps.
2. Auditory perception involving acoustic events.
3. Sensory perception through movement, encompassing horizontal, vertical, diagonal, and jumping motions.
4. Perception is mediated by the sense of balance, involving circles, curves, and spirals such as spiral staircases (Moholy-Nagy, 1970).

The Kaleidoscope Moholy (1970) mentioned in his anthology, created by Bauhaus students, is truly remarkable. It comprises vertical rods placed on a horizontal disk that rotates. At its core is a small elevator with a transparent, spiral-shaped body containing slats and rods. As the disk and the elevator move together, many intersections and spatial relationships between objects are created. The movement can be paused at any point, allowing for the easy recording of interesting spatial relationships through drawings or other means of representation.

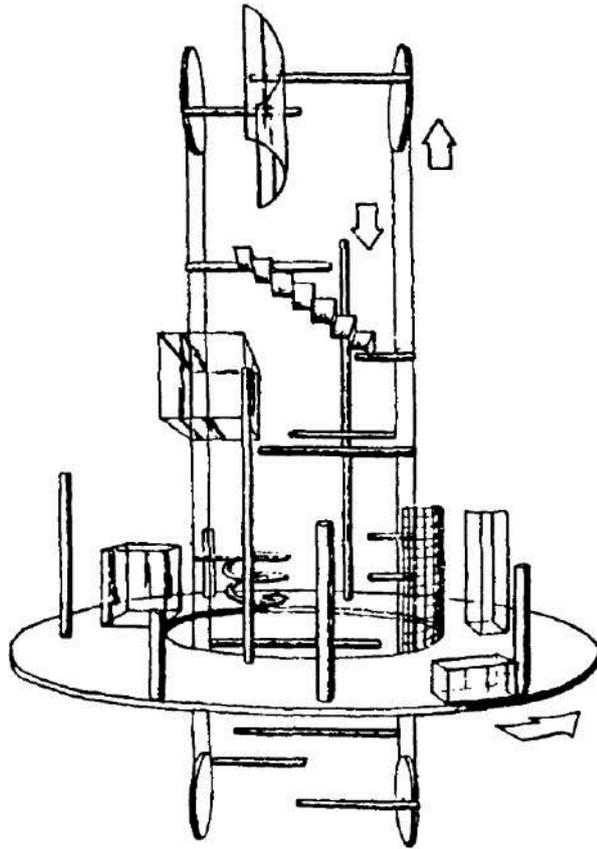


Figure 2.20: Kaleidoscope, suggestion from Laszlo Moholy-Nagy. From (Moholy-Nagy, Moholy-Nagy:an anthology, 1970).

Moholy, in his work *Vision in Motion* (1947), emphasizes that the experience of space is not exclusive to architectural geniuses but a biological function accessible to all. He believes that, like the experience of color or tone, our ability to perceive space is not fixed but can be honed through conscious effort and appropriate exercises. This potential for improvement should inspire us to engage in these efforts and exercises. He views architecture not just as a collection of interior spaces or a mere shelter but as a dynamic creation that profoundly shapes and enhances life. Moholy argues that true architectural realization can only occur when there is a deep understanding of human life within its biological context. Central to this understanding is the organization of space, which makes it coherent. He asserts that the core of architecture lies in mastering the challenge of space. At the same time its practical development hinges on construction (Moholy-Nagy, 1970, s. 108).

Moholy-Nagy believed in incorporating modern technology into architecture, using new materials and construction techniques to create innovative and functional

buildings with aesthetic appeal. His interdisciplinary approach and emphasis on human experience influence contemporary architecture and design. One of his notable works, 'Light-Space Modulator,' showcases his belief in the dynamic interaction between space, light, and the observer.

2.2.5 Deconstructivism

In the second half of the 20th century, deconstructivism emerged, a movement that challenged and redefined traditional architectural representation and spatial organization. This approach to architecture derived from Jacques Derrida's philosophical ideas, particularly the concept of "deconstruction," which involved dismantling traditional structures and questioning established meanings (Wigley, 1995).

Frank Gehry's work, exemplified by the Guggenheim Museum Bilbao, embodies the principles of deconstructivism with its fragmented, undulating forms and non-linear spatial arrangements. Gehry uses advanced digital tools to free architecture from traditional constraints, creating dynamic and unpredictable forms that engage and provoke viewers (Cohen, 2021). This process of "deconstruction" reflects Derrida's philosophy by subverting established architectural codes and adding an element of unpredictability and complexity.

Zaha Hadid has further expanded the narrative of deconstruction with her fluid, transformative designs that blur the boundaries between structure and space. Her projects, such as the Vitra Fire Station and the MAXXI Museum in Rome, emphasize movement and dynamism, creating spaces that resist static interpretations. Hadid's architectural approach incorporates sweeping curves and intersecting forms that produce a sense of continuous flow and transition (Schumacher, 2004). Her work demonstrates a fundamental critique of rigid Cartesian grids and encourages an experiential understanding of immersive and interactive space.

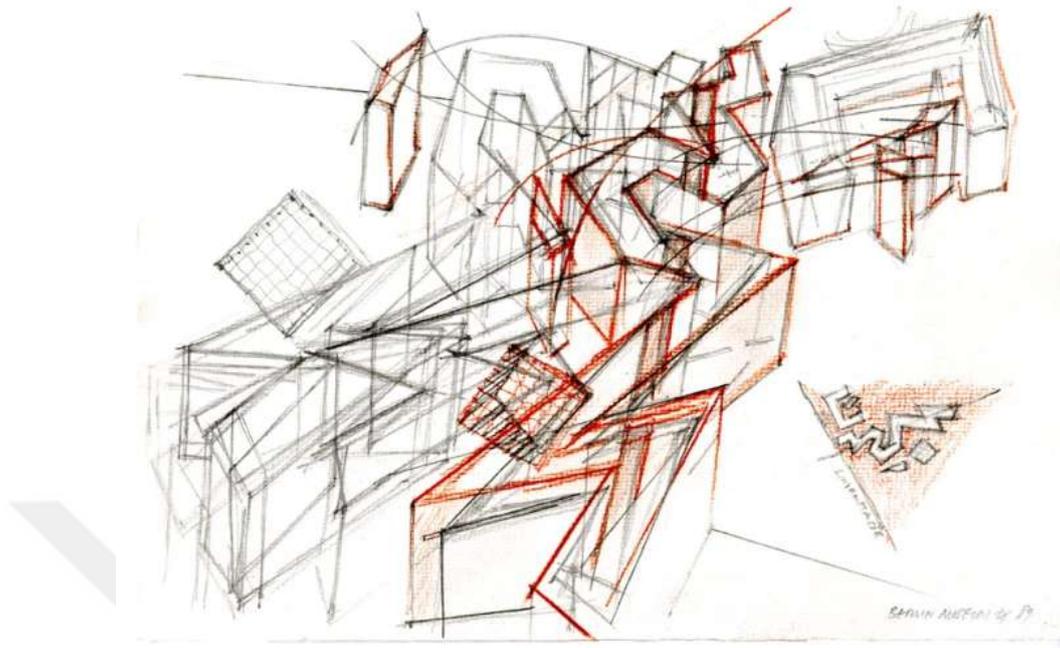


Figure 2.21: Concept sketch of Daniel Libeskind's Jewish Museum. Accessed August 12, 2024. Retrieved from <https://libeskind.com/work/jewish-museum-berlin/>

Daniel Libeskind's Jewish Museum in Berlin is another work that exemplifies the influence of deconstruction on spatial representation. The building's uneven, fragmented form and disconnected interiors evoke fragmentation and reflect the turbulent history of European Jewish communities (Young, 2000). Libeskind uses distorted lines and voids to symbolize absence and loss, engaging visitors in a deep dialogue between architecture and memory (Libeskind, 2004). His approach emphasizes the broader purpose of deconstructivism: to question and change traditional notions of architectural space and its meaning.

Deconstructivist architects sought to overthrow the hegemony of modernist rationality by advocating an architecture that reflected the complexities and contradictions of contemporary life. They embraced disorder, fragmentation, and dynamic forms, providing new ways of experiencing and interpreting space. This philosophical shift was not simply an aesthetic choice but a deliberate critique of the deterministic logic that dominated architectural practice for much of the 20th century (Tschumi, 1996). Deconstructivism's emphasis on fluidity and multiplicity inspires contemporary

architects and encourages a more nuanced, critical engagement with the built environment.

The relationship with orthographic 2D representation is fundamental to this discourse, especially when juxtaposed with the dynamic and four-dimensional essence of architecture proposed in contemporary theories. Architecture, an essentially four-dimensional phenomenon encompassing space and time, has traditionally been represented and conceptualized through non-dynamic 2D tools such as plans, sections, and elevations.

Deconstructivist architects have particularly challenged this static representation, advocating an architecture that reflects contemporary life's complexities, unpredictability, and contradictions. Their embrace of disorder, fragmentation, and dynamic forms transcends mere aesthetic experimentation; it represents a deliberate subversion of the deterministic logic that has historically underpinned architectural practice (Tschumi, 1996). This philosophical shift emphasizes a critical engagement with the built environment, encouraging architects to move beyond 2D representations and adopt a more holistic, four-dimensional approach to design.

2.2.6 Greg Lynn

The discourse on architecture and its representation has evolved significantly throughout the twentieth century. Among the architects who have contributed considerably to this dialogue is Greg Lynn, known for his avant-garde approach to organic architecture and the production of fluid spaces. While building on the fundamental ideas of his predecessors, Lynn's work moves the conversation into the realm of digital and algorithmic design, thus significantly departing from traditional Euclidean geometry. Greg Lynn's inclusion is notable because his work represents the next stage in the conceptual and technological advancement of architectural space. It builds on the legacies of earlier architects while introducing new methodologies and philosophies that continue to shape contemporary design practice. Lynn's approach to the organicity and production of space represents a significant departure from the static, rigid forms that characterize much of modernist architecture.

Greg Lynn is a significant figure in contemporary architectural theory, primarily through his research on digital tools and non-linear forms. His pioneering essays, such as "Fold, Bodies & Blobs: Collected Essays," explore the potential of digital

techniques to create spaces that eschew rigid structural norms in favor of more natural, fluid forms (Lynn, 1998). This approach not only resonates with the 20th century's ongoing quest for spatial innovation but also inspires further exploration, as evidenced by earlier pioneers such as Le Corbusier and Adolf Loos.



Figure 2.22: Greg Lynn's, Embryological House: Size "A" Retrieved from (Folds, Bodies & Blobs: Collected Essays, 1998)

The dynamic forms of the Embryological House (1997–2001) comprise flowing and vector-based surfaces, sometimes referred to as “blob” architecture, made possible through animation software (Shubert, 2016). Greg Lynn's use of CATIA², a digital tool originally developed for the aerospace industry, allowed him to explore unprecedented forms and complexities in architectural design, exemplified by Greg Lynn's “Embryological House.” The software's capacity to handle non-linear, variable forms enabled the creation of a “family” of houses, each unique yet derived from a common set of principles. This concept of variability and evolution in architectural form was groundbreaking and aligned with Lynn's vision of architecture as a dynamic and responsive system rather than a static, singular object. Today, this approach

²CATIA (Computer-Aided Three-Dimensional Interactive Application) is a powerful multi-platform software suite developed by Dassault Systèmes.

resonates with the ongoing architectural integration of parametric design and generative algorithms that enable architects to push the boundaries of form, adaptability, and customization, reflecting a continuing evolution from Lynn's pioneering work. The relevance of Lynn's work today lies in its foresight into how digital tools can transform architectural practice.

Lynn's conceptualization of the 'blob' – soft, flexible forms that adapt to environmental and functional demands – epitomizes his vision of organicity. This methodology contrasts markedly with the orthogonality promoted in Le Corbusier's *Plan Libre* (1923) and the spatial divisions seen in Loos's *Raumplan* (1930). Instead, Lynn advocates an architecture that is not static but constantly changing and responsive, embodying the principles of constant change and transformation. His dynamic vision of architecture engages the audience and challenges the traditional notions of spatial design.

The concept of a fluid, dynamic and organic production of space also resonates with philosophical investigations into space, such as Henri Lefebvre's exploration of lived space. In his work "The Production of Space," Lefebvre advocates an understanding of space that transcends purely physical constraints and recognizes it as a socially constructed and constantly evolving phenomenon (Lefebvre, 1991). Lynn's digital manipulations can be seen as an extension of this idea, as architectural forms are not fixed entities, but adaptable systems influenced by many environmental, cultural, and technological factors.

Greg Lynn's contributions to 20th-century architectural discourse ultimately represent a critical questioning and expansion of established spatial paradigms. By using digital tools to grasp organic forms, Lynn advances the aesthetic and functional potential of architecture and redefines the understanding of space as a dynamic, living construct. However, Lynn takes these concepts even further by utilizing computational tools to produce forms that are organically derived and dynamically responsive to their environment. His work challenges the traditional Cartesian grid that has dominated architectural design for centuries, advocating instead a non-linear, topological approach to the production of space. His work thus seamlessly integrates with and goes beyond the groundbreaking ideas of his predecessors, reinforcing the enduring importance of spatial innovation in architectural theory and practice.

To summarize, this chapter explores transformative architectural manifestos of the 20th century that challenged traditional conventions and introduced pioneering

concepts in spatial design. Adolf Loos's Raumplan emphasized the importance of three-dimensional spatial planning to enhance the experiential quality of spaces. His work emphasized moving beyond conventional, two-dimensional floor plans to create more dynamic and functional interiors (Colomina, 1992). At the same time, Le Corbusier's Plan Libre encouraged open and flexible layouts that liberated interiors from the constraints of load-bearing walls. This approach allowed for a more fluid and adaptable use of space, aligning with the modernist vision of architecture to improve living conditions and reflect contemporary lifestyles (Curtis W. J., 1986). The De Stijl movement, which included such notable figures as Piet Mondrian and Gerrit Rietveld, championed abstraction and harmony, encouraging the integration of diverse artistic disciplines into unified spatial compositions. Their work emphasized using geometric forms and primary colors to create visually and spatially balanced environments (Jaffe, 1982). László Moholy-Nagy's innovative work with light in his 'Light-Space Modulator' demonstrated the dynamic nature of spatial perception and its potential for refinement through application. Building on these fundamental ideas, architects such as Greg Lynn and advocates of deconstructivism have continually redefined our understanding of space and its representation, pushing the boundaries of architectural thought and practice even further. These manifestos and their authors have left a lasting legacy in contemporary architectural discourse and practice, inspiring designers to explore new dimensions in the creation and experience of built environments.

The reason for examining some manifestos and approaches in the 20th century regarding the representation, production and experience of architectural space is to see how new ideas can be produced with new research in each period. When they all come together, some problems have deepened since the 20th century and have met with today's technology regarding establishing and discovering spatial relations in a representational environment—the tools we have now allow us to experience the space while designing or experiencing it. Therefore, research on virtual reality, one of these technologies, will be discussed in another thesis chapter.

2.3 Constructing Spaces in Virtual Reality

In Vitruvius's 'Ten Books on Architecture,' (1914), the oldest known architectural text, practitioners are described as imparting knowledge through practical experience and apprenticeship. The establishment of schools and academies throughout Europe in the

18th Century marks the roots of architectural education. The introduction of architectural education brought a structured curriculum and systematic teaching methods to the field (Edwards B. , 2008). During this time, educators particularly emphasized classical principles and history, playing a pivotal in teaching students about proportion, symmetry, and classical order (Lefaivre & Tzonis, 1986). Educators rigorously trained students to produce hand-drawn renderings of classical buildings and architectural details as integral to their educational curriculum (Bergdoll, 2000). During the 1960s, a new architectural production emerged with groups like Archigram³ in England, the Situationists⁴ in France, and Superstudio⁵, UFO⁶, and Archizoom⁷ in Italy. Although these movements were motivated by different factors, they shared the goal of reproducing architecture through drawings that replaced the physical objects the architect had initially created in the Renaissance (Rowe C. , 1994). Drawing became a powerful tool, allowing architects to express abstract concepts, explore novel spatial relationships, and challenge conventional design conventions (Droste, 1998). In the 20th Century, integrating novel drawing technologies into architectural education revolutionized the field by enabling more accurate and standardized drawings. This advancement proved instrumental in honing students' technical drawing skills and producing detailed construction documents. Moreover, the inception of modernism and experimentalism in the early 1900s brought about a transformative shift in architectural education (Wingler, 1978). Renowned institutions such as Germany's Bauhaus, under the guidance of visionary educators, championed interdisciplinary collaboration, cutting-edge research, and the fusion of art and technology. The practice of drawing remained an integral part of architectural education. Technological developments in the 21st Century have significantly impacted

³ Archigram were a collective of British architects established in the sixties and dissolved by the mid-seventies. Retrieved from <https://architectuul.com/architect/archigram>

⁴ The Situationist International was an avant-garde group that existed from 1957 to 1972. Retrieved from <https://www.oxfordreference.com/display/10.1093/oi/authority.20110803100509221>

⁵ Superstudio was a major part of the radical architecture and design movement of the late 1960s. Retrieved from <https://www.italiandesignclub.com/2023/12/11/superstudio-pioneers-of-radical-architecture/>

⁶ UFO was a design and architectural group founded in Florence, Italy, active between 1967 and 1978. Retrieved from <https://www.frac-centre.fr/en/expositions/ufo-performing-architecture/>

⁷ Archizoom Associati drew on influences of Pop Art to formulate provocative, avant-garde ideas for reorganizing living space. Retrieved from <https://www.italiandesignclub.com/2021/11/08/archizoom-a-story-of-rebellion-shapes-and-provocations/>

architectural pedagogy, coinciding with the emergence of innovative tools and technologies in the field. This change has led to the development and use of new forms of architectural representation.

Although the basic concepts and principles remain the same in the twenty-first Century, technological advances, such as Computer-Aided Design (CAD) software, have significantly improved students' grasp and understanding of complex 3D geometry. Technologies such as CAD allow students to create and manipulate 3D models on the computer, making complex geometric concepts more accessible and understandable. For example, a Design Studies study shows that using CAD software in architectural education allows for more interactive and practical learning (Salman, Laing, & Conniff, 2014). A report by Autodesk highlights how CAD tools support visualization and precision in engineering and architectural design, allowing students to experiment and visualize complex structures more effectively (Autodesk, 2021). This integration of technology into descriptive geometry education not only facilitates understanding but also equips students with the skills necessary for careers in architecture and engineering. This innovative technology has become integral to many school curricula, equipping students with digital drawing, modeling, and visualization skills. CAD software has revolutionized how architects approach their projects, providing them with new opportunities for exploration and representation (Szalabaj, 2001). The field of architecture underwent a significant transformation during the latter half of the 20th Century with the introduction of CAD software. Today, CAD tools are widely used in architecture offices, enabling architects to create, modify, and visualize designs in digital formats. These tools offer a range of drafting, modeling, rendering, and documentation capabilities, streamlining the design process and promoting collaboration among project stakeholders. Integrating digital tools has transformed architectural drawing practices, empowering architects to conceive more intricate and inventive designs while enhancing precision and efficiency. In modern architectural education, collaboration is a key focus as the field integrates with other disciplines, such as engineering, environmental science, and digital fabrication.

Drawing and projective methods have formed the basis of modern architecture, and the teaching process must suit changing student profiles and evolve. In other words, different educational needs between generations should also lead to the emergence of different educational model models (Bates, 2005). Developing technologies will

inevitably bring about new discussions about the representation, understanding and discovery of architectural space. In the context of the book "The Death of Drawing: Architecture in the Age of Simulation," David Sheer (2014) uses the term "simulation" to express the increasing reliance on digital technologies in the design field, especially computer-generated simulations. "Simulation" means imitating or representing real-world processes or environments through computer-generated models. These simulations may include 3D modeling, VR and other computer-generated representations that allow architects and designers to visualize and analyze architectural spaces and designs more dynamically and interactively. The word "simulation" highlights the transformative impact of digital technologies on the way architects conceptualize, communicate and experience architectural designs in the contemporary era. In this era of rapid technological developments, digital representations and simulations are replacing traditional hand-drawing methods.

As in David Sheer's simulations (2014), once an architect decides to work in simulation, the values implicit in drawing no longer apply. As simulation tends towards an identity of model and building, it also blurs the distinction between design and construction that has been the basis of the definition of architecture since the Renaissance. The simulation medium does not build an understanding of representation—quite the contrary. Simulation collapses the distance between representation and referent, establishing a functional near equivalence instead. The figurative aspect of building stands to be lost as architects lose the ability to think metaphorically (Stubbs, 2020). As a medium, simulation is immaterial. Suppose a notion of craft exists in simulation. In that case, it can only mean ensuring the accuracy of predictions based on the model (Perez-Gomez & Pelletier, 1997). The 21st Century has seen a significant shift in architectural drawing methods from traditional approaches to digital tools and technologies. This change has brought about numerous advancements in architectural drawing within contemporary practice. One of the most significant developments is the emergence of BIM, which allows architects to create intelligent 3D models with detailed information about building elements and attributes. Building Information Modeling (BIM) facilitates the digital representation of places' physical and functional characteristics, enabling better collaboration, visualization and decision-making throughout a project's lifecycle (Succar, 2008). This approach increases efficiency and accuracy in planning, design, construction, and maintenance

by integrating multidisciplinary data to create detailed digital models (Bolpagni, 2013). BIM has revolutionized architectural drawing by enhancing efficiency, precision, and communication throughout the building's lifecycle, facilitating integrated design, coordination, and analysis (Abernathy, 2024). The advent of digital tools has revolutionized architectural education. Students are now equipped with the skillset to utilize various software, such as CAD and BIM platforms and other digital tools, which have become essential for their education. However, balancing digital and traditional drawing skills and preserving hand-drawing techniques remains a concern. Incorporating digital tools in architectural education has greatly enhanced communication and collaboration among architects, clients, consultants, and other stakeholders involved in the design process. BIM platforms facilitate real-time cooperation and coordination among multidisciplinary teams working on intricate building projects. Projects conceived and conducted within computerized environments have become a prevailing norm in contemporary architecture (Noble & Kensek, 2014).

