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Tasarımda Hesaplamalı Model

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Tasarımda Hesaplamalı Model

Editörden

JCoDe'un dokuzuncu sayısı, tasarım pratiğinin ayrılmaz bir bileşeni olan ve gerçek dünyanın soyutlanmış temsillerini oluşturan model olgusuna hesaplama perspektifinden yaklaşmayı hedeflemektedir. Tasarım sürecinde somut ve soyut çıktılar üreten bir eylem olarak modelleme ile modelleme eyleminin kavramsal, fiziksel ve dijital çıktısı olarak model, tasarım alternatiflerinin üretimi, sınanması ve değerlendirilmesinde önemli rol oynamaktadır. Bu anlamda model, tasarım sürecinin bir girdisi ya da bir ara ürünü olabilmekte, tasarım düşüncesinin yinelemeli bir biçimde geliştirilmesine katkıda bulunmaktadır. Model ve modelleme sadece tasarım problemlerinin çözümüne değil, aynı zamanda iyi tanımlanmamış ve birbiri ile ilişkisiz görünen çeşitli veri katmanlarını anlamlı alt parçalara dönüştürerek tasarım probleminin kurgulanmasına da destek olmaktadır.

Tasarımda hesaplamalı model eskiz, çalışma maketi, prototip ya da 3 boyutlu katı modelin ötesinde benzetim modeli, davranış modeli, bilgi modeli, bilişi (enformasyon) modeli, bilişsel (cognitive) model, performans modeli gibi dinamik süreçlerin temsilini olanaklı kılan yaklaşımlar sunmaktadır. Karmaşık bir sürecin kural, parametre ve ilişkiler aracılığıyla temsili ise prosedürel (yordamsal), üretken, algoritmik modellerin zeminini oluşturmaktadır. Hesaplamalı modeller farklı tasarım/analiz/eniyileme/üretim bağlamlarına adapte edilen soyut yapılar sunarken, kimi zaman da bir dijital zanaat etkinliği olarak bağlam-duyarlı ve probleme özgü şekilde geliştirilmektedir. Diğer yandan her model belirli bir indirgeme içermektedir. Bir hesaplamalı modelde hangi varsayım, koşul ya da yöntemlerin ön plana çıkıp hangilerinin gözardı edileceği modelin hassasiyet, geçerlilik, doğruluk ve etkinliğini etkilemektedir. Dolayısıyla, hesaplamalı model ile tasarım bağlamı ilişkisi kurulurken eleştirel bir değerlendirmeye ihtiyaç duyulmaktadır.

Bu bağlamda JCoDe'un dokuzuncu sayısında (Cilt 4 Sayı 2) tasarımda hesaplamalı modellerin kuramsal ve kılgısal temelleri; tasarımda eniyileme ve benzetim için hesaplamalı modelleme; hesaplamalı model kullanan üretken tasarım yaklaşımları; tasarım analizi ve değerlendirmesi için hesaplamalı modeller, hesaplamalı modellere dayalı vaka çalışmaları tartışmaya sunulmaktadır.

Tasarımda yaratıcılık ve kuram ağırlıklı ilk bölümde Betül UÇKAN, Pelin DURSUN ÇEBİ ve Fatma Ahsen ÖZSOY mimari tasarımdaki form kavramını kendi önerdikleri "formun evrimi"/"canlı form" (vital form) kavramı üzerinden tartışmaya açmaktadır. Üç ana eksenden oluşan çalışmada, form kavramının taşıdığı anlamlar tasarım ve üretim teknikleri ile ilişkili olarak tarihsel bir perspektiften çözümlenmiş, "canlı form" olarak adlandırılan yeni bir kavramsal açılım önerilmiş ve form ile canlı form arasındaki karşılıklı etkileşim, çalışma kapsamında sunulan bir model ve kuramsal tartışmalardan elde edilen kavram setleri ışığında irdelenmiştir.

Büşra ŞIK, Merve Şule YÖRÜK ve Serdar AYDIN, Mardin Artuklu Üniversitesi, Mimarlık Bölümü' mimari proje stüdyolarından Dijital Rastlantı'ya retrospektif ve eleştirel bir anlayışla mercek tutmaktadır. Spekülatif çizimin apriori hesaplamalı ölçütlerle bütünleştirilerek teşvik edildiği, dört aşamadan oluşan ve yenilikçi bir öğrenim deneyi sunan Dijital Rastlantı stüdyosu süreci incelenmektedir. Tasarım temsillerinin bu dört aşamada farklı bağlamlarda yeni anlamlar kazanmasının öğrencilerin yaratıcı düşünme becerilerini desteklediği gözlemlenmiş ve dört aşamalı model tekrarlanabilir bir pedagojik yaklaşım olarak sunulmuştur.

İkinci bölümde, Buket SAMANCI, Özge TAŞPINAR, Yaşar Emir KARCI, Başak CENGİZ, Selen ÖZDOĞAN, Dilek YILDIZ ÖZKAN ve Michael Stephan BITTERMANN mimarlık öğrencilerinin tasarımın erken aşamalarında kullandıkları modelleme teknikleri ve bunun nedenleri üzerine nicel araştırma yöntemine dayalı bir çalışmanın bulgu ve sonuçlarını paylaşmaktadır. 101 katılımcılı anket aracılığıyla gerçekleştirilen çalışma, fiziksel maket ya da bilgisayar destekli model tekniklerinin verimliliğinde anlamlı bir fark olup olmadığını ve tercihin öğrencilerin deneyim düzeyine göre nasıl değiştiğini araştırmaktadır.

Üçüncü ve son bölümde, Faruk Can ÜNAL, mevcut bir mimari cepheyi referans alan yeni cephe görsellerinin üretilebilmesine olanak sağlayan ve genetik algoritmaya dayanan bir model önerisi sunmaktadır. Doluluk-boşluk ilişkisi, yapı elemanları ve üçüncü boyutun etkisi ölçütlerini içeren modelin Hamburger Kunsthalle yapısının cephesi üzerinden bir uygulaması ve sonuçları ortaya konulmuştur. Gülce KIRDAR'ın çalışması, veriye dayalı yaklaşımların kamusal mekanların dinamiklerini keşfetmede nasıl yardımcı olabileceğini ve tasarım kararlarını nasıl destekleyebileceğini sorgulamaktadır. Kamusal alandaki veriye dayalı ölçme ve gözlemleme yöntemlerinin dijital araçlar ile keşfi, verinin Coğrafi Bilgi Sistemi'nde haritalanması, veri haritalama sonucunda veriler arasındaki ilişkinin tanımlanması aşamalarından oluşan ve 27 öğrencinin katılımıyla gerçekleştirilen bir kent mobilyası tasarımı süreci değerlendirilmiştir.

Computational Model in Design

Editorial

The ninth issue of JCoDe approaches the concept of modeling from a computational perspective. Modeling is an essential part of the design process, creating abstract representations of the real world. Modeling as an action that produces concrete and abstract outputs in the design process and the model as the conceptual, physical and digital output of the modeling action play an important role in the production, testing and evaluation of design alternatives. In this sense, the model can be an input or an intermediate product of the design process, contributing to the iterative development of design ideas. Model as an action and object not only enhances problem-solving processes in design but also supports the constitution and refinement of the ill-defined design problems by transforming various data layers that seem unrelated to each other into meaningful sub-parts.

Beyond a sketch, working model, prototype, or 3D solid model in design, computational models offer approaches that enable the representation of dynamic processes such as simulation models, behavior model, information model, cognition model, cognitive model, performance model. The representation of a complex process through rules, parameters and relations form the basis of procedural, generative and algorithmic models. Computational models provide abstract structures that are versatile and can be adapted to a variety of design, analysis, optimization, and production contexts. However, in some pioneering cases, they are developed as a digital craft activity that is context-sensitive and problem-specific. However, every model has its limitations and reductionism is inherent in the modeling process. The assumptions, conditions, or methods emphasized in a computational model can significantly impact its sensitivity, validity, accuracy, and effectiveness. Therefore, it is crucial to evaluate the critically relationship between the computational model and the design context.

In this context, the ninth issue of JCoDe (Volume 4 Issue 2) is intended to stimulate discussions on the theoretical and practical foundations of computational models in design; computational modeling for optimization and simulation in design; generative design approaches using computational models; computational models for design analysis and evaluation, case studies utilizing computational models.

In the first part, which focuses on creativity in design and theory, Betül UÇKAN, Pelin DURSUN ÇEBİ, and Fatma Ahsen ÖZSOY discuss the concept of form in architectural design through their proposed concept of “evolution of form”/”living form” (vital form). In their study, which consists of three main axes, the meanings of the concept of form are analyzed from a historical perspective concerning design and production techniques, a new conceptual expansion namely “vital form” is proposed, and the interrelations between form and vital form are investigated through the model presented within the scope of the study and in the light of concept sets obtained from theoretical discussions. Büşra ŞIK, Merve Şule YÖRÜK, and Serdar AYDIN focus on Digital Spontaneity, one of the architectural project studios of Mardin Artuklu University, Department of Architecture, with a retrospective and critical approach. The Digital Spontaneity studio process, which consists of four stages and offers an innovative learning experiment where speculative drawing is encouraged by integrating an apriori computational criteria, is examined. It has been observed that design representations gaining new meanings in different contexts in these four stages support students' creative thinking skills, and the four-stage model is presented as a repeatable pedagogical approach.

In the second part, Buket SAMANCI, Özge TAŞPINAR, Yaşar Emir KARCI, Başak CENGİZ, Selen ÖZDOĞAN, Dilek YILDIZ ÖZKAN, and Michael Stephan BITTERMANN share the findings and results of a study based on quantitative research method on the modeling techniques used by architecture students in the early stages of design and the underlying reasons. The study, conducted through a survey of 101 participants, investigates whether there is a significant difference in the efficiency of the physical or computer-aided model techniques and how the preferences vary based on the students' experience levels.

In the third and final part, Faruk Can ÜNAL, offers a model proposal based on a genetic algorithm that allows the generation of new facade visuals that take an existing architectural facade as a reference. Implementation and results of the model, which includes the criteria of mass-void relationship, building elements, and the effect of the third dimension on the facade of the Hamburger Kunsthalle building, are presented. Gülce KIRDAR's study explores the utilization of data-driven approaches in investigating the dynamics of public spaces and their contribution to facilitating design choices. The study examines an urban furniture design process integrating publicly sourced data-driven techniques, digital tools for observational disruption, Geographic Information System (GIS) data mapping, and their connections. The study evaluates the outcomes of this process, which involved 27 student participants in implementing urban furniture designs.

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The Evolution Narrative of Architectural Form and The State of *Vital Form*

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The concept of *form* in architectural design has been debated since prehistoric times. In its most straightforward meaning, *form* can be defined as the shape, shell, and inhabited volume of a structure. This study aims to explore the historical process of the transformation and evolution of form, as well as to discover new meanings and potentials of form through analysis, and to develop a critical perspective on form. The study is structured around three main axes. In the first stage, a mapping is designed to analyze the evolution of form throughout history. This mapping focuses on the changes in the approach to form, design, and making techniques chronologically. This stage reveals that form is no longer merely a final product represented by drawings or statically produced, but rather a concept that involves process and dynamism in a temporal-spatial dimension, whether in its design or production. In the second stage, the evolution of form is discussed through a new concept called '*vital form*'. In the comparison between *form* and *vital form*, while *form* represents something static or stationary, *vital form* signifies a dynamic and fluid state. While *form* describes a state that is symbolically designed with analogue drawing or produced by the designer from top to bottom, *vital form* represents a bottom-up, autonomous state formed by the influence of actors involved in design or production. Subsequently, the relationships, transitions, interactions, and changes between *form* and *vital form*, as well as their interpretations, are discussed within the proposed model in the study, based on conceptual sets derived from theoretical debates and the implications in design and making processes. It is believed that such exploration and awareness of form in architecture will bring new dimensions to the contemporary understanding, design, and making practices of form.

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Keywords: Architectural Form, Form, Form Design, Form Making/ Production, Vital Form.

Mimari Formun Evrim Anlatısı ve *Canlı Form* Hali

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Mimarlık tasarımında *form* kavramı, tarih öncesi dönemlerden beri tartışılmaktadır. En yalın haliyle, *form*, yapının şekli, kabuğu, içinde yaşanan hacim olarak ifade edilebilir. Çalışmada hedeflenen, tarihsel süreçteki formun değişimini ve evrimini analiz ederek yeni anlamlarını ve potansiyellerini keşfedebilmek ve form üzerine eleştirel bir bakış açısı geliştirebilmektir. Bu hedef doğrultusunda çalışma üç ana eksen üzerinde kurgulanmıştır. İlk aşamada, tarihsel süreçte formun evrimini analiz etmek için tasarlanmış bir haritalama yer almaktadır. Bu haritalama ile kronolojik olarak, formun ele alınış biçimindeki değişimler, form tasarım ve üretim tekniklerine odaklanılarak tartışılmaktadır. Bu aşama ile, formun artık sadece çizimlerle temsil edilen ya da statik olarak üretilen nihai bir ürün olmadığı, aksine zaman-mekânsal bir düzlemde, tasarımında ya da üretiminde süreç ve dinamizm içeren bir kavram olduğu anlaşılmaktadır. İkinci aşamada ise, formun evrimi *'canlı form' (vital form)* olarak ifade edilen yeni bir kavram üzerinden tartışılmaktadır. *Form* ve *canlı form* karşılaştırmasında, *form*, statik veya durağanı temsil ederken, *canlı form*, dinamik ve devingen bir hal tarif etmektedir. *Form*, tasarımcı tarafından çizim ile sembolik olarak tasarlanan veya yukarıdan aşağıya oluşturulan bir hal ifade ederken, *canlı form*, tasarım veya üretimine etkide bulunan aktörlerin etkisiyle aşağıdan yukarıya oluşan, otonom olan bir hal ifade etmektedir. Ardından, çalışma kapsamında önerilen model üzerinde, *form* ve *canlı form* arasındaki ilişkiler, geçişler, etkileşimler, değişimler; kuramsal tartışmalardan elde edilen kavram setleri ve üretim, tasarım süreçlerindeki açılımları birlikte ele alınmakta ve yorumlanmaktadır. Mimarlıkta forma ilişkin böyle bir okumanın, farkındalığın, günümüz form kavrayışına, tasarlama ve üretme pratiklerine yeni açılımlar getireceğine inanılmaktadır.

Anahtar Kelimeler: Mimari Form, Form, Form Tasarımı, Form Üretimi, Canlı Form.

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1. INTRODUCTION

The concept of form in architecture has been evolving and transforming with new meanings since the early debates in the field. The aim of this study can be described as investigating the approach to form throughout its historical process and exploring its potential avenues. This purpose and exploration are rooted in *critical theory* which seeks to examine the logic and foundations of events and ideas, aiming to ask questions rather than provide answers (Raymond, 1981; Rendell, 2008). The goal is to develop a critical perspective on form within this context.

In the study, research on the form is conducted through the lens of *form design* and the *making* processes. This is because it is believed that changes in the conceptual understanding of *form* shape its *design* and *making* practices, and similarly, *form design* and *making* processes also transform *form*. This dual relationship can be examined through the *Sapir-Whorf hypothesis* (Terzidis, 2005; Kay & Kempton, 1984).

Exploring the form concept can be beneficial in defining the scope and limitations of the article:

"Form in everything and anything, everywhere and at every instant. According to their nature, and their function, some forms are definite, some indefinite; some are nebulous, others concrete and sharp; some symmetrical, others purely rhythmical. Some are abstract, others material. Some appeal to the eye, some to the ear, some to the touch, some to the sense of smell… But all, without fail, stand for relationships between the immaterial and the material, between the subjective and the objective -between the infinite spirit and the finite mind…" (Sullivan, 1947).

To understand the concept of form, it can be examined Sullivan's (1947) descriptions using abstract and material planes to express, and Forty's (2004) definition as the representation of massed solidity or the void in its negation or the representation of space. Alternatively, another approach to consider is the description of architectural design as the act of giving form to three-dimensional objects to serve as an external shell and create an inhabitable space within. In this perspective, form is expressed as a boundary that defines the structure and space (Williams, 2022).

Considering such discussions, in the study, *form* can be defined as a shell that constructs space or a building envelope that physically encloses the void. And *form design* and form making/ producing refer to the tools, processes, methods, and practices through which the designer's idea of form is transformed into a design product, where the idea is materialized as physical or digital through techniques such as drawing, modeling, and fabrication.

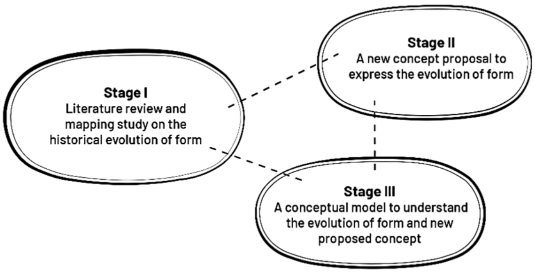


Figure 1: The stages of the study, adapted from (Author, 2023).

The study is structured around three main axes in order to bring a critical perspective on form (Figure 1). The first stage involves a mapping where information is gathered through literature research. It focuses on the changes in the approach to *form, design, and making* techniques in the historical process. In the second stage, a new concept called *vital form* is proposed to express the transformation and evolution of form. In the last part, there is a conceptual model that aims to comprehend *vital form* concept through a comparison with *form*.

2. THE EVOLUTION NARRATIVE OF *FORM*

A mapping is carried out within the scope of the study to examine the changes in form throughout the historical process in relation to events, phenomena, theories, approaches. It has been constructed in chronological order, based on main headings, to highlight the paradigm shifts where form undergoes fundamental changes in meaning and acquires new significances. The narrative can be followed on the mapping in Figure 2 which created by the four main headings as *The*

Origin of Form[1]*, Form in the Analog Era, Form in the Digital Era,* and *Form in the Millennium.*

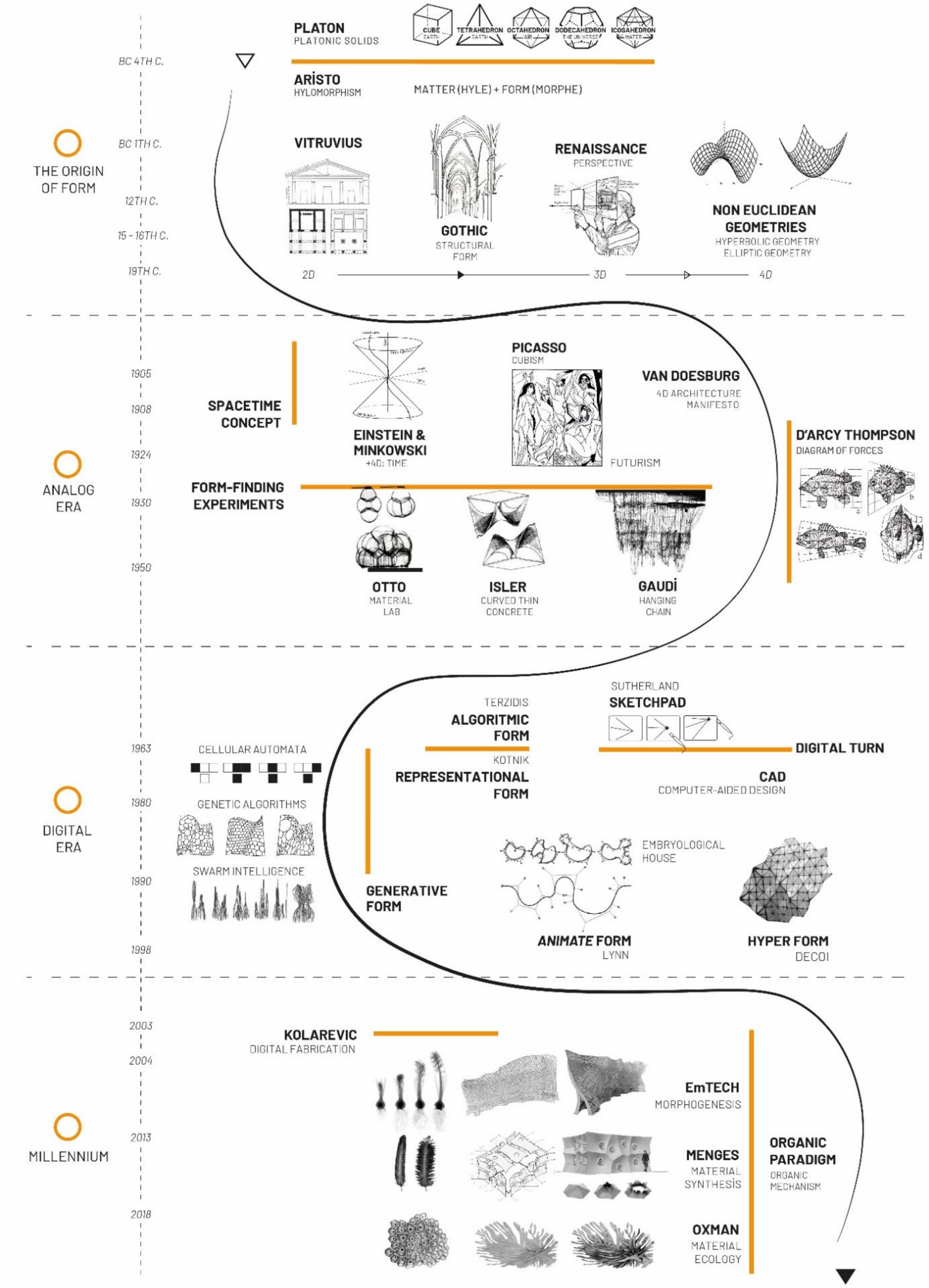
The first one, *The Origin of Form* (Figure 2)*,* which corresponds to the period from ancient times to the beginning of the 20th century, focuses on establishing a common understanding of form and exploring its origins, and initial approaches.

The narrative begins with the dialectic between Plato and Aristotle. Plato explains the universe using the symbolic and solid geometries called *Five Platonic Solids* (Plato, 4th century BC/2022; Forty, 2004; Dehovitz, 2016). On the other hand, Aristotle, presents the theory of *hylomorphism*, stating that form is shaped by matter, and they both arise from their inherent carriers (Aristotle, 4th century BC/2019; 4th century BC/2020; Forty, 2004). While Plato's form is static and represents fixed geometries in a top-down system, Aristotle's form is dynamic and emerges from generative minds in a bottom-up approach. This dialectic between representation and generative one provides a foundation of the study.

After this dualism, understanding Vitruvius would be helpful to analyzing form concept in ancient architecture.

Figure 2 (next page):
The mapping designed to follow the evolution narrative of form, adapted from (Author, 2023).

[1] The title is derived from Darwin's (1859/2012) book "The Origin of Species," where he explains the theory of *evolution*.


PLATON
PLATONIC SOLIDS
CUBE
TETRAHEDRON
OCTAHEDRON
DODECAHEDRON
ICOSAHEDRON
BC 4TH C.
ARİSTO
HYLOMORPHISM
MATTER (HYLE) + FORM (MORPHE)
THE ORIGIN OF FORM
BC 1TH C.
12TH C.
15 - 16TH C.
19TH C.
VITRUVIUS
GOTHIC
STRUCTURAL FORM
RENAISSANCE
PERSPECTIVE
NON EUCLIDEAN GEOMETRIES
HYPERBOLIC GEOMETRY
ELLIPTIC GEOMETRY
2D
3D
4D
ANALOG ERA
1905
1908
1924
1930
1950
SPACETIME CONCEPT
EINSTEIN & MINKOWSKI
+4D: TIME
PICASSO
CUBISM
VAN DOESBURG
4D ARCHITECTURE MANIFESTO
FUTURISM
D'ARCY THOMPSON
DIAGRAM OF FORCES
FORM-FINDING EXPERIMENTS
OTTO
MATERIAL LAB
ISLER
CURVED THIN CONCRETE
GAUDİ
HANGING CHAIN
DIGITAL ERA
1963
1980
1990
1998
CELLULAR AUTOMATA
GENETIC ALGORITHMS
SWARM INTELLIGENCE
TERZIDIS
ALGORITMIC FORM
KOTNIK
REPRESENTATIONAL FORM
GENERATIVE FORM
SUTHERLAND
SKETCHPAD
DIGITAL TURN
CAD
COMPUTER-AIDED DESIGN
EMBRYOLOGICAL HOUSE
ANIMATE FORM
LYNN
HYPER FORM
DECOI
MILLENNIUM
2003
2004
2013
2018
KOLAREVIC
DIGITAL FABRICATION
EmTECH
MORPHOGENESIS
MENGES
MATERIAL SYNTHESİS
OXMAN
MATERIAL ECOLOGY
ORGANIC PARADIGM
ORGANIC MECHANISM

Vitruvius formulates form by establishing specific parameters and verbal equations among various elements such as plan size, column height, column thickness, and intercolumnar spacing (Vitruvius, 1st century BC/1990). Design relies on parameters, but form is generated using specific, fixed geometries and drawing-based techniques. This approach implies that form in ancient examples is visually represented.

Figure 3: Different rib vault structures (Siegel, 1962).

In the Gothic period, it can be observed that form acquires another meaning in conjunction with *structural form*. *Structural form* is an approach where form and the structural system are designed and calculated together (Siegel, 1962). Figure 3 illustrates three examples of rib vault structures. The first example, which is an extension of the structural system, is referred to as a *structural form*. The other two examples are considered *decorative forms* since they lack structural considerations. (Siegel, 1962). Form in conjunction with *structural form* is designed and produced to serve a kind of performance for the structure beyond being representational with simple geometries.

When examining the Renaissance period, a significant change can be observed in the difference between *form design and making*. The discovery of perspective and new three-dimensional drawing techniques provided architects with a new avenue to convey their designs to those responsible for the making process, even without being present at the construction site (Roth, 1993). This development led to the widespread use of drawing as a method for form design, which continued for a considerable period after the Renaissance (Menges, 2015).

These new drawing techniques are examined under the title of *Euclidean geometries* and new quests' existence in the 19th century are expressed that surpass these *dead geometries* (Evans, 1995). The fundamental change at this point can be considered as overcoming planarity and parallelism, which can be examined under the title of *non-Euclidean geometries* like *hyperbolic* and *elliptic geometries* (Figure 4) (Henderson, 1983; Faculdade De Ciências Universidade De Lisboa, 2017). *Euclidean geometry* and solid Platonic shapes, which have been used in architecture since ancient times, are being surpassed, and new forms are emerging, that go beyond the concept of three dimension. These searches also lay the groundwork for the concept of *space-time*, which will be detailed in the next part of the narrative (Giedion, 1941; Frampton, 1995; Kolarevic, 2003).