Over the past three decades, computers have become essential tools in shaping distinctive architectural creations. They facilitate the design process by rendering it swifter, more streamlined, and remarkably precise. The advent of computer software has enabled the seamless coordination of detailed design schemes, particularly in the realm of large-scale projects. Also, the digitization of architecture has transcended the boundaries of what was once considered unreachable. By harnessing the power of computerization, formerly impossible forms, construction methods, and complicated details can now be realized. Computerization has revolutionized the field of architecture, making it possible to tackle complex forms, construction techniques, and once unmanageable information. The digitization of architectural design has become an indispensable tool for modern architects to bring their creative visions to life. While some dreams may seem unattainable, Harbison (2001) notes that the collection of once unmanageable building elements has been significantly narrowed. Thanks to these technological advancements. Among emerging architects, digitization serves as a conduit to transform architectural visions into tangible realities, liberating creative imagination from conventional constraints. Despite its various benefits, the latest software-equipped computer remains an assistive tool rather than an automated replacement for the architect or student (Juzwa & Krotowski, 2018). The pivotal role

of the designer in the creative process remains irrefutable. Even amidst the escalating influence of architectural optimization, computer software remains inert without tracing parameters or managing scripts. The synergy between the designer, computer, and concept hinges upon applying architectural skills and introducing fundamental concepts. This dialogue assumes a nuanced complexity, particularly in the developing stages of design conception, where ideas experience iterative transformations.

The symbiotic relationship between architectural design and computerization exemplifies a dynamic interplay between tradition and innovation in the contemporary architectural milieu. While technological advancements have undoubtedly revolutionized the design process, empowering architects to realize once-unthinkable creations, the centrality of human ingenuity and creative vision remains paramount. As Harbison (2001) aptly observes, the narrowing gap between conceptualization and realization owes much to the transformative potential of digital tools. Nevertheless, the architect's skillful orchestration of these tools ultimately breathes life into architectural endeavors. Indeed, the architect's role as a visionary and custodian of design integrity persists amidst the evolving digital architecture landscape. In this intricate dance between human intellect and technological prowess, the designer's discernment and creative acumen continue to shape the built environment, ensuring that each architectural creation bears the indelible imprint of human imagination and innovation.

For centuries, architecture has utilized various methods, from traditional drawing to advanced computer production, to address physical space's production, design, and experiential aspects. The exploration of each question within this domain has the potential to uncover new methodologies. In contemporary architectural education, particularly within the framework of basic design for the 21st century, there is an ongoing quest for innovative tools to facilitate a deeper understanding of spatial concepts among students. This thesis aims to identify such a tool that leverages embodied cognition, distinguishing it from conventional methods. Accordingly, the subsequent section will focus on the application and implications of Virtual Reality in this educational and design context.

2.3.1 Implementing Virtual Reality

Visual representation of ideas where designers can externalize and explore their initial design thoughts by perceptually interacting with them is a crucial part of the design process (Suwa & Tversky, 1997). These representations allow designers to externalize an idea, better explore its features and relationships, and further assist, inform, and inspire design (Schon & Wiggins, 1992). Engaging in practical experiences allows students to learn architectural principles, materials, and construction methods firsthand. Integrating advanced technologies like virtual and augmented reality, 3D modeling and printing, and simulation software has transformed traditional teaching methods in modern architectural education. These tools enable students to visualize and manipulate three-dimensional spaces more efficiently and accurately than traditional drawing and modeling techniques. One of the most significant technological advancements in this field is VR glasses, which provide an immersive and interactive platform for exploring spatial relationships, manipulating design elements, and experiencing architectural spaces in three dimensions. VR technologies are increasingly used in architecture, providing a powerful tool for visualizing and manipulating three-dimensional spaces.

Virtual reality (VR) is a truly transformative technology, revolutionizing how we perceive and interact with space (Greengard, 2019). By creating immersive environments that simulate the real world or imagined scenarios, VR allows us to experience, design, and understand space in profound new ways. This title explores the representation and production of space through VR, highlighting technological developments and theoretical concerns from the 20th century to the present. Virtual reality provides a new medium for exploring and understanding spatial relationships. Creating highly detailed and interactive 3D environments allows users to experience space before it is physically present.

The representation of space in VR is deeply rooted in theories of spatial cognition and human-computer interaction. As discussed in Yi-Fu Tuan's "Space and Place: The Perspective of Experience" (1977) the way we perceive space is influenced by our physical and sensory experiences. VR significantly enhances this understanding by providing a sense of presence that closely mimics real-world experiences. Integrating VR into the design process allows architects and designers to experiment with spatial configurations in previously impossible ways. The iterative nature of VR design tools means designers can make changes in real-time and experience the immediate effects of those changes.

Creating sketches directly in 3D in VR opens a new dimension in the application of sketching in architectural co-design (Dorta, Kinayoglu, & Hoffmann, 2016). Immersive 3D sketching is proposed to evolve the traditional 2D sketch (Donath & Regenbrecht, 1995). This approach, completely different from conventional sketching, creates new problems besides traditional sketching: control of proportions in perspective view, accuracy problems, scale and configuration in 3D space. Moreover, other solutions for drawing in VR with a non-immersive approach have also been proposed (Achten & Vries, 2000). However, it remains to be investigated whether these successfully replicate the freedom of traditional drawing, instead using it mainly as a trigger (Dorta, Kinayoglu, & Hoffmann, 2016).

Tools like Autodesk's Revit and Unity's VR integrations are crucial. According to Alexander Schreyer's (2015) "Architectural Design with SketchUp: 3D Modeling, Extensions, BIM, Rendering, Making, and Scripting," VR platforms allow designers to visualize and edit elements in a 3D environment, increasing both the creativity and fidelity of architectural projects. VR's most significant breakthrough lies in its transformative potential to inhabit a virtual space while designing. This immersive experience is not just a tool, but a gateway to a new era of architectural design. It allows designers to understand spatial dynamics from a first-person perspective, leading to more intuitive and user-centered design solutions.

Despite VR's potential for spatial design and representation, several challenges must be addressed. These include technological limitations such as resolution and latency issues and the need for more intuitive user interfaces.

As noted in Jason Jerald's (2015) "The VR Book: Human-Centered Design for Virtual Reality," ongoing discussions exist about the psychological effects of long-term VR use and the ethical implications of creating hyper-realistic virtual environments. These discussions are vital as VR technology continues to evolve and become more deeply integrated into our daily lives.

Today's tools, such as VR headsets and advanced 3D modeling software, allow us to experience space while we design and design while we experience it. This dual capability marks a significant shift in our approach to spatial relationships, opening up new possibilities for innovation and creativity.

The computer generates the virtual environment, and the interaction makes the interactive visual scene simulation of the immersive feeling of visual, auditory, and tactile effects on users (Youshuang, Xianglong, & Fei, 2004). This technology can give

architects and designers a powerful tool for visualizing and manipulating three-dimensional spaces. It can help improve the design process, collaboration, and client communication. A new way of visualization with immersion in VR is improving communication in coordinating construction projects between designers, contractors, and investors (Milovanovic, Moreau, Siret, & Miguet, 2017). As described by Dillenbourg, Schneider, and Synteta (2002), virtual educational environments are designed as "knowledge spaces" where students actively participate and engage in the learning process. These environments utilize various methods of information exchange, from plain text to immersive VR experiences in a 3D setting, fostering interactive learning and deeper engagement with architectural concepts and practices. One of the key advantages of using VR technology in architectural education is that it allows for life-size and real-time design. This technology enables students to experience their designs in a more immersive and realistic way. It can help them better understand their designs' spatial relationships and scale. Hence, considering these rationales, the methodological approach adopted for this investigation entailed utilizing a VR environment. Within this framework, researchers administered diverse VR applications to the participants as part of the experimental protocol.

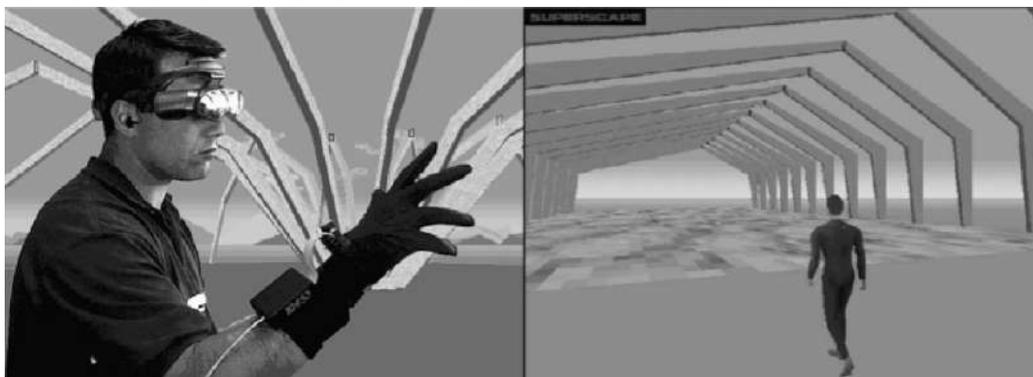


Figure 2.23: Picture from experiment. Up Designs with Vr Systems, Down Control Designs. From Qualitative Contribution of a Vr-System to Architectural Design: Why We Failed?

In 2001, Alvarado, Marquez, and Vildosola experimented to develop a VR system to model wooden structures and evaluate their contribution to architectural projects (Alvarado, Marquez, & Vildosola, 2001). This experiment involved senior students from two universities, divided into teams of 15 members each. One team utilized the VR system to design at a 1:1 scale, while the other used traditional design methods. At

the end of the activity, each student produced a page containing the plan, view, and perspective of their proposed design. Professors evaluated these submissions through a blind comparison process to ensure unbiased assessments.

Additionally, students completed a questionnaire to provide feedback on their experiences and perceptions of the design process. The resulting designs were analyzed to quantify differences in spatial volumes, environmental divisions, and other architectural groupings, as represented in Figure 2.24 The designers also synthesized the designs in both plan and facade views.

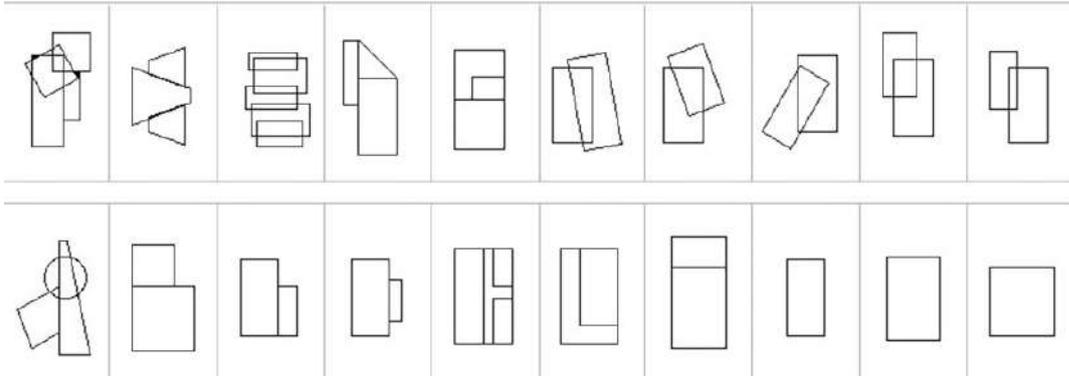


Figure 2.24: Schematic Plans Up Designs with Vr Systems, Down Control Designs. From Qualitative Contribution Of A Vr-System To Architectural Design: Why We Failed?

The analysis revealed that the VR system designs were significantly more complex and diverse than those produced with traditional methods. Students working with VR reported that the system was particularly effective for exploring possibilities at the beginning of the design process rather than defining the final design. Despite these differences, researchers found the overall design quality of both teams to be quite similar. This experiment highlights the potential of VR systems to enrich the architectural design process by offering new avenues for exploration and creativity. However, it also raises an important question: As of 2024, why do conventional approaches in design education persist despite the advancements in VR and other technologies? This question underscores the ongoing relevance of traditional methods, possibly due to their foundational role in architectural education, the familiarity and comfort they provide to educators and students, and the enduring importance of tactile, hands-on design experiences that VR may not fully replicate.

Another study is "Spatial Understanding in Immersive Virtual Environments" by Marc A. Schnabel and Thomas Kvan. This research investigated how people perceive and understand spatial volumes in immersive and non-immersive virtual environments compared to traditional media (Schnabel & Kvan, 2003). The main aim was to identify how designers perceive space in Virtual Environments and evaluate the quality, accuracy, and comprehension of reconstructing architectural spaces and forms. The study included twenty-four architectural students from two universities randomly assigned to one of three conditions: traditional 2D-floor plans, a Desktop Virtual Environment (DVE), or an Immersive Virtual Environment (IVE). The researchers asked the participants to explore a volume defined by interlocking cuboids constructed on a 4x4x4 grid and then reconstruct this volume using wooden blocks. The tools and technologies used included printed 2D plans for the traditional condition (Figure 2.25), a standard computer with a VRML plug-in for the DVE condition, and the 3D MAZE application with a Head Mounted Display (HMD) and a tracking device for the IVE condition. Participants had 25 minutes for exploration and 20 minutes for reconstruction.

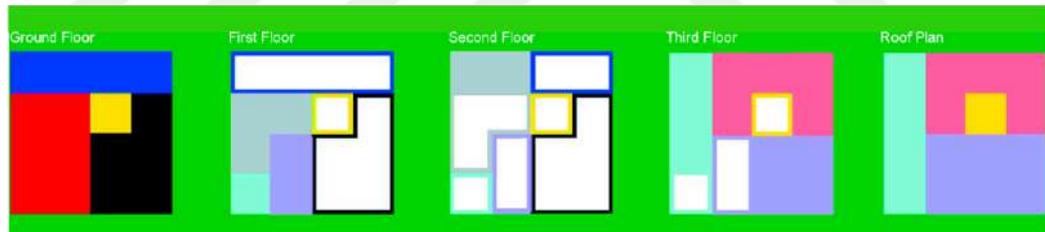


Figure 2.25: 2D plans for the 2D condition. From Spatial Understanding in Immersive Virtual Environments

The experiment's design involved an abstract architectural arrangement of eight distinct colored cuboids to facilitate more straightforward navigation and perception. In the 2D condition, participants used colored floor plans representing different levels and the top view of the cube. Participants interacted with the 3D volume on a PC monitor in the DVE condition. In contrast, in the IVE condition, participants navigated the 3D volume using VR technology. The results indicated significant differences in spatial understanding across the three conditions. Students working with 2D plans achieved the highest accuracy in reconstructing the volume. However, they exhibited

limited spatial knowledge, focusing on replicating floor plans without comprehending the three-dimensional structure. In contrast, participants using VE conditions demonstrated a better holistic understanding of the three-dimensionality of the volumes and spatial relationships despite a relatively lower success rate in accurately reconstructing the entire volume. VE users comprehended and rebuilt distinct shapes within the structure more accurately.

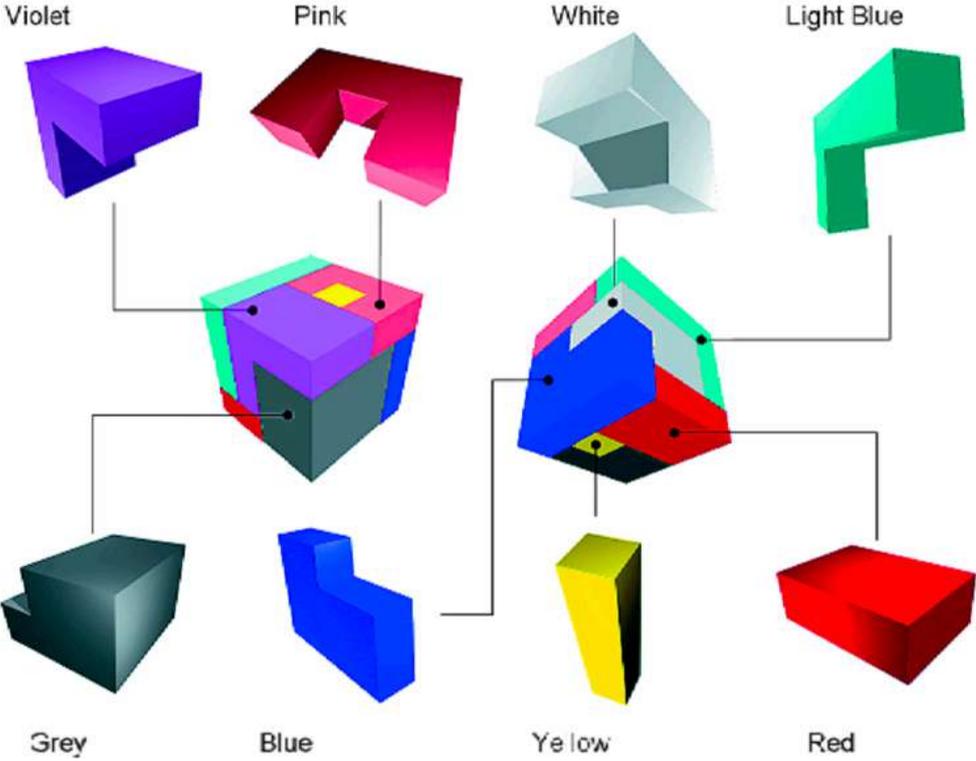


Figure 2.26: The 8 cuboids that defined the experimental volume. From Spatial Understanding in Immersive Virtual Environments

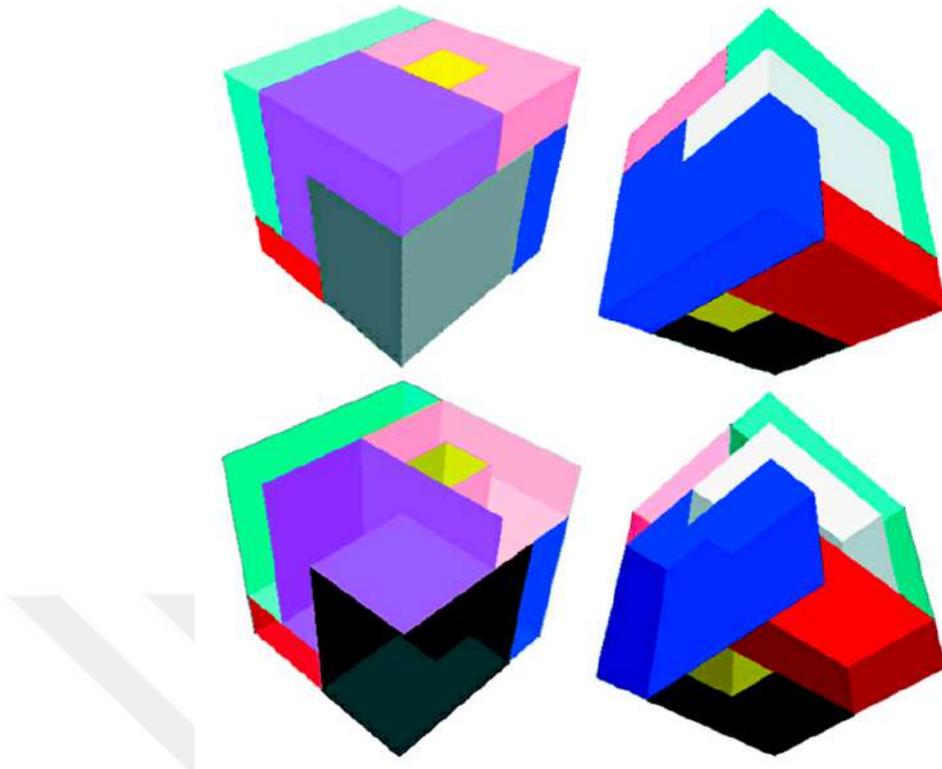


Figure 2.27: External and internal view of the volume. From Spatial Understanding in Immersive Virtual Environments

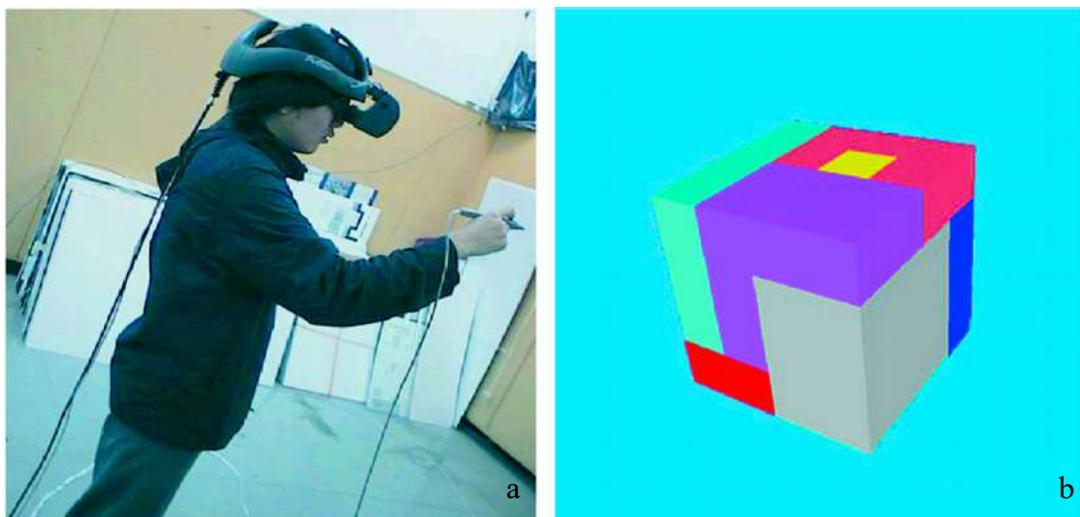


Figure 2.28: (a) Photo of an IVE-Participant using the HMD and tracking device From Spatial Understanding in Immersive Virtual Environments. (b) A depiction of the experimental volume using the 3D MAZE application. From Spatial Understanding in Immersive Virtual Environments.