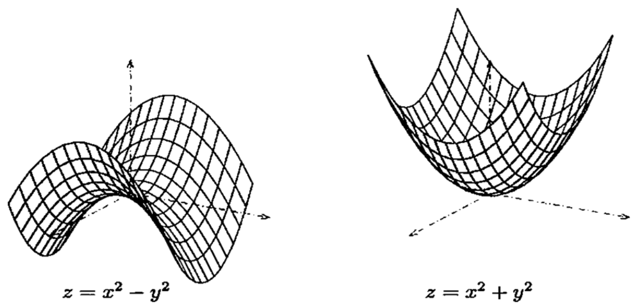


Figure 4: *Hyperbolic* and *elliptic geometries,* adapted from (Wikipedia, 2015).

Under the second heading, *The Form in the Analog Area* (Figure 2), which corresponds to the first half of the twentieth century, the effects of the paradigm shift caused by the concept of *space-time* on form are examined. Giedion (1941) describes this change as a new era where the static is demolished, and the dynamic is sought.

In the initial stage, it can be useful to examine the early periods of this concept. Einstein articulates the concept of *space-time* in his *Theory of Relativity* (Miller, 2001). The inclusion of time (t) as the fourth dimension, in addition to the three spatial ones (x, y, z), indicates that the discussion is not only about spatial but also about spatiotemporal dimension (Bakırcı et al., 2022). On the other hand, Picasso, regarded as the beginning of *Cubism*, also demonstrates the discussion of space-time with 'The Young Ladies of Avignon' (Giedion, 1941; Miller, 2001). He surpasses the three-dimensional perspective by incorporating the simultaneous and relative representation of various time frames

(Figure 5) (Miller, 2001). Later, *Futurist* artist explored this concept as a representation of movement and dynamism in art (Figure 6) (Giedion, 1941). In the same periods Doesburg (1924) published his manifesto which calls for four-dimensional *space-time* aspects in architecture shaped by *non-Euclidean mathematics.* It signifies the beginning of a new era in the architectural form (Burry, 2016).

Figure 5: The Young Ladies of Avignon, adapted from (WikiArt, 2020).

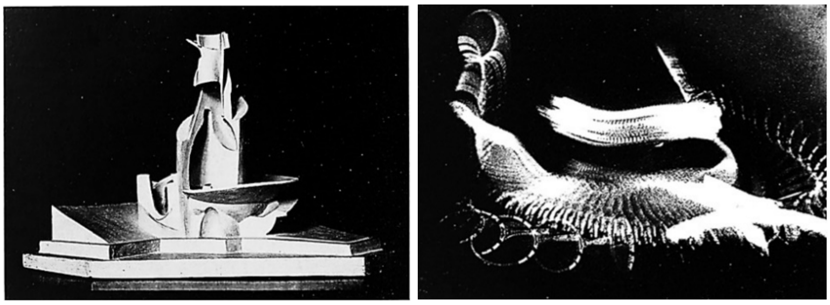


Figure 6: Boccioni's development of bottle in space (left), Edgerton's high-speed photography (right), (Giedion, 1941)

To further explore the topic, it may be useful to examine Thompson's (1917/1945) form analysis with the *diagrams of forces*. He focuses on the formation of form under the influence of physical forces and explores transformations of different species' forms (Figure 7). This approach emphasizes form's ability to evolve, grow, develop, and change over time through a continuous process.

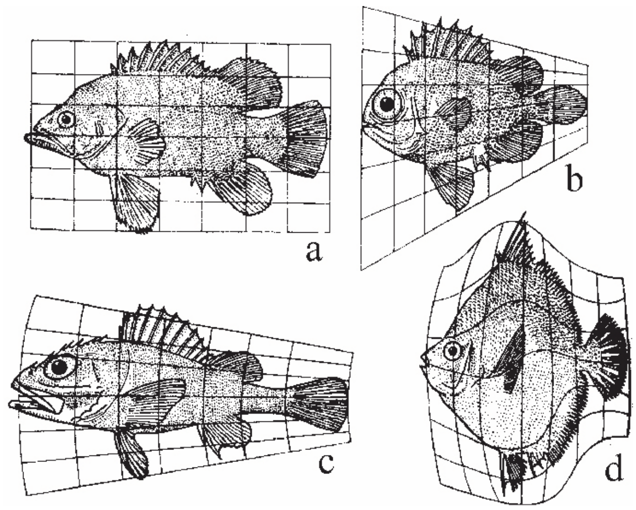


Figure 7: Thompson's (1917/1945) form analyses.

Thompson's studies contribute to the concept of *form-finding* being discussed in the ongoing narrative (Goldsmith, 2014). *Form-finding* can be described as a method where the form is designed, calculated, and optimized in accordance with the forces that shape it (Lewis, 2003). With this technique, form transcends its static state as a two-dimensional or three-dimensional product drawn on paper or created in physical models, and it becomes a process-driven entity existing in four dimensions under the influence of environmental forces. For example, Antonio Gaudi, designed his projects through dynamic *models* and experiments based on *material computation* (Burry & Burry, 2010;

Claypool, 2017). He created various *analog models* where forms were shaped and structurally optimized under the influence of gravity by *hanging chains* and *sandbags* (Figure 8).

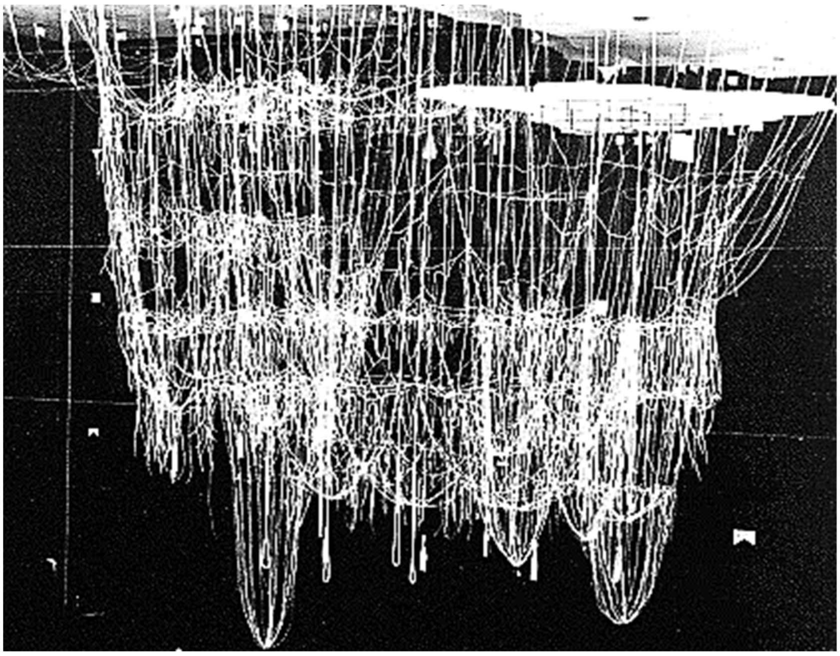


Figure 8: Gaudi, *hanging chain* model (Burry et al., 2005).

Similarly, Heinz Isler focused on thin, curved concrete shell forms that achieved high strength while utilizing minimum material (Chilton & Isler, 2000; Kloft, 2011). He describes his design process not as 'creating form' but rather as 'allowing the form to emerge according to its own internal dynamics' (Billington, 2003). In another example, Frei Otto, created an extensive material laboratory for *form-finding* experiments (Otto & Rach, 1995). In this laboratory, he conducted various experiments including *soap film experiments* based on the principle of minimum surface area (Figure 9), *pneumatic models*, *plaster bandage models*, *hanging chain networks*, sand pile models, and *thread models* (Drew, 1976; Otto & Rach, 1995; Frei Otto Film, 2017). In Otto's experiments, it is observed that after achieving the internal balance and optimization of the form, digital systems are employed to test and improve the structure (Glaeser, 1972; Boller & Schwartz, 2020). These processes can be considered as a precursor to the transition from the analog era, which is being examined in this heading, to the digital era.

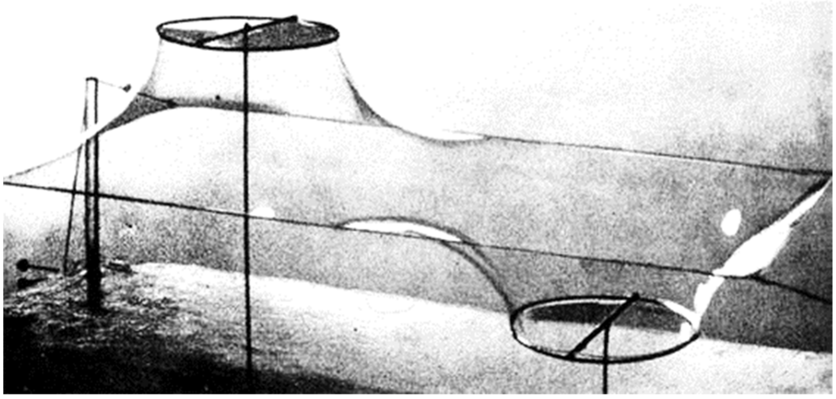


Figure 9: Soap film experiments (Otto & Rach, 1995).

In the third heading, *Form in the Digital Era* (Figure 2), which pertains to the latter half of the 20th century, the effects of the *digital turn* (Carpo, 2013) are examined in relation to form. This paradigm shift occurred with the integration of computer technologies and *computation* into the design process.

With the recognition of computer-aided design (CAD) in 1960 (Llach, 2015), new kind of tools emerged in the design process. Ivan Sutherland's *Sketchpad* is considered the first design tool that allows drawing on a computer screen with a *light pen* and incorporates parametric relationships (AA School Of Architecture, 2010; Tedeschi, 2014). With Sketchpad, it can be observed that the static and immutable straight lines previously used in form design are evolving into dynamic lines that consider parametric relationships (Figure 10).

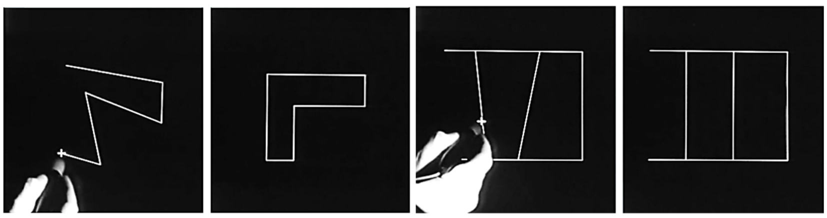


Figure 10: Drawing at Sketchpad (Morphocode, 2020).

Due to significant later developments such as the emergence of AutoCAD in the 1980s, architects were able to create two-dimensional drawings digitally, replacing traditional pen and paper with the use of a mouse and computer screen (Tedeschi, 2014). Similar to the discovery of *perspective* at Renaissance, the shift from two dimensions to three dimensions in the digital realm can be examined through software such as CATIA, which enables three-dimensional modeling (Team D3, 2016).

CATIA and AutoCAD, unlike Sketchpad, are considered static drawing tools due to their lack of parametric relationships. This limits designers' control over lines on the screen and restricts their freedom in the digital environment during this period (Terzidis, 2005). The suggested solution is the use of *algorithms* that allow direct intervention on the digital screen through *scripting* instead of predefined buttons with fixed functions (Tedeschi, 2014). *Algorithms* are defined as a process with a finite number of steps. The era of designing forms with a pen or mouse is being replaced by designing forms with codes and words (Tedeschi, 2014).

Terzidis (2005) discusses the shift from representing forms through three-dimensional solid modeling tools to designing the process of formation through planned steps in *algorithmic form* generation. To understand this shift, Kotnik's (2010) conceptual model can be examined which classified design programs under three main categories: *representational, parametric,* and *algorithmic*. The transition from a model where geometry of form is directly represented to a model where the functional definition of form is designed signifies the overcoming of the *digital threshold* between these categories (Kotnik, 2010).

During this period, it seems that another design approach is discussed on literature as *generative design*. It disrupts predictable form-representation relationships by utilizing computationally generated complexities, providing new design possibilities (Agkathidis, 2015; Singh & Gu, 2012; Abrishami et al., 2014; Çağdaş, 2021). Form goes beyond geometric models and gains a generative meaning by autonomously reproducing itself through rule sets, even exhibiting self-design capabilities (Figure 11).

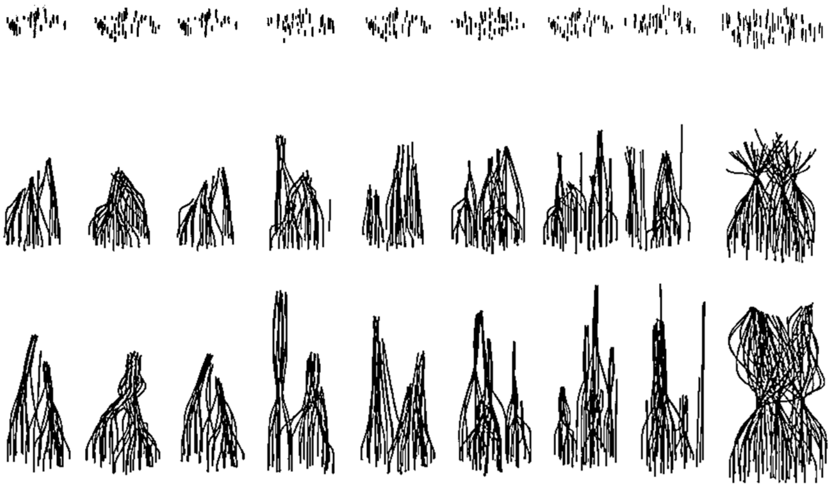


Figure 11: Form generation by agent-based modelling, adapted from (Chen, 2016).

To understand the impact of the *digital turn* on architectural form, it is beneficial to examine its manifestations in the field of architecture. Lynn (2005) suggests that designers no longer rely on simple geometric patterns like squares, circles, and rectangles as a starting point. Instead, with the aid of computer technologies, form has evolved into a fluid, dynamic, continuous state as described by Lynn's *animate form* (Lynn, 1999). The 'Embryological House' project, depicted in Figure 12, exemplifies this principle with its various variations (Lynn & Rappolt, 2008).

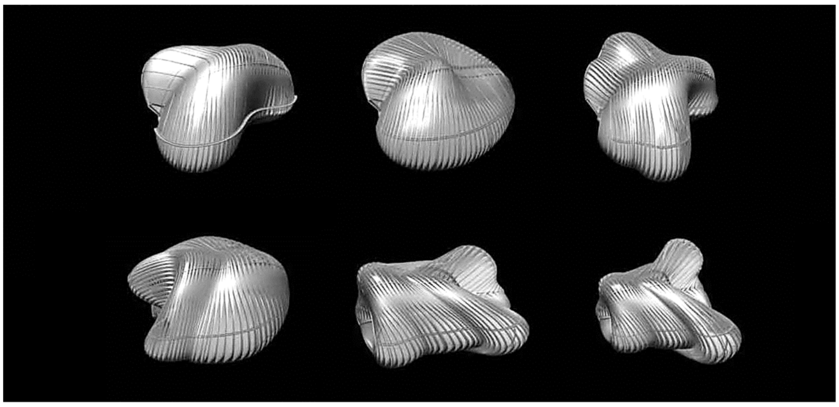


Figure 12: Embryological House project, adapted from (SFMOMA, 2002).

In dynamic form designs based on curvature, various drawing tools such as *splines* that utilize *control points* are employed (CCAchannel, 2012). Notably, there is a resemblance between Lynn's curves shaped through *control points* and Gaudi's *hanging chain* model mechanism, as depicted in **Figure 13**. This similarity holds the potential to bridge discussions conducted in both the analog and digital eras, leading to a shared understanding.

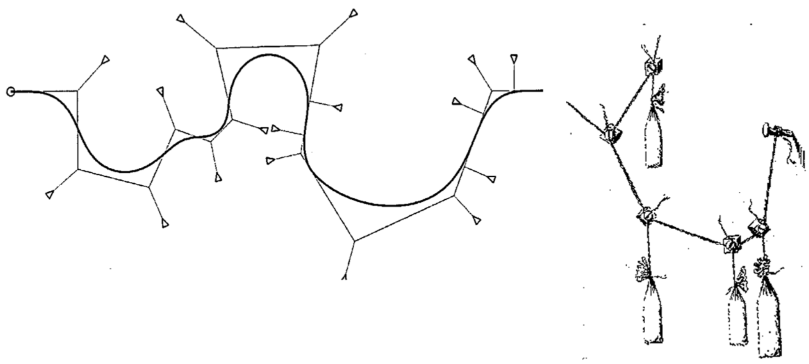


Figure 13: (left) Lynn's (1999) *splines*, (right) Gaudi's hanging model (Lazaro, 2017).

Examining the works of dECOi, during a similar period to Lynn, can contribute to the integration of different approaches. Mark Goulthorpe, the founder of dECOi, introduces the concept of *alloplastic* to describe their design approach, which emphasizes processes that evolve interactively in relation to the environment (Goulthorpe, 2009; Burry, 2012). For instance, the 'Aegis Hyposurface' project represents a four-dimensional animated wall that continuously interacts with light, sound, and motion in the physical environment (**Figure 14**) (Burry & Burry, 2010; Burry, 2011). Through dECOi, a new *hyper-form* approach emerges, capable of being shaped by environmental forces in real-time within the physical environment (Goulthorpe, 2009).

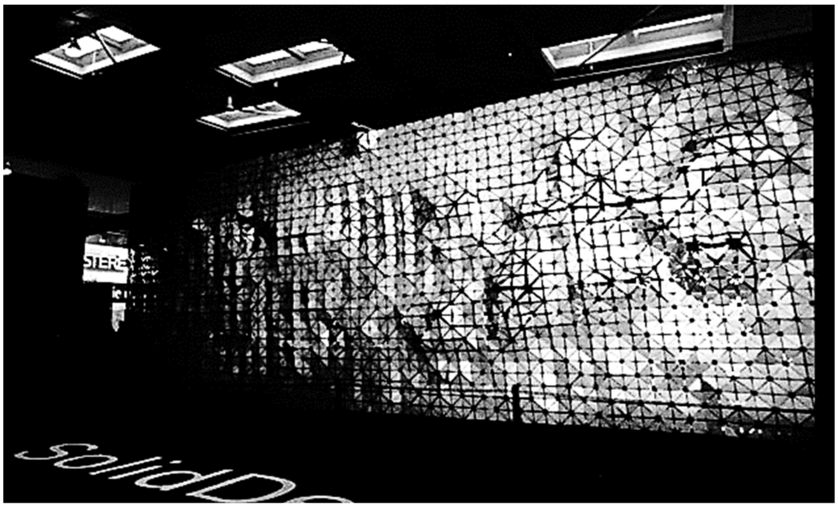


Figure 14: Aegis Hyposurface, (Burry, 2012).

Lynn emphasizes the difference between his pursuit of *animate form* the digital realm and Goulthorpe's exploration of *hyper-form* that extends into the physical environment (Melbourne School of Design, 2017). This distinction leads to the next heading, where form is designed and created collaboratively in both the digital and physical realms, merging the narrative of form evolution.

The last title, *Form in the Millenium* (Figure 2), encompasses the first quarter of the twenty-first century, the effects of the paradigm shift resulting from the development of fabrication technologies (Oxman, 2009; Demir, 2020) are explored in relation to form.

Kolarevic (2003) emphasizes the reduction of distance between design and production through the direct transfer of design information in the fabrication equipment (Scheurer et al., 2005; Bayram et al., 2023). To understand the design approaches of this era, it is helpful to consider the emerging *organic paradigm*. Giedion (1948) suggests that new theorems in physics are leading to a transition from the mechanical realm to the organic one, as described by Whitehead's (1920/2017) *organic mechanism* approach (Giedion, 1948; Molella, 2002). Oxman (2015) also highlights this shift from *the age of the machine* to *the age of life*. These concepts have become more evident in practice due to advancements in production technologies and the emergence of new design approaches in the 21st century.

To understand the impact of this transformation on form, it is of value to examine the pioneering figures of the era. EmTech, for instance, approaches form through *morphogenesis*, viewing it as a dynamic entity that can grow, evolve, and adapt (Hensel et al., 2004). Their design approaches are not defined by traditional categories such as *form*, *material*, or *structure*, but rather by a *holistic model* that emerges from their combination. The 'Honeycomb' project is an example where form, material, and structure are explored through genetic algorithms, shaping a honeycomb in the digital, and produced at 1:1 scale in the physical realm (Figure 15) (Hensel et al., 2010).

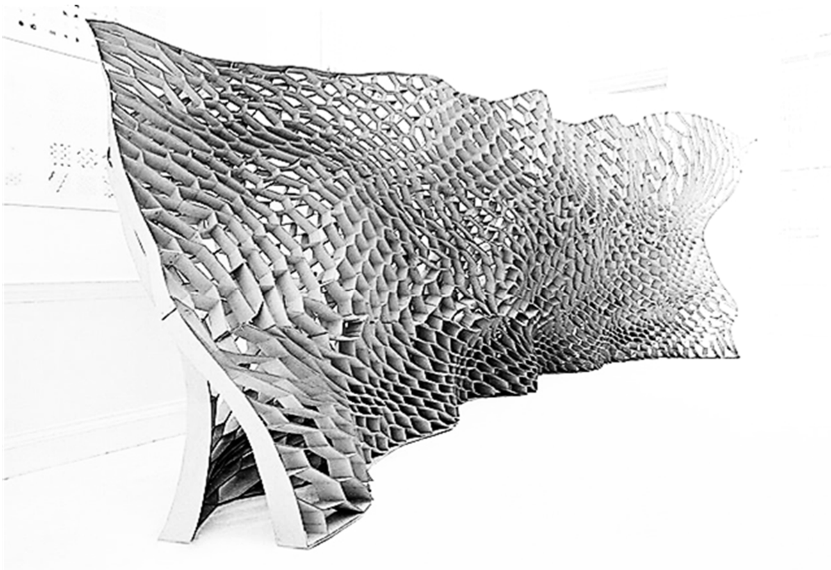


Figure 15: Honeycomb project, (Kudless, n.d.).

In another example, Achim Menges (2012) criticizes the previous era's tendency to produce form exclusively in the digital realm, detached from materiality. He proposes an approach called *material synthesis*, which seeks to intertwine the physical world with digital computational methods (Menges, 2015). For instance, his 'Hygroskin' project, a system is designed using wood that responds to its environment, closing in humid and rainy weather and opening in sunny and dry conditions (Figure 16). These systems, capable of movement without a motor, can be discussed within the theme of *material as a machine* (Menges, 2015). The ability of the form to self-formation in physical realm brings the narrative of form evolution to a stage where organic vitality is being explored.

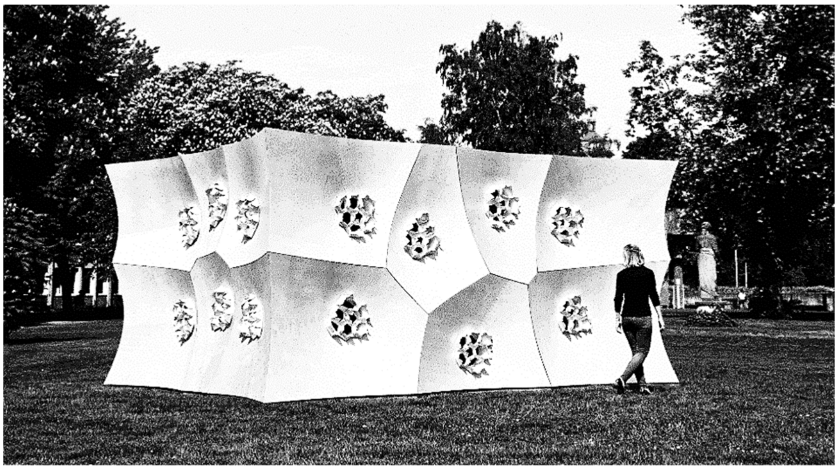


Figure 16: Hygroskin project, (Hensel et al., 2010).

To delve deeper into the discussions, Neri Oxman's approach of *material ecology* can be analyzed. She aims to establish deeper relationships between design and the environment through computational design, digital fabrication, and material behavior (Oxman, 2012; 2015). In 'Living Hybrid Materials' project, forms that respond and adapt to their surroundings are designed and produced using 3D printers (Bader et al., 2016; Smith et al., 2020). Figure 17 showcases the self-formation process of a leaf-like hybrid material. In addition to Menges' *material synthesis*, *material ecology* shows that materials are programmed and fabricated from scratch.

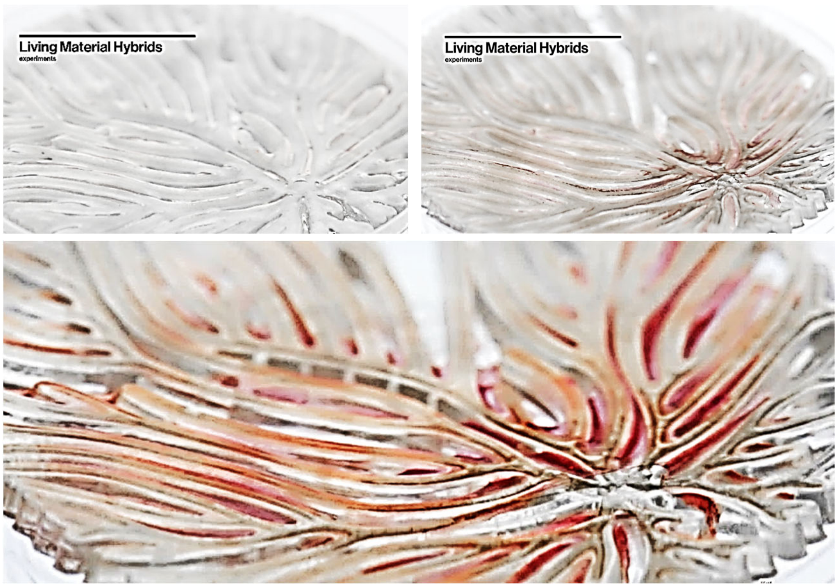


Figure 17: Living Hybrid Materials, (Oxman, n.d).

The narrative of form evolution, driven by factors like events, phenomena, concepts, theories, evolving technologies, and techniques, can be further continued through various ongoing research. As the narrative unfolds, it becomes clear that forms, once designed symbolically and produced statically, now possess a more dynamic and generative nature, imbued with new meanings. This newfound meaning and the state of exploration will be discussed in detail in the subsequent section of the study.

3. THE STATE OF *VITAL FORM*

In the study, a new concept is proposed under the title of *'vital*[2] *form'* to understand, discuss, and critically examine the new characteristics of form which discussed in the first part.

First of all, to comprehend this new concept, it is necessary to understand the state of *being vital / alive / living:*

Alexander (2002) states, "All space and matter, organic or inorganic, has some degree of life in it, and that matter/space is more *alive* or less *alive* according to its structure and arrangement." This idea aligns with DeLanda's (1992) concept of *having life* as self-organizing, dynamic, and interactive systems beyond the individual organism. Likewise, Deleuze (1969/1995) emphasizes the continuous flow, movement, differentiation, and creative power associated with *being alive*. In addition to these, the theory of *autopoiesis* describes *living beings* as self-renewing, autonomous, and dynamic entities characterized by continuous change (Varela et al., 1974). According to these approaches, the state of *being vital* can be defined through subcategories such as being dynamic, generative, autonomous, and interactive.

After analyzing the concept conveyed by the state of *being vital / alive / living*, the focus can be directed towards what *vital form* signifies:

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[2] *Vital* as a word can be seen in various discussions, such as Giedion's (1941) space and time, Bergson's (1911/1944) élan vital, Tange's *metabolism* and *vitality* approach (Tolunay Berber & Özkar, 2020) and more. The choice of this word to convey the intended meaning has been informed by these usages.

Vital form is introduced to engage in a discussion that aligns with the new positions acquired by the form throughout the narrative and the emergence of its new states. It criticizes the state where form is designed symbolically or made statically. If *form* represents the expression of a spatial volume, then *vital form* can be described as a spatiotemporal dimension and includes a notion of process. *Vital form* can be understood as the state that emerges when the *form* is considered at the spatiotemporal level, involving all four dimensions. It is concerned with the process of *formation* rather than the final and static state of *form*. Within the literature, the discussions focus on the concept of '*becoming'* rather than just '*being'* (Deleuze, 1969/1995) and '*formation'* rather than just '*form'* (Oxman, 2006; Alaçam, 2019).

In alignment with the characteristics described in the state of being vital, *vital form* can be expressed through being dynamic, generative, autonomous, and interactive:

- *Being dynamic: Vital form* transcends the spatial boundaries of the three dimensions and explores the possibilities of the fourth dimension, which involves the spatiotemporal dimension and allows for a process-oriented existence.
- *Being generative: Vital form* is created through a bottom-up model rather than a top-down representation, allowing for generative potential.
- *Being autonomous: Vital form* shows self-organization and self-formation and emerges presenting unexpected outputs by resembling the intelligence of the human designer.
- *Being interactive: Vital form* can reshape itself in response to environmental stimuli and being sensitive to the given external data in the physical environment.

Vital form serves as a comprehensive framework that integrates theories underlying this concept within the narrative. It can be juxtaposed with existing approaches in the narrative of form evolution, allowing for an interpretation of their interconnections and elucidating its significance. It is crucial in differentiating *vital form* from other form-related definitions and comprehending its contributions to the field. In

Figure 18, the relationship between the *vital form* and other related form definitons can be observed:

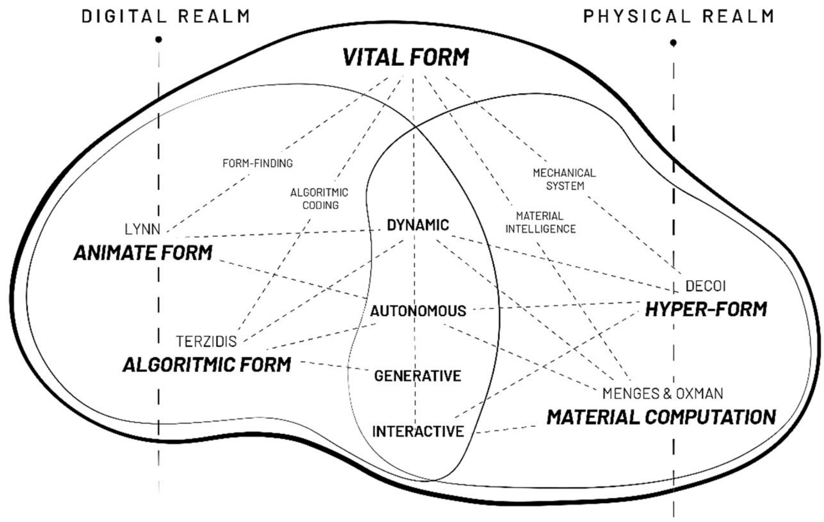

Figure 18: The relations *between vital form* and other form-related concepts defined within the narrative, adapted from (Author, 2023).

For example, in the digital realm, the relationship between Terzidis' *algorithmic form* and Lynn's *animate form* can be explored within the context of *vital form*. Briefly stated, a*nimate form* is defined as a state that emerges through various processes of digital form-finding (Lynn, 1999), while *algorithmic form* refers to a bottom-up state constructed through algorithms in the digital realm (Terzidis, 2005). Picon (2010) highlights the distinction between these two definitions by suggesting that *algorithmic form* goes beyond mere animation and implies a state of *being alive*. Consequently, *animate form* can be associated with qualities of vital form such as *dynamism* and *autonomy*, while *algorithmic form* can be linked to attributes such as *dynamism*, *generativity*, and *autonomy*.

On the other hand, in the physical realm, the relationship between dECOi's *hyper-form* and Menges and Oxman's material computation-based form approaches can be explored within the context of *vital form*. Shortly, the *hyper-form* refers to a state created interactively through mechanical systems (dECOi Architects, 2000), while the other involve a state generated interactively based on material intelligence (Menges, 2012; Oxman, 2012). Soulaf (2019) emphasizes the distinction between these two situations, offering an example where one system relies on electrical and mechanical components, while the other is dynamic and interactive due to its inherent material properties. As a result, both approaches can be associated *vital form's* dynamism, autonomy, and interactivity.

While the concepts/approaches described in the narrative represent singular and specific instances, the concept of *vital form* aims to encompass both the digital and physical realms with a holistic approach. In the next section of the research, the meaning of *vital form* is discussed in more detail, using a more comprehensive model to explore its distinctions from *form*.

4. A CONCEPTUAL MODEL TO COMPREHEND *VITAL FORM*

To better articulate the *vital form* and to analyze its difference from *form*, a conceptual model is generated through the *deconstruction*[3] of the evolution narrative of form, which is constructed on the first chapter linearly by following the chronological order.

The narrative of form evolution explores the changes in form within a historical context, examining the practices of design and making. However, it does not distinguish between the design and making stages. During the *deconstruction* of the narrative on this part, a dialectic between *form design* and *form making* emerges when analyzing *form* and *vital form*. In order to compare and understand the states of *form* and *vital form* in these two completely different phases, it is necessary to first accurately distinguish these phases.

Examining the various approaches of thinkers from different centuries can enrich this discussion:

While Aristotle (4th century BC/2019) discusses *potentiality* and *actuality*, Alberti (15th century/1988) talks about *lineament* and *structure* (Tan & Paker, 2018; Roth, 1993; Forty, 2004), and Deleuze (1977/2007; 1969/1995) presents *virtual* and *actual* terms (Deleuze & Guattari, 1980/1987; Sönmez, 2020). The first concept addressed by these three thinkers —*potentiality*, *lineament*, or *virtual*—refers to a

[3] The concept of *deconstruction* is used to analyze through the parts, disrupting the integrity of the structure (Derrida, 1967/2001).

stage where something has not yet occurred in the physical world but has the potential to happen. This can be thought of as the *form design* in an immaterial environment. The second concept —*actuality*, *structure*, or *actual*—represents the realization of something in the physical world. It denotes the *form making* in a material environment.

Based on this theoretical framework, in the emerging model, *form* and *vital form* are separately addressed and compared in the *design* and *making* phases. And to facilitate a clean examination, the model has been designed as a matrix allowing for cross-referencing and comparison. The X-axis of matrix represents ***form*** and ***vital form*,** while the Y-axis represents the ***design*** and ***making phases***. Additionally, to facilitate this arrangement and group the pieces together, various subdivisions within the matrix are created through form design and making methods. For instance, distinctions such as analog or digital, two-dimensional or three-dimensional, and scaled or 1:1 scale, etc. Figure 19 illustrates the placement of events that are sequentially arranged in the narrative onto the matrix plane. Each deconstructed section of the narrative falls onto the matrix under its relevant title.

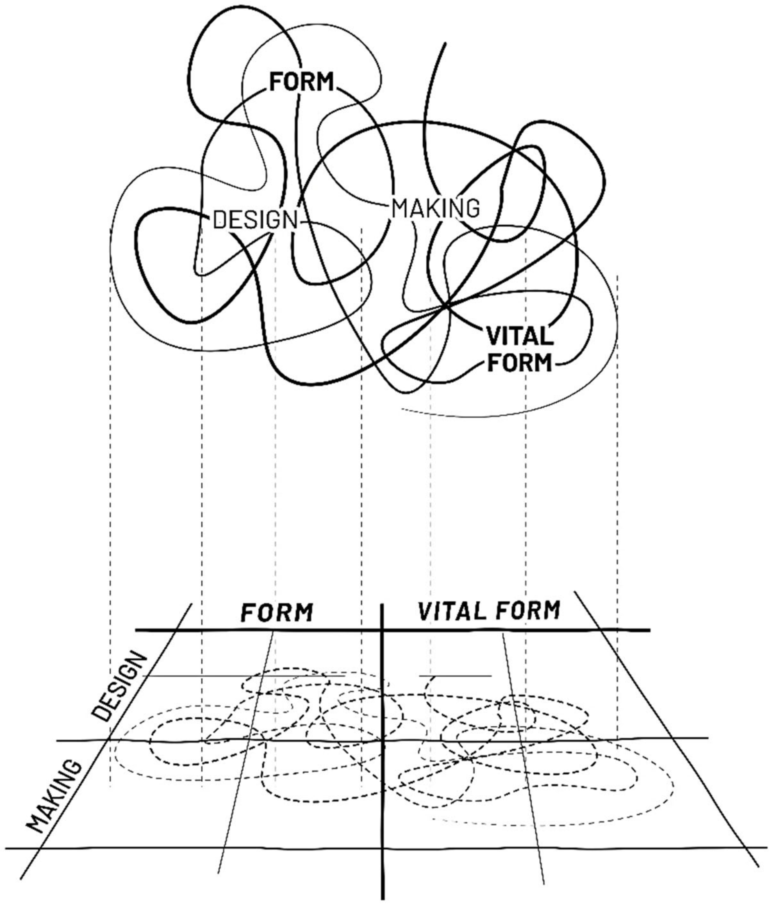

Figure 19: Deconstruction of the narrative on the matrix, adapted from *(*Author, 2023).

Figure 20 illustrates the placement of each theory/event/approach conveyed in the narrative of form evolution into the matrix that has been created to better understand the *vital form.*

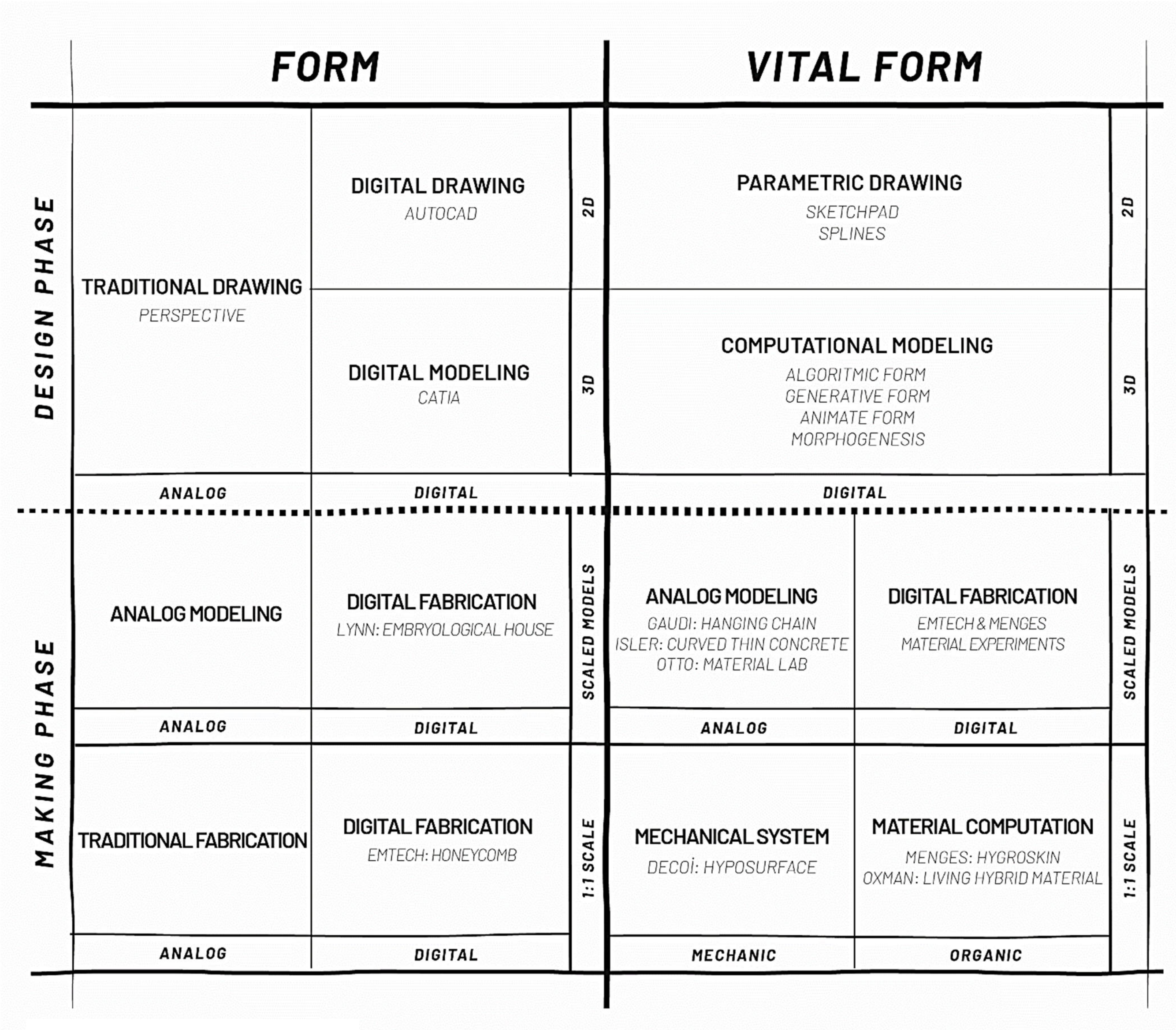

Figure 20: The conceptual model, adapted from (Author, 2023).

*S*ome of the cells of matrix can be examined briefly. For example, when examining through the ***design phase***:

In the ***form*** cell of the ***design phase,*** it can be observed that there is a subdivision under the title of ***analog*** and ***digital*** drawing methods. ***Digital*** drawing also subdivides into ***two-dimensional*** and ***three-dimensional.*** In the examples (such as *Perspective drawing, AutoCAD, CATIA*, etc.), the symbolic, representative, and static state of the form can be seen.

In the ***vital form*** cell of ***design phase***, examples (such as *Sketchpad,* Lynn's *Spline, Algorithmic Form, Generative Form, Animate Form, Morphogenesis*, etc.) exhibit the *dynamic*, *autonomous*, *interactive,* and *generative* state of the form.

When examining through the ***making phase***, it can be observed that cells subdivide into ***scaled models*** and ***1:1 scale:***

In the ***form*** cell of the ***making phase***, all examples (such as *Embryological House's* 3D printed model, *Honeycomb* project, etc.) show representational and static state of form which is produced according to the final form information.

In the ***form*** cell of the ***making phase***'s examples (such as Gaudi, Isler, Otto's *form-finding* experiments, EmTech, Menges' *material behavior* experiments, Hyposurface, Hygroskin, Living Hybrid Material, etc.), *dynamic*, *autonomous*, and *interactive* state of form can be seen during production or after production.

In a general assessment, when examining the examples, it is observed that the ***form*** cell contains examples where form is designed as representation or produced statically. On the other hand, the ***vital form*** cell examines *dynamic*, *generative*, *autonomous,* or *interactive* states, incorporating the parameter of time which vary depending on the specific case being examined.

In summary, through the analyzing of which events/theories/approaches are categorized as *form* and which ones as *vital form* within this conceptual model, the aim is to reinforce the understanding of the concept of *vital form*. In this study, the matrix is constructed solely within the framework of the narrative of form evolution. However, in the subsequent stages, the matrix can be further developed and enriched by incorporating theories, approaches, practices, and comparative readings that contribute to the discussions on *form* and *vital form.*

5. CONCLUSION

It is observed that the concept of *vital form,* which criticize symbolic and static state of form, has evolved with paradigm shifts, incorporating qualities like dynamism, autonomy, generativity, and interactivity. If read through the evolution narrative established in the initial stage of the study, in the Analog Era part, its definition was limited to *dynamism* and *autonomy*. However, it appears that in later the Digital and Millennium Era sections, its definition has expanded over time to include *generativity* and *interactivity*. It indicates that the concepts and definitions are open to development. Therefore, it is important to emphasize that evolution is ongoing, and both *form* and *vital form* continue to evolve.

The future scenarios of the study can explore the ongoing evolution of *vital form* and the emergence of alternative understandings. For example, Allen (1997) proposes a *field theory* that views architectural buildings as dynamic systems interconnected on a network. In this framework, form extends beyond the building envelope, inviting a holistic perspective. In this point, *vital form* can be open to discussion as a *vital space* that encompasses not only form but also all elements of architectural design. It can be defined as an environment intimately connected with its inhabitants, continuously evolving and responsive to their movements in real-time. It is not merely a surface, but a space that surrounds and swarm arounds the users. It can also be characterized as a generative entity that is constructed and deconstructed in a real time according to the user within it.

From another perspective, the future scenario discussions can be continued on *design* and *making* practices. To feed into this discussion, Kiesler's critique can be examined:

"If God had begun the creation of man with a footprint, a monster (of) all heels and toes would probably have grown up from it, not a man. He might have been without a head and arms, to say nothing of his internal structure. Fortunately, the creation proceeded otherwise, growing out of a nuclear conception." (Kiesler, 1949).

Introducing *vital form* within architectural design studios can enhance form investigations and foster innovation. For example, a kind of design tool can be developed to generate the praxis of *vital form* through practical application to explore and advance *form design and making processes*. It can foster a forward-thinking and innovative approach to form investigations, challenging conventional methods and opening new possibilities.

The ongoing discussions on future scenarios can further explore new inquiries and possibilities in form by utilizing various examples. The intention is not to provide definitive answers but to spark curiosity, inspire exploration, and encourage critical thinking about the future trajectories of form in architecture. This study which examines form as an evolving concept and introduces the concept of *vital form* as its ultimate state aims to create awareness, explore new potentials, and foster critical thinking about form in architectural design.

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Conflict of Interest Statement

The authors of the study declare that there is no financial or other substantive conflict of interest that could influence the results or interpretations of this work.

Author Contribution

The authors declare that they have contributed equally to the manuscript.

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A Correlation Study of Creativity in Speculative Architectural Drawings

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This study explores apriori computational benchmarks embed in architectural design processes that hybridise representations made of 2D and 3D drawings. The paper presents creative design experiments from an unconventional architectural design studio at graduate level that takes advantage of digital design methods taught in the course. In orthodox architectural studios where drawings are seen as means of blueprints, the processes of design ideation, abstraction and speculation remain in a nominal position. The research approach of this study lies in a 3-dimensional design thinking process that extends beyond the formal fixations of drawings onto the statements and reductions of unequivocal representational norms. The present work is conducted as part of the Digital Spontaneity which is one of the third- and fourth-years' architectural design studios given at Mardin Artuklu University, Department of Architecture. The paper introduces the pedagogical aspects of the Digital Spontaneity studio by informing about the design process that offers a methodological foundation. The methodology is illustrated through stages with 2D, 2.5D and 3D representations, including scalar, geometric, material transfigurations. The studio outcome is evaluated through a correlation diagram that relate the drawings in different stages to each other. The findings suggest that the correlative interpretation of computational processes during the design ideation process may include intuitive, reflective and retrospective synthesis. The research contributes to the novel understanding of the role of digital design tools and methods in the generation and emergence of design ideation as meaningful, conceptual, speculative representations directly related to buildable forms and spaces of architecture.

Keywords: Digital design, Correlation, Intuitive Design, Speculative Architectural Drawing.

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Spekülatif Mimari Çizimin Yaratıcılık Rolü Üzerine Bir Korelasyon İncelemesi

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Bu çalışmada dijital tasarım araçlarının yer aldığı keşfe dayalı temsil dili üretiminin, mimari nesne tanımlama gücü üzerinde durulmaktadır. Çalışmanın amacı nesneleşme sürecine giren mimari temsiller arasındaki korelasyonları bulmaktır. Mimari proje süreçlerindeki konvansiyonel pratiklerin maslahatçı yaklaşımları çizimi sadece bir temsil aracına ve görsel son ürün (blueprint) olma durumuna sınırlandırmaktadır. Bu araştırmada ele alınan çizimlerde ise fikirlerin gerçek nesnelere dönüşürken virtüel değerlerini kaybetmemeye zorlayarak tasarım sürecinin bir sınaması yapılmaktadır. Dijital tasarım süreçlerinin sayısal tabanlı yaklaşımları, tasarım ürününü çeşitlendirip ürettiği alternatiflerin bilgisini de tasarım alanına (design space) dahil eden ve dönüştüren şekliyle gelişmektedir. Gelişen bu metodolojik çeşitlilik içinde çizim nesnelerinin tanımlanması ve bu nesnelerin arasında kurulan ilişkilerin tasarıma dahil edilmesi, daha öznel bir varoluş süreci arayan mimari elemanların çelişki üreten temsildeki ve mekânsal gerçekliğini sorgular hale getirir. Bir taraftan çizim, değişken karakterli, çok yönlü, rastlantısal ve belirsiz öğeleriyle tasarım sürecinde ve sezgisel tasarımda etkili yönlerini ortaya koymaktadır. Bu bakımdan çizimin çalışmadaki vurgusu, tasarlamanın erken dönem pratiklerini de bütün sürece dahil ederek, çizimi sezgisel ve yaratıcı sıçrama yönelimleri üzerinden ele almaktadır. Diğer taraftan ise temsili oluşturan dijital materyal ve zihin arasındaki etkileşimli süreç; çizimi araştıran, kendi kaynaklarına yönelen ve kendini üreten yeni bir nesne olarak da düşünülebilir. Çalışmanın, ikircikli alana yaptığı katkı; çizim nesnesinin tanımını yapmak, tanımlı nesnenin tasarım sürecine dahil ettiği farklı değişkenleri belirlemek, değişken arasındaki belirsiz ve tanımlı korelasyonları doğrusal, doğrusal olmayan veya döngüsel şekliyle sezgisel süreçlerin çağrılmasına bağlıdır. Tasarım araştırmasının değerlendirilebilir ve kıyaslanabilir bir ölçeğinin oluşturulması için pozitif ve negatif ([-1,0]-[0,1]) korelasyonlar kullanılmıştır. Korelasyon değişkenleri sabit (sıfır [0]) kılan doygun durumlar, çizim nesnesinin ortam ve materyalini değiştirmeye dolayısıyla tasarımın sezgisel süreçte ilişkilerini değişikliklere zorlamaktadır. Atölyedeki tasarım süreçleri içerisinde eş zamanlı olarak üretimler; ölçekler arasında gidip gelerek bu yaklaşımını modelleme, görselleştirme, aktör(ler) ile ilişkilendirme ve hikayeleştirme amacıyla aramaya ve tanımlamaya çalışmıştır. Bu yaklaşım sürecinin gözlenmesi ve dokümantasyonu mimari proje atölyesinin deneysel gelişimiyle kayıt altına alınmıştır.

Anahtar Kelimeler: Dijital Tasarım, Korelasyon, Sezgisel Tasarım, Spekülatif Mimari Çizim.

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1. GİRİŞ (INTRODUCTION)

Dijital, parametrik, algoritmik ve hesaplamalı tasarım gibi mimarlık üretim biçimlerine dair paradigma dışı alanların keşfedilmesi proje stüdyolarının alışılagelmiş yöntemlerine yenilik ekler. Boyutlar arası geçişlerde kullanıldığında bu paradigma değiştirici yöntemler için de yeni temsil alanları doğurur. Akın'a (1986) göre "temsil, mimarlıkta tasarım süreci sırasında gerçek nesneler yerine geçen, tasarımcının yaratacağı yeni biçimleri bu yolla gerçekleştirdiği ve nesneleri ve süreci organize eden olgu olarak" tanımlanır. Kullanılan nesneler, temsil ettiklerinin ötesinde anlam fazlalıkları taşırlar. Bu anlam fazlalıklarının sebeplerinden bir tanesi kullanılan çizim yöntemlerinin kendi sınırları iken, diğeri ise temsilin üretildiği araçlardır.

Spekülatif mimari çizimin yeni temsilcilerinden Perry Kulper ve Bryan Cantley gibi isimlerin tasarım fikri üretimini bir yandan keşif aracı olarak kullandığı, bir yandan da eklemeli ve birikime dayalı klasik mimari çizim üretim pratikleri üzerine eleştirel düşünce denemelerini getirdiği özelliklerle donatır (Brown, 2022). Deneysel tasarım pratikleri yapan FORM: ULA araştırma grubunun çalışmaları bağlamında, "mimarlıkta onun temsili arasındaki tanımlanmamış alanı bulanıklaştırma girişiminde bulunur ve bu süreçte çizimin rolünü irdeler" şeklinde bir tanımlama mevcuttur (Cantley, 2014).

El çizimi, bilgisayar tabanlı çizimler ve maketlerin temsil ettiği fikirlerin gerçekliğini nesneleşme süreci içerisinde değerlendiren bu tip örnekler mimarlığın formalite icat eden tarafını özgün temsil dili üretiminde aramaktadırlar. Dijital tasarımı ilgilendiren tarafı ise araştırılmayı bekleyen bir alan olarak görünmektedir. Yalnız, dijital mimari tasarımın aktüel tartışmalarından biri olan parçacıl (discrete) ve sürekli parametrisizm perspektiflerinin kurduğu teorik tartışmalarla ilginç bağlar da kurulmaktadır.