The study concluded that immersive virtual environments significantly enhance the understanding of complex spatial volumes compared to traditional 2D representations. Although VE tools are currently limited, they hold substantial potential for improving the design process in architecture. As technology evolves, IVEs are expected to play a more critical role in spatial understanding, form-finding, and collaboration in architectural design. The study underscores the importance of developing better tools for translating virtual designs into physical representations.

Finally, in this example, Özkan and Yıldırım's study, conducted in 2016 with a group of 18 male students in the 4th grade who received intensive technical drawing training at Gazi University Furniture and Decoration Education Department, was examined (Ozkan & Yıldırım, 2016). These students were selected based on their ability to provide reliable results in a survey setting. The researchers gave them 60 minutes to create a two-dimensional interior layout plan using computer-aided drawing. The study aimed to assess the students' understanding of technical drawing principles and their level of proficiency in applying them. Researchers carefully designed the experimental environment to ensure accurate and sufficient data collection. Traditional drawing requires more extraordinary artistry and skill in spatial awareness, visualization and pre-planning (McLaren, 2008). Research suggests that 2D programs can speed up repetitive tasks when modifying drawings (Downey, 1992).

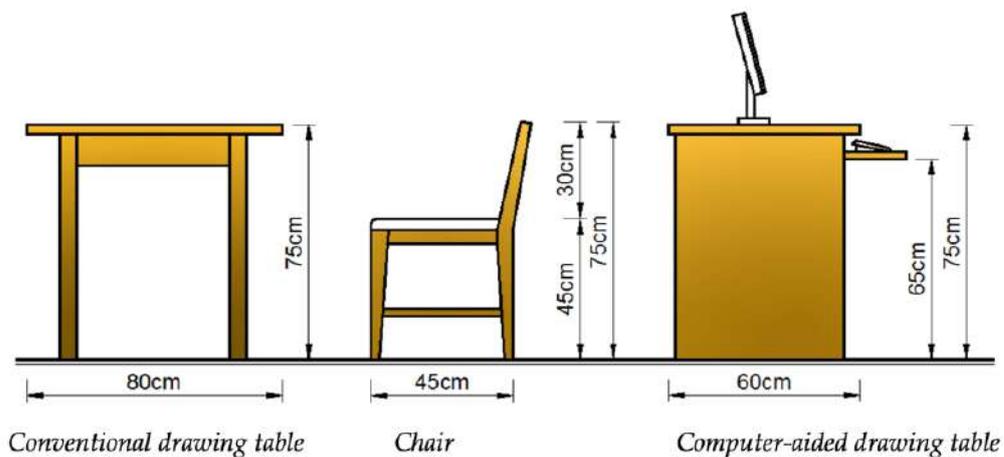


Figure 2.29: Drawing tables and chairs used in the study. From Comparison of Conventional and Computer-Aided Drafting Methods from the View of Time and Drafting Quality

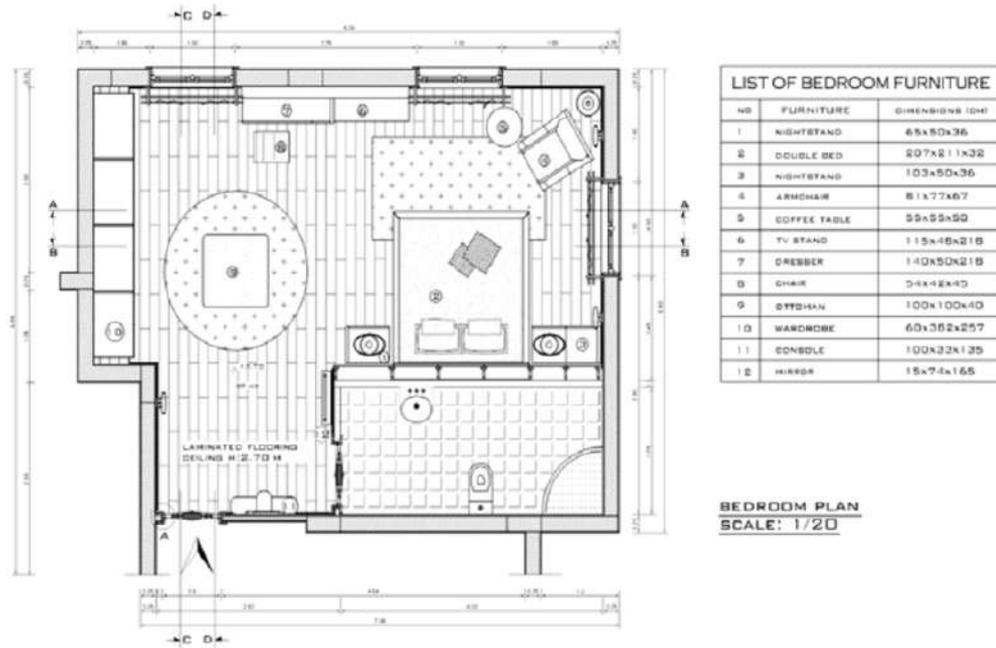


Figure 2.30: The task of the bedroom plan drawing sheet that was given to the students. From Comparison of Conventional and Computer-aided Drafting Methods from the View of Time and Drafting Quality.

However, the CAD technique may compel students to conclude their designs hastily without fully comprehending what they are depicting. Furthermore, negative consequences such as eye strain, heightened equipment demands, and added expenses may result from this technique. Numerous studies have examined the impact of both traditional and CAD techniques on the design process (Brandon & McLain-Kark, 2001). This study aimed to compare furniture and interior architecture students' levels of completion of 2D technical drawings using traditional drawing and CAD techniques. The evaluation scores of these drawings at different times were analyzed to determine when quality and speed increased.

The results showed that the CAD technique was superior to traditional drawing by average rendering time. The study concluded that CAD positively impacts drawing performance over time and that departments should prioritize training in drawing techniques to improve quality and save time. In addition, researchers revealed that the weekly course hours dedicated to drafting and CAD need to be increased. Therefore, more comprehensive course hours and contents are required (Ozkan & Yıldırım, 2016). Conceptual refinement needs various solution options, which might be challenging to navigate in digital domains but are susceptible to manual inquiry. Furthermore, proficiency in operating computer software poses a significant limitation

for inexperienced students or budding architects. Thus, the manual performance of early design processes emerges as more productive, producing more original outcomes than digital counterparts.

In summary, centuries of educational advances, technological developments, and shifts in architectural paradigms have significantly influenced the evolution of architectural drawing. Historically, drawing has been an indispensable tool for expressing architectural ideas and principles in transitioning from practical apprenticeship training to the structured curriculum of formal architecture schools. Integrating CAD software has revolutionized architectural education, equipping students with essential digital skills and transforming the design process. However, this reliance on digital tools has fueled debates about balancing traditional hand-drawing techniques with modern digital methods. As discussed in "The Death of Drawing: Architecture in the Age of Simulation," computer-generated simulations challenge conventional drawing and architectural representation notions. While simulations offer new opportunities for visualization and analysis, they also raise concerns about the loss of symbolic and metaphorical thinking in architectural design. Despite these challenges, digital tools have improved collaboration and communication between architects and clients, improving architectural practices' efficiency and precision. Contemporary architectural education emphasizes interdisciplinary collaboration, creative research, and integrating traditional and digital drawing methods. Examining the examples provided by Alvarado, Marquez, and Vildosolo, as well as Marc A. Schnabel and Thomas Kvan, it becomes evident that VR systems can significantly enhance architectural education and practice when implemented correctly. Despite the early inception of VR studies, these cases demonstrate VR technologies' enduring efficiency and potential to improve spatial understanding and design skills.

In contrast, the survey by Özkan and Yıldırım, which focuses on CAD, underscores the necessity of incorporating such technologies into educational curricula. Their findings suggest that comprehensive integration within the academic framework is essential for successfully applying CAD and similar technologies. These results ensure that students acquire proficiency in these tools and understand their practical implications and advantages in the design process.

Looking to the future, architectural education must continue adapting to technological advances while preserving the fundamental principles of drawing for creative expression and effective communication in the collaborative design process. It is

important to emphasize that maintaining the balance between tradition and innovation is both a challenge and a necessity. Thus, architectural drawing will continue to evolve in the 21st century and beyond while preserving its fundamental principles.





3. BASIC DESIGN STUDIO EXPERIENCE

This research focuses on the Basic Design Course for first-year architecture students at TOBB University of Economics and Technology. The content, scope and method of the course have been extensively elaborated. They should be placed in a larger perspective in relation to the dynamic of architecture and experiential learning. Each and every exercise, feedback mechanism, and individual and social learning ecosystem is concerned with a dynamic form. The discussion of the course topic will explain why theoretical discussions are explored in the following sections. In phenomenological research, thoroughly examining the context is essential for ensuring the study's validity. This thesis will investigate a semester, focusing on the behaviors and actions of students introduced to the concept of space for the first time in basic design courses. The content of the fall semester basic design course coded as MIM101, opened for first-year architecture students at TOBB ETU, has been defined by its instructors as follows:

Philosophy, art, design and architectural space as a means of inquiry and research. To expand the cognitive flexibility, metacognitive awareness, visual-spatial thinking and perception skills, intellectual awareness and perspectives of first-year architecture students.

This course aims to create awareness of design tools, environments and methods, research and thinking through design, concepts, terms and subjects specific to space and architecture and to ensure that this awareness turns into operational knowledge and permanent learning through design exercises to create awareness of the mutual relationship and interaction between philosophy and art and design, architecture and space; to increase awareness of personal knowledge and skills; and to provide awareness and sensitivity towards humans and they are built, cultural and social environments.

The objective of this course is to increase the awareness and knowledge of the concepts of philosophy, art, aesthetics, space and architecture. The student is taught to develop an understanding of design tools, environments, and methods. Through short design exercises, they can test, experience and transform what they have learned into knowledge. They take responsibility for teamwork according to their knowledge and skills and fulfill them. They can conduct activities to understand, change and sustain this relationship as a design and space research and the relationship between man and their built, cultural and social environment.

Considering the goals, objectives and expectations stated in the curriculum of the second term course of Basic Design coded as MIM102, which is the continuation of the Basic Design course, these courses aim to expand the cognitive flexibility, meta-cognitive awareness, visual-spatial thinking and perceptual abilities, intellectual awareness and design and architectural views of first-year architecture students. It aims to raise awareness about design tools, environments, techniques, research design, space and architecture/specific concepts, terminology, and topics and transform this awareness into practical knowledge and lifelong learning through design studies. To raise awareness about the relationship and interaction between philosophy and art, design, architecture, and space; to raise awareness about knowledge and skills; and to develop teamwork skills (MIM 101 and MIM 102 Basic Design Course Curriculum, 2021).

According to studio instructor Aktan Acar, the studio offers everyone a learning and development environment. The architecture student may also challenge the instructor's knowledge, aesthetic tendencies, and judgments (Acar et al., 2022). Students' prior learning and experiences, uniqueness, predispositions, biases, and knowledge should not be ignored. Students' prior learning and experiences are acknowledged and appreciated for strong communication and collaboration in the first year and foundation design studios. This should result in a more inclusive and engaging learning environment. Students should be encouraged to think, design, and adapt design tools in their zone of proximal development through their activities in the studio (Acar et al., 2022).

Within the scope of the MIM101 Basic Design Fall semester course, students were given various assignments to develop their understanding of architectural principles. The semester began with an interactive 'Treasure Hunt' game designed by the

instructors, in which students followed clues related to architecture, philosophy, and art and solved puzzles. Students were introduced to 3D pens and encouraged to apply the concepts learned in class through hands-on activities. A trip to the Erimtan Museum in Ankara provided the backdrop for a reflective assignment: Students were asked to present scenarios where two or more elements (material, human, structural element, light, shadow, etc.) came together to form a new entity. This exercise excluded direct visual representation.

In another assignment, students, working in groups, built the Bianchi House, designed by Studio Mario Botta, in Minecraft⁸. They matched the actual dimensions of the Bianchi House to Minecraft-specific blocks and explained the impact of proportional adjustments on the overall structure. Students were also asked to play the Manifold Garden game, draw the spaces they encountered, or produce plans, sections, and perspectives using different materials.

The expectations were that students would progress in a personal spatial puzzle using the masses recognized in the Manifold Garden game and gradually design the space.

The rules were:

1. The game's masses would form the spaces of the puzzle.
2. All elements would initially be rotated 90 degrees.
3. Design navigation tools (stairs, ramps) to facilitate movement.
4. Complete a loop route, then turn the entire structure 90 degrees again to create a new route.
5. Continue cyclically until returning to the starting point.

The evaluation criteria included:

- Connection to a "place" both horizontally and vertically.
- Consideration of light and shadow to guide the design.
- Relationship of structures to their context.

Another assignment required students to use dough and clay to create surfaces, volumes, and self-supporting spatial experiments, using improvisation as a method of thinking and production. Students were to reflect on the transition from improvisational activities to concrete design decisions regarding material, size, and

⁸ Minecraft is a game made up of blocks, creatures, and community. May 6, 2023, <https://www.minecraft.net/en-us/article/what-minecraft>

proportion, examining volume, solid-empty relationships, light and shadow, support structures, and openness.

For the final assignment, students investigated the conditions of improvised volumes to organize the following two experiences:

1. A bread oven with defined stages and conditions.
2. A public bathroom toilet.

The evaluation criteria included:

- Relationship between form and function.
- Adaptation of functionless volumes to defined functions.
- Effective use of architectural design, expression, and representation tools.

The aim was for students to examine the practical aspects of designing functional spaces from initial improvised volumes and critically analyze the interaction between form, function, and spatial organization.

The MIM102 course has begun with a long-term project that will contribute to the final assessment for the spring semester. The assignment includes the following:

Students are required to design a TIME CAPSULE, which is planned to be opened on the 200th anniversary of the Republic and will be updated with an event, festival, or ceremony every ten years (2033, 2043, 2053, 2063, 2073, 2083, 2093, 2103, and 2113).

This time capsule is not a monument, box, or package; the term 'capsule' is used conceptually. The design should facilitate transferring cultural and historical elements to future generations. The capsule will be continuously updated and maintained every ten years, ensuring a cultural exchange that encompasses the elements within it and the community activities it fosters around it. The design specifications include a minimum volume of 27 cubic meters. The floor area and height must be determined to meet this volume requirement. Importantly, the capsule is conceptualized as an architectural space that interacts with its surroundings physically and visually. Careful design considerations should be made for each decade's interior, exterior, roof, eaves, surrounding hardscape, and green spaces. The aim is for the space and its surroundings to develop their living culture and create excitement for future generations.

Key design considerations include materials used, structural integrity, durability over a century, and climate and environmental conditions. The designated project area is a

semi-open park in Çankaya, Ankara. Integrating hardscape and green space in a balanced manner is very important within the region. Given its location on the main traffic axis, the design should consider how passing traffic will perceive it and its physical and visual relationship with the adjacent neighborhood, university buildings, and the Bus Terminal.

The project should be portable. The project area was presented to the students as a drawing file. Slope data showed 895.62 elevations in the southwest corner, 892.22 in the northeast end, and 891.49 near the AŞTİ bridge. These values can be used to derive the slope of the terrain.

Each group must create a terrain model reflecting elevations, local structures, border roads, and the ANKARAY line. The students were provided with all relevant mathematical data about the area. Surveys were then administered to assess student productivity through forms addressing group work dynamics, project specifics, and personal reflections.

For the final assignment, students were introduced to a new world-order scenario:

35th Century

Humanity is facing the consequences of unprecedented destruction on Earth.

Your mission: To build a new living space by integrating the remains of humanity's architectural heritage.

- Assignment Summary

Many historical structures considered architectural milestones, symbols, and examples of heritage have been destroyed. You are tasked with utilizing this heritage in various forms and scales to create a new living environment.

- Choosing Structures

Explain the logic behind your choice of structures and which components, features, and attributes are used in each structure. The hypothetical New World will accommodate your envisioned conceptual and architectural design elements.

- Initiating the Project

Begin by choosing a basic starting point and determining the location and structure that will serve as the foundation or root for the New World.

- Possible Elements of Interest

From the selected structures, you may include the following:

Space, Program, Building Element, Structural System, Material, Organizational Concept, Circulation, Light, Harmony with Nature, Technology

You are encouraged to use various narrative and expressive techniques using drawings and visual representations of these structures.

- Key Considerations

Topics covered over the past two semesters, such as void, volume, space, circulation, form, structure, material, scale, context, daylight, habitability, program, and experience, should inform and reflect your New World project.

We anticipate that you will explain the reasons behind your choice of structure and how you integrated these into your design using architectural language. Sharing your views and evaluations of structures considered humanity's architectural heritage is important. The project is given on the morning of the first day, and the participants work for three days. Then, the process continued with a different evaluation method. On the first, second and third days, the evaluators ask the students questions to evaluate what process they follow, and their skills, potential and competence in transforming the idea into architectural design. They did not give criticism during this time because they tried to understand how they worked on their own and with their initiative in 3 days.

As stated in the methodology section of the thesis, the phenomenological research method was used. The phenomenological research of the thesis focused on students who took the basic design studio repetition. In the basic design repetition course given in the summer term, an attempt was made to design a learning environment in line with the student's personal experiences, knowledge and orientations as much as possible, considering their differences and previous learning. In the fall and spring terms, they could not establish communication that would support their gains with the content and method of the course. The practices of the previous semester were too recent. They might have an inhibition impact.

Moreover, the previous design tasks and methods might have prevented a fruitful communication and learning experience for those retaking the course. This shows that a productive environment could not be created for them. For this reason, a different method was followed in the summer term course than in other courses. The main reason was not to leave them alone with the same concerns and to create an

environment where they could feel more productive. For this reason, we aimed to provide an opportunity for the process of discovering the space by creating a relatively 'free' environment where they could use VR, artificial intelligence, modeling, drawing and all these together. Thus, instead of implementing the same exercises, a more dynamic learning environment was structured to encourage individual contribution in a collaborative social context. This studio does not aim to create a studio environment where students will use only new technologies but to support them in gaining a new perspective in researching the continuation and representation of the idea in the transition between media and environments, where they will use all methods in cooperation.

Throughout the semester, OneNote⁹ and Microsoft Teams¹⁰ played vital in facilitating communication and documentation for the nine students enrolled in the TOBB ETU summer term Basic Design Studio course. OneNote was a versatile digital notebook where students could record their comments, reflections, notes, and observations after each lesson. The platform allowed students to organize their thoughts in various formats, including typed text, hand-drawn sketches, photos, and audio recordings. The collaborative nature of OneNote encouraged continuous and dynamic learning by allowing students to share their insights and feedback with their peers and instructors. Microsoft Teams, on the other hand, served as a central hub for real-time communication and group activities. It was used for announcements, planning, and virtual meetings, encouraging seamless interaction among students and between students and instructors. Students engaged in discussions, participated in group projects, and played educational games through Teams, contributing to their overall understanding and integration of course materials. Combining OneNote for documentation and Microsoft Teams for interactive collaboration created an environment that encouraged active learning and increased student engagement.

⁹ OneNote is a digital note-taking app that provides a single place for keeping all of your notes, research, plans, and information — everything you need to remember and manage in your life at home, at work, or at school. <https://support.microsoft.com/en-us/office/introducing-onenote-38be036d-5b5a-49ad-83be-292fe53ad7b3>

¹⁰ Microsoft Teams is the ultimate messaging app for your organization—a workspace for real-time collaboration and communication, meetings, file and app sharing, and even the occasional emoji. <https://support.microsoft.com/en-us/topic/what-is-microsoft-teams-3de4d369-0167-8def-b93b-0eb5286d7a29>

The first week aimed to understand why the students could not communicate with the tools taught in the previous term's course. Each of these students had individual differences and had different reasons for taking the course again. For this reason, the first lessons started by discussing how the spring term basic design course went with the students. Game environments were created to relieve the students' tension, and they were expected to work as a group. During this process, they were expected to participate in the game as observers and players. The students stated that they noticed the mistakes they did not see while they were players when they were observers and watched from outside.