Bu çalışmanın kapsamı Mardin Artuklu Üniversitesi, Mimarlık Bölümü'nde verilen mimari proje stüdyolarından olan Dijital Rastlantı atölyesinin üretimlerini ve yukarıda bahsedilen teorik yansımalarla kurmaya çalıştığı tartışma zeminini içermektedir. Burada, şunu açıklamak gerekir ki, spekülatif mimari çizimin temsilcilerinin aradığı bir nesnenin bir başka nesneye evrilmeye duyduğu Deleuze'e göre "arzu" açıklaması, parametrisist mimar Patrick Schumacher'in tartıştığı mimarlık nesnesinin sürekliliği ve kente yayılma isteği ile paralellik göstermektedir. Tam da nesneleri kendi üzerinden okumaya çalıştığı bir noktada Tom Wiscombe, Gilles Retsin ve Mark Foster Gage gibi isimlerin tartıştığı parçacıl mimarlık üretimi ile bağlantı kurarken açığa çıkardığı tezatlığı da göstermektedir.

Dualiteler arasında tarafını seçmekle meşgul olmayan bu çalışma, korelasyonlar üzerinden tasarım süreci okuma yöntemi kurulmasını öngörmektedir. Bütün çizim nesneleri arasında ilişkilerden hesaplanabilir dokuların varlığını aramak bu yazının amacını belirlemektedir. Güncel parametrik tasarım tartışmasının yoğunlukla 3 boyutlu modelleme üzerinden yapıldığı bu alana metin-dışı 2 boyutlu nesnelerin dahil edilmesine çalışılacaktır.

Çalışmada ele alınan mimari proje dersi kapsamındaki üretimlerdeki parametrik parçalar, oluşturulan kural/kurallar dizisi ile bir araya getirilir. Kullanılan kombinasyonlar sayesinde alternatif birleşim biçimleri ortaya çıkartır. Bir araya gelen parçaların birleşim detayı ise çizim nesnelerini farklılaştırarak üretimin zenginleşmesini sağlar.

Bu yazı, çizim nesneleri ile kurulmak istenen işlevsel parametrik ilişkilerin sonrasında üretilen yapı elemanları ile sınırlarının zorlandığı anları ve tasarımcının sezgisel kararlarının da kaydını tutmaktadır. Bunun için de korelasyona dayalı değerlendirmeler yapılmıştır.

Korelasyon, birbirine karşı etkili ve birbirinden etkilenen değişkenlerin arasındaki eş-ilişkisellik bildiren “bağıntı”dır (TDK, 2007). Değişkenler, ilişkisel durumları aralarında nedensel veriler oluşturmaz ya da oluşturmak amaçlanmamıştır. Korelasyon değişkenlerin seçimi, geçerlilik, güvenilirlik, özgünlük ve süreç yönetimine dair ölçme yöntemlerinin verdiği bilgiyi üretmek ve içgörü kazandırmak üzerine kullanılır. Değişkenler, mimari atölye sürecinin aşamalarında aranmıştır.

İkinci bölümde çalışmanın bağlamı ve tasarım stüdyosundaki pedagojik yaklaşımı hakkında bilgi verilmektedir. Yöntem üzerinde durulan bir sonraki bölümde çalışmanın aşamaları üzerinden kullanılan metotlar ve üretimler, görseller üzerinden anlatılmaktadır. Çalışmanın sonuçları ve değerlendirilmesi dördüncü kısımda tartışılmıştır.

2. DİJİTAL NESNE YÖNELİMLİ TASARIM İLE BAĞLAMIN KURULMASI (SETTING THE CONTEXT WITH DIGITAL OBJECT ORIENTED DESIGN)

Mardin Artuklu Üniversitesi, Mimarlık Bölümü'nde verilen Dijital Rastlantı atölyelerinden 6'ncısındaki üretimlerin değerlendirmesini ele alan bu yazıda dijital nesne yönelimli tasarım yöntemleri üzerine çalışılmıştır. Atölyedeki proje çalışmasının bağlamı Mardin'in Midyat ilçesine bağlı Anıtlı (Hah) ve İzbırak (Zaz) mahallelerinde fütüristtik bir siborg ziyaretçi merkezi kurulması üzerinedir. Anıtlı ve İzbırak köyleri, bir zamanlar yoğun Süryani nüfusunun olduğu ve çoğunlukla terk edilmiş evlerden, harabeye dönmüş tescilli veya tescil edilmeyi bekleyen ve halen kullanılmakta olan kilise ve manastır gibi yapıları barındırmaktadır. Proje bağlamının istediği öyküleştirme ile alanın barındırdığı potansiyellerini, paralellikle okumak mümkün hale gelmiştir (Şekil 1).

Şekil 1: Mor Sobo Katedrali, Anıtlı, Midyat, Mardin (Mor Sobo Cathedral) (Fotoğraf yazarlara aittir).

Mardin Artuklu Üniversitesinde verilen mimari proje atölyelerine 1'inci sınıfta yaratıcı fikir temsilleri üzerinden tasarım üretimi gerçekleştirilmekte ve 2'nci sınıftan itibaren daha teknik ve konvansiyonel alanlara yönelmektedir. 3'üncü sınıfın ortasından itibaren keşfe dayalı atölyelerin ağırlık kazandığı bir ortamda Dijital Rastlantı atölyesi, dijital tasarım yöntem ve araçlarının kazandırabileceği hesaplamalı tasarım yöntemlerini incelerken, atölyeyi alanlara ölçekler arası geçişi ve temsil üretiminin nitelik ve hızını arttırmaya dönük becerileri öncelemektedir. Mimari proje dersinin bir öncül tasarım-araştırması olarak görülmesinin önünün açıldığı Dijital Rastlantı atölyesinde her dönem yaklaşık 15-17 öğrenci, bir yürütücü ve bir yardımcı yer almaktadır. Haftada 2 gün 4'er saat toplanılan atölyede yüz yüze görüşmelerin dışında Google Drive, Google Chat, Trello, Zoom ve WhatsApp ile iletişim seviyesinin hızlandıran araçlar kullanılmaktadır. Bu çalışmanın gerçekleştiği dönemde Mimari Proje 6 ve 7'den karma bir grubun oluşturduğu atölyeden toplamda 7 proje çıkmıştır ve bu projelerden özellikle birinin ele alınarak, tasarım süreci üzerinden bir yöntem okuması yapılmaktadır.

3. YÖNTEM: TEMSİL VE ÖLÇEKLER ARASI GEÇİŞ (METHOD: REPRESENTATION AND INTERSCALE TRANSITION)

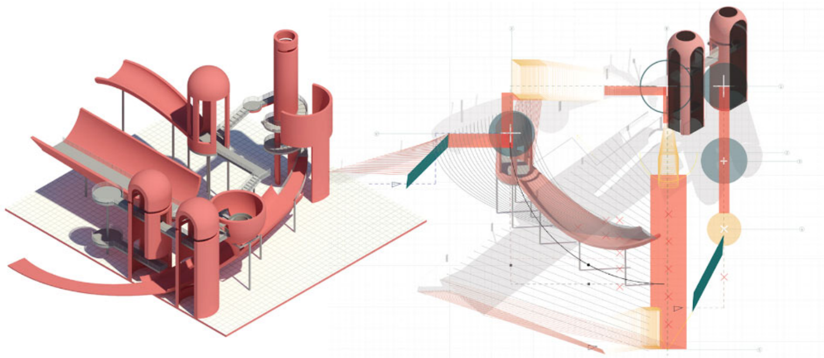
Çalışmanın yöntemi, projenin gerçekleştirildiği atölye sürecine dayalı olarak farklı tasarım aşamalarını içermektedir. Tasarım aşamalarındaki farklılaşmalar, temsil boyutu (2B veya 3B) ile çalışma ölçeği (makro veya mikro) arasındaki permütasyonlardan türeyerek 4 başlıkta incelenmiştir. Her aşamanın bir sonrakini beslemesi bakımından lineer bir akış takip edilmiştir. Fakat bu ilerleyici akış, aşamalar arasındaki tersine ilişkilerin her yeni başlık içerisinde ayrıca değerlendirilmesiyle çok yönlü bir şekilde ele alınmıştır. Temsil boyutları ve çalışma ölçekleri arasında ortaya çıkan ara durumlar (2.5B veya mezo ölçek) da ilgili aşamalara dağıtılarak hibrit değerler incelenmiştir.

İlk aşama atölyenin genel hedeflerinden biri olan 3 boyutlu düşünce pratiğini çalışmaktadır ve tekil yapı elemanları arasında kompozisyonlar kurmaktadır. İkinci aşama farklı ölçeklerdeki 3 boyutlu haritalama yöntemlerini göstermektedir ve bağlamsal incelemeyi mümkün kılmaktadır. Üçüncü aşamada 2 boyutlu haritalar ve 3 boyutlu modeller ile mikro ve makro arasındaki ara ölçek üretimler yer almaktadır ve 2.5 boyutlu temsiller sunmaktadır. Dördüncü ve sonuncu aşamada ise temsiller ve ölçekler arası kompozisyonların hibrit sahnelere dönüşümü üzerinde durulmaktadır.

Teknik olarak ayrı ayrı ele alınan bu 4 aşamanın ortak yönü spekülatif mimari çizim nesnelerinin sezgisel ve yaratıcı sıçrama aracı olarak kullanımını inceleyebileceğimiz korelasyonlar sunmasıdır. Bütün aşamalarda gözlenen bulgular yöntemin içerisinde ayrıca ele alınmaktadır ve spekülatif mimari çizim aşamaları arasındaki ilişkileri incelemektedir. Yazının bundan sonraki kısmında tasarım süreci aşamaları ve bulgular üretilen temsiller üzerinden açıklanmaktadır.

3.1 Aşama 1: 3B Yapı Elemanları ile Bütün-Parça (Stage 1: Whole-Part with 3D Building Elements)

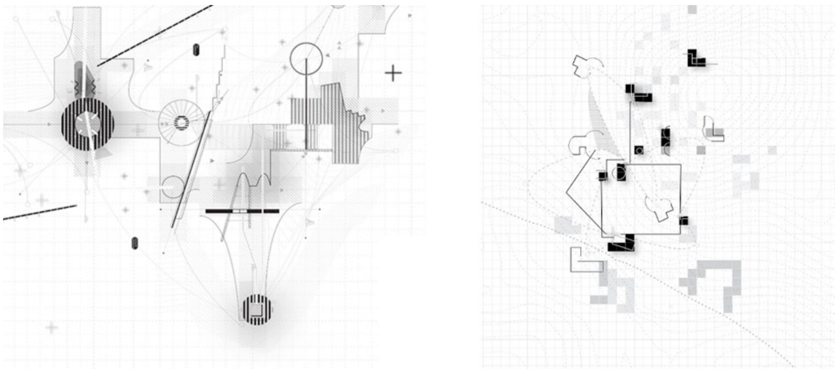
Atölyedeki deneylerin ilk aşamasında mimari tasarımda önemli bir yeri olan "tekrar" üretiminin 3 boyutlu hacimsel düşünceye yansıtılması denenmiştir. Bu denemelerdeki sınırlayıcılar, yaklaşık 10x10m ebatlarındaki bir düzlemin kullanılması ve en az iki yapı elamanın yeniden yorumlanmasıdır. Üretilecek olan genotip sahnelerin tekrarlanarak yayılabilecek parametrelerinin düşünülmesi istenmiştir. Böylece soyut anlamda, geometri, bağlam ve işlev arasında hacimsel ilişkilerin çalıştırılması beklenmiştir. Şengün'ün (2016) belirttiği gibi yapısallığa dönük yeni bir "iç bağlamı" ifade eden tektonikler belirlenmiştir. Radikal ilişkiler içinde bu bağlamı yakalaması beklenen tasarımcının incelediği yapı elemanlarını alternatif kompozisyonlarda kullanması için spekülatif çizimler, işaretler ve notasyonlar üzerinden yeni bağlamlar aranmıştır (Şekil 2).



Şekil 2: 3B yapı elemanlarının tasarımında bütün-parça ilişkisinden türeyen nesneler (Objects derived from the whole-part relation in the design of 3D building elements) (©2022, MŞY).

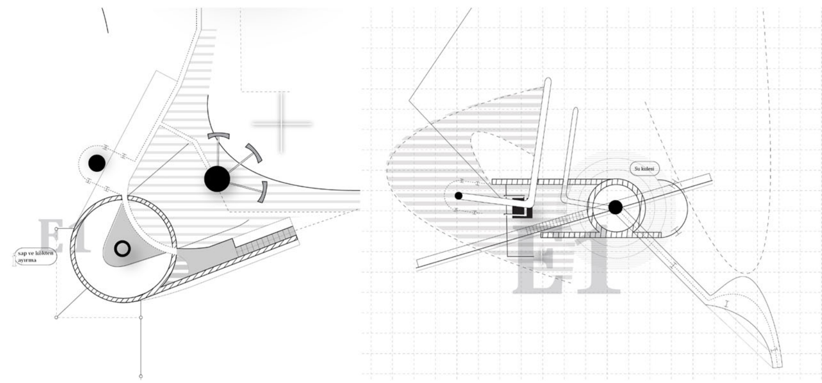
3.2 Aşama 2: Haritalama ve Alan Tanımları ile Dikim-Söküm (Stage 2: Sewing-Disassembly with Mapping and Area Definitions)

Çizim nesnelerinin üretilmesi ve tanımlanması, harita ve alan tanımları üzerinde çalışılmıştır. Haritalama süresince çizim nesnelerine öznel ve işlevsel tanım kazandırmak üzere, çalışmada kullanılan çizim nesnesinin aldığı biçim, alan konumu, yerleştiği yön, boyut ve tekrar sayısı ilgili niceliklerin esneklikle kullanılmasına olanak tanınmıştır. Nesnelere karakteristik özellik kazandıran nitelikler, tanımlı alanın ölçek farklılıklarına göre değişen ihtiyaçlarına bağlı olarak yeniden çizilerek değerlendirilmiştir (Şekil 3).



Şekil 3: Haritalama süreci (Mapping process) (©2022, MŞY).

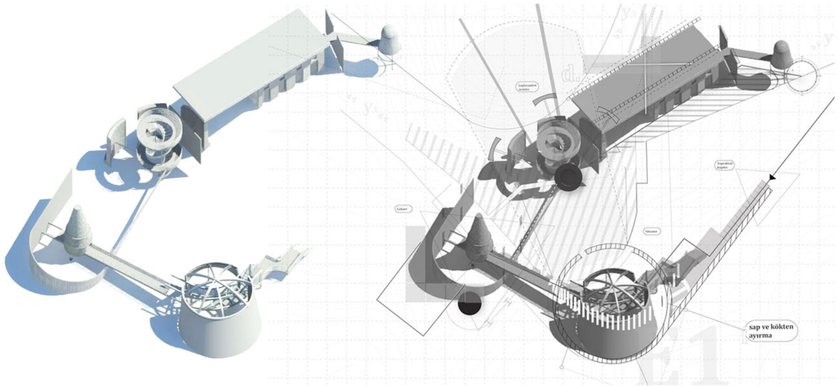
Çizim nesneleri üretildiği ölçekten, mevcut koordinatından farklı ölçeklerde ve alanlarda tanımlanırken dönüştürülmüştür. Nesneler çoğaltılmış, kaybedilmiş, yeniden çizilmiş ve yeni tanımlar kazandırılmıştır. Haritalama süresince kullanılan sezgisel ve sistemli süreç, çizimin nitel ve nicel değerlerini bir arada kullanarak karma paradigması ile tasarımcının ürettiği çizim nesnesinin özgünlüğü belirlenmiştir. (Şekil 4).



Şekil 4: Haritalama sürecinden türeyen nesneler (Object derived from the mapping process) (©2022, MŞY).

3.3 Aşama 3: Sahne Yaratımı (Stage 3: Scene Creation)

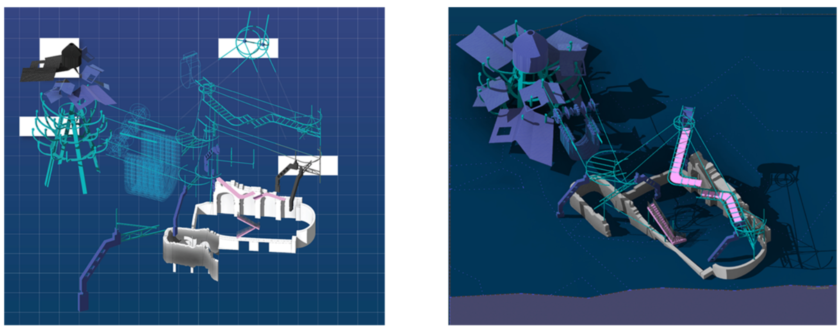
Çizim nesneleri, atölye süresince tasarımcının kurgusal ve kavramsal düşünme süreçlerini de tartışmaktadır. Bu tartışma tasarımcının hikayesinin olgunlaştırılabileceği sahne yaratımı üzerinde değerlendirilmiştir. Bir taraftan kurgu bağlamını destekleyerek üretilmiş 3 boyutlu yapısal ve tekil elemanlar üretilirken, öncesinde üretilmiş elemanlar ise kurgu bağlamı ile yeniden düşünülmüştür. Çizim nesneleri her iki süreci de dönüşlü olarak desteklemiştir. Nesneler, mekâna ait kurucu elemanlar ile çakıştırılmıştır. Yapısal elemanın model algısına, mekânsal deneyim hikayesini okunur hale getiren ilişkisel bir düşünmenin sonucu olarak anlam kazandırmıştır. Böylelikle, nesnelerin ortaya çıkardığı düşünsellik, mekânın işlevsel ve nesnel tanımını izlenebilen bir süreç ve oluş(um) haline getirmektedir. Nesneler, ilişkiler ve çokluklar üretebilmek adına geçişli(edilgen) hale getirilmektedir. (Şekil 5).



Şekil 5: Sahne nesnelerinin mekansal deneyim hikayesinin üretimi (Production of spatial experience story from stage object) (©2022, MŞY).

3.4 Aşama 4: Hibrit Atmosfer (Stage 4: Hybrid Atmosphere)

Atölyenin son aşaması çizim ve sahne nesneleri arasındaki ilişkilerin, bütüncül ve tutarlı yaklaşımını değerlendirmektedir. Bu bağlamın görselleştirme aşamasında atmosferik mekân deneyleri ile çalışılmıştır. Sis, bulut, buhar, ışık atmosferik nitelikler olarak tanımlanmıştır. Yapısal elemanların, içerik ve zamanla kurduğu ilişkiselliklerin, kullanılmakta olan atmosferin niteliklerine uygun şekilde görsel doygun hale getirilmektedir. Çizim nesneleri ve kullanılan sahne elemanlarıyla bir aradalık kurgulanması için çizim ve sahne nesneleri öncelikle kendi aralarında ilişkilendirilmektedir. Nesnelerin ve elemanların birleşim detayları üreterek mekân atmosferini hibrit hale getirmesi beklenmektedir. Hibrit atmosfer yaklaşımı, Batuk'a göre atmosfere ait niteliklerin mekanla bütünleşen, dönüştüren ve bitmemişlik kazandıran mekân tanımı ile ilgilidir. Mekân tanımına katılmak üzere, çizim nesnesinin değişken ve öznel tanımının bu aşamada tasarımcısı, kullanıcı ve seyircisine göre değişkenlik gösteren özelliklerini aranmaktadır. (Şekil 6).



Şekil 6: Nesneler üzerinden atmosferik hibritleme (Atmospheric hybridization on objects) (©2022, MŞY).

Geleneksel mimari mekânın temsil nesneleri, özneyi "çizimden sonra olmak üzere" aktif ya da pasif olarak çağırmaktadır. Tasarım girdisinin birinci öncülü olan özne, temsil alanında okunmaz hale getirilebilir. Sahneyi oluşturan aksonometrik ve perspektif projeksiyonlar, öznenin temsil alandaki potansiyellerini oluşturmaktadır. Atmosferik nitelikler ve elemanları ile çakıştırılmalar üzerine çalışılmış çizim nesneleri, imajinatif mekanlara dönüştürülmüştür (Batuk, 2019). Her gözlemci, seyirci, özne veya aktöre göre farklılaşan mekânsal deneyimler, temsil alanına çizim nesnelerinin tanım süreciyle aktarılmıştır. (Şekil 7).

Şekil 7: Haritalama sürecinden türeyen nesneler (Object derived from the mapping process) (©2022, MŞY).

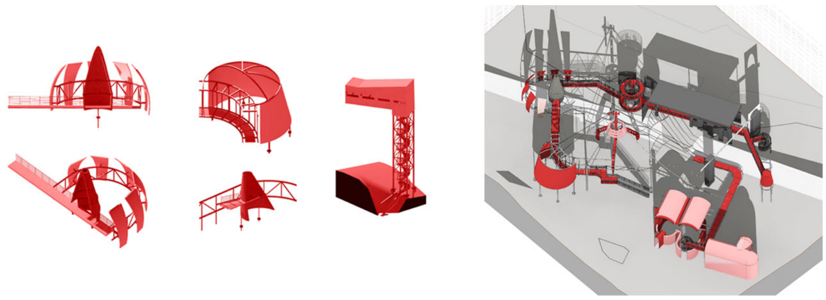
4. DEĞERLENDİRME VE TARTIŞMA: ÇİZİM NESNELERİ ÜZERİNDEN YARATICILIK (EVALUATION AND DISCUSSION: CREATIVITY THROUGH DRAWING OBJECTS)

Çalışmadaki spekülatif çizim nesneleri gerçek nesnelerin yerine geçen ve tasarımcının yaratıcılığını ortaya koyan farklı biçimleri anlamlandıran temsillerdir. Kullanılan nesneler, temsil boyutu değiştikçe farklılaşır ve yeni şekillere bürünür. Üretim sırasında karşılaşılan nesnenin sahip olduğu paradigmanın dışına çıkarılması hedeflenir. Konulan yeni kurallar ile nesneler ihtiyaç duyulduğu kadar değişir ve dönüşür. Çizilen her nesne, yerine geçtiği gerçek nesnenin kendisini temsil etmekten daha fazlasını ifade eder. Çizime eklenen "tarama", "çizgi"," gölge" ya da "boşluk" nesne katmanlarını oluşturur. Katmanlar, biçim farklılaşmasını, bir araya geliş yöntemini ve nesnesel özelliklerin ifade biçimidir. Ölçü bağlamında kullanılan katmanların ifade diliyle birlikte sahip olduğu anlam da farklılaşır. Örneğin tekil nesnenin yer aldığı yakın bir ölçekten bakıldığında kullanılan çizim elemanlarının ifade biçimi daha hassastır. Kullanılan her araç mekân için bir bağlamı temsil eder. Kullanılan araç, yeri geldiğinde mekânın sınırlarını da oluşturabilir, kullanıcının sirkülasyon akışını da sağlayabilir ya da doğal ışığın geçiş alanlarını da gösterebilir. Daha uzak bir ölçekten bakıldığında ise durum biraz farklıdır. Söz konusu nesneler kadar nesnelerin bir araya geliş biçimi de önem kazanır.

Çalışmanın yöntemi tasarım sürecinin aşamaları ile üretilen temsiller arasındaki ilişkiyi sağlamaktadır. İlk olarak temsil ve ölçekler arası geçişlerin tanımı yapılmalıdır. Projenin yapıldığı yerleşim alanının, kullanılan malzemenin ve yapı elemanlarının girdileri, kurguyla harmanlanarak çizim sürecindeki ana hatları oluşturur. Rastlantısal ya da bilinçli karşılaşma noktaları yeni nesnelerin üretilmesine imkân sağlar. Üretilen her nesne bir veya birden fazla karaktere sahiptir. Çizimin bütününe bakıldığında göze çarpan karmaşa, inilen her ölçek boyutunda tanımlı hale gelir ve karakteristik özelliklerini ortaya koyar.

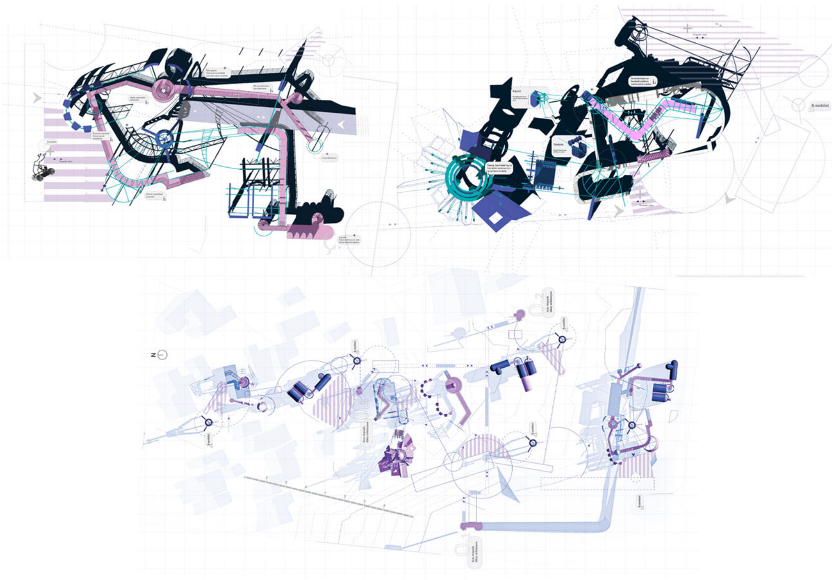
Çizim nesneleri, kâğıt üzerinde süzülerek, kulaç atarak ya da öylece dikilerek okuyucunun dikkatini çekmeye çalışır. Yer değiştirdiğinde arkasında bıraktığı iz hareketin tanımını yapar. Oluşan izler, temsil için yeni bir çizim elemanına dönüşür. Durağan nesneler ise üzerine gelen ışığın etkisiyle yansıttığı gölgeler ile öngörülemeyen parçalar yaratırken var olan elemanlar arasında da köprü kurar. Böylece rastgele oluşan nesneler, bilinçli yerleşen nesneler ve diğer çizim elemanları paradigma dışı oluşum biçimlerini temsile yansıtır. Ölçek, farklılaşan çizim boyutları arasında istenilen yaklaşma biçimini yakalamak için kullanılan araçtır. Boyut değişimine duyulan ihtiyacın temelinde nesne tabanlı düşünme biçimi yatar. Çizim elemanları, kendisinden daha küçük elemanların bir araya gelmesiyle oluşur. Her nokta, bulunduğu ölçek boyutunun izin verdiği kadar moleküllerini açığa çıkarır. Parçaların görünürlüğü, nesnelerin bir araya geliş biçimini tanımlar ve kullanılan örüntü bilgisini okunur kılar. Böylelikle nesnelerin değişken algısal ifadelerini karşılayan temsiller ortaya çıkarılır.