After this phase, since the students were expected to look from perspectives they had not looked at before, different activities were carried out; a trip to an art museum was organized, they were expected to comment on the works they saw, and they read various books and discussed them. The aim was to create an environment where more introverted students could discuss their ideas. A free environment was organized, and everyone was allowed to express themselves the way they wanted. The students who spent the first two weeks this way had a slightly different perspective on the course. According to their writings on their OneNote pages, they clearly stated the mistakes they made in the previous term, what they did not understand or what they could not communicate with.

Starting in the third week of this assignment, students were asked to design a shelter accommodating at least three people. However, unlike other terms and courses, no drawing, model or visual requirement was given. Instead, they were asked to focus on finding where they could best express themselves. They were asked to experiment with space by experiencing new tools because the aim here is not only to introduce new technologies to students but also to open a space for them to discover the space and the representation of space and design in this way, according to the interests and knowledge of each technology and the student.

In this context, students were first introduced to Skybox AI. This program is not just prompt-to-text like other AI programs but also draws to text. The purpose of using this AI program is to question the relationship between words and their visuality.

The students participating in the first two weeks had a slightly different perspective on the course. Their OneNote pages, filled with their feedback, were a testament to their integral role in the learning process. They clearly stated their mistakes in the previous term, what they did not understand, and what they could not communicate.

Students were introduced to different applications within this scope, which will be examined in detail in the thesis's 'Basic Design Studio Experience' section. The aim of this teaching is not only to be innovative but also to bring students together with design and space in as many different tools and environments as possible. Although architecture is a phenomenon experienced 1/1, its representation and production through representation tools constitute the essence of education. There is a difference between knowing something from one's reality and knowing it through representation tools. This course aims to enrich the environment in which representation tools create space, that is, architecture, and to ensure that students encounter as many tools as possible.

As the first application, students were introduced to Skybox Ai. This is because this program is prompted to text like other AI programs and draws to text. The purpose of using this AI program is not only to question the relationship between words but also its visuality. This course offers an opportunity to discuss the relationship between how space is represented and its possible visual counterparts. They used the Skybox Ai program to investigate the relationship between the visual and representation in their minds. These tools are still not a design method but a starting point for discussing possible visual counterparts. Therefore, the next week, the target was not to produce a visual of this AI production. Instead, they were asked to try it on the VR program Open Brush upon this investigation. That week, Oculus 2¹¹ VR glasses set, and Open Brush were taught, and the students who adapted very quickly were asked to produce something different from what they produced with AI and to discuss whether they could produce its spatial qualities. In the following weeks, they investigated different spatial qualities with different tools such as models, drawings, collages, 3D models,

¹¹ Meta Quest 2: From multiplayer games to unique social experiences to joining up with friends at a live show or instructor-led workout, Meta Quest 2 provides new opportunities to meet and connect with others in VR. <https://www.meta.com/help/quest/articles/getting-started/getting-started-with-quest-2/what-is-meta-quest-2/#>

etc. and produced different productions each time. The main purpose here can be summarized as follows: Architecture is dynamic. However, we always discuss this with 2D tools that we can call static. What is tried in the VR tools focused on in this thesis is whether those dynamic features can be revealed. Dynamic features are the involvement of one's body in the work, in other words, the experience of producing and being in it. Here, we can return to the question at the beginning of the thesis: Is the dynamic four-dimensional nature of architecture better explored with the tools we use to produce it and with the participation of the body? Or can it be experienced? Or are two-dimensional representation tools sufficient in this regard? To answer these questions, we conducted phenomenological research within the scope of the thesis and the entire process was observed. Each student and their movement were followed from inside and outside; this process was documented with the questions and their feedback, and discussions on this will be made in the continuation of the thesis.

3.1 Research Through Basic Design Studio

The research context is environments that combine traditional methods and technological tools in studio-based courses, where physical cognition and learning by doing are effective. These courses form the basis of design education.

The study's focus is on investigating whether integrating virtual reality into architectural education can improve students' capacity to understand, represent and explore complex spatial environments compared to traditional orthographic projection. It also examines the strengths and weaknesses of both methods and proposes a more effective educational approach that combines the best aspects of traditional and modern techniques.

- TOBB ETU architecture undergraduate students who retook the first-year basic design course during the summer term were observed in their work environments throughout the term.

- The participants included nine undergraduate students (20-24 years old, eight female and one male).

- Task: Students were tasked with designing a simple shelter and exploring different tools. VR was one of these tools. In this study, based on before and after experimenting with VR with Open Brush, they sought various materials to transform their designs into physical models and drawings and capture the spatial properties of their VR

creations. The students compared their thoughts before working with VR with their thoughts after working with VR. They wrote reviews that reflected their experiences and provided insights into their transition from VR-based design to traditional architectural practices. In doing so, they produced different spaces from the first idea to the final idea using different tools.

- Data Collection and Analysis: Data sources include observations of daily studio activities, participant interviews, researcher reflections on studio visits, and course artifacts such as syllabus and assignment notes.

- Findings/Results: All students were examined regarding the designs they created and their evaluations; the process was discussed in the thesis and analyzed in the conclusion section.

This study argues that traditional orthographic projection methods, which have been systematically used since the 18th century, require a comprehensive investigation of spatial dynamics. It advocates for change by integrating a design tool that promotes embodied cognition into students' learning processes. Finally, the thesis compares the limitations of these traditional methods with the capabilities of innovative tools that include VR technologies. The study analyzes the impact of VR as a design tool on the learning environment. This approach is consistent with the principles of bodily cognition and suggests that cognitive processes are significantly affected by the body's interactions with the world. The findings are expected to provide valuable insights into how VR can be integrated into the curriculum to enhance the educational experience, improve spatial understanding, and better prepare students for professional architectural practice. Quantitative research involves the systematic empirical investigation of observable events through statistical, mathematical, or computational techniques (Hinkel, 2005). They generally use tools such as surveys and instruments to collect numerical data. Quantitative research begins with a clear and testable hypothesis. Based on the data collected, it aims to support or refute hypotheses. Controlled studies are conducted in which variables are manipulated to observe their effects on other variables (Babbie, 2020). Quantitative research methods are necessary to produce reliable and objective data that can be generalized to larger populations (Bryman, 2016). In this research, data was collected through 2 applications used in VR glasses. By observing these tools during the application, personal reports were taken, and an evaluation was written based on similarities and differences. The research area

should allow clear observation because the researcher needs to take notes regularly or use the information obtained quickly.

Moreover, field notes and observations must be put in writing (Myers, 1999). Finally, the collected data is evaluated. Does the information obtained in the research contribute to the research subject? It is very important to assess the data collection process. Were the data collected in high quality? Is there sufficient information about the research method? An evaluation should be made within these and similar questions (Sangasubana, 2011). The quantitative tools used in the study are described below. In conclusion, regardless of the outcome, this study aims to contribute to ongoing debates on the future of architectural education by advocating the adoption of innovative methods compatible with contemporary cognitive science and educational psychology understandings.

3.2 Tools Used in The Studio

The first part of the thesis conveys the basic design course. In this context, more than one tool is used in the course. In fact, all the tools cooperate with each other, and there is no preference here. By using them all together, students are supported to gain a perspective on researching the continuation of the design idea, especially in the transition between media and environments.

The first tool used is the Skybox AI program. Skybox AI is a cutting-edge program that uses artificial intelligence to generate detailed and realistic 3D environments and landscapes (Skybox AI, 2024). Developed by Blockade Labs¹², this tool leverages advanced algorithms to create immersive virtual worlds primarily used in gaming, virtual reality, and architectural visualization. Skybox AI allows users to generate skyboxes—360-degree panoramic images that simulate the sky, horizon, and surrounding environment—through simple text prompts. This innovative approach significantly reduces the time and effort required to produce high-quality 3D assets, making it a valuable tool for professional designers and hobbyists.

¹² Blockade Labs is a tech company offering an AI-powered solution for generating 360° skybox experiences.



Figure 3.1: Images generated with Skybox AI. Accessed August 20, 2024. Retrieved from <https://mixed-news.com/en/meta-quest-2-create-your-own-skyboxes-with-ai-guide/>

Skybox AI works with two key features:

1- Text to prompt: This feature allows users to create 3D worlds, environments, and skyboxes by simply entering descriptive text. For example, a user can type “sunset on a tropical beach with palm trees and gentle waves,” Skybox AI will generate a corresponding 3D environment that captures those elements. This is especially useful for rapid prototyping, allowing creators to visualize and iterate on ideas without complex coding or design expertise.

2- Image to prompt: This feature allows users to enter an image, and Skybox AI analyzes the visual content to create 3D elements or environments that match the image’s characteristics. For example, uploading an image of a dense forest can result in a 3D forest environment with similar lighting, color schemes, and spatial arrangements. This tool is ideal for projects where a specific visual style or theme needs to be maintained across different 3D elements.

These tools in Skybox AI enable content creators of all skill levels to produce high-quality 3D content efficiently, increasing flexibility and creativity in digital design projects.

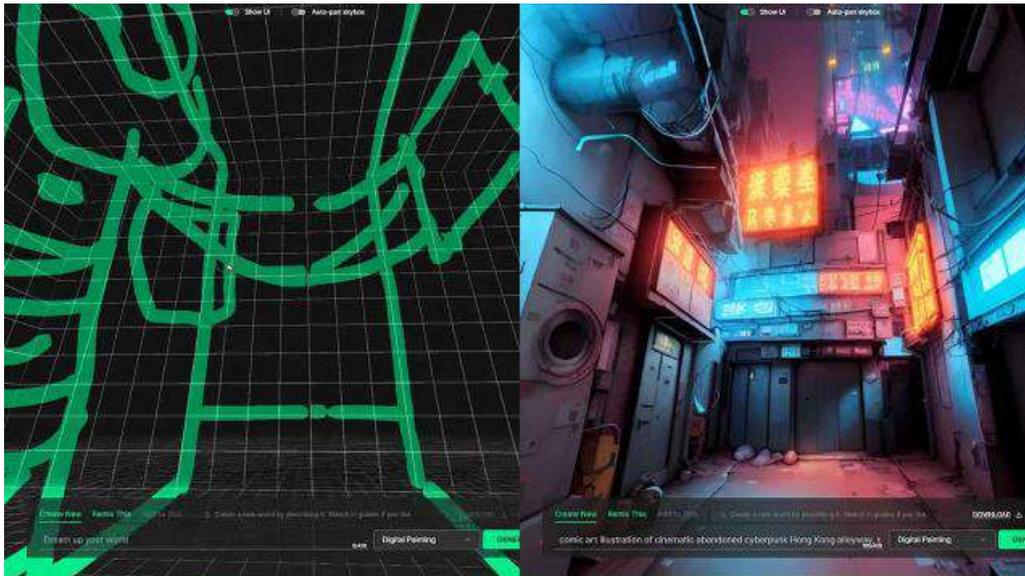


Figure 3.2: A visual obtained by drawing outlines in Skybox AI. Retrieved from (Blockade Labs Introduces Sketch-to-Skybox AI Tool, 2023).

The main reason for choosing Skybox for this course is its “Sketch Mode” feature, designed to enhance the creative process by allowing users to create environments based on drawn lines and text prompts. This innovative mode provides a set of tools and guides that give users more control over the creation of their skyboxes, enabling the production of 360-degree scenes with simple sketches. With this addition, Skybox AI continues to expand its capabilities by making it easier for creators to bring their visions to life in immersive 3D environments.

VR applications were also used within the course to evaluate their effectiveness in architectural education and spatial understanding. VR applications to assess their efficacy in architectural education and spatial comprehension. Arkio was presented to students as a VR application on architecture at the end of the study. Arkio is a cutting-edge VR tool that facilitates collaborative design and idea-sharing among architects, designers, and video game-level designers (Arkio , 2022). It provides a platform for rapidly sketching and reviewing architectural designs within an immersive VR environment, enabling real-time discussion and evaluation of various design options by multiple participants. Arkio is notable for its ability to support up to 24 users concurrently working on the same scene using multiple devices such as VR headsets, computers, tablets, and smartphones, thus fostering a highly collaborative and co-design-oriented environment (see Figure 3.3).



Figure 3.3: Pass through modelling in Arkio. From <https://www.roadtovr.com/arkio-vr-architecture-collaboration/>

This feature is particularly beneficial in architectural education, where collaborative learning and peer feedback are integral to the design process. The platform offers versatile functionality, allowing users to design interiors, buildings, sandboxes, and gaming environments. Moreover, it incorporates Passthrough technology on Quest devices, enabling users to merge virtual and physical realities and enhancing the realism and practicality of architectural simulations. Additionally, Arkio integrates experimental hand tracking, allowing users to interact with the VR environment using their hands instead of traditional controllers. This enhances the naturalness and intuitiveness of the design process, resembling the physical act of model-making and object manipulation (see Figure 3.4). A distinguishing feature of Arkio is its focus on collaboration and accessibility. The program is designed to facilitate inclusive and flexible design sessions where multiple users can contribute to and build upon each other's ideas. This collaborative aspect is crucial for fostering a dynamic learning environment in architectural education, where diverse perspectives and iterative feedback play a pivotal role in the design process. Furthermore, Arkio offers a unique capability that allows users to work at any scale, providing the exceptional ability to 'immerse' themselves in their models at a human scale. This feature enhances users' understanding of spatial relationships and dimensions, bridging the gap between abstract representation and tangible experience and enhancing spatial comprehension and design proficiency.

To sum up, Arkio emerges as a powerful tool in architectural education due to its strong support for collaborative work, innovative interaction mechanisms, and ability to provide a realistic and immersive design experience. The application's capabilities align with this study's goals, which seek to investigate how VR can enhance the representation, comprehension, and exploration of architectural space compared to traditional orthographic projection methods.



Figure 3.4: Pass through modelling in Arkio. From <https://www.roadtovr.com/arkio-vr-architecture-collaboration/>



Figure 3.5: People draw in the Arkio program. From Authors' archive.

The course used Open Brush; an open-source VR application designed to democratize art creation in a virtual environment. According to the developers, Open Brush is founded on art preservation and artistic freedom, aiming to provide accessible tools for everyone to create their art. This application is a free derivative of Tilt Brush, initially developed by Skillman & Hackett and later acquired by Google (About Open Brush, 2021). Open Brush is an expansive 3D canvas that offers various versatile tools, empowering users to unleash their creativity within an unlimited virtual space (see Figure 3.6). The application allows users to craft and manage surface volumes using intuitive VR controllers. This capability enables artists and designers to manipulate their creations in a manner that mimics physical interaction, enhancing the intuitive and immersive nature of the creative process.

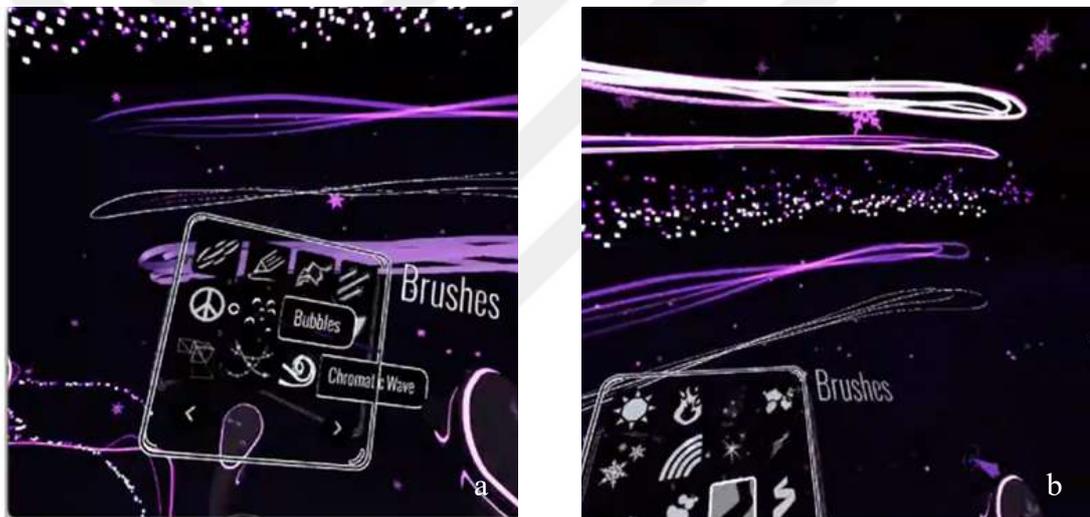


Figure 3.6: (a) (b) Screenshots from Open Brush Control Center. From Open Brush Tutorial <https://openbrush.app>

Open Brush, a standout feature of this study, is a tool for individual creativity and a catalyst for collaboration. It brings diverse individuals together in shared virtual rooms, enabling real-time collaboration and the exchange of creative ideas. This collaborative environment is particularly beneficial in architectural education, where teamwork and peer feedback are integral to learning. The selection of Arkio and Open Brush for this study was driven by their capacity to provide a realistic and immediate design environment that deeply engages both the body and the intellect. These tools are instrumental in facilitating a comprehensive exploration of production and

representation processes within immersive 3D domains. By engaging the entire body in the design process, these applications align with the principles of embodied cognition, which emphasize the interconnectedness of the mind and body in cognitive activities.



Figure 3.7: Using Open Brush. From https://gigazine.net/gsc_news/en/20210127-google-tilt-brush-open-source/

Open Brush supports the study's objectives by enabling users to experience and manipulate their artistic creations in a spatial context. Thus, it bridges the gap between traditional 2D representations and fully immersive 3D environments. This transition from conventional methods to VR applications allows a more holistic understanding of spatial relationships and design dynamics. This spatial freedom encourages creativity and is intended to help users develop a stronger sense of spatial awareness, which is essential for fields such as architecture, game design, and virtual storytelling. As an open-source platform, Open Brush invites a community-driven approach to innovation. Creators from various backgrounds contribute to continuous improvement, resulting in a rich feature set tailored to various spatial applications.

Open Brush enables professionals to prototype ideas, experiment with forms and structures, and communicate complex spatial relationships more effectively. This speeds up the design process and increases the precision of final outputs.

Educators and researchers have used Open Brush as a powerful tool to teach spatial concepts and art engagingly and interactively. By providing students with hands-on experience with 3D creation, they can better grasp abstract concepts, explore geometric principles, and develop fundamental technical skills. The tool's versatility

allows for including dynamic elements, lighting, and textures, producing artwork that is not only seen but experienced. This feature has even given birth to a new immersive digital art genre that showcases VR's profound impact on artistic expression.

These applications not only support the principles of embodied cognition but also provide a dynamic environment to explore the complexities of the architectural field. Integrating these VR tools into the educational framework is expected to provide valuable insights into the effectiveness of immersive technologies in developing spatial understanding and design skills among architecture students. Its intuitive interface and versatile tools allow students to work with various design techniques and approaches in a virtual space. This hands-on interaction is expected to develop spatial awareness and design skills that are very important for architects and designers. Students were allowed to produce drawings, models, 3D programs, collages, illustrations, etc., in every environment where they could produce both AI and VR. In addition, since the thesis included research on virtual reality and embodied cognition, it focused its phenomenological research on this area.

The reason why artificial intelligence and virtual tools such as Skybox AI, Arkio and Open Brush are taught and implemented within the scope of the Basic Design course is not only to aim for an innovative approach. It is to be able to discuss design and space in as many different tools and environments as possible. Architecture is a discipline experienced 1/1 but works at scale in its representation and design. Therefore, experiencing the concept of embodied cognition mentioned at the beginning of the thesis with these tools will help students find the method that suits them and will help compare before and after embodied cognition applications.

3.3 Basic Design Studio Process

The research is based on embodied cognition, which suggests that our thinking is strongly influenced by how our bodies interact with the world around us. In traditional architectural education, methods like orthographic projection may only partially capture the spatial experience. This thesis suggests that VR tools could enhance embodied cognition, providing a more comprehensive educational experience. Within the scope of this thesis, the students' process was followed, notes were taken, research was done, and phenomenological research was carried out during the summer term of the TOBB ETU basic design course.

As stated in the Basic Design title of the thesis, the shelter project given to the students at the beginning of the semester was not only produced with a specific tool, but they were expected to redesign it with a different tool almost every week. Students had the opportunity to produce with AI, VR, drawings, models, 3D programs, collages, illustrations, etc. When homework was given at the beginning of the semester, they preferred to try it first in the Skybox AI program. However, some did this by writing prompts and some by preparing visuals.

The goal is to familiarize students with new technologies and create an environment where each technology, along with the student's interests and knowledge, can be explored in terms of space, representation, and design. The aim is not only to introduce students to new technologies but also to provide a space for each technology, their interests, and their knowledge to explore space, its representation, and design. Students who were introduced to different tools and made designs throughout the semester also used AI and VR applications, which are systems that include embodied cognition. The aim of these applications was not only to learn them, but the Skybox AI program, unlike other AI programs, is a program that can produce from drawing to visuals. Students worked on AI not only by preparing prompts in the form of text but also by preparing drawings. They questioned the relationship between words and simple drawings and their visuality. This course discusses the relationship between the way we describe space and its possible visual counterparts. After producing in the AI program, they were surprised when they were expected to produce a space again in VR with Open Brush. However, when they encountered a very different environment in Open Brush than the AI program, they started to explore that space and produce different spaces with new tools instead of making the same production as the previous one. In the ongoing process, they worked on the same space again with drawings and models, and the space they produced changed.

In this thesis, phenomenological research was conducted by examining the students' production processes rather than by comparing them.

3.4 Observations

When conducting qualitative research, observations and subjective opinions are as important as the results (McMillan & Schumacher , 2009). Therefore, the students' general conditions, perspectives and behaviors during the lesson were also examined

and recorded as necessary. Nine undergraduate students participated in this course during the summer repetition of the Basic Design undergraduate course, and the course progress was recorded.

It is an important issue in this study that the students took the basic design course again in the summer term because the course content was completely prepared for them, and they wanted to produce the same space with different tools. In addition, the students' age group varies between 18 and 23. This means they were all born in the digital age and used digital tools well. This may have affected their use of 3D modeling programs and their mastery of AI and VR programs.

After the conversations and discussions about the term project shelter design, they discovered design inputs, context, and the potential changes that context could bring to the design. After these discussions, everyone resorted to different ways to express their ideas.

- Student L1

L1 began the process, which he re-took from his basic design class, by prompting a text: a small dark room with a closed door, a bed, a table, a chair, and a single small window. Initially, he tried to outline the boundaries of the space using AI and incorporated furniture into these boundaries through AI's design with drawing.

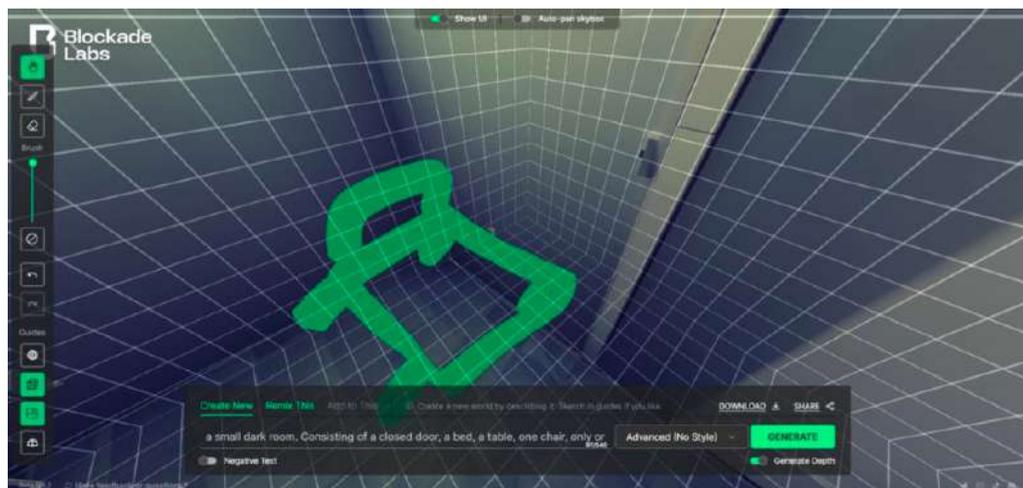


Figure 3.8: L1's attempts with Skybox AI. From L1's OneNote page.

Subsequently, L1 aimed to generate visual representations solely through textual prompts, employing varying inputs. For instance, he described a post-apocalyptic desert shelter for 2-3 people beside a rock (Figure 3.9). Progressing, the prompts were

refined: "An emergency shelter for 2-3 people in the desert should have sun protection, wind protection, insulation, and ventilation to cope with the harsh conditions. It should also provide a means to store drinking water and be made of durable materials to withstand high temperatures and sandstorms. Additionally, the shelter should be portable and easy to set up for quick emergency deployment. Overall, it should prioritize the safety and well-being of the occupants while providing adequate protection from the desert environment" (Figure 3.10).



Figure 3.9: L1's attempts with AI. From L1's OneNote page.



Figure 3.10: L1's attempts with AI. From L1's OneNote page.

Recognizing a need for material specificity, L1 prepared a more detailed prompt: "In a post-apocalyptic setting, imagine a desert emergency shelter for 2-3 people made from mud bricks. Constructed using weathered metal and concrete, it provides shade from the sun, withstands high winds and sandstorms, offers insulation and ventilation,

and includes water storage. This vital refuge ensures survival in the harsh desert wasteland" (Figure 3.11).



Figure 3.11: L1's attempts with AI. From L1's OneNote page.

Advancing to the next phase, L1 sought to redefine her creations by incorporating plan sections (Figure 3.12). Utilizing a 3D pen acquired in previous sessions, L1 replicated the initial space. Upon modeling the space in SketchUp, she consistently recreated the same forms, revising her approach only on her third attempt to explore new geometric configurations.

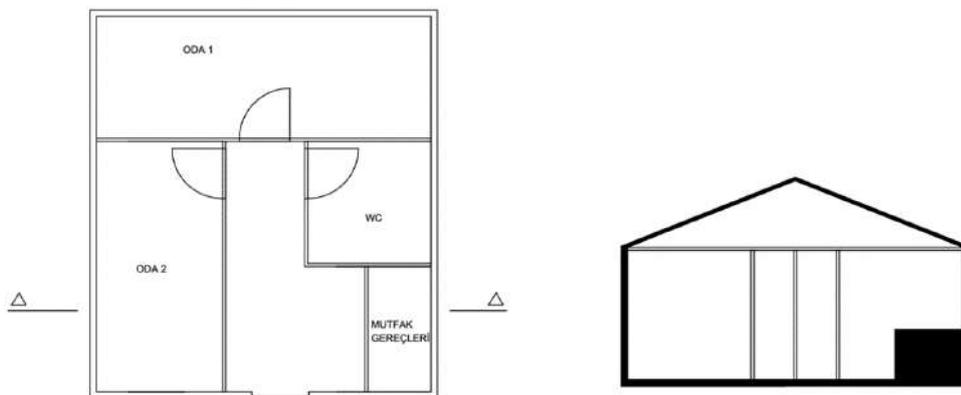


Figure 3.12: L1's plan/section studies. From student L1's OneNote page.

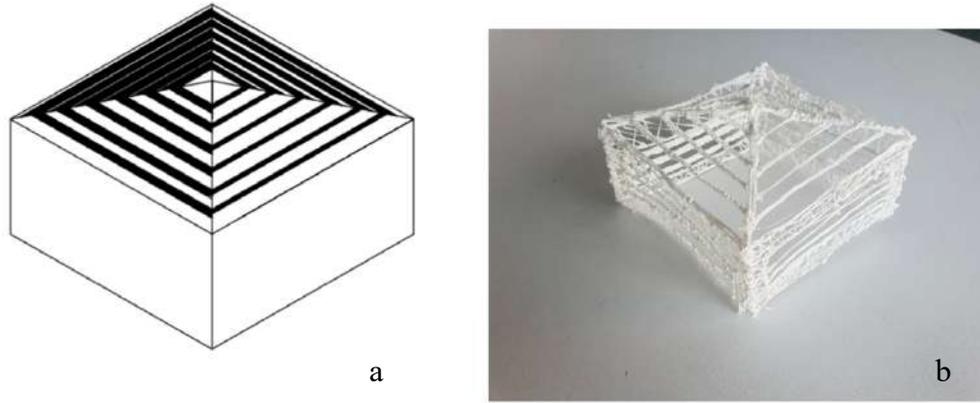


Figure 3.13: (a) L1's model studies with Sketchup. From student L1's OneNote page.
(b) L1's model studies with 3D Pen. From student L1's OneNote page.

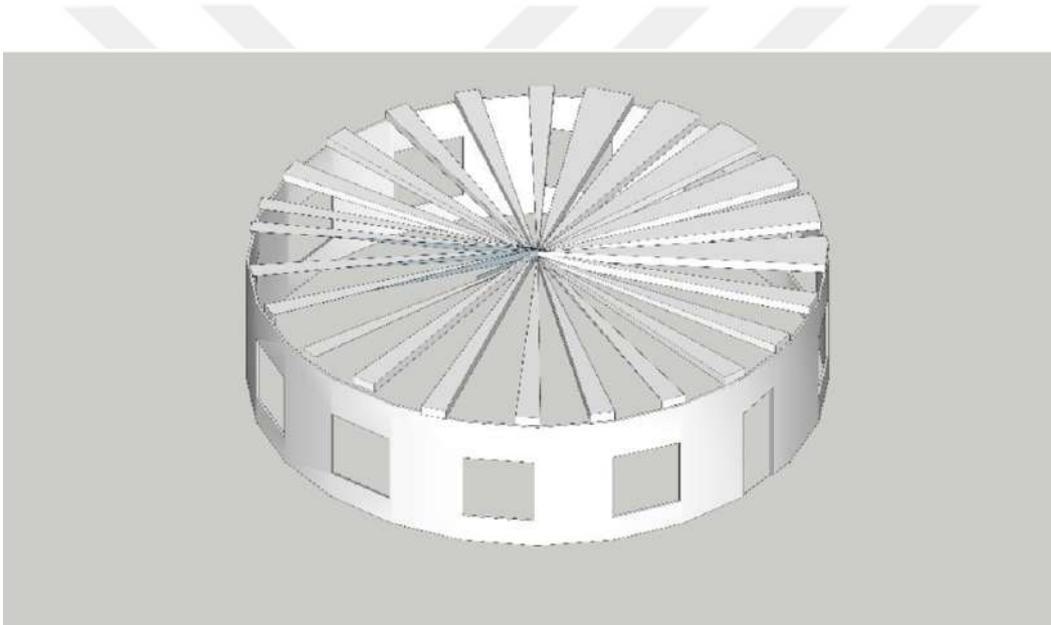


Figure 3.14: L1's model studies with Sketchup. From student L1's OneNote page.

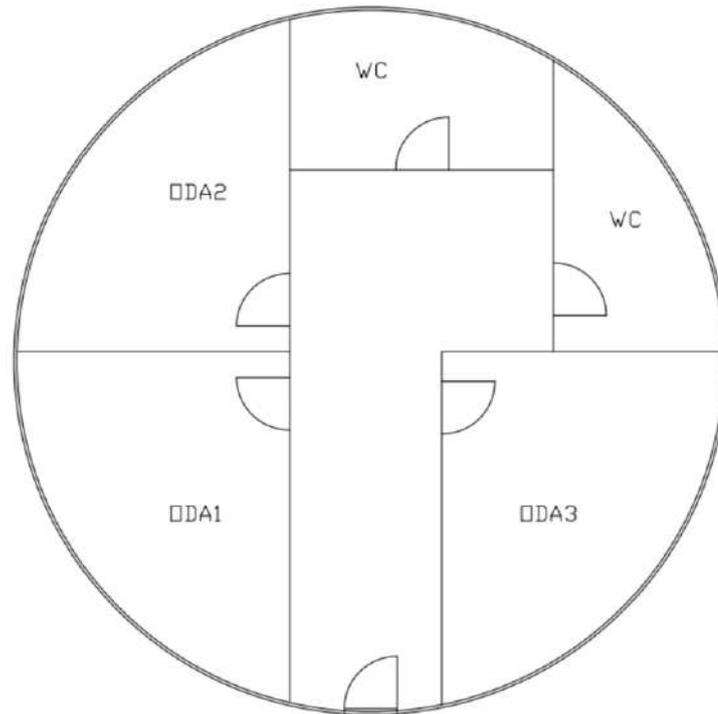


Figure 3.15: L1's plan studies with Sketchup. From student L1's OneNote page.

In subsequent weeks, L1 engaged with the VR environment and Open Brush. Familiarizing herself with diverse brush tools in Open Brush, L1 opted to reconstruct her space from the ground up, altering its form. She commented on the transformative impact of the zero-gravity environment in Open Brush, expressing a desire to adapt her designs accordingly. Reflecting on her VR experience, L1 noted, "Designing at a 1:1 scale allowed us to traverse the virtual ground without a physical surface. However, as we zoomed in and out, the floor's location within the building shifted, affecting our perception of the ground. This prompted modifications, including adding a distinct floor surface to accommodate structural size and elevation changes." When questioned about his experience with Open Brush, L1 displayed a strong inclination to innovate, stating, "In my design, I aimed to achieve a more organic form, departing from conventional vertical lines and angular shapes." She further articulated the aspiration to create a structure adaptable to the unique zero-gravity conditions of the VR environment.



Figure 3.16: (a) Structure of model. From student L1's OneNote page. (b) Materials of model. From student L1's OneNote page. (c) L1's model studies. From student L1's OneNote page.

After generating the model with new materials, L1 oscillated between the VR environment and orthographic drawing methods. In the final stage, it was observed that he revised his model once more, incorporating new materials.

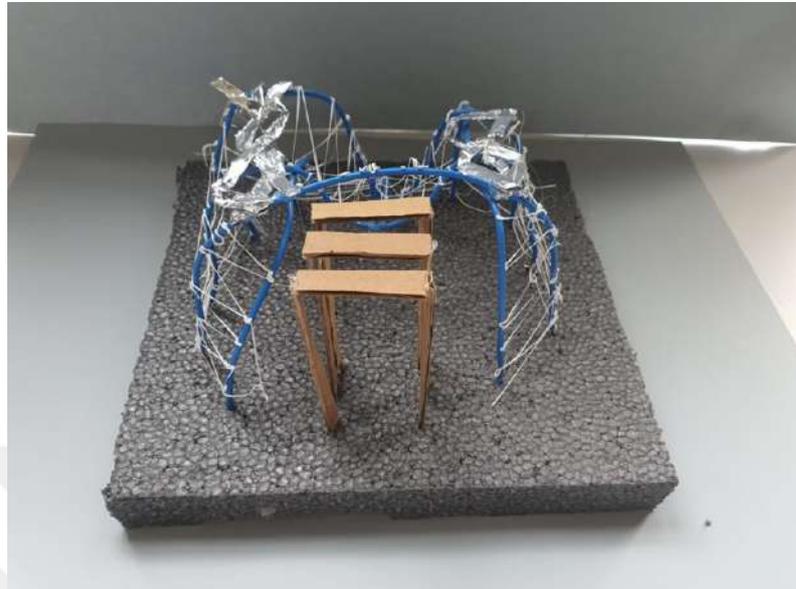


Figure 3.17: L1's final model studies with different materials. From student L1's OneNote page.

- Student L2

L2 began the process by utilizing the text-to-prompt feature to make initial AI-generated visualizations with the prompt: "A shelter for two in a desert climate that is hot during the day and cold at night. Post-apocalyptic style" (Figure 3.18). Following this, L2 decided to explore various climatic conditions and produced different visualizations based on distinct prompts:

- Shelter in a place with sandstorms (Figure 3.19).
- Shelter in a climate with a significant daily temperature difference (Figure 3.20).
- A shelter for two in the desert, featuring a two-person dining area in a post-apocalyptic style (Figure 3.21).

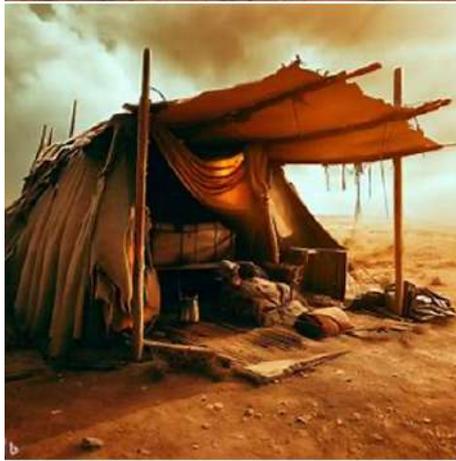


Figure 3.18: A shelter for two in a desert Climate that is hot during the day and cold at night. From student L2's OneNote page.



Figure 3.19: Shelter in a place with sandstorms. From student L2's OneNote page.



Figure 3.20: Shelter in a climate with a significant daily temperature difference. From student L2's OneNote page.



Figure 3.21: A shelter for two in the desert, featuring a two-person dining area in a post- apocalyptic style. From student L2's OneNote page.

Upon completing the AI-driven studies, L2 transitioned to direct drawing methods, as seen in Figure 3.22, and delineated areas according to their spatial features.



Figure 3.22: L2's plan studies. From student L2's OneNote page.

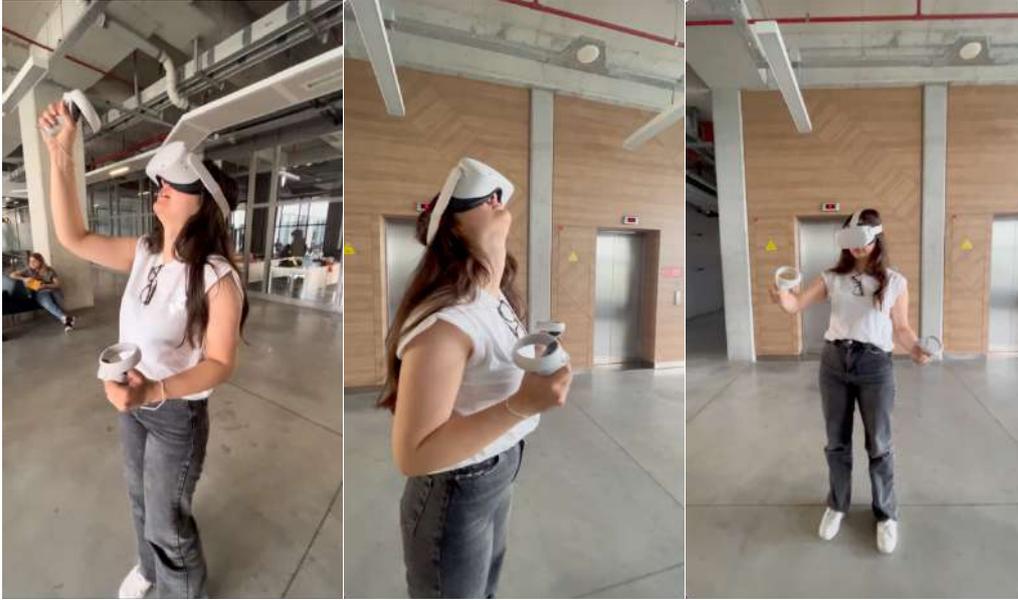


Figure 3.23: Student's work with VR glasses. From the author's archive.

Upon completing the AI-driven studies, L2 transitioned to direct drawing methods, as seen in Figure 3.22, and delineated areas according to their spatial features.

Subsequently, L2 was introduced to VR technology and provided reflections on the experience. L2 stated, "When we utilize bubble or snowflake-shaped brushes in a conventional two-dimensional program, they appear as icons. However, these brush types symbolize dynamic entities. Thus, in their application within Open Brush, where their movement is accentuated, they become more aligned with their inherent characteristics."

L2 expressed significant interest in using the various brushes available within the VR environment, particularly highlighting the star brush for designing in the sky. With VR goggles on, L2 consistently raised her arms, attempting to ascend within her spatial creation (figure 3.23).

L2 then reverted to orthographic drawing and modeling, creating new designs based on the initial sketch.

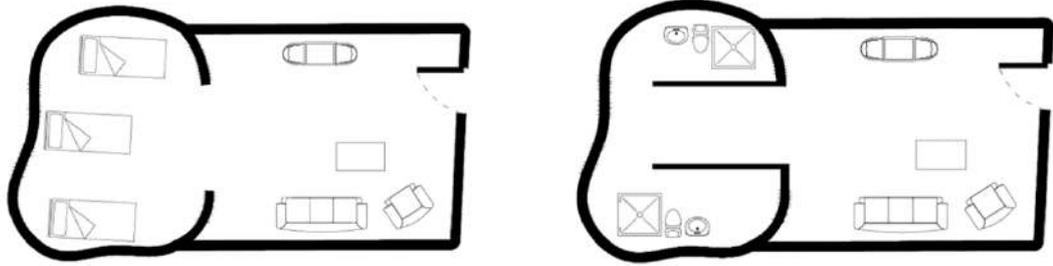


Figure 3.24: L2's plan trials. From student L2's OneNote page.



Figure 3.25: L2's model studies. From student L2's OneNote page.

Following this, L2 meticulously examined all the brushes available in Open Brush and created a painting as part of the exploration process. After completing the painting, L2 returned to the virtual environment to experience the newly discovered brushes further. This exploration led to subsequent modifications in the previously designed space.

		charcoal		
		digital		
		double flat		comet
		drafting		faceted tube
		dry brush		icing
		feather		light wire
		fire2		lofted
		gouache		spikes
		ink		toon
bubbles		lacewing	coarse bristles	neon pulse
embers		leaky pen	dot marker	waveform
smoke				
particle	flat		spray	tube
			leaves	bubble wand
snow	fairy		splatter	guts
stars	marker			keijiro tube
rising bubbles	oil paint			rain
	paper			sparks
	race			tapered wire
	single sided			wire
	space			disco
	tapered marker			petal
	watercolor paper			
	wet paint			
	wind			
				diamond
				matte hull
				shiny hull
				until hull

Figure 3.26: L2's brush table. From student L2's OneNote page.