Plug-in City ütopyasında kullanılan çizimlere dair aktarımla ortaya çıkan, kentsel/mimari/mekanik/beşerî sistemler birlikte çalışır (Cook, 1999). Çizim nesneleri, kentin var olan fiziksel ve zihinsel tetikleyicileri ile yer değiştirir. Bu sayede değişken, dinamik ve kente eklenebilen “oluş halindeki yapının (building-in becoming)” takılmasına olanak tanır. Mimarın çizim nesnelerini çağırdığı alan ile kurduğu “ilişkisi olmayan” yaklaşım bir imalat alanı yaratırken çizim nesneleri aralarında yeniden ilişkilenir (Sandler, 2015). Haritalama sürecinden türeyen nesneler, mevcuttaki çevresel verilerin süperpozisyonları ihmal etmeyerek haritalama sürecine parçacıl eleman ve ilişkiselliklerini ekler. Parçacıl elemanların çizimleri ve mekânsal yorumları işleyiş, ölçek, bilgi katmanları arasında korelasyonlar üretir. Harita süreci, oluş halindeki devinimli serüveni beslemektedir (Şekil 8).



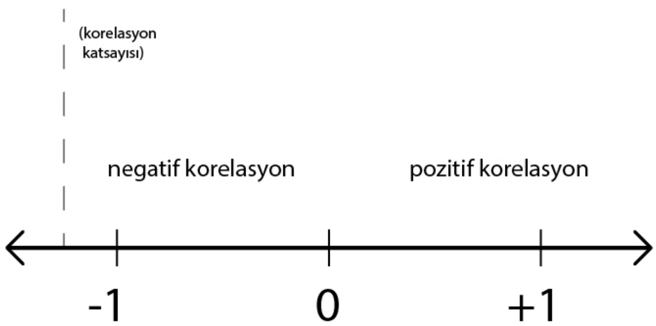
Şekil 8: Parçacıl elemanlar, korelasyonlar ve "oluş" devinimi (Discrete elements, correlations and motion of "becoming") (©2022, MŞY).

Çalışmanın görselleştirme aşamasında kuş bakışı ve seyirci projeksiyonları kullanılmıştır. Üretilen temsiller, zihinsel görüntüleri hedefsel veya kendiliğinden oluşturulmak üzere kişiselleştirmiştir. Kuş bakışı projeksiyondan, seyirci projeksiyonuna geçişler aktör perspektifliyle tanımlanmaktadır (Şekil 9). Bryan Cantley, deneysel çalışmalarında kullanılan mekanik parçalar, işaretlemeler, taramalar, iki ve üç boyutlu çizimlerin bir arada kullanılması anlamsal ve sembolik katmanlaşmalar üretir. Çizim, kişisel deneyim ve birikimleri saptamak için içine dönerek hangi elemanın nasıl kullanılacağı, ne türden ilişkiler kurabileceğine alternatif yollar ortaya çıkarır (Asar, 2020).



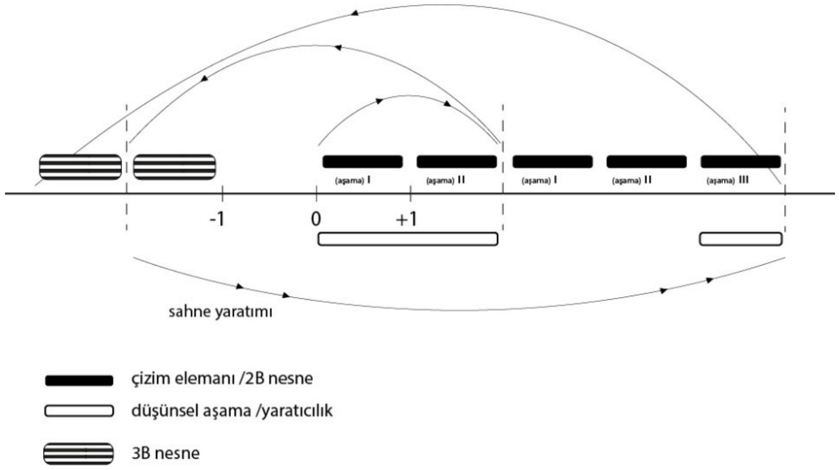
Şekil 9: Nesneler üzerinden atmosferik hibritleme (üst) ve ilişkisellik (alt) (Atmospheric hybridization on objects(top) and relationality (bottom)) (©2022, MŞY).

Aksonometrik ve izometrik çizimler ile desteklenmiş mekanik ve tekno-morfik çizim sahneleri hikâyenin beslendiği korelasyon yöntemiyle oluşturulur. Hikâye ve çizim nesnelerinin ilişkisi arasında üretilen pozitif-negatif [-1,1] korelasyon, mekanın temsil alanında potansiyellerini ortaya çıkarır (Şekil 10).



Şekil 10: Korelasyon grafiği (Correlation graph) (©2022, MŞY).

Tasarım sürecinin değerlendirilebilir ölçek yaklaşımlarıyla ele alınması, çizim nesnesinin tekrarlanamaz ve öngörülemeyen keşiflere olanak sağladığı değişkenleriyle ilişkilerine odaklanmaktadır. Çizim; pratik, edim ve ortam araçlarıyla çoğalttığı korelasyonları, lineer ve döngüsel grafikleriyle okunaklı hale getirebilmektedir. Bu çalışma özelinde de yukarıda alt başlıklara ayrılarak çizim nesneleri üzerinden okunaklı hale getirilmeye çalışılan sezgisel süreçlerin sayısallaşmasına dair korelasyonlar resmedilebilir (Şekil 11). Değerlendirilirken sezgisel süreçlerin algoritmasını çıkaran, sayısallıkta üretimine işaret edilen korelasyon grafiği 2B çizim elemanları ile 3B nesneleri iki uca taşıyan bir özelliğe sahiptir. Aynı zamanda 2B nesneler ile subjektif yaratıcı düşünsel faaliyetler arasındaki bir paralellik üzerinden kurulan değerlendirme kanalı açılmıştır. Grafik, mimari atölye sürecinin en başından itibaren yeniden tekrar edildiği varsayımındaki düşünme edimselliğinde dahi proaktif tavır takınarak değişkenler ve ilişkiselliklerine dair farklılaşan olasılıklarını ortaya çıkarabilir. Bu sayede mevcut olasılıklar kapasitesinin doğurduğu değişim dinamikleri, üretilen korelasyon grafiğinin etkin faktörlerini oluşturabilir.

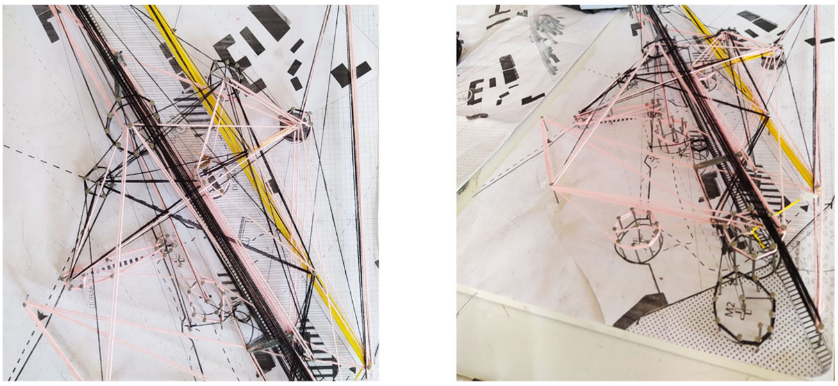


Şekil 11: Çizim nesnelerine ait süreç korelasyon grafiği (Process correlation graph of drawing objects) (©2022, MŞY).

Dijital araçların kullanımı üzerinden yaratıcı temsil üretiminin bir matematiğini arayan bu çalışmanın katkılarını birkaç ölçeğe birden ilişkilendirerek değerlendirmek mümkündür. Bu değerlendirmeler:

1. Sezgisel süreçlere ilişkin,
2. Korelasyonlar ve çağırdığı yanal ortamlara ilişkin
3. Dijital Rastlantı atölyesi ve mimari atölye süreçlerine ilişkin

Katkıları okutmaktadır. Bu bağlamda, sezgisel/bilişsel süreçler ile beklenmedik öğeler veya birikimle ortaya çıkarılan düşünsel aşamanın sahne yaratım izleğini takip ve tekrar edebileceği sayısal yaklaşımları aranması hedeflenmektedir. Korelasyon sağlayacak değişkenlerin zaman-mekân yönüyle sürece dahil edilerek belirsiz kılındığı üst-üste çakıştırmalar mevcuttur. Çakıştırılan temsillerin kurduğu bağıntılara farklı dijital tasarım araçlarının kullanıldığı denemeler de eklendiğinde çok boyutlu bir korelasyon ağının oluşumu gözlenebilmektedir. Korelasyonlar aracılığıyla bu belirsiz gibi görünen karmaşıklığın okunmasına dönük bilgi üretimi olanakları keşfedilebilecektir. Farklı seviyelerdeki mimari proje atölyelerinin sezgisel düşünme pratikleri ve süreçleri desteklenerek özgünleşebileceği ortamlara yönelen sınamalar, denemeler ve çalışmanın mimari atölye süreçlerine etkisini görünür kılan analitik veriler de araştırılmalıdır (Şekil 12). Böylece ortaya çıkarılmasını mümkün kılan potansiyeller ve tartışmalar yaratabilir.



Şekil 12: Farklı seviyelerdeki mimari atölye süreçlerinden yöntem denemesi, haritalama-maket çalışması (Method test, mapping-model study from architecural processes at different levels) (©2022, Habat Bekiroğlu).

5.SONUÇLAR (RESULTS)

Çalışmada Mardin Artuklu Üniversitesi, Mimarlık Bölümü mimari proje atölyelerinden biri olan Dijital Rastlantı tasarım stüdyosunun süreçlerinden beslenen temsil üretimi süreçleri üzerinde durulmaktadır. Çalışmanın, atölyenin sunduğu tasarım araçlarını bir yönteme dayandırma çabası vardır. Bu yöntemin üretilebilmesi için korelasyon kavramından ve bunun üzerinden okunabilecek bir değerlendirme biçiminden bahsedilmektedir. Korelasyona dayalı değerlendirme biçimi spekülatif mimari çizimin, dijital mimari tasarımın güncel tartışmalarından biri olan parçacıl ve sürekli elemanlar düalitesi ile kurduğu tezat ilişkiyi açığa çıkarması bakımından bir tartışma alanı açmaktadır. Spekülatif mimari çizimi öne çıkarırken el çizimi, maket ve kolaj yöntemlerinin arasında, konvansiyonel mimari tasarım süreçlerinin aksine sıralı eklemeli bir şekilde mimari nesneleşmenin aynı zamanda sayısallaştırılabileceği bir alan aranmaktadır. Bu sayısallaştırma, görsel kodlama dillerinin sunduğu kütüphane ve algoritmalardan ziyade, sezgisel tasarım sürecinin ürettiği matematiği açığa çıkarmak olarak ele alınmaktadır. Ele alınan atölye çalışmasının bağlamını oluşturan Mardin mimarisi üzerine lokal düşünceler üreten bu araştırma, sunduğu korelasyona dayalı yöntem ve değerlendirme biçimleriyle de daha geniş kapsamlı katkılar sunmaktadır. Bu bakımdan çalışmanın sunduğu mimarlıkta tasarım araştırmasına dönük değerlendirmeler (1) sezgisel süreçlere, (2) korelasyonlara dayalı yanal virtüel alanlara ve (3) dijital tasarım yöntemlerinin kullanıldığı mimari proje atölyelerinin temsil üretimi bakımından kabul edilebilirliği üzerine tartışmalar sunmaktadır.

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Katkı oranı (Author Contribution)

Yazarlar makaleye eşit oranda katkı sağlamış olduklarını beyan ederler.

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Mock-up versus CAD Modeling Preferences of Architecture Students in the Early Design Phase

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Preferences for using physical mock-up modeling or computer-aided design (CAD) among architecture students in the early design phase are analyzed. The data is obtained from a questionnaire, consisting of a of nine questions. The majority of the respondents are still in their undergraduate studies. As quantitative analysis methods hypothesis tests based on the probability distributions known as the z-distribution, and the Chi-squared distribution were carried out. Three issues were investigated. The first is whether or not there is a significant difference in the efficiency of one representational technique in the early design phase. The second is, whether preference for one over the other technique depends on the experience level of the students. Here two indicators for experience level were analyzed separately, namely age and the number of years of study. Third is the relative importance of reasons for having a preference. The results indicate that there is a strong dependence between experience and preference. Explicitly, less experienced students prefer CAD, while more experienced ones prefer mock-up technique. Since the choice of mock-up modeling or CAD modeling can have a strong impact on the design processes of both, students and professionals, the result of the study is relevant, because it gives a hint about probable future architecture practice.

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Keywords: Mock-up modeling, Computer-aided design modeling, Architectural design studios, Early design phase.

Erken Tasarım Aşamasında Mimarlık Öğrencilerinin Fiziksel ve Bilgisayar Destekli Modelleme Kullanım Tercihleri

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Bu çalışmada mimarlık öğrencilerinin erken tasarım aşamasında fiziksel maket ve bilgisayar destekli tasarım (CAD) yoluyla modelleme konusundaki kullanım tercihleri analiz edilmiştir. Veriler, dokuz sorudan oluşan bir anketten elde edilmiştir. Ankette katılımcılara erken tasarım aşamasında hangi modelleme tekniğin verimliliği ve tercih sebebi sorulmuştur. Katılımcılar mimarlık öğrencileridir ve çoğunluğu lisans eğitimine devam etmektedir. Kantitatif analiz yöntemleri olarak, z-dağılımı olarak bilinen olasılık ve Ki-kare dağılımına dayalı hipotez testleri gerçekleştirilmiştir. Araştırma kapsamında üç konu araştırılmıştır. Birincisi, erken tasarım aşamasında bir temsil tekniğinin verimlilik açısından önemli bir fark gösterip göstermediğidir. İkincisi, bir tekniğin diğerine göre tercih edilmesinin öğrencilerin deneyim düzeyine bağlı olup olmadığıdır. Burada deneyim düzeyine ilişkin iki gösterge, yani yaş ve öğrenim yılı ayrı ayrı analiz edilmiştir. Üçüncüsü ise, tercih nedenlerinin tespit edilmesidir. Çalışmanın sonuçları deneyim ve tercih arasında güçlü bir bağımlılık olduğunu göstermektedir. Fiziksel maket yoluyla model üretiminin daha verimli olarak değerlendirilmesine rağmen bilgisayar destekli modellemenin erken tasarım aşamasında daha sık tercih edildiği bulgusu ortaya konulmuştur. Sonuç olarak, daha az deneyimli öğrenciler CAD'i tercih ederken, daha deneyimli olanlar ise maket tekniğini tercih etmektedir. Son olarak ortaya çıkan bu farkın nedenleri analiz edilmiştir. CAD tercihi daha çok teknik ve ekonomik nedenlere dayandırılırken fiziksel maket yaparak modelleme ölçek algısına dayandırılmıştır. Elde edilen sonuçlar uzaktan eğitim ve yaş faktörü ilişkilendirilip tartışmaya açılmıştır. Fiziksel maket yaparak veya CAD yoluyla modelleme seçimi hem öğrencilerin hem de profesyonellerin tasarım süreçleri üzerinde güçlü bir etkiye sahip olabileceği için çalışmanın sonuçları gelecekteki olası mimarlık uygulamaları hakkında önemli ipuçları ortaya koymaktadır.

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Anahtar Kelimeler: Fiziksel modelleme, Bilgisayar destekli modelleme, Mimari tasarım stüdyoları, Erken tasarım aşaması

1. INTRODUCTION

Design is a multi-phase problem-solving process in which the method used varies depending on the preferences a designer has. This process starts with the production of various suggestions/ideas on the determined problem and continues with the contribution of different architectural representational tools. This phase has been referred to as the ideation phase (Dorta, 2008). The utilization of representational means is known to influence the content of the idea being represented. This influence can be understood considering that the human mind has limitations as to the amount of information it is able to process overtly. One of the earliest and most well-known studies of the limitations is the study by Miller (1956) and the ensuing work on working memory in Psychology. From this perspective, the role of representation in design is to temporarily externalize properties of the design being developed in some abstract form. Theoretically, it is justified to expect the form of a selected representation to influence the refinement process of the design idea. This is because, each form permits the abstraction of a specific set of design properties more effortlessly, more precisely, or more flexibly compared to another one. For instance, mock-up modeling starts from some physical substance having inherent properties as to its amenability for bending, cutting, or molding, as well as its reflectance of light, Whereas in CAD modeling materiality is assigned after geometric features have been specified in sequence while constraints inherent to material as to interaction with light or ensuing shape modification are subject to explicit simulation in the computer-based representation, if such is taken care of at all. The process ends with the development of the most consistent proposal among the alternatives and obtaining a final product.

The early design phase refers to the preliminary process of developing a preliminary design idea, i.e., establishing a basis for specifying details of the design later on. From this point of view, a study with both qualitative and quantitative content was designed together with the hypothesis, experiment/research carried out, and it was aimed to bring a new perspective to the literature on this subject. The early design phase is one of the most important ones, in which the design idea is grounded in the conceptual sense. It covers the steps of researching, analyzing, and producing information about the problem, synthesizing information, searching for alternatives, screening, and forming ideas that will be input into the design. There may be transitions between the mentioned phases, or the early design phase can be completed with the idea based on a single phase.

For conceiving and verifying a design idea, every design discipline uses some technique to represent it. Techniques vary according to the working principle of the respective discipline. In architecture, there are two commonly used techniques, which are mock-up modeling and computer-aided design (CAD). Mock-up modeling refers to representing a design by means of a physical entity, generally produced at a significantly different scale compared to the design it represents. CAD refers to representing a design in virtual reality, namely via a 3-D object stored in computer memory, that is subject to visualization on a screen.

Each of the representational techniques has a specific benefit to the professionals and students using them. The extent to which these techniques are used becomes more important, especially for architecture students, since they are learning to express their thoughts and transform their ideas into the real world.

The hypothesis of the research is that in architectural design studios, the level of design experience of a student and the preference for representational means are independent; while the alternative hypothesis is they are dependent. Investigating the mock-up and CAD modeling preferences of architectural students in the early design phase, while taking the experience of the students into account, is an issue that has been omitted in the existing literature thus far. In this respect, this work fills a gap in the literature.

In a time where computer-aided-design techniques, such as parametric design are on the way to becoming an industry standard, it is relevant to make explicit the apparently prevalent popularity of a more traditional technique, namely mock-up modeling and the reasons for it, to verify the justifications of the preferences. The purpose is to conscientiously choose among the techniques for the benefit of the design result.

In section no.2, a literature review is presented, about the advantages of CAD modeling and mock-up modeling as well as the concept of the early design phase. A number of advantages one representational technique has over the other one have been described in the existing literature, and these were taken as the categories of the questionnaire prepared in this research. As a refinement of the existing works, the advantages described in the existing publications are further investigated in this study; namely, the existence of the preference is analyzed in terms of statistical significance; the dependence of preference on experience is analyzed as well as the relative importance among the reasons for the preference are quantified.

In section no.3, the research methodology is explained. According to the hypotheses, a questionnaire is prepared and applied to the students of architectural design studios from different universities including Istanbul Technical University and Middle East Technical University.

In section no.4, the collected data is statistically analyzed and discussed. Quantitative analysis is carried out by testing several hypotheses using the appropriate statistical tests; namely a test based on the z-distribution, and one based on the Chi-squared distribution. This is followed by conclusions.

2. LITERATURE REVIEW OF MOCK-UP MODELING AND CAD MODELING AND THEORETICAL FRAME

2.1 Literature Review

A design idea is essentially generated in the human mind essentially in three-dimensional form (Hadia & Elias Özkan, 2016). Until a design idea is converted into a physical object, a 'design is essentially a figment of the designer's imagination', although, ideas may be communicated through drawings or specialized design media (Collopy, 2004). Ideation, in this case, can be described as a reflective representational conversation (Dorta, 2008). The effective use of architectural representation media (sketches, physical-digital models, technical drawings, etc.), which serve as the expression of figments throughout different design phases, starting from the early design phase, contributes to the idea development process (Cannaerts, 2009). Marcos (2022, p.823) puts forward the stages of architectural design:

"The process of architectural design is complex and progressive. To achieve its final form a work of architecture must undergo several stages in a formative process such as inception design, schematic design, design development, and construction documentation. The two initial phases could be regarded as part of the ideation process whereas the other two could be regarded as more descriptive and representational: the development of the design."

Different authors present different ideas on design processes and describe the phases of the design process. While these process definitions differ in detail, the common idea is that these steps consist of a set of definable activities in a logical way. However, it is not always possible to carry out these steps in a certain order. Analysis, synthesis, and evaluation steps are included in this process, but the development of the design process need not be in a foreseen direction. The design product emerges because of complex mental processes; thus, it is not the result of a linear production process. It is produced by experiencing different steps in a tight sequence, possibly with repetition (Lawson, 2005).

Throughout the design processes, students need to visualize their ideas in a 3-dimensional manner. For this purpose, a model of a design, either in physical or digital form is established. Such a model can be metaphorically referred to as a lens that accompanies the development of ideas throughout the design process from the early design phase, sometimes focusing on a specific point, and sometimes taking a general point of view. The purpose is to prepare the ground for the exploration of alternative approaches with transitions among different scales. A virtual model contributes to the development of ideas by revealing new questions and revealing non-obvious aspects such as a greater definition of each element, amount check, and details of data (Empler, 2018). Prototypes obtained by modeling are important to realize inconsistent situations in the solutions produced for the problem in design. Especially in the early design phase, the margin of error that may occur within the scope of the proposal can be reduced to the minimum, together with the inquiries and trials made by producing prototypes (Heidari, 2018).

There are two modeling techniques commonly used in architectural design. These are mock-up and CAD modeling. There are different studies in the literature about mock-up and CAD modeling preferences, their effects on education, design thinking, etc. (Table 1). Some of the research studies these different methods during the early design phase and some of them point out how the techniques are preferred among architecture students. Özbaki et al. (2016) compare a designer's preference between the physical model and the digital model. The comparison focuses on the relationship between design and productivity, suggesting that digital modeling provides higher productivity than physical modeling. Kristianova et al. (2018) investigate the trends in the use of mock-up and CAD combination in the design of architecture, trends can be listed as the capacity for production, the sophistication of representations, and the ability to define complex geometries. Throughout the article, the potential of the techniques to improve the educational environment in the academy is emphasized while handling different techniques simultaneously. Sun et al. (2013) put forward the reason why physical modeling is still used commonly even after the developments in digital modeling is because of enhanced comprehension of the scale of a design. Hadia and Elias Özkan (2016) found that among the two different techniques, the majority of architecture students prefer mock-up modeling compared to CAD.

Production of mock-up models is one of the means of expression in design processes. It is an important tool in terms of testing the three-dimensional organization of the design and studying the visual perception of spatial relations. Preparing a mock-up model is to produce in physical form a scaled variant of the proposed design. Sometimes the representation includes the surroundings of the design object; it can be made from different materials having different textures.

The mock-up model, as a three-dimensional and concrete expression, has an important place in design studios and architectural design processes. Beginning from the early design phase, in terms of practical intellectual expression, a product can be easily created even with a small number of materials. Learning continues while making the mock-up model during the production process. When combining the materials used, new possibilities are investigated with the material properties (Kim, 2019). The usage areas of mock-up modeling in the studio environment and professional life have been diversified since the early design phase, such as working models, sketch models, presentation models, etc. (Empler, 2018). The fact that the mock-up model is a tangible entity makes it easy for the designer to become aware of the implications of the design idea (Rowe, 1987).

With the development of personal computers, CAD became another frequently used representation technique in design processes (Sun et al., 2013). CAD offers a new medium for designing architectural objects, enriching the design process culture. It has features that pertain to different phases of the design process. It is sensitive, detailed, easy to produce, can be easily intervened, and can construct different options with different geometries (Empler, 2018). However, according to Dorta (2008), when it comes to generating new ideas, there is a void of digital tools in the early design phases. On the other hand, Lee and Yan (2016) show that participants feel restricted in ideation while sketching in terms of expressive capability after using CAD.

During the modeling process in CAD, the designers' personal speed, and dominance over the program allows them to express themselves competently through that design. The CAD features and digital modeling process gives faster results compared to the mock-up modeling process. However, the longer time spent producing the mock-up model compared to CAD has perhaps more potential for the development of ideas. A good understanding of the limits of CAD can generate new inspiration for its design potential (Empler, 2018).

The other spatial technological movements such as augmented reality VR (Virtual Reality), and AR (Augmented Reality) in CAD have also increased the popularity of this genre. Such developments offer designers an experience, similar to the spatial experience directly delivered by the mock-up model. VE (Virtual Environment) studies are carried out to strengthen the physical experience side of VR and AR technologies (Kristianova et al., 2018). With the easy manipulation of CAD, student groups working in studios, especially in the early design period, are likely to use environmental factors as input to the design and quickly create options with new geometries (Heidari, 2018). In addition, another important feature of CAD is the ability to quickly produce alternative ideas, which are developed with computational designs of geometric forms with its parametric, algorithmic, infrastructure (Empler, 2018). As changing the viewing location and direction in CAD is effortless, the same virtual object is subjected to visual inspection from different angles, such as the perception of space from the perspective of a driver and a pedestrian (Özbaki et al., 2016).

From **Table 1**, one notes that there are very few quantitative studies dealing with a similar research question. Among those that do use a quantitative method, it is important to point out that their research question does not concern the difference in the preference between CAD and mock-up modeling, which is the question addressed in this work. There is a single study in the table, Hadia, H. & Elias Özkan, B. S. (2016), that does the preference question. The differences with the present work are as follows. The sample is not exclusively taken from students, but it involves practicing architects. The experience levels among students are not specified and therefore the dependence of preference on experience level is not subject to consideration in that study. Thirdly, the usage data of CAD in phases other than the early design phase is mixed with the data for the early phase. That is, the present work uniquely deals with the preference question for the early phase in a quantitative manner.

Table 1: Table summarizing the comparison of some of the existing literature.