Upon returning to the model work after the virtual environment experience, L2 abandoned her initial design. Influenced by the new brushes, she opted to create a new model, selecting a different material for this iteration (figure 3.27).

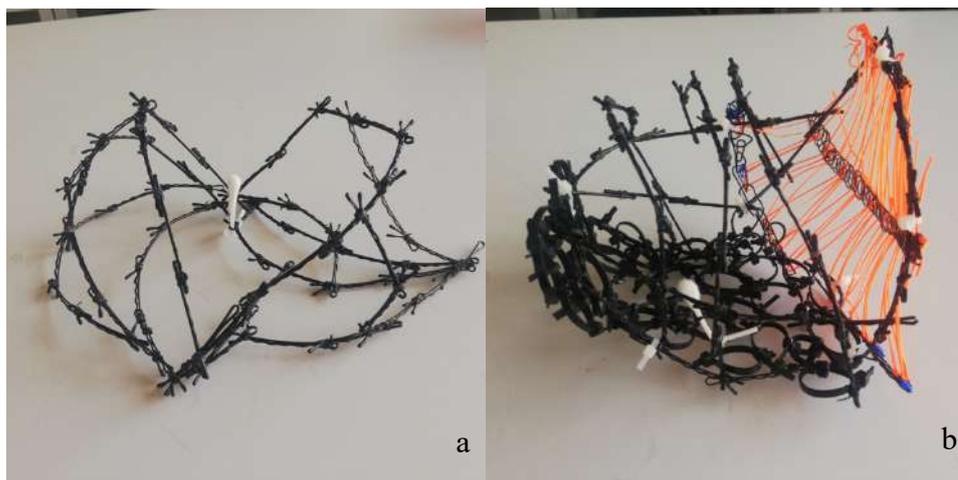


Figure 3.27: (a) L2's model's structure. From student L2's OneNote page. (b) L2's model. From student L2's OneNote page.

- Student L3

L3 commenced the lesson by generating visuals from text-to-prompt inputs (Figures 3.28-3.29). Subsequently, L3 engaged in sketch studies, creating visual prompts from his drawings and producing corresponding visuals based on these sketches (Figures 3.30-3.31).



Figure 3.28: L3's attempts with AI. From student L3's OneNote page.



Figure 3.29: L3's attempts with AI. From student L3's OneNote page.

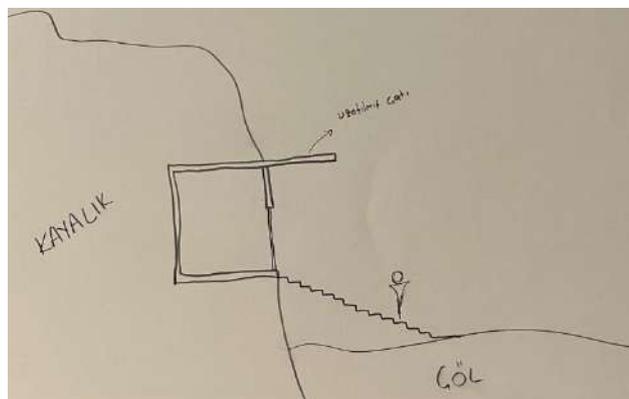


Figure 3.30: L3's sketch studies. From student L3's OneNote page.



Figure 3.31: L3's AI attempts through his Sketch studies. From Student L3's Onenote page.

Throughout the process, L3 iteratively refined his prompts, tailoring the text to address specific concerns related to roof, window, and door features, along with material considerations. This iterative process guided further AI-generated visual productions (Figures 3.32-3.33).

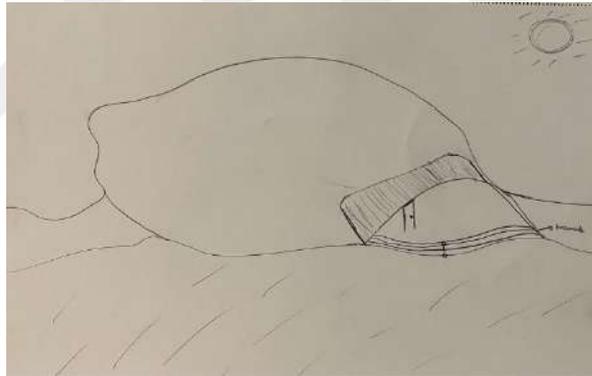


Figure 3.32: L3's sketch studies. From student L3's OneNote page.



Figure 3.33: L3's AI attempts through his Sketch studies. From Student L3's OneNote page.

In later lessons, it was observed that L3, upon trying VR, remained relatively stationary and confined to the same area.



Figure 3.34: Student's work with VR glasses. From the author's archive.

Continuing with sketch work, L3 began to explore the capabilities of Open Brush. He prepared a sketch for a new form and investigated which brushes would be suitable for his designs. However, L3 noted that he ultimately opted for a box form, citing ease of work as the primary reason for this choice.

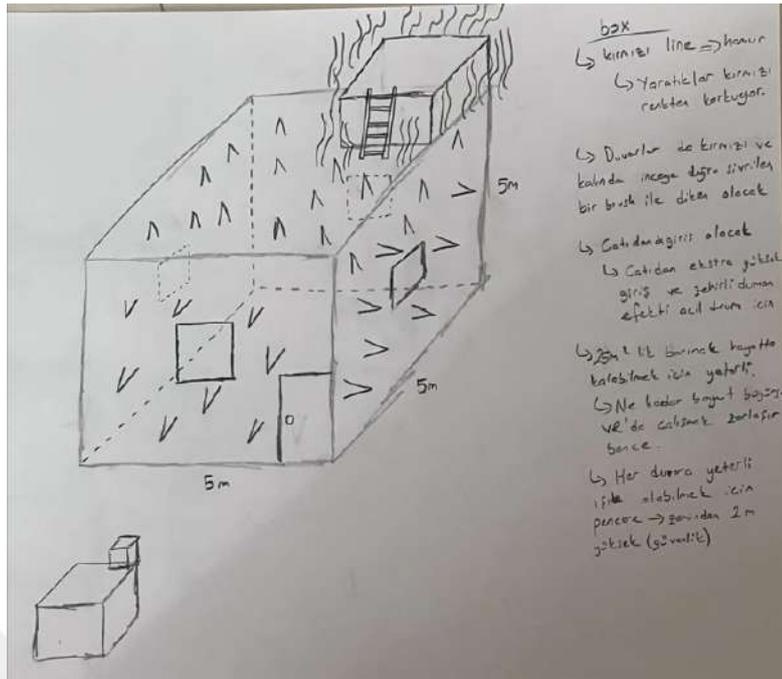


Figure 3.35: L3's sketch studies. From student L3's OneNote page.

L3 envisioned a unique context for his shelter, aligning it with the virtual space in Open Brush. He articulated his intentions to impose design rules based on the imagined presence of creatures within this environment.

He described his conceptual approach as follows: "For example, I decided that creatures are afraid of the color red, so I planned to construct the shelter using red. To prevent creatures from approaching the structure, I intended to create thorns on the outer walls using a brush that transitions from thick to thin. Additionally, I wanted to add an emergency door to the roof because I imagined the environment in the Open Brush world as a dangerous place. This perception was influenced by the surroundings, ground, and overall black color scheme. To enhance security, I planned to give extra height to the entrance from the roof, ensuring that creatures climbing up would encounter a new wall before reaching the door. I considered using a smoke brush to simulate a poison effect around the shelter. For the windows, I started them 2 meters above the ground. This elevation minimizes weak points since there are no thorns in the areas where the windows are located."

L3's imaginative approach demonstrates a thoughtful integration of environmental storytelling and practical design considerations within the virtual space.

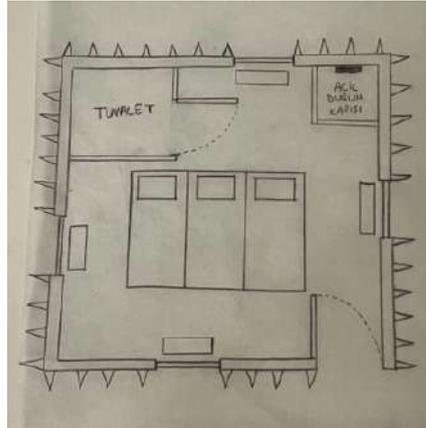


Figure 3.36: L3's plan trials. From student OneNote page.

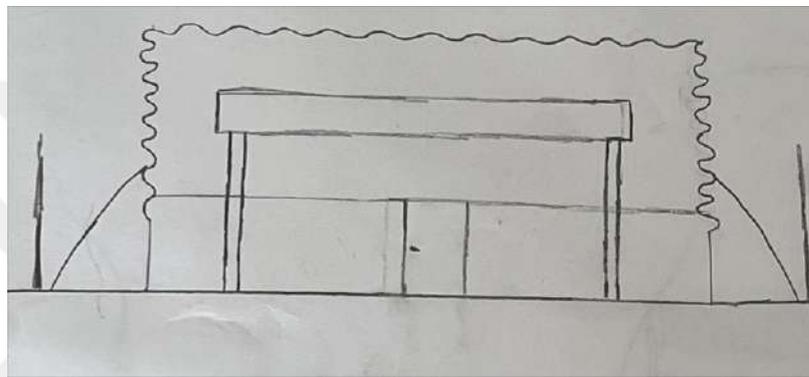


Figure 3.37: L3's section/elevation trials. From student L3's OneNote page.

In the final stage, L3 translated his drawings directly into a physical model. He applied the design elements and features he had conceptualized and sketched, ensuring that the model accurately reflected his initial drawings.

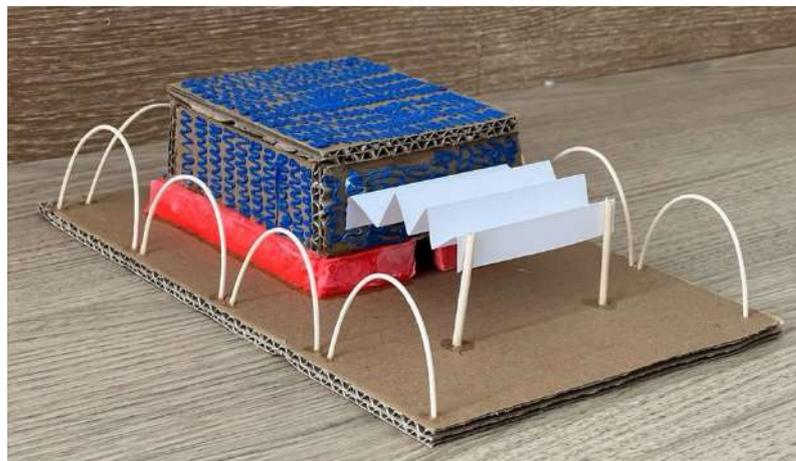


Figure 3.38: L3's final model for the shelter. From student L3's OneNote page.

- Student L4

L4 is one of the students who initially proceeds with the text-to-image method followed by drawing enhancements. L4 applies this approach specifically to objects within the space after generating the overall environment.

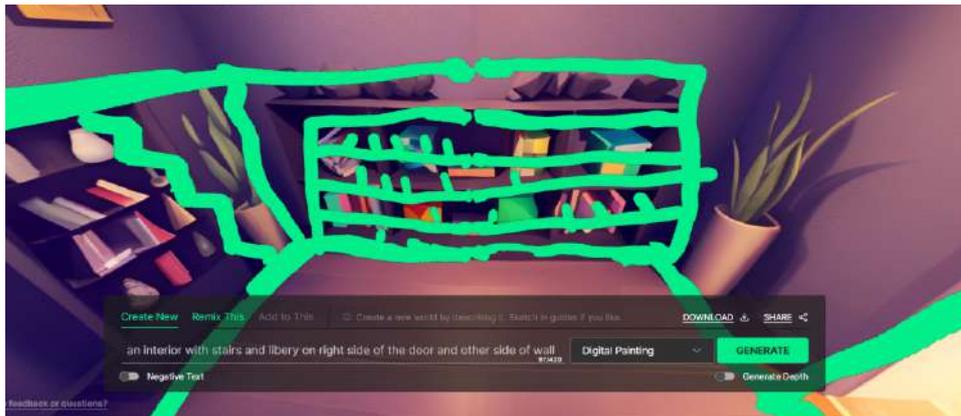


Figure 3.39: L4's attempts with Skybox AI. From L4's OneNote page.

Following this, L4 attempted to generate different spaces from the same text by inputting the same prompt into various AI engines. This approach allowed L4 to explore and compare the varied interpretations and outputs produced by different AI systems.

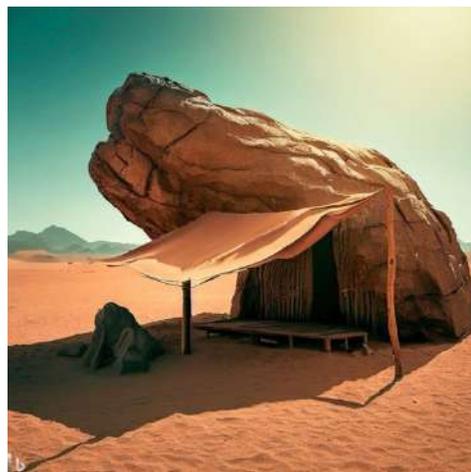


Figure 3.40: Prompt: A shelter in dessert climate near a rock dessert climate near a rock. From L4's OneNote page.



Figure 3.41: Prompt: A shelter in dessert climate near a rock protect from sun with Freeway. From L4's OneNote page.

L4 continued her process by experimenting with collage techniques using 3D layouts.

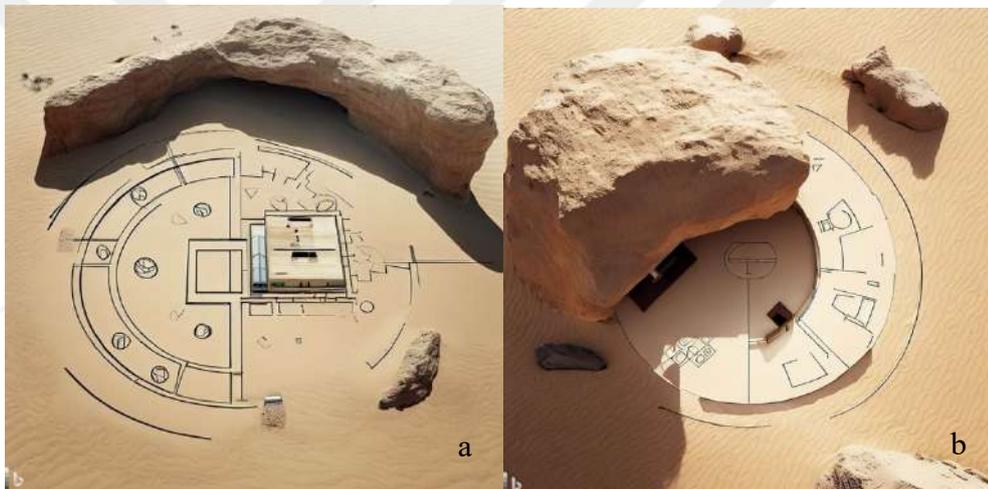


Figure 3.42: (a) L4's AI attempts. From student L4's OneNote page. (b) L4's AI attempts. From student L4's OneNote page.

The student who began working in the virtual environment consistently observed her surroundings while engaged in her tasks. She aimed to create an electrifying atmosphere and maintained constant movement throughout her work, enhancing her dynamic interaction with the virtual space.

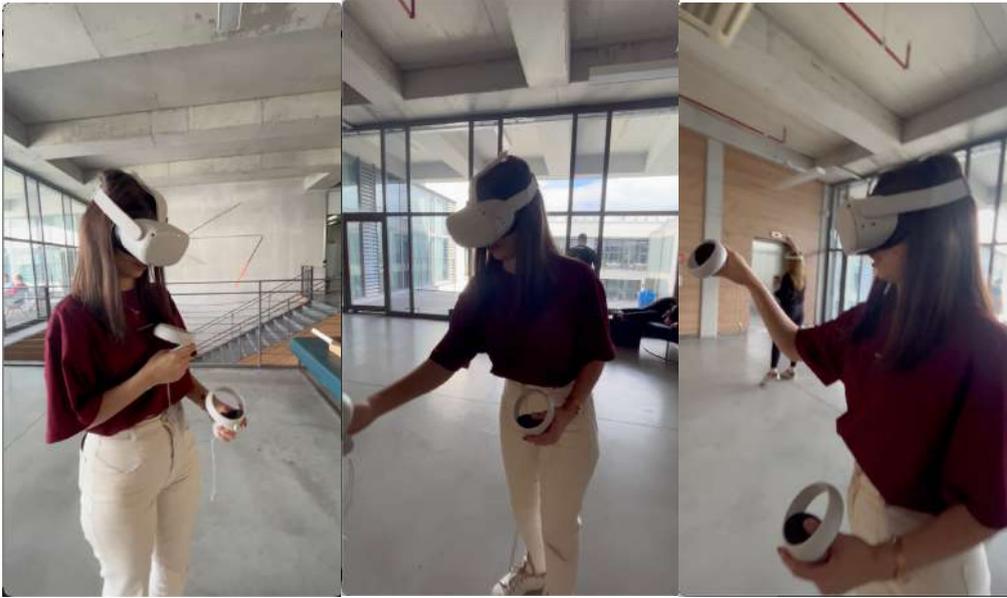


Figure 3.43: Student's work with VR glasses. From the author's archive.

After working in virtual spaces, L4 returned to sketching and drawing to continue her work. Initially, she attempted to integrate insights gained from both his AI studies and VR experiences. Based on this integrated approach, L4 proceeded to create detailed drawings and subsequently produced a physical model.

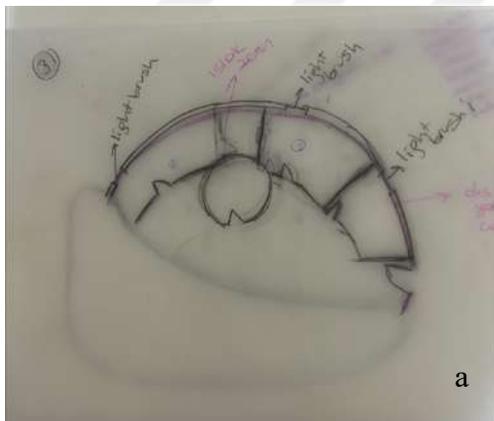


Figure 3.44: (a) L4's sketches. From student L4's OneNote page. (b) L4's model studies. From student L4's OneNote page.

She then recreated the same production in SketchUp, remodeling it and making changes to certain elements along the way. This iterative process allowed her to refine her design based on the insights gained from previous stages of her work.

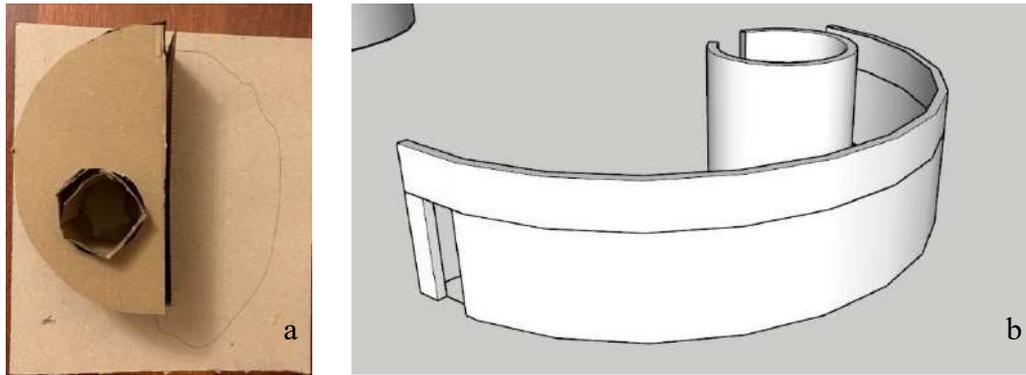


Figure 3.45: (a) L4's physical model. From student L4's OneNote page. (b) L4's SketchUp model studies. From L4's OneNote page.

After this part, the student returned to working with Open Brush in the virtual environment. Following the VR trials, he transitioned back to modeling in SketchUp. In SketchUp, she created a grid prism, mirroring his work in Open Brush, and attempted to form the shelter. At this point, she decided that switching back to physical model work would be more efficient. She then resumed working on the model, experimenting with different materials to further develop and refine his shelter design.