REF.	*Subject / Aim*	*Qualitative / Quantitative*	*Statistical Method & Significance Level (if any)*	*Result*
Bhavnani, S. K. (2000).	Comparing the functionality among different commonly used software for visualization, propagation, organization, and iteration	Qualitative	not applicable	Identification of a set of effective strategies; guidelines for developing such strategies and detecting missing functionalities.
Bhavnani, S. K., & Bates, M. J. (2002).	Develop a method that is suitable as a basis for testing and research on the cognitive aspects of information searching on CAD	Qualitative	not applicable	Suggesting potential applications in improving search expertise, training, and design of educational materials.
Bhavnani, S. K., & John, B. E. (1997).	Improve design processes in CAD environment. The different ways of design are analyzed and an efficient one is found to decrease time consumption in processes.	Qualitative	not applicable	The study analyzes and suggests user algorithms to increase efficiency and productivity.
Bhavnani, S. K., John, B. E., Flemming, U. (1999).	Teaching students efficient strategies to use computer-aided drafting systems rather than the persistence of inefficient methods.	Qualitative	not applicable	The study shows the strategic use of CAD training can provide efficiency and productivity.
Bhavnani, S. K., Reif, F., & John, B. E. (2001).	Presenting efficient and general strategies for using computer applications, and identifying the components of strategic knowledge required to use them.	Qualitative	not applicable	Efficient and general strategies can be taught to students of diverse backgrounds in a limited time without harming command knowledge.
Bhavnani, S., Garrett, J., & Shaw, D. (1993).	To advocate for the development of adaptive interfaces in CAD systems, based on the study of user behavior patterns, to improve user performance, and to address the challenges posed by the complexity of CAD software.	Qualitative	not applicable	If today's CAD interfaces are designed for an unchanging canonical user and allow minimal customization, tomorrow's CAD interfaces should dynamically adapt to the needs of many different users.
Bhavnani, S., Garrett, J., & Shaw, D. (1993).	To advocate for the development of adaptive interfaces in CAD systems, based on the study of user behavior patterns, to improve user performance, and to address the challenges posed by the complexity of CAD software.	Qualitative	not applicable	If today's CAD interfaces are designed for an unchanging canonical user and allow minimal customization, tomorrow's CAD interfaces should dynamically adapt to the needs of many different users.

REF.	*Subject / Aim*	*Qualitative / Quantitative*	*Statistical Method & Significance Level (if any)*	*Result*
Cannaerts, C. (2009).	Questioning the relationship between digital and physical models and their status as architectural models through their relationship with the early design phase.	Qualitative	not applicable	Digital modeling brings an exploratory approach in the design stages, as it is faster than physical modeling and allows for multiple changes.
Chapman, G. (1995).	To show the links between the learning process of industrial design with the adaptation of CAD.	Qualitative	not applicable	Students experimented extensively with the computer and came up with designs that they would never have thought of had they been using conventional means.
Chester, I. (2008).	To discuss the teaching environment of CAD learning by understanding and showing pedagogic links between expert-studentrelations.	Qualitative	not applicable	Students, who spend more time on the computers, had equal command knowledge but greater strategic knowledge.
Çil, E., & Pakdil, O. (2007).	To explore and identify the instructors' conceptualizations and evaluations of the relationship between design and computers in education.	Qualitative	not applicable	The design faculty sees the computer as a drafting tool and an aid for visualization and 3D modeling, emphasizing that the potential of computers is not fully used in terms of design thinking tools.
Dorta, T. (2008).	To create a system that enables designers to sketch and make models all around them in real-time and real scale using a digital tablet, image capture, and a spherical projection device.	Qualitative & Quantitative	NASA Task Load Index (TLX). Significance Level is not given.	The students reported being in the state of flow more often in the Hybrid-Ideation-Space (HIS) than with digital or physical modeling.
Hadia, H. & Elias Özkan, B. S. (2016).	To establish the degree of tangibility in model making as opposed to conventional and computational design approaches; and the iconic limitation of both types of modeling in design.	Qualitative & Quantitative	descriptive statistics	Between the two different, handcrafted and digital modeling, 61% of the 87 participants, preferred to use the handmade while 39% chose digital modeling techniques.
Hanna, R., & Barber, T. (2001).	To examine the advantages and disadvantages of students' design experiences before and after using CAD through an experiment.	Qualitative	not applicable	The shifting in the quality of design solutions is observed. However, CAD was found to help design cognition, creativity, and intuition.
Kristianova, K., Meciar, I., Joklova, V. (2018).	To evaluate the possibilities and the feasibility of using innovative technologies in physical 3D modeling education.	Qualitative	not applicable	Rapid developments of new technologies that influence the design process substantiate the constant research on aspects of their impact on the ways of education.
Lee, S. & Yan, J. (2016).	Questioning how the experience of a design tool affects the designer's ideation.	Qualitative & Quantitative	Wilcoxon's signed-ranks test. * $p < 0.05$; ** $p < .01$; *** $p < .001$	The silhouette-drawing interface of Silhouette Modeler performed better than SketchUp in terms of the diversity of supported shapes a decisive advantage in the conceptual stage.
Özbaki, Ç., Çağdaş, G., Kilimci, E. (2016).	To analyze the design processes carried out with different design tools on an individual designer basis in terms of design productivity.	Qualitative & Quantitative	Linkograph method. 4 CM4> and 2 CM4< in the range M1-43	Productivity levels of protocol studies carried out in mock-up and CAD environments are close to each other. Structural patterns seem to be different.
Stevens, G. (1997).	To describe the evolution of CAD-based programs in the market over time, and their use by designers, firms, and architecture schools.	Qualitative	not applicable	CAD programs should be used to assist the professional development of designers.
Sun, L., Fukuda, T., Tokuhara, T., Yabuki, N. (2013).	To focus on the differences in spatial understanding between physical and virtual models. In particular, it emphasizes the perception of scale.	Qualitative & Quantitative	Infinitesimal change calculation %5 & %1	Compared with the virtual model, the physical model tended to enable quicker and more accurate comparisons of building heights.
Taşlı-Pektaş, Ş, & Erkip, F. (2006).	The article aims to show the link between CAD user and their attitudes to the design process.	Qualitative & Quantitative	*t*-test *$p< 0.05$; **$p<0.001$; *** $p < .005$	As a result, the male learning attitude is more positive than the female attitude towards the CAD design process. However, it is not related to the instructor or learning environment.
Togay, A., Coşkun, M., Güneş, S. & Güneş, C. (2016).	To frame the problems related to the structure and timing of CAD courses.	Qualitative	not applicable	It was observed that their knowledge regarding the program that they first met is more durable and they were more enthusiastic to develop their skills.
Wood, J. (2003).	To investigate and compare how technology, specifically information and communication technology (ICT), is used in the field of Art and Design education compared to its use in other subjects.	Qualitative	not applicable	The study found that each curriculum subject uses ICT distinctively, has singular hardware requirements, and is treated differently in terms of resourcing and access.
Yang, F. C., & Lynch, R. (2014).	To create a database for student learning types and differentiation; comparison of learning styles, learning performance of learning styles, of new and current students and their styles of learning, the exercise repetition numbers of the CAD users to learn and improve.	Qualitative & Quantitative	ILS Test. CTC Score. Significance Level is not given.	There was a correlation between the perception of learning style and grade; in terms of demographic factors and learning style preferences, no statistically significant differences were found
Ye, X., Peng, W., Chen, Z., & Cai, Y. (2004).	The article aims to answer the roles of CAD education curricula in the professional industry.	Qualitative	not applicable	Certain topics are required for all CAD users and should be taught in university education for the professional career. However, for engineering disciplines CAD is a communication tool, it does not do their job or make them better engineers.

2.2 Theoretical Frame

Recognizing the complexity and diversity of the cognitive process involved in the early design phase, as well as the diversity of objects that can be subject to architectural design, postulating a general preference for one representational medium over another one exclusively based on theory is a problematic issue. Accordingly, a study combining qualitative and quantitative considerations was devised, establishing several hypotheses and carrying out the experimental verifications of them. It was tried to find answers to the question, of whether one of the representational techniques is to deem more preferable and more efficient by students in early design phases, and on which condition such a preference depends, if any. A number of advantages one representational technique has over the other one have been described in the existing literature, and these were taken as the categories of the questionnaire prepared in this research.

Due to the complexity of the cognitive process involved in the early design, in particular, referring to the entanglement of ideation and representation, the theoretical frame underlying the knowledge elicitation in the study at hand is the probability theory of mathematics. Specifically, the concept of probability density is applied, while the following two positions are taken. The first one: the probability density known as the Chi-squared distribution is deemed to duly represent the sample noise when the independence in probabilistic sense among two variables is being verified, while no assumption is being made about the probability distribution underlying the variables themselves. The latter approach belongs to the inference paradigm known as non-parametric statistics. The second one: the Gaussian-shaped probability distribution known as the z-distribution, when the shape parameter of the distribution is determined by the quantity known as the standard error of the mean, is deemed to represent sample noise when two samples are taken from the same population. The latter approach belongs to the inference paradigm known as parametric statistics. Details on the probability theoretical aspects of both paradigms are described, for instance, in (Ash 1996), while details on the justification from the application perspective are described, for instance, in (Freund and Perles 2004).

3. METHODOLOGY

3.1 Scope of the Research Methodology

The scope of the research is to investigate the preference for mock-up and CAD modeling in the early design phase, in terms of different age groups as well as revealing the preference reasons of each. Also, it examines the efficiency rate of these modeling types for the early design phase. The hypothesis of the research is that the modeling type preference is independent of age, whereas the alternative hypothesis is that the younger generation tends to use CAD, whereas the older generation is inclined to use mock-up modeling in the early design phase.

To test these hypotheses, a questionnaire is prepared to use both qualitative and quantitative data. While the questionnaire consists of questions for ensuing statistical treatment based on the z-distribution, and Chi-squared distribution, it also includes questions that can be analyzed according to the qualitative value of the answers.

One can note that the above data collection implies that the conclusions are limited to the student population, that is the result may not apply to professionals in the same way. Another limitation of the study is that it is restricted to comparing CAD with mock-up modeling, that is other representational techniques are out of the scope. The third limitation is that the questionnaire is used as a data collection technique rather than an interview or other techniques. The rationale is the effectiveness of statistical inference.

3.2 Data Collection

The questionnaire technique was used to collect data from graduate and undergraduate architecture students. It is collected online via forums, social media of two state universities, and commonly used telecommunication applications. It must be supposed that the access to the questionnaire was equal for every student. The age of the students differed from 18 years to about 30 years of age, a total of 101 people participated in the questionnaire. The sample was formed by randomized sampling as it always must be in statistical inference. The questionnaire was created with the title "*Which is better; Mock-up modeling versus CAD modeling in the early design phase in architectural design studios?*". The questionnaire consists of 9 questions. 1 question is to determine the preference of modeling technique, 2 of the questions are rating-based, 5 of them are multiple-choice, and 1 of them is an open-ended question (Table 2). The questionnaire starts with general questions, such as which one is preferred, and which one is more effective as well as the reasons for preference of use. Then, the reasons to prefer the chosen modeling type were the subject of the questions. Some of the options of reasons for preferences were listed according to the codes mentioned in the existing literature. It was also asked to rate the preferred modeling technique in terms of efficiency. Another question was to select three advantages of efficiency for mock-up and CAD modeling respectively. In the open-ended question, the participants were asked to explain the reasons for their preferences, which were not mentioned in the other multiple-choice questions. The last three questions of the questionnaire concerned the participants' educational status, age, and gender information as demographic information.

Table 2: Questions that are conveyed to the respondents.

	Questionnaire
1.	Which tool (CAD or Mock-up) do you usually prefer in the early design phase?
2.	Which of the following are the reasons for the preference for mock-up modeling?
3.	How would you rate the efficiency of using a Mock-up model in the early design phase?
4.	Which of the following are the reasons for the preference for CAD modeling?
5.	How would you rate the efficiency of using CAD modeling in the early design phase?
6.	Is there anything that you want to add about your preference for Mock-up or CAD modeling in the early design phase?
7.	What is your academic level?
8.	How old are you?
9.	What is your gender?

3.3 Analysis Techniques and Respective Purposes

To examine the hypothesis about the relationship between the preference for modeling technique and age groups, the hypothesis test for two means based on the z-distribution was used to test whether the efficiency of two different modeling techniques differs significantly or not. The sample size is selected so that the probability distribution known as the z-distribution applies for high sensitivity in the estimation of the standard error of the mean. The explanation is included in the theoretical part of the work. The chi-squared distribution is applied to identify whether the preference is dependent on age or not. To compare the dependency of preference for modeling technique and age, the data consisting of 101 responses are categorized with respect to age.

4. FINDINGS & DISCUSSION

4.1 Descriptive Statistics

The first question was ‘Which one do you use more frequently in the early design phase’. It is to obtain an important part of the answer to the main question of the study. The majority of the participants (62.4%) prefer CAD modeling over mock-up modeling (37.6%) as seen in **Figure 1**.

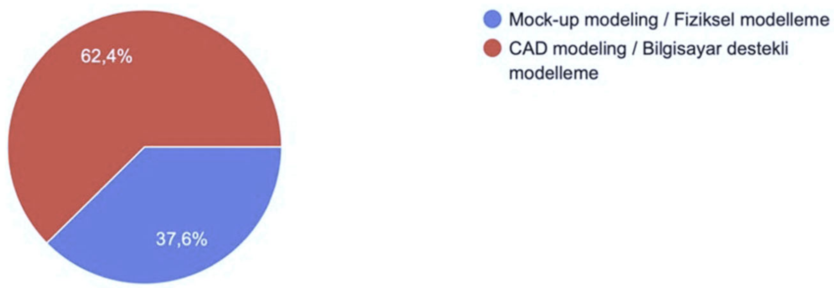


Figure 1: Pie chart showing the preference ratio of mock-up versus CAD.

Among the most preferred reasons for using a mock-up model, *perceiving the scale* ranks first*, flexibility to modify* ranks second, and *producing time and efficiency* ranks third among the relevant reasons for preference. From this point of view, it may be possible to evaluate the reasons for to use of physical models as tangible aspects **(Figure 2).** Understandably, none of the 38 students had chosen the economic issues for mock-up modeling, since clearly, mock-up requires the purchase of materials.

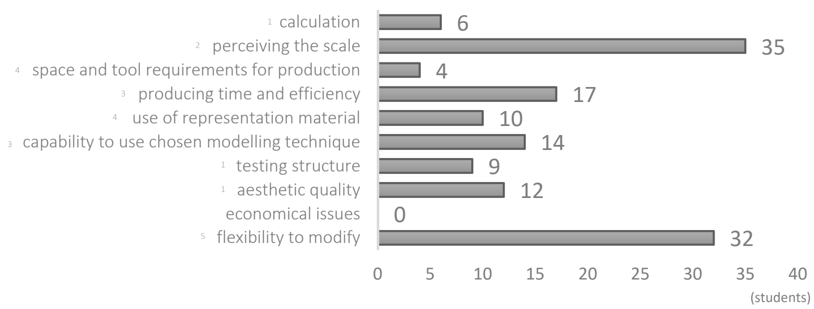


Figure 2: The histogram showing the reasons why students prefer mock-up modeling.

[1] Empler, 2018
[2] Sun et. al., 2013
[3] Özbaki et. al., 2016
[4] Kristianova et. al., 2018
[5] Heidari, 2018

The question underlying **Figure 3** was rating the efficiency of mock-up modeling and **Figure 4** of CAD modeling. The two mean values and standard deviations are indicated in the figure in red font. The mean of mock-up is higher than that of CAD, and the significance of this difference is identified in the following subsection.

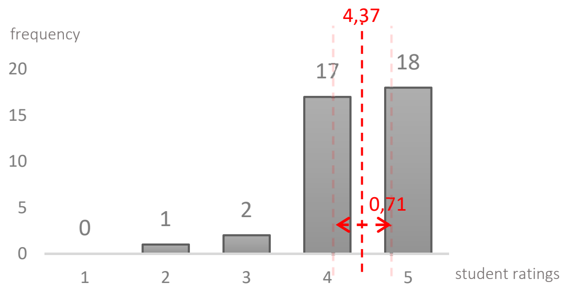


Figure 3: The histogram showing the efficiency ratings of mock-up modeling.

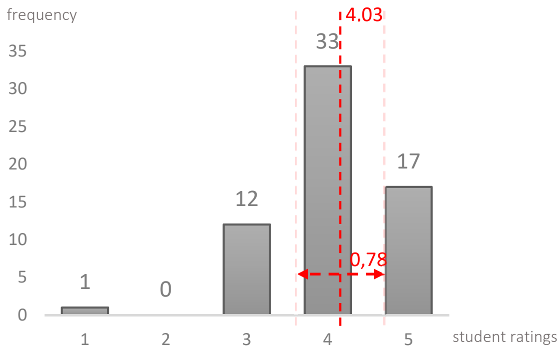


Figure 4: The histogram showing the efficiency ratings of CAD modeling.

The questions were asked in the same order in CAD modeling. Among the most preferred reasons for using a CAD model, *flexibility to make changes* ranks first. This answer was one of the most given answers for Mock-up modeling. Therefore, the flexibility to make changes has been a valid and important reason for both methods in this sense. *Production time and efficiency* rank second and, *economic reasons* rank third among the relevant reasons for preference as seen in **Figure 5**.

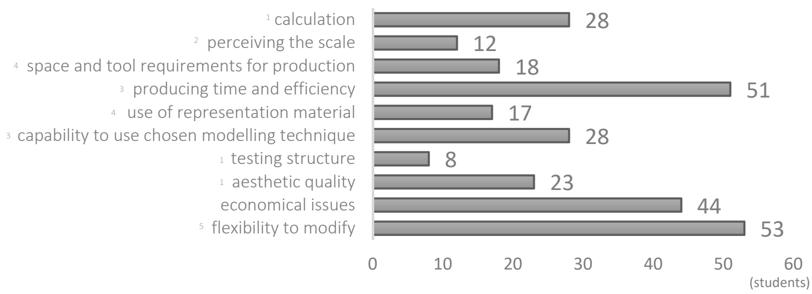


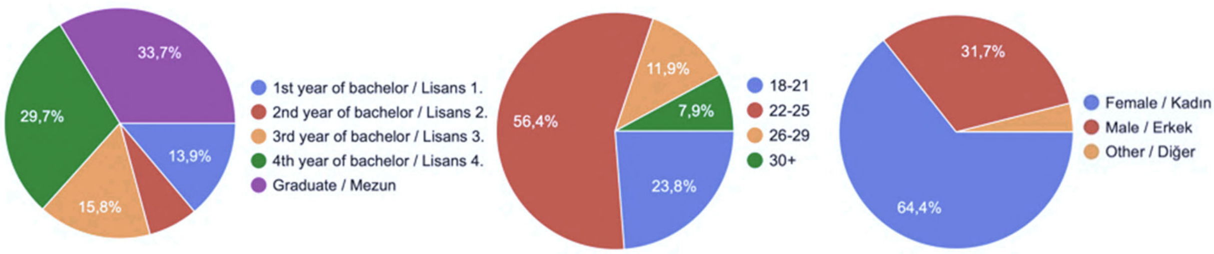
Figure 5: The histogram showing the reasons why students prefer CAD modeling.

[1] Empler, 2018
[2] Sun et. al., 2013
[3] Özbaki et. al., 2016
[4] Kristianova et. al., 2018
[5] Heidari, 2018

In this age of technology, where everything starts going digital, economic reasons may be both a preference based on location and a result of this transformation. The possibility to calculate fast and design accordingly seems to be another important factor in the preference for CAD modeling.

In the open-ended question left as an option, the reasons for preferring Mock-up or CAD modeling in the early design period were asked and different answers were received. The most common point is that the form of education and experience in the chosen technique play an active role in making one of these two choices. 33.7% of the respondents are graduates. 29.7% of them are 4th-year, 15.8% of them are 3rd-year, 6.9% are 2nd-year and 13.9% are 1st-year undergraduate students. The age range of the responders; is 56.4% of them are 22-25; 23.8% of them are 18-21; 11.9% of them are 26-29; and 7.9% of them are 30+ years old. 64.4% of the respondents were female and 31.7% were male (Figure 6). As a result, the fact that experience and education are kept in the foreground together with the open-ended question and the radical change in age ranges emphasizes that preferences change over age in the early design phase. After training in CAD programs at a younger age, young people tend to prefer CAD more, while the older generations tend to produce physical modeling. CAD modeling, which started to be used more widely and frequently with online education, was seen as more productive by the students who coincided with this online education period.

Figure 6: Demographic characteristics of respondents.



4.2 Inferential Statistical Analyses

We identify whether the difference between the two mean values seen in Figure 3 and Figure 4 is significant. For this hypothesis test for two means using z-distribution applies (Johnson & Wichern,2007). The z score obtained was z = 2,21 (Table 3). The hypothesis we are about to test is explicit as follows:

H_o: the difference among the sample means is not significant, i.e. it is likely to be merely a manifestation of sampling noise, and unlikely due to some discernable cause or reason.

H_A: the difference among the sample means is significant, i.e. it is unlikely to be merely a manifestation of sampling noise, but it is likely due to some discernable cause or reason.

The obtained z value is above the z critical value (1,96) when significance level $\alpha = 0.05$ is applied. As a result of this test, it can be said that the efficiency of mock-up and CAD in architectural studios differs. Mock-up modeling is considered significantly more efficient than CAD modeling. (Table 3).

Table 3: Z distribution on efficiency of two techniques.

	CAD MODELING	MOCK-UP MODELING
Mean	4,03	4,37
Standard Deviation	0,78	0,71
Number of participants	63	38
z	2,21	
z Critical one-tail	1,64	
z Critical two-tail (α=0.05)	1,96	

At first glance, the superiority of mock-up as to efficiency is contradictory to the preference for CAD modeling seen in Figure 1. The reconciliation of this apparent contradiction will be given in the discussion section.

Emphasizing the age of the students differs substantially, it is interesting to consider whether age affects the preference of CAD over mock-up. To verify the possible dependency among the two variables age and preference we apply the Chi-squared test of independence (Johnson & Wichern, 2007). A contingency table was formed by classifying the respondents into CAD or mock-up preference, as well as four age groups as seen in Table 4. The hypothesis we are about to test is explicit as follows:

$H_o: p(age|pref) = p(age)$; that is, age and preference are independent variables.

$H_A: p(age|pref) \neq p(age)$; that is, age and preference are dependent variables.

Table 4: Chi-Squared distribution calculations of the parameters age & preference.

Contingency table						
Age	18-21	22-25	26-29	30+	Grand Total	
CAD modeling	21	38	3	1	63	0,62
Mock-up modeling	3	19	9	7	38	0,38
Grand Total	24	57	12	8	101	
	0,24	0,56	0,12	0,08		
Probabilities under hypothesis						
Age	18-21	22-25	26-29	30+	Grand Total	
CAD modeling	0,15	0,35	0,07	0,05		
Mock-up modeling	0,09	0,21	0,04	0,03		
Grand Total	24	57	12	8	101	
expected frequency						
Age	18-21	22-25	26-29	30+	Grand Total	
CAD modeling	14,97	35,55	7,49	4,99		
Mock-up modeling	9,03	21,45	4,51	3,01		
Grand Total						
chi-squared value						
Age	18-21	22-25	26-29	30+	Grand Total	
CAD modeling	2,43	0,17	2,69	3,19		
Mock-up modeling	4,03	0,28	4,46	5,29		
Grand Total					22,53	

A contingency table was created by considering age groups and preference parameters as prescribed by the statistical inference method. Explicitly, the number of students in each parameter was summed. The probability of each parameter is estimated based on the data obtained from a total of 101 students. Then, a common probability is obtained by multiplying the disaggregated probabilities to get the common probability of the two parameters. The expected frequency is obtained in accordance with the rule from probability theory. As a result, the frequency of students expected under the hypothetically assumed independence is subject to comparison with the observed frequency. The comparison is carried out by applying the Chi-squared distribution as follows. The noise that is due to sampling, thus that is not indicative of the hypothesized independence of the two variables at hand, is deemed to be Chi-square distributed when the squared difference between the two frequencies are respectively scaled by the expected frequency and the results summed up (Freund and Perles, 2004).

The total Chi-squared value for the contingency table is 22,53 and applying the significance level $\alpha = 0.01$ the value is significantly greater than 11,34 which is the critical Chi-squared value at this significance level (Table 4). Therefore, the null hypothesis is to reject, and the alternative hypothesis is to accept; namely, the result is strong evidence that the two variables are dependent on each other.

The expected frequency of CAD modeling between the ages 18-21 was approximately 15 students, and mock-up modeling was 9 students; although, it obtained 21 CAD and 3 mock-up on the questionnaire. Moreover, the expected frequency of CAD modeling at the age of 30+ was 5, and mock-up modeling was 3 students; although, it is obtained 1 of CAD and 7 of mock-up modeling. The expected frequency and the obtained values from the questionnaire would be similar if the two variables were independent of each other. Following the lower Chi-squared value would result in a lower than the Chi critical value.

Explicitly, older students prefer mock-up modeling over CAD modeling, while younger students prefer CAD modeling over mock-up. The Chi-squared distribution value of the participants aged between 22-25 is close to zero. This means the observed frequency of preference is close to that in case the two variables age and preference are independent.

However, age is not the sole indicator of the experience level of a student. A second indicator is in the education level, i.e. the year of study the student is currently registered in. Thus, in order to verify the dependence between preference and experience level more thoroughly, a second Chi-squared test of independence is carried out. This time, five categories containing the educational level are taken into account with respect to their preference for modeling techniques. The aim is to compare two results of the two Chi-squared tests to verify whether both yield the same conclusion or not. Explicitly, the hypotheses we are about to test are explicit as follows:

$H_o: p(experience\ level|pref) = p(experience\ level)$; that is, experience level and preference are independent variables.

$H_A: p(experience\ level|pref) \neq p(experience\ level)$; that is, experience level and preference are dependent variables.

The total Chi-squared value for the contingency table is 24,41 and applying the significance level $\alpha = 0.01$ the value is significantly higher than 13,28 which is the critical Chi-squared value at this significance level (Table 5). Therefore, the null hypothesis is to reject, and the alternative hypothesis is to accept: the result corroborates the one that is due to Table 4; namely, there is strong evidence that the two variables are dependent on each other. Explicitly, when the educational level is high, mock-up modeling is preferred over CAD modeling, while students who are early in their study prefer CAD modeling over mock-up. The Chi-squared distribution values of the participants of the 2nd, 3rd, and 4th levels are close to zero. This means the observed frequency of preference is close to that in case the two variables age and preference are independent.

Table 5: Chi-Squared distribution calculations of the parameters experience level & preference.

Contingency table							
Bachelor Degree	1st Year	2nd Year	3rd Year	4th Year	Graduate	Grand Total	
CAD modeling	14	5	13	20	11	63	0,62
Mock-up modeling	0	2	3	10	23	38	0,38
Grand Total	14	7	16	30	34	101	
	0,14	0,07	0,16	0,30	0,34		

Probabilities under hypothesis						
Bachelor Degree	1st Year	2nd Year	3rd Year	4th Year	Graduate	Grand Total
CAD modeling	0,09	0,04	0,10	0,19	0,21	
Mock-up modeling	0,05	0,03	0,06	0,11	0,13	
Grand Total	14	7	16	30	34	101

expected frequency						
Bachelor Degree	1st Year	2nd Year	3rd Year	4th Year	Graduate	Grand Total
CAD modeling	8,73	4,37	9,98	18,71	21,21	
Mock-up modeling	5,27	2,63	6,02	11,29	12,79	
Grand Total						

Chi-squared value						
Bachelor Degree	1st Year	2nd Year	3rd Year	4th Year	Graduate	Grand Total
CAD modeling	3,18	0,09	0,91	0,09	4,91	
Mock-up modeling	5,27	0,15	1,51	0,15	8,15	
Grand Total						24,41

The expected frequency of CAD modeling on the 1st level was approximately 9 students, and mock-up modeling was 5 students; although, it obtained 14 of CAD and 0 of mock-up on the questionnaire. Moreover, the expected frequency of CAD modeling at the graduate level was 21, and mock-up modeling was 13 students; although, it obtained 11 CAD and 23 mock-up modeling.

Taking both tests of independence together, very strong evidence is obtained that the two variables, experience level and preference for representational technique are dependent in the sense defined by probability theory. When the experience level of students is very high compared to novice students it is significantly more likely compared to the other students that he or she uses mock-up. The same conclusion applies in reverse. From Table 5 one notes the influence of experience on the preference of mock-up becomes gradually more and abruptly more after graduation. Precision identification of the cause of this sudden increase in preference is subject to further study in future work.

4.3 Discussion

According to the statistical analyses mock-up modeling is considered to be more efficient for the early design phase among architectural design studio students, for the following top three reasons that are provided by those respondents, for whom the preference rate of mock-up is as low as 37.6%. The leading reason why mock-up modeling is preferred is that *it helps to perceive the scale of the work*, which 35 of 38 people chose in the questionnaire (92%). The second leading reason is that mock-up modeling *gives the flexibility to modify the model*, with the choice rate being 32 of 38 people (84.2%). The third leading reason is that *producing time is efficient*, with the choice rate being 17 out of 38 people (44.7%). In the 'other' section, a respondent who is between 26-29 years old has written down the reason why she prefers the mock-up modeling as '*including the coincidence circumstances into the model while producing*'. Other additional responses can be listed as '*better kinesthetic perception of the model*' and '*the feeling of the modeling*'. When these answers are analyzed and compared within the group of mock-up modeling sections, the options that have more sensual and aesthetical qualities are selected as the reasons why mock-up modeling is preferred.

CAD modeling is more frequently used in the early design phase among architectural design studio students. In this case, CAD modeling is the preferred technique because of the following three reasons that are provided by the respondents, among which the preference rate of CAD modeling is 62.4%. The leading reason why CAD modeling is preferred is that *it is flexible to modify* CAD models, which 53 of 64 people chose in the questionnaire (82.8%). The second leading reason is the *production time and efficiency*, with the choice rate being 51 out of 64 people (79.7%). The third leading reason is *economic issues*, with the choice rate being 44 out of 64 people (68.7%). Another reason that has been mostly selected is the *potential of calculation* and *capability to use the chosen modeling technique* at the rate of 28 of 64 people (43.7%). Also, in the 'others' section, another reason was written that can be considered very important, being '*the possibility to produce different types of drawing by using a single digital model*'. When the CAD modeling answers are analyzed within the group CAD modeling section, it can be said that the options that have more technical qualities are selected as the reasons why CAD modeling is preferred. Moreover, according to the data from the questionnaire, it is interesting to find that even though sometimes students know that a specific modeling technique is more appropriate for them, they prefer the other one. The result of the efficiency comparison of CAD and mock-up modeling of this research verifies this fact. The ability to use "control + z" in computers to erase their mistakes in a millisecond, duplicate their work with no effort, or save money from the rising cost of corrugated/modeling cardboards become more appealing to students who have the technological backup knowledge to support their work. Although they think mock-up is more efficient in early design phases, they mostly prefer to use CAD modeling.

It is worth dwelling on the apparent contradiction that the more efficient technique is not used as much as the less efficient technique. The logical reconciliation of this finding is that efficiency is of inferior importance in the face of other reasons. Apparently, the shorter production time, lower cost, and greater flexibility to modify CAD are more relevant issues for the students than more accurately perceiving the scale of the design that mock-up would provide them.

Some students prefer to use mock-up because they believe that the 2D screen of a computer is interfering with 3D perception and the understanding of the spatial relations and the conceptual masses. When the reasons and comments are considered synoptically, the commonly held expectation, that each modeling method has its own advantage in producing a design, is verified. Some students specified in the additional part of the questionnaire that they both use mock-up modeling and CAD modeling for different purposes simultaneously in the early design phase. A student specified that s/he uses mock-up modeling because the education system in her/his time was mock-up dominant. This brought the research to a point that not only the advantages and qualities of both methods but also the age is important in preference of the students.

When the age of the respondents is considered for calculations, a strong argument has been raised. It is a fact that the younger population prefers to use CAD modeling when compared to the older population which prefers to use mock-up modeling. However, students aged under 26 tend to use both mock-up modeling and CAD modeling. When the additional analysis is made by the written open-ended questions of the questionnaire, remember that the previously mentioned student says the reason for preferring mock-up modeling is because of the dominant education system of her/his times. It is interesting that the circumstances of the education system are so dominant that most of the students seem to follow this dominance. Especially when the COVID-19 pandemic is thought of, almost every architectural studio has become online, in most times there was no opportunity to produce mock-up modeling but the rising possibility to use computer-aided programs for designing, sharing, and even meeting online. The students did not develop the concept by producing mock-up in the early design phases, so they continued to produce digital models because it was a useful method in that condition. It is again interesting and might be coincidental that the age group under 26 is the interval where the population in this group mostly consists of the students who caught the pandemic in their 3rd or 4th year of bachelor's degree. For this reason, it is possible for them to use both mock-up and CAD modeling because they have the concept of mock-up modeling from the preliminary years of their bachelor's degree and the CAD practice throughout their education. The population aged between 18-21 is the population that started the preliminary years of their bachelor's degree during the pandemic. When it is considered that most of the architectural schools did not necessitate the production of mock-up modeling among students, the concept of it was not practiced for those who started their education during the pandemic.

The preference for a modeling technique is apparently influenced by the experience a student has gained using the technique as well as cost factors. This factor may be more important knowing the technique's superiority. For this reason, architecture faculties ought to encourage or even financially support the use of mock-up models in the early design phase.

With reference to the study by Hadia and Elias Özkan (2016) seven years later, an opposite result is found. The preferred technique of the architectural students is reversed. A possible explanation of this is that during the Covid-19 pandemic, online education forced a preference for CAD identifying whether this is the cause or whether there is a trend toward CAD at large that is independent of pandemic conditions and would prevail anyhow, for instance, frequent computer usage in daily life, is beyond the scope of the study at this time.

When the findings are discussed together, it can be seen that a significant number of students, whether classified over age or expertise level, use both tools in their early design phases. These observations also corroborate the work of Dorta. As mentioned above, Dorta (2008) introduced a concept called Hybrid Ideation Space (HIS). The idea is that the students are in the state of 'flow' more often while working in a hybrid manner (using mock-up and CAD together) than with only digital or physical modeling. Remembering each student's unique ideation process in the early design phases, design schools are encouraged to embrace a variety of representational techniques rather than focusing on only one of them.

For this study, the two architecture faculties from where the student sample was taken are state universities that are among the best-known and oldest architecture faculties of the country, and the students permitted to join these faculties are among the high school graduates with the highest grades in the country. That is the architecture curricula have been refined over a long period of time. Regarding the importance given to CAD and mock-up modeling, the curricula do not imply obvious bias for one technique over the other. In this respect, the sample can be considered rather representative of architecture education at large. Considering the significance level of the results we found in our study, and the fact that the non-parametric tests are rather conservative, it is likely the results we found will show up in other educational contexts within the field of architecture as well.

5. CONCLUSION

There are differences between the efficiency as well as the preference for using physical mock-up and CAD in the early design phase. Mock-up is considered to be more efficient by students in case we do not differentiate the students with respect to their age. In case we do take the age of the students into account, then we find that the younger students prefer CAD whereas the older students prefer mock-up. In case we take the experience level into account, then we find that freshman students prefer to use CAD modeling and more experienced students prefer mock-up modeling in their early design phases. The most relevant reasons for preferring mock-up are perceiving the scale and flexibility to modification. The most relevant reasons to prefer CAD are flexibility to modify, production time & efficiency, and lower cost. It is noteworthy that, although the majority of students find mock-up more efficient, nevertheless they prefer CAD modeling. Although it might be coincidental, it is possible that with the online education forced by COVID-19, another reason why students prefer CAD modeling came into play. The youngest population consists of the students, who started their undergraduate studies during the pandemic, in which mock-up modeling was inconvenient and therefore minimally applied.

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Conflict of Interest Statement
The authors of the study declare that there is no financial or other substantive conflict of interest that could influence the results or interpretations of this work.

Author Contribution
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A model for generating visuals related to architectural facades through genetic algorithm

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In this study, a genetic algorithm based model related to architectural facades was developed for generating visuals to be used in spatial augmented reality presentations. First of all, the visuals of the projection mapping referring to the architectural facade were reviewed within the scope of the study. It was seen that architectural facades could be defined by using mass/void relationship, building elements, and 3D effect. Based on this inference, the facade of the Hamburger Kunsthalle, which was also used in one of the pioneering examples of projection mapping regarding the architectural language of the facade, was used to redefine the architectural facade in the study. A genetic algorithm based framework was developed to generate visuals from the model. It was presented as a model from the perspective of mass/void relationship, building elements, and 3D effect on the redefined facade of the Hamburger Kunsthalle. The model allows different visual possibilities to be derived from identified initial visual elements. The generation of the gene population is based on the identified initial visual elements. It is provided to determine and limit the generation of visuals by the specifically defined fitness functions for the selected architectural facade. Depending on the evaluation ranking of the generated visuals, while appropriate visuals are selected, others that are not appropriate are genetically processed to enrich the gene pool. The evaluation ranking at this stage has an impact on the visuals to be produced in the cyclical process. Therefore, the user of the model has a decisive role in the visuals to be produced and must be an expert in the selection of visuals appropriate to the architectural language of the facade. At the intersection of genetic algorithms and spatial augmented reality, this model offers the possibility of generating and presenting virtual variations that include the language of architectural facades.

Keywords: Genetic Algorithm, Architectural Facade, Visual Production, Projection Mapping, Spatial Augmented Reality.

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Genetik Algoritma Aracılığıyla Mimari Cephelere İlişkin Görsellerin Üretimi İçin Bir Model

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Bu çalışmada, uzamsal artırılmış gerçeklik sunumlarında kullanılacak görselleri üretmek için mimari cephelere ilişkin genetik algoritma tabanlı bir model geliştirilmiştir. Öncelikle, mimari cepheye referans veren projeksiyon haritalama görselleri çalışma kapsamında incelenmiştir. Mimari cephelerin doluluk/boşluk ilişkisi, yapı elemanları ve 3. boyut etkisi üzerinden tanımlanabildiği görülmüştür. Bu çıkarıma dayalı olarak, cephenin mimari diline ilişkin projeksiyon haritalamalarının öncü örneklerinden birinde de kullanılan Hamburger Kunsthalle'nin cephesi çalışmada mimari cepheyi yeniden tanımlamak için kullanılmıştır. Modele dayalı görsellerin üretilmesi için genetik algoritma tabanlı bir çerçeve geliştirilmiştir. Hamburger Kunsthalle'nin yeniden tanımlanan cephesinde doluluk/boşluk ilişkisi, yapı elemanları ve 3. boyut etkisi üzerinden model sunulmuştur. Model, tanımlanan başlangıç görsel bileşenlerinden farklı görsel olasılıkların türetilmesine izin vermektedir. Tanımlanan başlangıç görsel bileşenleri, gen popülasyonunun üretilmesinde temel alınmaktadır. Seçilen mimari cepheye özgü olarak tanımlanan uygunluk fonksiyonları aracılığıyla, üretilecek görsellerin belirlenmesi ve sınırlanması sağlanmaktadır. Üretilen görsellerin değerlendirme sıralamasına bağlı olarak uygun görseller seçilirken, uygun bulunmayanlar genetik işlemlerden geçirilerek gen havuzu zenginleştirilmektedir. Bu aşamadaki değerlendirme sıralaması, döngüsel süreç içerisinde üretilecek görseller üzerinde etkili olmaktadır. Bu nedenle model kullanıcısı üretilecek görsellerde belirleyici bir role sahiptir ve kullanıcının cephenin mimari diline uygun görsel seçiminde uzman olması gerekmektedir. Bu model, genetik algoritma ve uzamsal artırılmış gerçeklik kesişiminde mimari cephelerin dilini taşıyan sanal varyasyonlarını üretme ve sunma imkânı sağlamaktadır.

Anahtar Kelimeler: Genetik Algoritma, Mimari Cephe, Görsel Üretim, Projeksiyon Haritalama, Uzamsal Artırılmış Gerçeklik.

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1. GİRİŞ (INTRODUCTION)

Günümüzde kültür sanat bağlamındaki organizasyonlar kapsamında projeksiyon haritalama uygulamalarıyla karşılaşılmaktadır. Bu uygulamalar genellikle kamusal alanlardaki yapıların mimari cephelerine yansıtılmaktadır. Belirli bir süre için düzenlenmiş görsellerin bir araya getirilmesiyle uygulamalar oluşturulmaktadır. Mimari cephe ile bir bütünlük taşıyan görsellerin yanı sıra, kimi örneklerde yapı ile etkileşimin yapının sadece bir perde yüzeyi görevi görmesine varacak derecede düşük olduğu da görülmektedir. Uzamsal artırılmış gerçeklik kapsamında incelenebilecek olan projeksiyon haritalama uygulamaları için mimari cephe ile kurulan etkileşim önemlidir. Bu nedenle çalışma kapsamında mimari cephenin karakteri ile görsel üretimi arasında ilişki kurabilme üzerine odaklanılmıştır. Öncelikle mimari cepheyi referans alan projeksiyon haritalama uygulamaları incelenmiş, incelenen örnekler üzerinden de çıkarımlarda bulunulmuştur. İncelemeler genel bir çerçeve altında değerlendirildiğinde mimari cephenin doluluk/boşluk, yapı elemanları ve 3. boyut etkisi üzerinden tanımlanabileceği görülmüştür.

Bu çalışmada mimari cephe ile ilişkili görsellerin üretilebilmesi için genetik algoritma tabanlı bir modelin geliştirilmesi amaçlanmıştır. Modelin sunumu için incelenen örnek çalışmalardan Hamburger Kunsthalle'nin cephesi, mimari açıdan farklı üretimlere sunduğu potansiyeller göz önünde bulundurularak çalışmada cepheyi yeniden tanımlamak için kullanılmıştır. Doluluk/boşluk ilişkisi, yapı elemanları ve 3. boyut etkisi üzerinden tanımlamalar gerçekleştirilmiş, tanımlanan başlangıç görsel bileşenlerinden farklı görsel olasılıkların türetilebilir olması hedeflenmiştir. Bu doğrultuda genetik algoritma tabanlı bir iş akış diyagramı kurgulanmış ve çalışmada görselleştirilerek süreç açıklanmıştır. Çalışma kapsamında genetik algoritma ve uzamsal artırılmış gerçeklik kesişiminde ortaya konulan model, mimari cephelerin dilini taşıyan sanal varyasyonlarını üretme ve sunma imkânı açısından önemli görülmektedir. Bu sayede mevcut mimari cepheyi referans alan yeni cephe görsellerinin üretilebilmesi ile inşa edilemeyen diğer olasılıklar da ortaya çıkarılabilir ve sunulabilir. Mimari cephenin görsellerle etkileşimi güçlendirilerek, sunum açısından mimari bir projeksiyon haritalama yaklaşımı kazandırılabileceği düşünülmektedir.

2. PROJEKSİYON HARİTALAMA VE MİMARİ CEPHE (PROJECTION MAPPING AND ARCHITECTURAL FACADE)

Projeksiyon haritalama, tasarlanmış ya da mevcut hali ile bir yüzeye görsel verilerin yansıtılması yöntemidir. Bu yöntemde projeksiyon cihazından yansıtılan 2 boyutlu olarak üretilmiş görüntü kullanılan yazılımlar aracılığı ile yansıtıldığı fiziksel yüzey ile eşleştirilir (Burczykowski ve Thébault, 2020). Genellikle bu görseller gösterim sırasında ses ile desteklenir. Görüntünün elde edilmesinde sanal objelerin gerçek objeler üzerinde hizalanması, projeksiyon cihazının konumu ve yansıtılan fiziksel yüzey önem taşımaktadır (Stella, 2020). Projeksiyon haritalama uygulamalarında özellikle yüzey üzerinde uygun yansıtma alanının belirlenmesi önemlidir. Bu alan sunulacak verinin karmaşıklığını ve miktarını sınırlar niteliktedir (Grundhöfer ve Iwai, 2018). Yüzey geometrilerinin farklılaştığı durumlarda görsellerin sunumunda ayarlanmış koordinat sistemleri kullanılabilir. Uygulamaya daha fazla sayıda projeksiyon cihazı dahil edilerek görüş açısı da genişletilebilir (Head, 2012). Günümüzde projeksiyon haritalamanın farklı görsel üretimlere olanak sağlayan, izleyiciyi de bir parçası haline getiren kamusal alanlardaki yapılar üzerinde uygulamaları ile karşılaşılmaktadır.

Moloney'e (2007) göre yapı cepheleri mimarlığın kamusal yüzü ve bilgi akışını sağlayan kentsel ara yüzlerdir. Yapıların yüzeyleri ya da cepheleri aracılığıyla uzamsal çerçevede tanımlanmış bölgeler kentsel mekânı tanımlamakta; yapı formları bağlamında biçimlenen yapı cepheleri ise bu bölgelerde yapıların karakterini yansıtarak kentlinin deneyimlemesine olanak tanımaktadır (Zülkadiroğlu, 2013). Sürekli bir devinim ve sürerlilik altında olan kentsel mekanlar için yapı yüzeyi ve kentlinin etkileşimi önem taşımaktadır (Albayrak, 2017).

Mimarlık alanına ilişkin olarak projeksiyon haritalamanın farklı kullanımları olmakla birlikte (Bölek ve diğ., 2022; Oury, 2020; Aksu, 2019; Lovell ve Griffin, 2019; Nofal ve diğ., 2018; Calixte ve Leclercq, 2017), mimari cephelerde kullanımı izleyicilere yeni bakış açıları ve mekânsal deneyimler sunmaktadır (Çetinkaya, 2020; Gökçen, 2016). Mimari cepheler, kamusal mekandaki projeksiyon haritalama uygulamaları ile izleyiciler için birer içerik taşıyıcı ara yüze dönüşür.

Yansıtılan sanal görüntüler farklı oluşlara açık ve sınırsız olasılıklar içerir. Aydınlı (2008), sanal mekânda sınırların, dokuların ve renklerin fiziksel mekânın Dekartçı anlayışının aksine her zaman dönüşebilir durumda olduğunu ve bu sayede mekânın süregelen ve sınırsız şekilde yeniden üretilen bir ortam haline geldiğine dikkat çeker. Sanal mekân bu yeniden üretilebilir niteliğiyle artık olasılıklı yapısı üzerinden yeni deneyimlere olanak tanımaktadır.

Griffin'e (2018) göre projeksiyon haritalama fiziksel olarak inşa edilmiş olan yapının mimari cephesinin ötesine geçip, dönüşüme açık sanal mekân olasılıklarını ortaya çıkarır. Bu sayede mevcut mimari cephe birden fazla üretilebilir ve mekânı tekrar kavrayıp yorumlama konusunda olasılıkları ortaya koyabilir. Yapılı çevrenin değişebilirliğini deneyimleme, izleyicinin meydana gelen değişiklikleri bilinçaltında sorgulamasını ve gözden geçirmesini sağlayabilir.

Işıkkaya (2023), projeksiyon haritalamayı ışık ve zaman kavramının yardımıyla görüntüler yansıtılarak yanılsamalar yaratarak cepheleri yeniden oluşturmak; bir melez görsel sanat veya aktivite olarak sayılabilecek, yapı yüzeyini yeniden inşa eden ya da onu yıkan, yapıdan bağımsız bir inşa olarak görmektedir. Kavramsal olarak projeksiyon haritalama aracılığıyla kent içinde düşsel bir mekân yaratma, kenti ve kentliyi kamusala geri kazandırma, kenti sahneleştirme, gerçeklik kavramını yeniden kurgulama, zamanda sürekli ve dinamik mekâna ulaşmanın karşılıkları aranmaktadır.

Işıkkaya ve Çatak (2010), projeksiyon haritalama uygulamalarının tasarım sürecinde yapı ile ilişkilendirilmesinde yapı yüzeylerinin ele alınış biçimleri ve tasarım yaklaşımlarına bağlı olarak farklılıkların ortaya çıktığını belirtmektedir. Her ne kadar her üretim kendine özgü olsa da, biçim üretiminde genellenebilir bir takım izlenimler olduğuna dikkat çekmektedirler. Işıkkaya ve Çatak (2010) projeksiyon haritalama uygulamalarının biçime özgü karakteristik sınıflandırılmasını şu şekilde ele almıştır;

- Mimari cepheyi koruma yaklaşımı ile mevcut cephenin varlığını renk ve ışık ile birleştirme
- Mimari cephedeki kütlesel yüzeyler ve açıklıkların yorumlanmasına dayalı olarak cephenin yıkımı/yeniden inşası

- Mevcut cepheye ekli somut objeler/modüller ile yansıtımın hibrit birleşimi
- Mimari cepheye yapının iç mekânına dair görsellerin yansıtılarak yapıya yapının yansıtılması
- Perspektifin yorumlanmasıyla birden çok cepheye yansıtım yapılarak kentsel perspektifi yeniden kurgulama
- Bağımsız tasarım yaklaşımı altında mimari cepheyle ilişkisi olmayan görsellerin kullanımı

Mimari cepheleri referans alan projeksiyon haritalama örneklerine bakıldığında ulusal ve uluslararası ölçekte farklı örneklerle karşılaşılmaktadır. Çalışmanın bu kısmında öne çıkan özellikleri ile örnek uygulamalar ele alınmıştır. Şekil 1'deki 555 Kubik uygulaması hem öncü hem de kapsamlı bir örnek olarak öne çıkmaktadır. Hamburg'daki Hamburger Kunsthalle yapısının cephesi üzerine yansıtılan projeksiyon haritalama çalışmasında, mimari cephe karakteristiğini takip eden yaklaşımların kapsamlı bir uygulama altında farklı biçimlerde kullanıldığı görülmektedir (Urbanscreen, 2009). Mimari cephenin doluluk/boşluk ilişkisi üzerinden değerlendirilmesiyle fiziksel olarak mevcut yapı yüzeyindeki dolu yüzeylerin sanal olarak boşaltıldığı görülmektedir. Mevcut mimari cephe farklı mimari düzenlemeler altında izleyiciye yeniden sunulmaktadır.

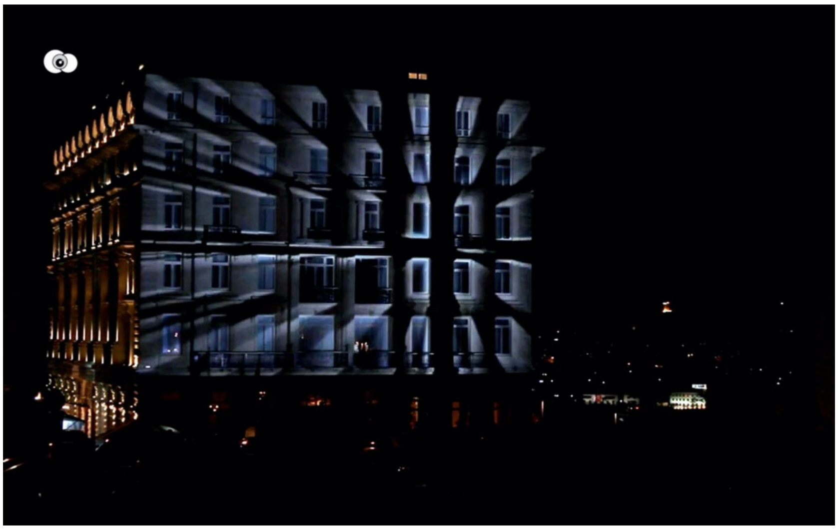
Şekil 1: 555 Kubik uygulamasında mimari cephedeki doluluk/boşluk ilişkisinin değişimi (The transformation of the mass/void relationship on the architectural facade in 555 Kubik) (Urbanscreen, 2009).

Şekil 2'de, cephenin yapı elemanı üzerinden değerlendirilmesi ile elemanın birimsel özelliği göz önünde bulundurularak oluşturulan bir tasarım kurgusuyla karşılaşılmaktadır. Bu kurgu dahilinde ele alınan 3.

boyut etkisiyle yapı elemanlarının öne çıkması ya da geriye doğru çekilmesi göze çarpmaktadır. Yapı elemanları üzerinden elemanlara dayalı birimsel bir yaklaşım benimsenirken, bu elemanlar üzerinde oluşturulan hareketli bir düzen ile de dinamik bir cephe görüntüsü oluşturulmaktadır. Mevcut mimari cephedeki sabit ve düz yüzeyler, sanalda hareketli olarak tasarlanmış yeni yüzeyler olarak izleyiciye sunulmaktadır. Ayrıca mimari cepheye yapının iç mekânına dair görselleri yansıtma/yapıya yapıyı yansıtma yaklaşımı ile de karşılaşılmaktadır. Mimari cephe karakteri açısından yapının geniş ve yalın boşluklar içeren yüzeylere sahip olması farklı yaklaşımların denenmesini de kolaylaştırmıştır.