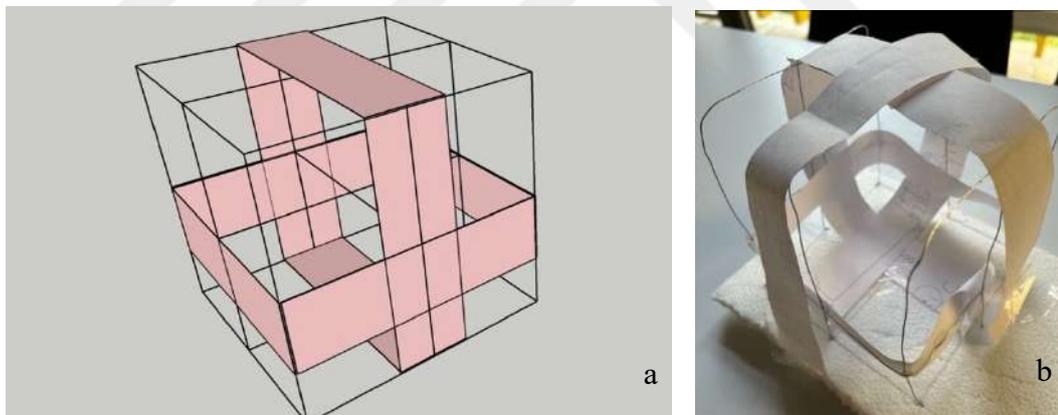


Figure 3.46: (a) L4's model studies with SketchUp. From student L4's OneNote page. (b) L4's model studies. From student L4's OneNote page.

L4 returned to the virtual environment, and then back to SketchUp, again altering her form based on her brush choices in the virtual environment. She adjusted her design with the intention of better utilizing brushes that emit spontaneous light, such as Chromatic Wave, Electricity, and Neon Pulse. This decision influenced her design direction, leading to revisions that would maximize the effects of these dynamic lighting elements.

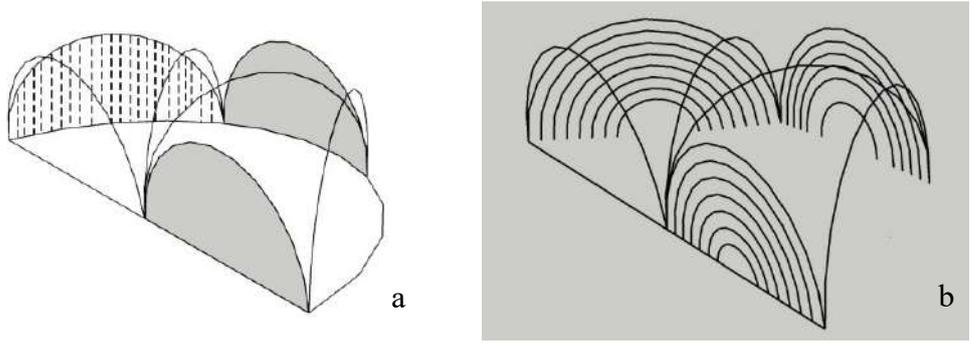


Figure 3.47: (a) L4's model studies with SketchUp. From student L4's OneNote page. (b) L4's model studies with SketchUp. From student L4's OneNote page.

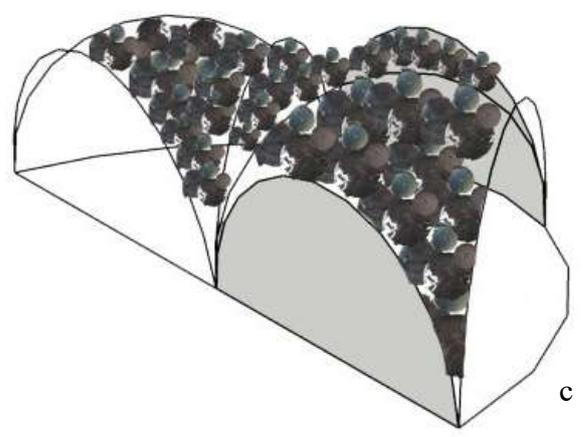


Figure 3.48: L4's model studies. (a) Structure of the model. From student L4's OneNote page. (b) Materials of the model. From student L4's OneNote page. (c) Collage made by L4. From student L4's OneNote page.

- Student L5

Unfortunately, Student L5's performance lagged behind due to limited participation in class. L5 missed the initial discussions and skipped the conceptual phase, proceeding directly to deciding on the shelter material and then on to drawing.



Figure 3.49: L5's material research. From student L5's OneNote page.

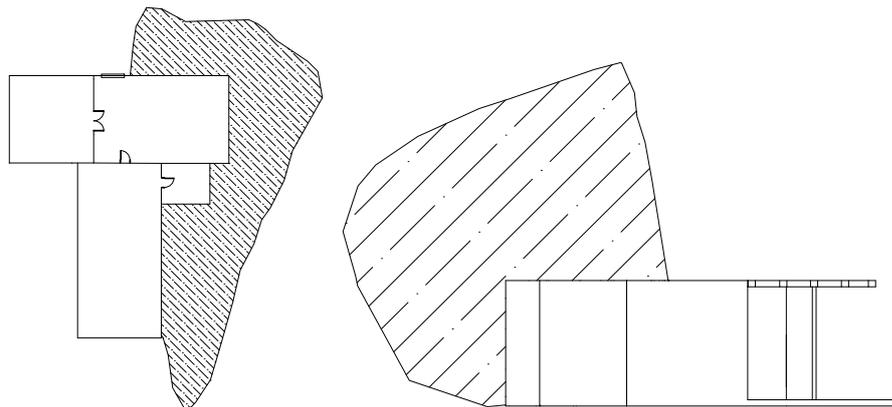


Figure 3.50: L5's plan and section studies. From student L5's OneNote page.

Although L5 expressed an interest in experiencing the virtual environment, he was unable to wear the VR glasses for a sufficient amount of time, citing that they caused

headaches. Consequently, because he missed both the classes and the opportunity to be in the virtual environment, L5 only managed to design a basic shelter by the end of the semester.

- Student L6

Student L6 approached the design of the desert shelter by first conducting a detailed analysis of the environmental conditions. This analysis encompassed thorough research on temperature fluctuations, roof types used in desert climates, and the impact of sandstorms. Based on these findings, L6 prioritized selecting appropriate materials for the shelter. L6 paid particular attention to the details of the windows, which subsequently informed the specific prompts used in her AI-powered research.



Figure 3.51: L6's AI attempts. From student L6's OneNote page.

Unfortunately, L6 also missed the remainder of the lessons and did not document their work until the final assignment. As a result, we are unable to provide insights into L6's process and final stages of the project.

- Student L7

Unfortunately, Student L7 did not show interest in the course. L7 reported feeling uncomfortable in the VR environment, citing difficulty in controlling the virtual space due to the absence of an external perspective on the created environment.

Consequently, the student did not attend the classes regularly and did not produce any work.

- Student L8

L8 began by conducting spatial experiments using Bing Ai and Freeway, generating visuals with text-to-image prompts. She iteratively refined her prompts to find the most suitable ones. Once she identified the optimal prompts, L8 applied them to Skybox AI for further experimentation and visualization.

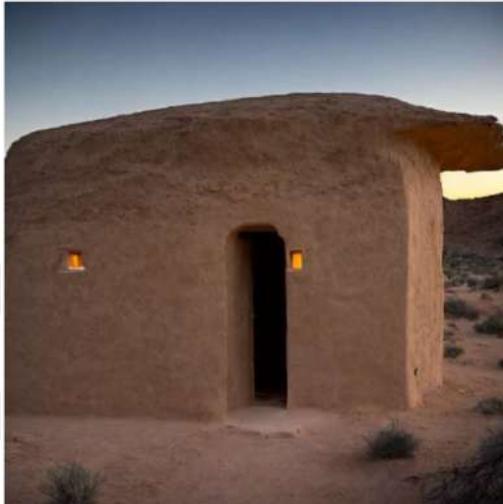


Figure 3.52: L8's AI attempt with Freeway. From student L8's OneNote page.

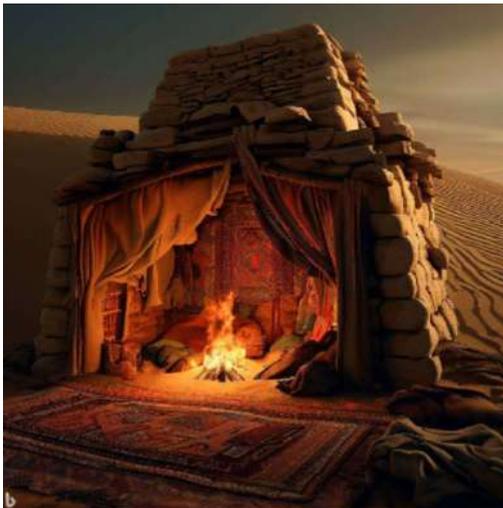


Figure 3.53: L8's AI attempt with Bing. From student L8's OneNote page.

After her work on Skybox AI, she redrew the plan she had created, incorporating spatial elements generated by other AI tools into her drawing. This integration allowed her to build design by leveraging the strengths of multiple AI-generated elements.



Figure 3.54: L8's AI attempt with Skybox AI. From student L8's OneNote page.

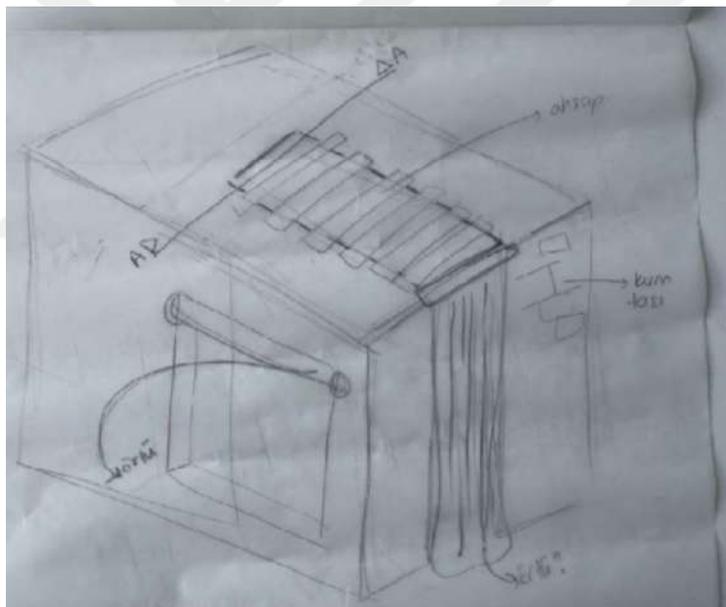


Figure 3.55: L8's sketches. From student L8's OneNote page.

L8 noted in her observations that she maintained a more reserved approach until she experienced the virtual environment, attributing this to her personal shyness. Initially, she felt inadequate upon entering the virtual environment. However, she persevered and continued to experiment with different brushes while wearing the VR glasses.

It was observed that she worked in a manner that complemented both the zero-gravity environment and her immediate surroundings, using her body to navigate and interact with the virtual space. L8 mentioned that she aimed to create architectural elements by

"crossing" the brushes she used, demonstrating an innovative approach to integrating brush techniques within the VR environment.



Figure 3.56: Student's work with VR glasses. From the author's archive.

L8 subsequently returned to sketching but decided to express her ideas within the context of the Minecraft game. She transitioned to modeling her designs in Minecraft, leveraging the game's environment and tools to bring her architectural concepts to life.

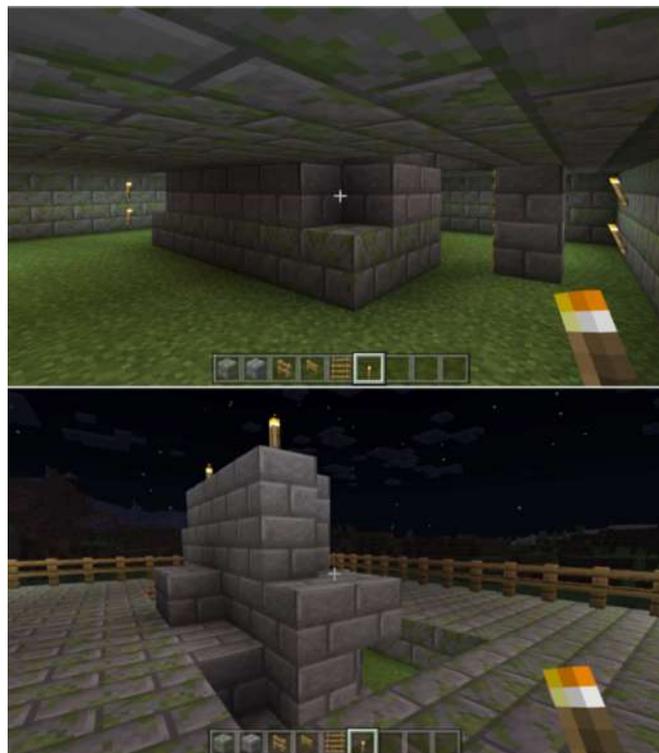


Figure 3.57: L8's Minecraft studies. From student L8's OneNote page.

After working in Minecraft, L8 returned to the virtual environment to continue her spatial experimentation. She aimed to express her ideas through sketches and produced new drawings for the shelter she intended to create.

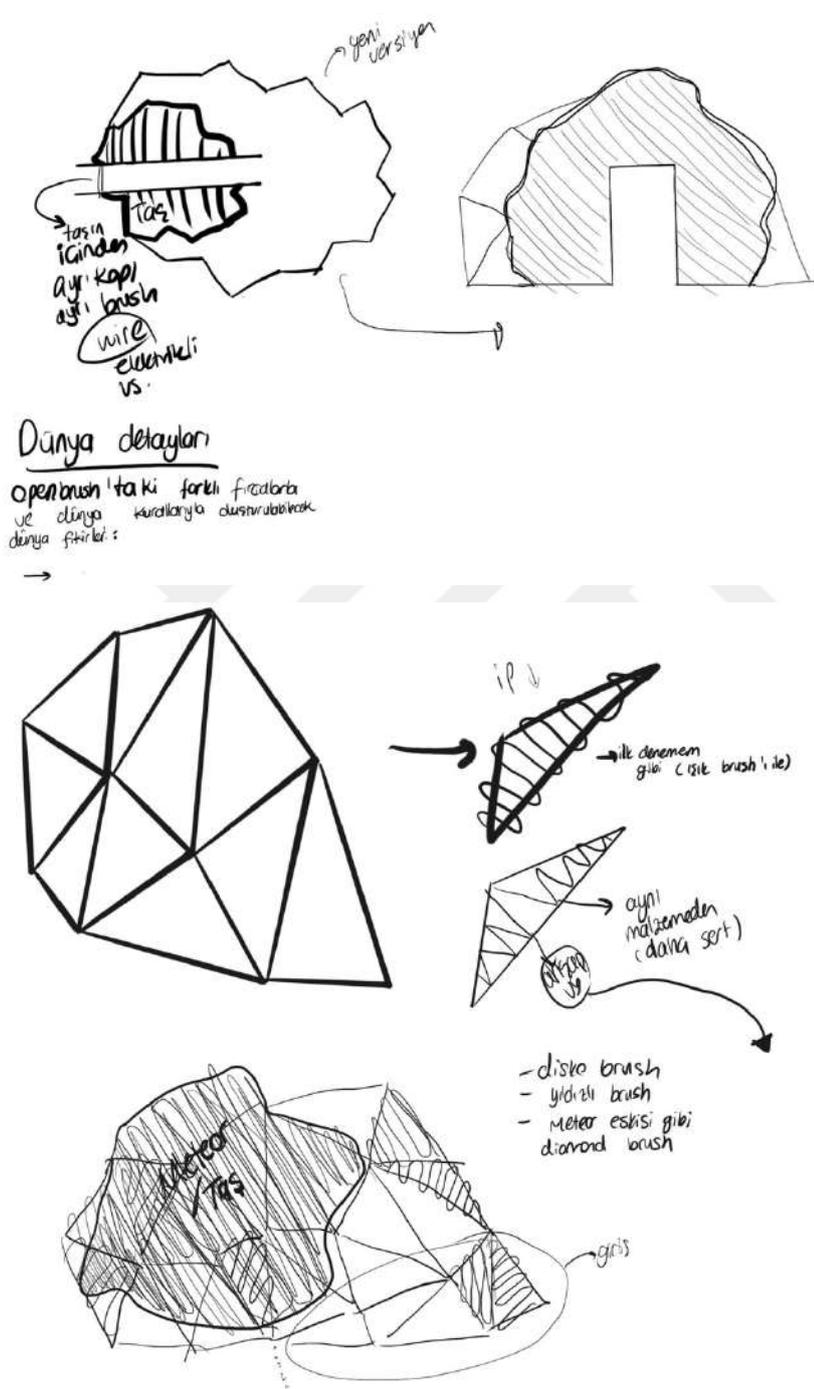


Figure 3.58: L8's sketches. From student L8's OneNote page.

- Student L9

L9 began by preparing a prompt and creating an initial drawing. She then transitioned from drawing to painting and subsequently used different AI programs to produce the final visual representation.

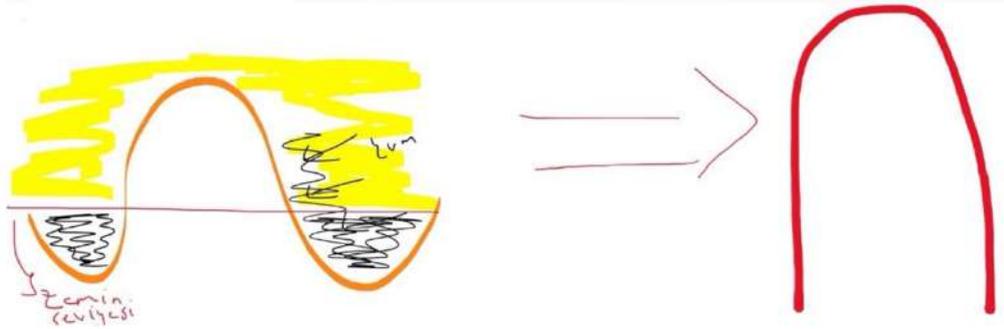


Figure 3.59: L9's initial drawings. From student L9's OneNote page.



Figure 3.60: AI attempts with different AI programs. From student L9's OneNote page.

Following this, L9 experienced the virtual environment. The student noted that being immersed in the virtual space helped him more easily embrace and express his identity as a designer while working on his spatial designs.



Figure 3.61: Student's work with VR glasses. From the author's archive.

L9 designed a shelter with an open-and-close mechanism, inspired by the mobility features of vehicles in Open Brush. She tested this dynamic design within a modeling program, ensuring its functionality and form. Following the digital modeling, L9 selected appropriate materials and proceeded to create a physical model, translating her design into a tangible format and evaluating its practical aspects.

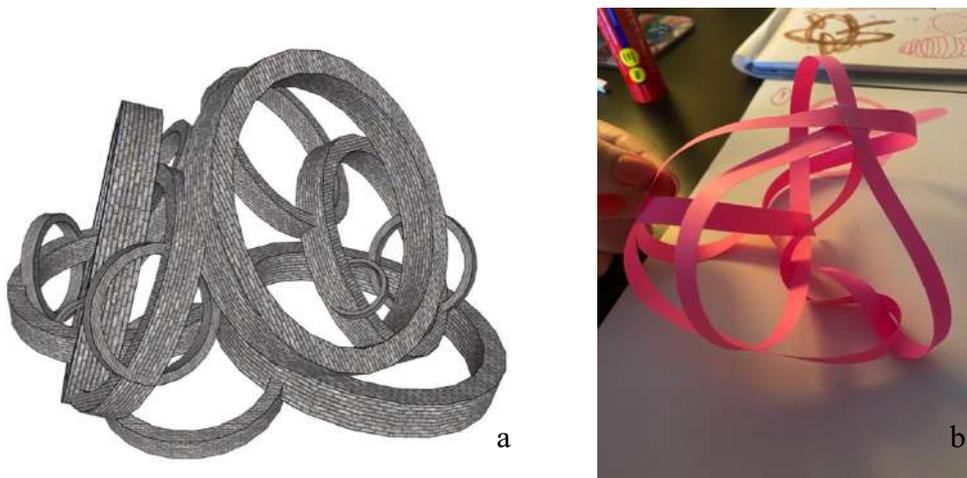


Figure 3.62: (a) L9's model studies with SketchUp. From student L9's OneNote page. (b) L9's model studies with materials. From student L9's OneNote page.

The observations presented in this ethnographic research were derived through a multifaceted approach, incorporating personal impressions, conversations with students, student evaluations, recorded videos, and the perspectives of other teachers.

This combination allowed for a comprehensive and holistic understanding of the student's experiences and attitudes. Both graduate and undergraduate students demonstrated a significant openness to working with VR. They preferred utilizing diverse tools over-relying on a single design tool, maximizing their creative potential. It is important to emphasize that undergraduate students often experience repetitive exposure to basic design principles. It is important to emphasize that undergraduate students must retake the basic design course. Consequently, any observable reluctance, lack of participation, or limited development in some students can be attributed to a general disinterest in the course rather than the students' abilities or the course content itself. In addition to these observations, the overall working process was quite positive. Recordings and notes taken throughout the semester documented the observations, personal impressions, conversations with students, student evaluations, and recorded videos presented in this phenomenological study. Thus, a comprehensive and holistic understanding of the students' experiences and attitudes was provided.

3.5 Results and Discussion

This study examined how students' use of their bodies, enabled by VR environments, contributed to collaborative design processes. The research focused on whether embodied cognition through these technologies increased students' integration into design activities and how VR was incorporated into their workflows.

In this research, no comparison was made between AI visuals produced by students within the scope of the basic design course, some expressed with drawings and some with models. It investigated what was transferred when moving from one to another, which qualities and quantities were transferred to another media and whether an effort was made to reproduce them. Furthermore, this situation gave us clues about which sides of the students needed to be supported; a research process was carried out by discussing with the student each time what you tried and how you tried, why you succeeded or failed, and how you measured whether the experiment reached a result. Most importantly, it tried to support these areas by evaluating how the student could do the things he said he could not achieve.

L1 began by exploring text-to-image commands, gradually moving to VR environments and integrating their physical movements into the design process. They

found that iterative exchanges between SketchUp and VR led to important design innovations, such as changes in form to adapt to the immersive environment's zero-gravity conditions.

L2 used AI to experiment with textual commands and visualizations and then returned to drawing methods to define spatial features. Her experience with VR and dynamic brushes demonstrated creative enhancements, and she modified her design adjustments based on physical movements and interactions in the virtual space. However, L2 was observed to change her design each time she returned to the virtual environment.

L3 initially focused on detailed AI-powered visualizations and orthographic drawings. Despite showing less mobility in VR, he eventually embraced the dynamic features of Open Brush. He modified her form and design elements to utilize better, more specific brushes that fit her imagination.

L4 demonstrated a balanced integration of AI and VR by combining 3D collages, SketchUp models, and virtual environments. Exploring dynamic lighting brushes in VR influenced her design choices, resulting in innovative shelter forms that combined digital and physical modeling techniques. The most significant observation for L4 was that she actively used all the tools she had used throughout the semester, transferring them to each other collaboratively.

L5 demonstrated limited engagement, missed important discussions and VR experiences due to discomfort, and could not produce significant work. This highlighted the challenges faced by students less attuned to VR environments.

L6 began with a comprehensive environmental analysis and material selection based on AI prompts. However, it needed to provide further documented progress, highlighting the importance of ongoing engagement in effectively using embodied cognition.

L7 also struggled to engage because she felt uncomfortable in VR due to the lack of an external perspective and the inability to produce design work. This highlights the need for alternative approaches for students less suited to immersive technologies.

L8 began with AI-powered spatial experiments, developing their designs through traditional drawings and Minecraft modeling. Eventually, they returned to VR to explore dynamic spatial elements further. Their iterative process captured the synergy between platforms using embodied cognition for architectural elements.

L9 demonstrated significant engagement with VR by producing mobile and dynamic shelter designs that he tested digitally and physically. The ability to visualize and manipulate his design in VR enhanced his creative process by allowing him to connect deeply with his identity as a designer.

Upon completing the students' explorations in this environment, comprehensive evaluation reports on the design activities within this context were requested. Students were tasked with completing a 29-question survey to articulate their thoughts more clearly. As a result, the study revealed that the students had various levels of integration and interaction with embodied cognition and VR.

The basic design course aims to develop the student's design skills and competence, not to improve the architectural quality of the product. The facilitators and students monitor the transformation of an idea into an architectural product using design and representation tools. It is checked whether they can use different environments and tools in a way that is related to each other, determine what they think is or is not by doing this, and look at something from different angles using different methods to decide whether to change or not to change something, etc. When the students' processes and opinions were evaluated considering these criteria, it was seen that the students enjoyed working with these new tools but had difficulty using them as a collaborative design method. Most of the students have worked with AI and VR, models and drawings, but most of them have not yet formed the perception of collaborative design to integrate all of them. According to the evaluation of the results obtained from the surveys, it can be said that VR is one of the tools that can represent the dynamic nature of architecture, and the students made new spatial discoveries while designing there, but this does not mean that VR has yet been integrated into the design process.

However, challenges like VR discomfort and uneven participation highlight the need for adaptable and inclusive approaches to foster collaborative design. Overall, VR and embodied cognition have shown significant promise in enriching the educational design process, albeit with individual variability in adoption and impact, but have yet to be fully integrated.

4. CONCLUSION

As stated in the introduction, architecture is dynamic. However, has architecture been discussed for centuries with two-dimensional representation and design tools sufficiently explored and experienced with the tools used to produce it? Or can different experiences and discoveries be made with the body's participation? The thesis seeks to answer this question. This study critically examined the potential limitations inherent in traditional drawing methods, particularly their capacity to understand and express spatial experience fully. The thesis theorized that production and representation processes in three-dimensional (3D), immersive VR environments characterized by active embodied cognition can significantly increase spatial understanding and cognition and transform how we perceive and design architecture.

The thesis investigated a specific period by focusing on the actions of students who repeated basic design courses, exploring, representing and understanding spatial concepts. The phenomenological research targeted students enrolled in a repeat of the basic design studio course during the summer term. Considering their differences and prior learning, this course aimed to design a learning environment closely aligned with the students' experiences, knowledge, and orientations. An attempt was made to encourage spatial exploration by creating a relatively 'free' environment where students could use VR, artificial intelligence, modeling, drawing and a combination of these tools. Instead of repeating the same exercises, a more dynamic learning environment was structured to encourage individual contributions within a collaborative social context. The most important aim of this course was not only to create a studio environment where students would use new technologies but also to support them in gaining a new perspective on exploring, pursuing and representing ideas while switching between different media and environments and to use all methods collaboratively.

The theory of 'embodied cognition' addressed this questioning by positing that cognitive processes are intricately linked with physical and sensory experiences. This theory presented a compelling framework for enhancing architectural education, effectively reshaping how spatial understanding is taught and learned. Spatial ability, encompassing the capacity to perceive, interpret, and manipulate spatial relations, is a critical skill in architectural education. Embodied cognition emphasized that these cognitive functions were not isolated from physical experiences but were influenced by our interactions with the environment.

Integrating embodied cognition into educational practices leveraged sensory and motor experiences to foster a more profound and intuitive understanding of architectural spaces. Experiential learning methods, such as hands-on design projects and practical engagement with architectural concepts, exemplified the application of embodied cognition in education. These approaches encouraged students to engage actively with their physical environment, enhancing their spatial reasoning and problem-solving skills. This aligned with the fundamental principles of embodied cognition, which asserted that learning was most effective when it involved direct physical interaction with the subject matter. The implications of applying embodied cognition through immersive technologies were profound. These tools enabled students to experience architecture in a way that mirrored real-world sensations and perceptions, thus enhancing their ability to design functional and aesthetically pleasing spaces. Moreover, immersive technologies democratized architectural education by providing access to various simulated environments, regardless of geographical or financial limitations. The thesis argued that applying Embodied Cognition Theory to architectural education offered a transformative approach to enhancing spatial understanding, particularly through immersive technologies. This integration enriched the educational process by bridging theoretical concepts with practical experience. It prepared students to navigate the complexities of architectural design with enhanced cognitive and perceptual skills. Therefore, embodied cognition emerged as a vital component in the evolving landscape of architectural education, promising more effective and engaging learning experiences.

Historical research was first conducted to reach these goals and questions in the thesis. This research started with the general history of drawing.

From ancient civilizations to contemporary practice, architectural drawing has evolved from rudimentary depictions to sophisticated instruments of technical precision and artistic expression. Historical evidence suggests that orthographic and projective methods have contributed to precision and consistency in architectural representations. The earliest known architectural depictions, such as those found in Çatalhöyük and Gudea's statue, demonstrate advanced understandings of spatial organization and construction techniques.

These ancient artifacts illustrate how early architects utilized drawing for storytelling, cultural transmission, and technical planning, which continue to resonate in modern architectural practice (Mellaart, 1967) (Langdon, 1927) (Frankfort, 1978). With roots in classical civilizations, particularly in Greek and Egyptian traditions, orthographic projection standardized drawing practices and laid the foundation for future innovations (Yee, 2012) (Wilkinson, 1992).

The Renaissance further refined projective techniques, enriching the visual language of architecture through contributions from figures such as Leon Battista Alberti and Filippo Brunelleschi (Pérez- Gómez & Pelletier, 1997). The convergence of art and science is exemplified in the works of Renaissance artists and mathematicians, such as Albrecht Dürer and Gaspard Monge. Their perspective and descriptive geometry advancements bridged the gap between aesthetic representation and mathematical precision (Gafney, 1965). Dürer's integration of artistic intuition with geometric accuracy and Monge's formal articulation of descriptive geometry equipped architects with powerful tools for visualizing and constructing complex spatial forms. Traditional drawing practices have also significantly contributed to architectural education. They function as representational tools and cognitive exercises that stimulate design thinking and spatial understanding (Pallasmaa, 2009). By adhering to established conventions, drawing teaches architects to explore the dynamic interplay between an idea and its visual representation, informing both practical application and theoretical discourse (Jones, 2011).

In conclusion, traditional orthographic and projective methods have fundamentally shaped architectural spaces' historical and practical understanding. They have provided the framework for precise and standardized representation, facilitated technological and artistic advancements, and continue to inform contemporary architectural practice and education.

Starting from the 18th century, drawing became systematic and became a tool of representation as well as a design tool. In the 20th century, other inquiries on space began, just like the ones questioned in this thesis. Therefore, the thesis also examines the influence of traditional approaches pioneered by influential figures such as Adolf Loos, Le Corbusier, the De Stijl movement, László Moholy-Nagy, Greg Lynn and Deconstructivist architects on modern architectural theory and practice. Adolf Loos's Raumplan, emphasizing three-dimensional design and dynamic interiors, resonates with contemporary concepts of embodied cognition but faces challenges in practical implementation due to the limitations of traditional orthographic projections. Le Corbusier's Plan Libre revolutionized interior space by promoting flexibility and fluid spatial experiences. However, it encountered criticism for functional and aesthetic uniformity, which could affect usability and spatial variety. The De Stijl movement, advocating for simplicity and abstraction, influenced spatial design through precise orthographic methods but struggled to capture architecture's experiential dimensions. László Moholy-Nagy's work considers that architecture should not be reduced to a single dimension.

By the 21st century, new tools had begun to produce new solutions to some questions. Historically, architectural education has transitioned from hands-on apprenticeships to structured curricula rooted in classical principles, technical education, and modernist pedagogy. This historical trajectory underscores the significance of drawing, both traditional and digital, as a fundamental element of architectural practice. The 20th and 21st centuries have witnessed a notable transformation driven by CAD and Building Information Modeling (BIM), which have enhanced precision, efficiency, and stakeholder collaboration. Empirical studies such as those conducted by Alvarado, Marquez, Vildosolo, Schnabel, and Kvan provide crucial insights into VR's potential to revolutionize spatial understanding and design processes. Özkan and Yıldırım's research on CAD systems underscores the necessity of proficient digital tool integration within educational curricula to harness the potential of these technologies effectively. Their findings indicate that while CAD enhances technical accuracy and efficiency, it must be supplemented with adequate instructional time and theoretical grounding to maximize its educational benefits.

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pedagogy. This historical trajectory underscores the significance of drawing, both traditional and digital, as a fundamental element of architectural practice. The 20th and 21st centuries have witnessed a notable transformation driven by CAD and Building Information Modeling (BIM), which have enhanced precision, efficiency, and stakeholder collaboration. Empirical studies such as those conducted by Alvarado, Marquez, Vildosolo, Schnabel, and Kvan provide crucial insights into VR's potential to revolutionize spatial understanding and design processes. VR significantly enhances students' capability to explore, manipulate, and comprehend three-dimensional spaces, offering a more immersive and interactive approach than traditional 2D plans or non-immersive environments. These studies posit that when effectively integrated, VR fosters a deeper understanding of spatial relationships and enhances design creativity, particularly in the early exploratory phases of the design process.

Similarly, Özkan and Yıldırım's research on CAD systems underscores the necessity of proficient digital tool integration within educational curricula to harness the potential of these technologies effectively. Their findings indicate that while CAD enhances technical accuracy and efficiency, it must be supplemented with adequate instructional time and theoretical grounding to maximize its educational benefits. Considering these insights, VR emerges as a promising avenue for the practical application of 'learning by doing' in architectural education. Nevertheless, it is not without its challenges. To fully leverage VR's potential, educators play a pivotal role in developing comprehensive pedagogical frameworks that reconcile the enduring value of traditional drawing techniques with the innovative possibilities of digital technologies. This equilibrium ensures that students are equipped with the technical skills and conceptual understanding required to navigate the intricacies of modern architectural practice.

After examining a nearly 200-year historical inquiry and the thoughts of architects, the thesis advocates the inclusion of embodied cognition in architectural education with virtual reality, which is quite effective among today's technologies. The thesis has conducted research on virtual reality and previous experiments.

Virtual reality (VR) is a truly transformative technology revolutionizing how we perceive and interact with space (Greengard, 2019) and by creating immersive environments that simulate the real world or imagined scenarios, VR allows us to experience, design, and understand space in profound new ways. VR enhances

students' capability to explore, manipulate, and comprehend three-dimensional spaces, offering a more immersive and interactive approach than traditional 2D plans or non-immersive environments. These studies posit that when effectively integrated, VR fosters a deeper understanding of spatial relationships and enhances design creativity, particularly in the early exploratory phases of the design process.

It can be concluded that VR and digital tools have advanced architectural education, but their exact contribution to education is still debatable today. The thesis aims to see the integration of these innovative, collaborative tools as a complementary process that enriches the learning experience, fosters creative expression and develops collaborative design practices. Considering these insights, VR emerges as a promising avenue for the practical application of 'learning by doing' in architectural education. Nevertheless, it is not without its challenges. To fully leverage VR's potential, educators play a pivotal role in developing comprehensive pedagogical frameworks that reconcile the enduring value of traditional drawing techniques with the innovative possibilities of digital technologies. This equilibrium ensures that students are equipped with the technical skills and conceptual understanding required to navigate the intricacies of modern architectural practice.

VR's integration should be viewed as a complementary process that enriches the learning experience, nurtures creative expression, and enhances collaborative design practices.

The thesis explores the following question in its phenomenological research: To what extent can virtual reality be integrated into design, and to what extent can students integrate into virtual reality?

Students used new technologies, such as VR programs like Skybox AI and Open Brush, along with traditional drawing and modeling methods, to investigate the relationship between words, images, drawings and representations and the dynamic qualities of space. The course aimed to design a learning environment that would enhance students' productivity and participation, adapted to their personal experiences and differences. The aim was to:

- Address communication problems in previous periods.
- Create a free and supportive environment for exploration and self-expression.

The research was specifically focused on understanding how the learning environment impacts students' learning and design processes. The goal was to provide insights into these processes and to document and analyze these experiences phenomenologically. Students were recorded throughout the semester as they explored this innovative environment. At the end of the semester, they completed a 29-question survey to express their thoughts and experiences more clearly. Those who consistently engaged with VR and AI demonstrated significantly improved design innovation and a deeper connection to their work. Since design is inherently subjective, this interpretation was made by considering the overall process rather than simply evaluating the end results. Student evaluation surveys at the end of the semester indicated that while students enjoyed the new tools, they needed help using them as collaborative design methods. Most students actively engaged with AI, VR, models, and drawings but had yet to fully embrace the collaborative design perception that seamlessly integrated all these elements.

Research, observations, and phenomenological studies have shown that virtual reality is a promising tool for representing the dynamic nature of architecture and enabling new spatial discoveries, but this does not mean that VR has yet been fully integrated into the design process. This may be because the students being monitored are first-year students, and it is also related to their knowledge and interests. However, the more these studies are applied and repeated to people with different knowledge backgrounds, the more results will be obtained.



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APPENDIX

Figure Appendix. 1 2023/2024 Fall Semester Basic Design Evaluation Format and Criteria

Figure Appendix. 2 Scoring Table

Figure Appendix. 3 Questions and Scores - Table 1

Figure Appendix. 4 Questions and Scores - Table 1.1

Figure Appendix. 5 Questions and Scores - Table 1.2

Figure Appendix. 6 Questions and Scores - Table 1.3

Figure Appendix. 7 Questions and Scores - Table 2

Figure Appendix. 8 Questions and Scores - Table 2.1





1	2	3	4	5
Hiç katılmıyorum	Katılmıyorum	Ne katılıyorum ne katılmıyorum	Biraz katılıyorum	Tamamen katılıyorum

Figure Appendix. 2: Score Table





	Olayları ne kadar kontrol edebildim?	Başlattığın (veya gerçekleştirdiğin) eylemlere ortam ne kadar tepki verdi?	Ortam ile etkileşimin ne kadar doğal görünüyordu?	Ortamın görsel yönleri seni ne kadar içine aldı?	Ortamdaki sesler seni ne kadar içine aldı?
Student 1	4	2	2	5	4
Student 2	5	4	3	5	5
Student 3	4	3	4	4	1
Student 4	4	3	5	4	3
Student 5	5	4	3	5	1
Student 6	5	4	3	4	3
Student 7	5	4	1	5	1
Student 8	4	5	3	5	4
Student 9	4	4	3	4	4

Figure Appendix. 3: Questions and Scores - Table 1





	Ortam içerisinde hareketin kontrol edildiği sistem ne kadar doğaldı?	Ortamda hareket eden nesnelerin sende uyandırdığı his ne kadar inandırıcıydı?	Sanal ortamdaki deneyimlerin, gerçek dünyadaki deneyimlerin ile ne kadar tutarlı görünüyordu?	Gerçekleştirdiğin eylemlere karşılık olarak bir sonraki adımda ne olacağını tahmin edebildin mi?	Gözlüğü kullanarak ortamı ne kadar aktif bir şekilde inceleyebildin veya araştırabildin?
Student 1	4	5	3	3	4
Student 2	5	5	4	2	2
Student 3	3	5	4	5	5
Student 4	2	3	3	3	4
Student 5	4	4	3	4	4
Student 6	4	3	3	4	4
Student 7	3	4	3	5	3
Student 8	5	4	3	2	4
Student 9	2	3	3	2	3

Figure Appendix. 4: Questions and Scores - Table 1.1





	Sesleri ne kadar tanıyabildin?	Seslerin geldiği yeri ne kadar belirleyebildin?	Dokunma aracını kullanarak sanal ortamı ne kadar aktif olarak inceleyebildin veya araştırabildin?	Sanal ortam içerisindeki etrafta gezinme hissi ne kadar inandırıcıydı?	Nesneleri ne kadar yakından inceleyebildin?
Student 1	3	3	4	4	5
Student 2	2	4	4	4	5
Student 3	2	4	5	5	5
Student 4	3	3	2	3	4
Student 5	2	2	3	3	5
Student 6	4	5	3	4	4
Student 7	2	1	3	5	5
Student 8	4	4	3	4	4
Student 9	4	4	3	4	4

Figure Appendix. 5 Questions and Scores - Table 1.2





	Nesneleri farklı bakış açılarından ne kadar inceleyebildin?	Sanal ortamdaki nesneleri ne kadar hareket ettirebildin veya yönlendirebildin?	Sanal ortam deneyimine ne kadar dahil oldun?	Ortamdaki hareketlerin ile hareketlerinin beklenen sonuçları arasında ne kadar gecikme yaşadın?	Sanal ortam deneyimine ne kadar çabuk uyum sağladın?
Student 1	2	4	4	2	4
Student 2	5	4	4	2	4
Student 3	5	5	5	2	4
Student 4	2	3	4	3	4
Student 5	4	3	4	2	4
Student 6	4	3	4	2	3
Student 7	5	4	5	2	5
Student 8	5	3	4	2	4
Student 9	3	3	3	3	3

Figure Appendix. 6 Questions and Scores - Table 1





	Yaşadığın deneyim sonrasında sanal ortamda hareket etme ve etkileşime girme konusunda kendini ne kadar yeterli hissettin?	Verilen görevleri veya gerekli etkinlikleri yerine getirirken, gözlüğün görüntüsü kalitesi seni ne kadar engelledi veya dikkatini dağıttı?	Kontrol cihazları, verilen görevlerin veya diğer etkinliklerin yerine getirilmesini ne kadar engelledi?	Ortamdaki görev veya etkinlikleri yerine getirmek için kullanılan sistemlerden çok verilen görevlere veya etkinliklere ne kadar konsantre olabildin?	Duyuların bu deneyimi ne kadar yoğun yaşadı?
Student 1	4	2	2	4	5
Student 2	4	2	2	4	4
Student 3	5	4	2	5	4
Student 4	4	3	2	4	3
Student 5	4	3	2	4	4
Student 6	3	2	3	4	4
Student 7	5	4	2	5	4
Student 8	4	3	3	4	5
Student 9	4	3	2	4	4

Figure Appendix. 7 Questions and Scores - Table 2



	Nesneleri fiziksel etkileşim yoluyla tanımak (bir nesneye dokunmak, bir yüzeyin üzerinde yürümek veya bir duvar veya nesneye çarpmak) ne kadar kolay oldu?	Sanal ortam deneyimi sırasında ortama veya göreve tamamen odaklandığını hissettiğin anlar oldu mu?	Sanal ortamla etkileşim kurmak için kullanılan kontrol cihazlarına ne kadar kolay uyum sağladın?	Sanal ortamda farklı duyularla sağlanan bilgiler (örneğin; görme, duyma, dokunma) tutarlı mıydı?
Student 1	4	5	3	4
Student 2	4	5	4	3
Student 3	5	5	4	4
Student 4	5	5	4	3
Student 5	2	3	5	3
Student 6	3	4	3	4
Student 7	5	5	4	4
Student 8	3	4	4	3
Student 9	4	4	3	4

Figure Appendix. 8 Questions and Scores - Table 2.1