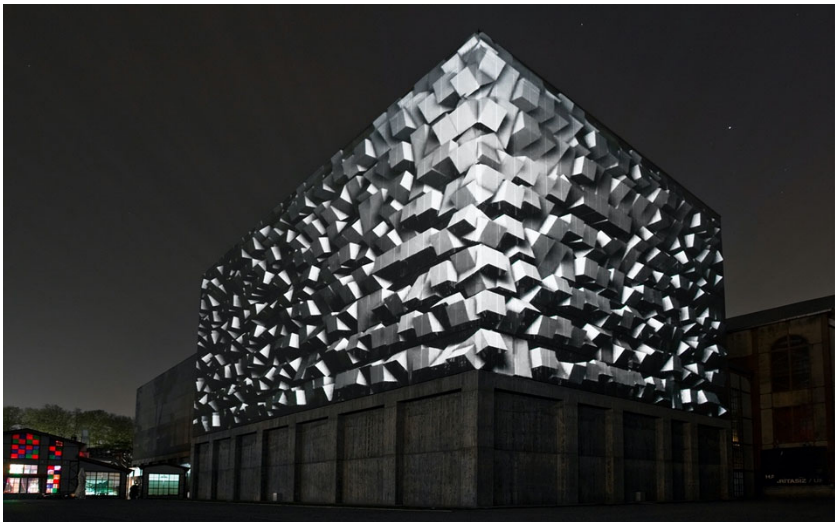
Şekil 2: 555 Kubik uygulamasında yapı elemanları üzerinden yaklaşım ve 3. boyut etkisiyle değişim (The transformation of the building elements and the 3D effect on the architectural facade in 555 Kubik) (Urbanscreen, 2009).

Şekil 3'deki görsel Pera Palas Oteli için ilk açılış gecesinin yıldönümü kutlamalarında Nota Bene Visual tarafından hazırlanan projeksiyon haritalama uygulamasıdır (Nota Bene Visual, 2010). Bu çalışmada da mimari cepheyi referans alan görselleştirmeler ile karşılaşılmaktadır. Çalışma genellikle cephenin mevcut biçimi üzerinden ışıklandırmalarla üretilmiş görsellerden oluşmaktadır. Belirli bir ritim ve düzen altında oluşturulmuş pencerelerin yoğun olduğu bir cephe biçimlenişi içerisinde, pencere boşluklarını referans alan ışıklandırmalar dikkat çekmektedir.



Şekil 3: Pera Palas Oteli için hazırlanan uygulamada mevcut cepheye referansla pencereleri öne çıkarma (Highlighting the windows with reference to the existing facade on Pera Palas Hotel) (Nota Bene Visual, 2010).

Şekil 4'deki Quadrature projeksiyon haritalama çalışması, Santralistanbul Çağdaş Sanat Müzesi'nin ana binasının mimari cephesi ile etkileşime giren bir görsel uygulamadır. Çalışma yapının cephesini oluşturan dörtgen alüminyum modüllerin gerçek boyutuna ve formuna uyan, monokrom geometrik biçimlerden oluşturulmuştur (Quadrature, 2013). Düzenli bir ritim altında olan mevcut cephenin görsel üretiminde de bu bileşen modüllerin dikkate alınarak çalışmanın tasarlandığı görülmektedir. Çalışma yansıtıldığı yüzeylerde yapıyı yeniden biçimlendiren ve dönüştüren görseller ortaya koymaktadır. Yapının mimari cephesindeki yalın yaklaşımın dışına çıkılarak, cephe yüzeylerinde farklı karakteristikler altında geometrik değişimler yapılabildiği görülmektedir.



Şekil 4: Quadrature uygulamasında yapı elemanlarının takibi ile geometrik dönüşümler (Geometric transformations with tracking of building elements in Quadrature) (Quadrature, 2013).

Şekil 5'deki Walt Disney Concert Hall yapısı üzerinde gerçekleştirilen WDCH Dreams projeksiyon haritalama uygulamasında yapıya ilişkin geçmişteki veriler toplanarak bu veriler doğrultusunda görseller üretilmiştir (WDCH Dreams, 2019). Yapının eğrisel ve karmaşık formu göz önüne alındığında, yapıya ilişkin olarak mimari cephenin yerinde durmasını sağlayan ama dışarıdan görünmeyen taşıyıcı sisteme ilişkin görsel sunumu dikkat çekmektedir. Yapıya ilişkin verilerin yansıtıldığı, yapıya yapıyı yansıtma yaklaşımının bir örneği olarak karşılaşılmaktadır.

Şekil 5: WDCH Dreams uygulamasında taşıyıcı sistemin mimari cephede sunumu (The presentation of the structural system on the architectural facade in WDCH Dreams) (WDCH Dreams, 2019).

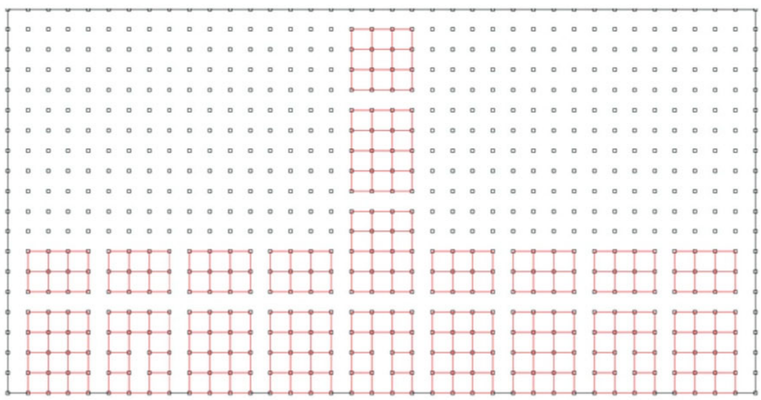
3. GENETİK ALGORİTMA ARACILIĞIYLA TANIMLAMALARA DAYALI GÖRSEL ÜRETİMİ (THE GENERATION OF VISUALS BASED ON DEFINITIONS THROUGH GENETIC ALGORITHM)

Evrim kuramı bilişim alanında farklı yaklaşımların ortaya çıkmasını sağlamıştır. Doğadaki evrim yaklaşımını referans alan evrim kuramı temelli olarak geliştirilen veri işleme teknikleri, geleneksel yöntemler altında çözümü zor olan karmaşık problemlerin çözümünde önemli bir yere sahiptir (Eiben ve Smith, 2015). Bu tekniklerden biri olan Genetik Algoritma yaklaşımı da doğadaki evrimsel sürecin işleyişini kendine temel alarak, bu doğrultuda probleme dayalı olarak verilerin işlenmesiyle çözüm üretmeye odaklıdır. Holland'ın (1992) canlılarda yaşanan genetik süreci hesaplama ortamında gerçekleştirmeyi düşünmesinin sonucu olarak ortaya çıkmıştır. Geniş bir çözüm kümesinin taranması gereken problemler için diğer yöntemlere göre daha kısa sürede kabul edilebilir sonuçlar elde edilmesini sağlamaktadır.

Tasarım ve mimarlık alanındaki farklı problemlere ilişkin olarak da çözüm üretmek konusunda genetik algoritmalar ile çalışıldığı görülmektedir (Turner, 2012; Fasoulaki, 2007; DeLanda, 2002). Bu çalışma kapsamında da mimari cepheler için cephe dilini taşıyan görsellerin üretimine yönelik bir model çerçevesinde genetik algoritma yaklaşımından faydalanılmaktadır.

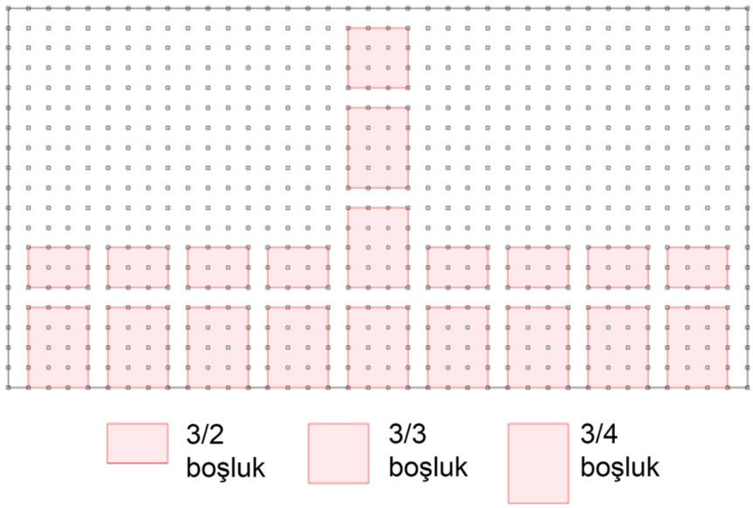
3.1 Mimari Cephenin Tanımlanması (Defining the Architectural Facade)

Modeli açıklamak ve görselleştirmeler ile desteklemek için çalışma kapsamında örneklerde ele alınan 555 Kubik uygulamasının gerçekleştirildiği Hamburger Kunsthalle yapısının cephesi kullanılmıştır. Bu cephenin tercih edilmesinde cephenin mimari açıdan farklı üretimlere sunduğu potansiyeller etkili olmuştur. Bu mimari cephe üzerinde tasarlanan 555 Kubik uygulaması ile Urbanscreen, German Design Award 2012'yi almıştır. Hamburger Kunsthalle yapısının cephesi rasyonel bir tanımlama altında ele alındığında x doğrultusunda 38, y doğrultusunda ise 19 nokta üzerinden tanımlanabileceği görülmektedir. Bu noktalar üzerinden ise ayrıt olarak x doğrultusunda 37, y doğrultusunda ise 18 olmak üzere gidilen tanımlamada, 666 adet tanımlı yüzey ortaya çıkmaktadır (Şekil 6).



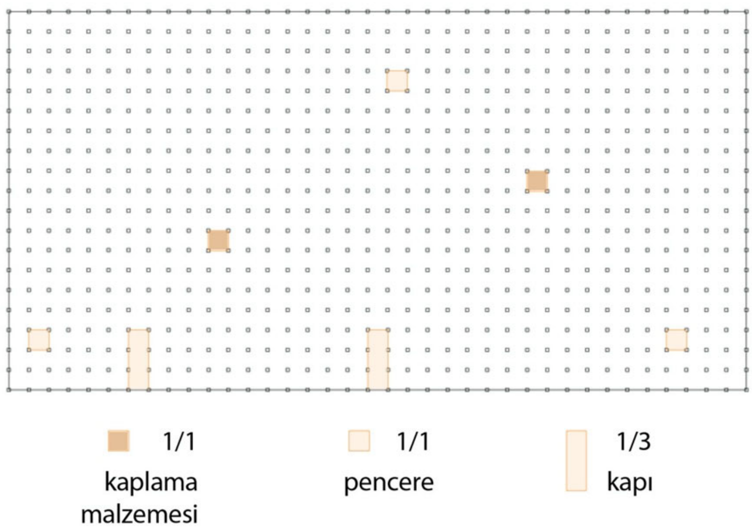
Şekil 6: Hamburger Kunsthalle yapı cephesinin gridal sistem altında tanımlanması (Defining the building facade of the Hamburger Kunsthalle under the gridal system)

Mimari olarak yapı cephesini referans alan projeksiyon haritalama uygulamalarının incelenmesinden sonra doluluk/boşluk ilişkisi, yapı elemanları ve 3. boyut etkisi üzerinden cephenin yeniden tanımlanabildiği görülmüştür. Bu üç tanımlama biçimi gridal bir sistem altında Hamburger Kunsthalle yapısının cephesi üzerinden değerlendirilmiştir. Mimari cephe görsellerinin bu tanımlamalar doğrultusunda üretilebileceği görülmüştür. Yapının doluluk/boşluk ilişkisi üzerinden tanımlanmasında yapıdaki boşluk verilerinden yola çıkılmıştır. Mimari cephe verileri 3/2 birim, 3/3 birim ve 3/4 birim boyutlarında açıklıkların yapının tasarım dilinde yer aldığını göstermektedir (Şekil 7).



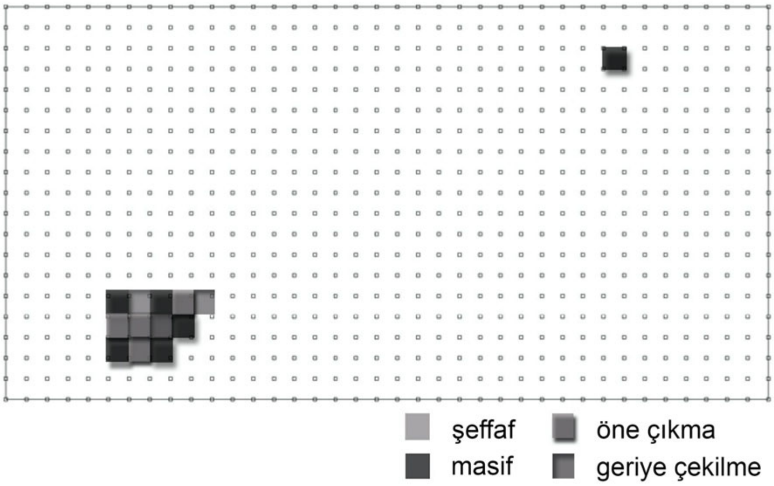
Şekil 7: Hamburger Kunsthalle yapı cephesinin doluluk/boşluk üzerinden tanımlanması
(Defining the building facade of the Hamburger Kunsthalle on mass/void relationship)

Yapı elemanları üzerinden yapılan tanımlamada yapının 1/1 birim boyutlarındaki kaplama malzemeleri, 1/1 birim boyutlarındaki pencere elemanları ve 1/3 birim boyutlarındaki kapı elemanlarından oluştuğu görülmektedir (Şekil 8).



Şekil 8: Hamburger Kunsthalle yapı cephesinin yapı elemanları üzerinden tanımlanması
(Defining the building facade of the Hamburger Kunsthalle on building elements)

3. boyut etkisi üzerinden yapılan tanımlamada ise yapıdaki birim elemanların tipolojisine ve çevresindeki diğer birimlerden farklı yükseklikte olmasına bağlı olarak tanımlanabileceği görülmektedir. Birim eleman tanımlanan yüksekliğe bağlı olarak öne çıkmakta ya da geriye çekilmektedir (Şekil 9).

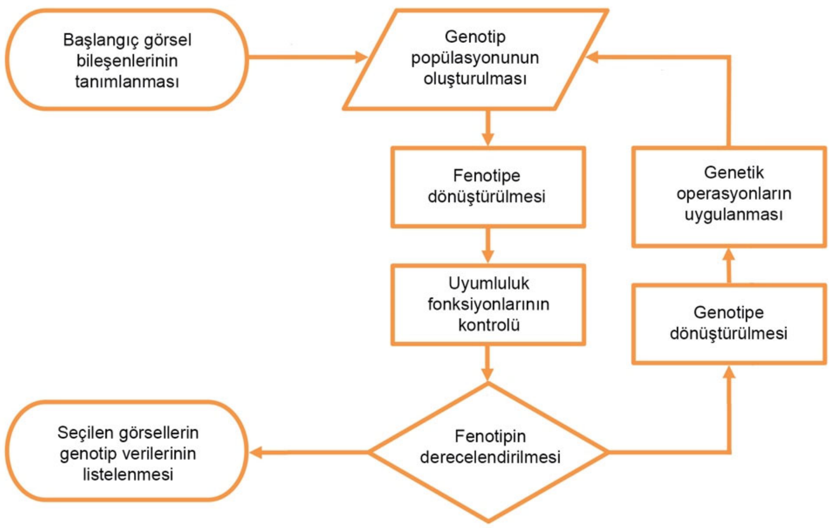


Şekil 9: Hamburger Kunsthalle yapı cephesinin 3. boyut etkisi üzerinden tanımlanması
(Defining the building facade of the Hamburger Kunsthalle on 3D effect)

3.2 Genetik Algoritma Temelli Model Önerisi (Genetic Algorithm Based Model Proposal)

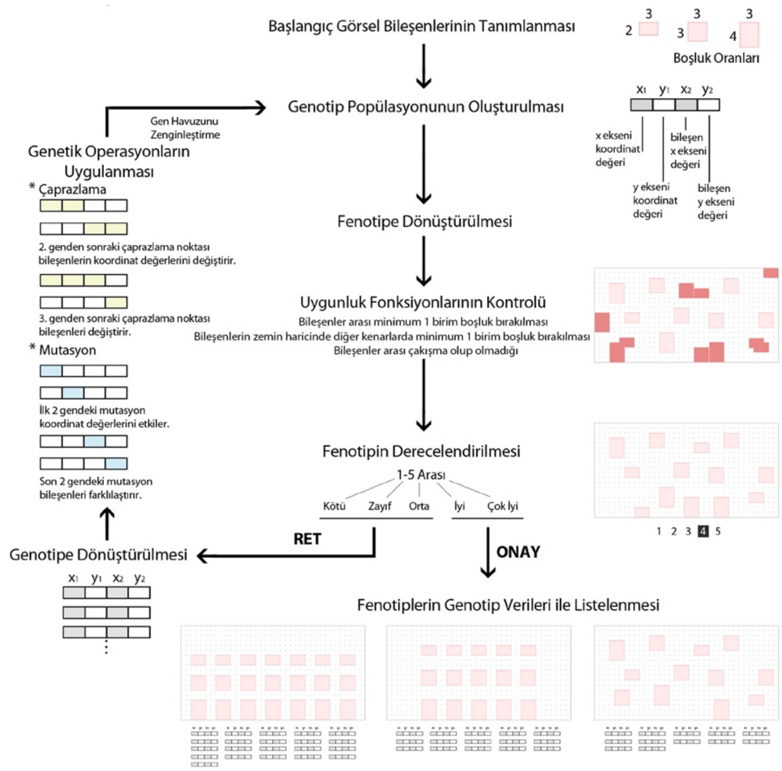
Genetik algoritma, evrimsel operatörlerin analojisine dayalı olarak işlemektedir. Kendi içerisinde barındırdığı gen, genetik kod, genotip, fenotip, popülasyon, genetik operasyonlar ve uygunluk fonksiyonu terminolojisi ile bilimsel çalışmalara hizmet etmektedir. Gen bir genotipin en küçük birimi iken, genetik kod bir genotipte kodlama için kullanılan rakamlar ya da harflerdir. Genotip, belirli bir düzene veya ilişkiye sahip gen dizilimi olarak ortaya çıkar. Fenotip ise genotipin görselleştirilmiş eşdeğer halidir. Aynı türden genetik kodlar altındaki genotiplerin bir araya geldiği topluluklar popülasyonları oluşturur. Popülasyon içerisindeki genotipler ise çaprazlama ve mutasyon gibi genetik operasyonlar aracılığı ile zenginleştirilir (Singh ve Gu, 2012). Genetik algoritma, üretken bir tasarım yaklaşımı olarak bileşenlere dayalı tasarımlarda birden fazla tasarım alternatifi sunma ve optimizasyon açısından kolaylıklar sunmaktadır. Genetik algoritma temelli çalışmalar için problemin formüle edilmesi, uygun genetik kodlar altında genotip ve fenotiplerin temsil edilmesi ve uygunluk fonksiyonlarının belirlenmesi önem taşımaktadır. Uygunluk fonksiyonu, ortaya konulan değerlendirme ölçütlerinin sağlanıp sağlanmadığının kontrol edilmesini sağlamaktadır. Bu nedenle genetik algoritma temelli çalışmalarda uygunluk fonksiyonlarının iyi tanımlanması gereklidir. Uygunluk fonksiyonlarının yanı sıra seçilimin yönlendirilmesinde değerlendirici katılımı, tasarımın değerlendirilmesiyle birlikte iyileştirme imkânı sunar (Bentley, 1999).

Genetik algoritma temelli olarak ortaya konulan model önerisinde doluluk/boşluk ilişkisi, yapı elemanları ve 3. boyut etkisi üzerinden yapılan tanımlamalardan faydalanarak görsellerin üretimi açıklanmıştır. Şekil 10'da gösterilen iş akış diyagramı, modelin çalışma sistematiğini ortaya koymaktadır. Süreç, başlangıç görsel bileşenlerinin tanımlanması ile başlamakta ve bu bileşenlerden oluşan bir genotip popülasyonu oluşturulmaktadır. Oluşturulan genotip bir sonraki aşamada fenotipe dönüştürülerek uygunluk fonksiyonlarının kontrolü yapılırken, kullanıcı tarafından da aynı zamanda görsel olarak takip edilebilmesinin sağlanması amaçlanmaktadır. Nesnel değerlendirme ölçütlerinden oluşan uygunluk fonksiyonlarını sağlayan fenotipler, öznel değerlendirme ölçütleri altında kullanıcı tarafından derecelendirilmektedir. Onay alan fenotipler genotip verileri ile listelenmekte, ret alanlar ise genotipe dönüştürülerek genetik operasyonlara sokulmaktadır. Genetik operasyonlar altında çaprazlama ve mutasyon ile gen havuzunu zenginleştirecek yeni nesiller üretilmekte ve genotip popülasyonuna dahil edilmektedir. Bu süreç kullanıcının istediği sayıda uygun görsel elde edilene kadar devam etmektedir.



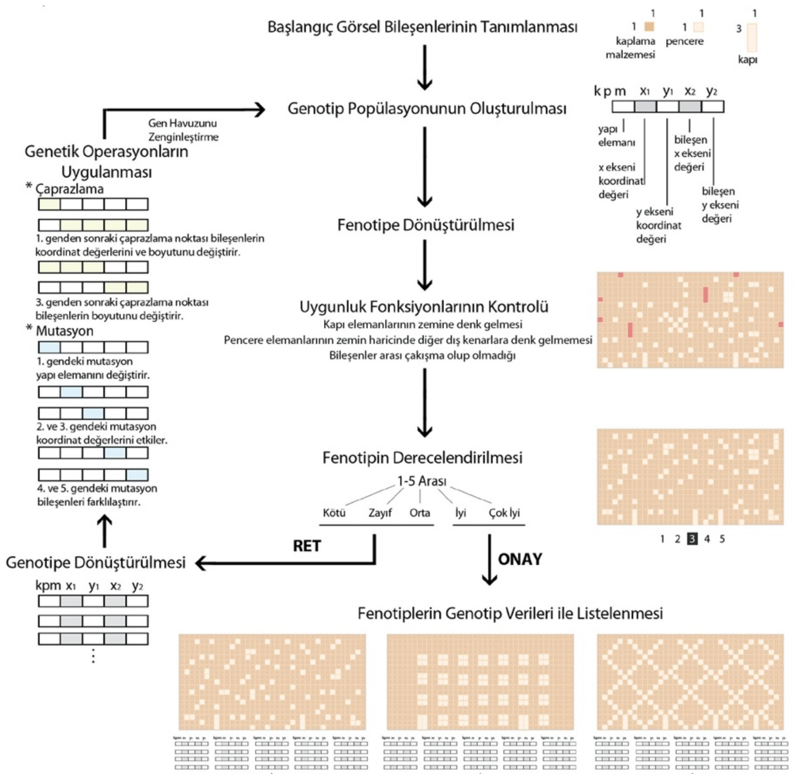
Şekil 10: Mimari cephe görsellerinin üretimi için genetik algoritma temelli modelin iş akış diyagramı (Workflow diagram of genetic algorithm based model for the generation of architectural facade visuals)

Şekil 11'de görüldüğü gibi genetik algoritma aracılığı ile doluluk/boşluk ilişkisi üzerinden mimari cephenin tanımlanması, çalışmadaki iş akış diyagramına göre oluşturulmuştur. Başlangıç görsel bileşenleri olarak yapı üzerindeki boşluk oranları birim üzerinden tanımlanmıştır. Tanımlama sonucunda 2/3 birim, 3/3 birim ve 3/4 birim oranlarında boşlukların yer aldığı görülmüştür. Tanımlanan boşluklardan seçilen bileşen sayısına bağlı olarak genotip popülasyonu oluşturulmuştur. Popülasyondaki genler 4 parçadan oluşmakta 1. parça x ekseni koordinat değerini, 2. parça y ekseni koordinat değerini, 3. parça bileşenin x boyutunun ve 4. parça ise y boyutunun verisini içermektedir. Oluşturulan genotip popülasyonu bir sonraki aşamada fenotipe dönüştürülmekte, kullanıcıya görsel olarak oluşturulan fenotip sunulurken uygunluk fonksiyonlarını sağlayıp sağlamadığı da görüntülenmektedir. Doluluk/boşluk ilişkisi üzerinden yapılan değerlendirmede uygunluk fonksiyonları olarak bileşenler arası minimum 1 birim boşluk bırakılıp bırakılmadığının, bileşenlerin zemin haricinde diğer kenarlarında 1 birim boşluk bırakılmasının ve bileşenler arası çakışma olup olmadığının kontrolü yapılmaktadır. Uygunluk fonksiyonlarını sağlayan fenotipler bir sonraki aşamaya aktarılmakta ve kullanıcı tarafından derecelendirilmesi beklenmektedir. Kullanıcı kötü, zayıf, orta, iyi ve çok iyi şeklinde 5 kademeli bir değerlendirmede bulunabilmekte, bu değerlendirme sonucunda iyi ve çok iyi alan fenotipler onaylanarak çözüm kümesine aktarılmaktadır. Uygunluk fonksiyonunun kontrolü sonrası gerçekleşen kullanıcı değerlendirmesi, çözüm kümesine aktarılan görsellerin nesnel değerlendirme ölçütleri sonrası kullanıcının öznel değerlendirme ölçütlerinden de geçmesini sağlamaktadır. Diğer kötü, zayıf ve orta değerlendirmeler ise ret alarak yeniden genotipe dönüştürülmekte ve genetik operasyonlara dahil edilmektedir. Çaprazlamada 2. genden sonraki çaprazlama noktası bileşenlerin koordinat değerini, 3. genden sonraki çaprazlama noktası ise bileşenleri değiştirmektedir. Mutasyonda ise ilk 2 gendeki mutasyon koordinat değerlerini etkilerken, son 2 gendeki mutasyon bileşenleri farklılaştırır. Genetik operasyonlar sonucu genlerde konum ve biçim bazlı zenginleştirme sağlanmış olur. Oluşan yeni genler gen havuzuna aktarılarak popülasyona dahil edilir ve döngü bu şekilde devam eder. Model kullanıcısı üretilen görselleri yeterli bulup, döngüyü sonlandırana kadar üretim gerçekleşir.



Şekil 11: Genetik algoritma aracılığıyla doluluk/boşluk ilişkisi üzerinden tanımlamalarla görsel üretimi (Visual generation with definition of mass/void relationship through genetic algorithm)

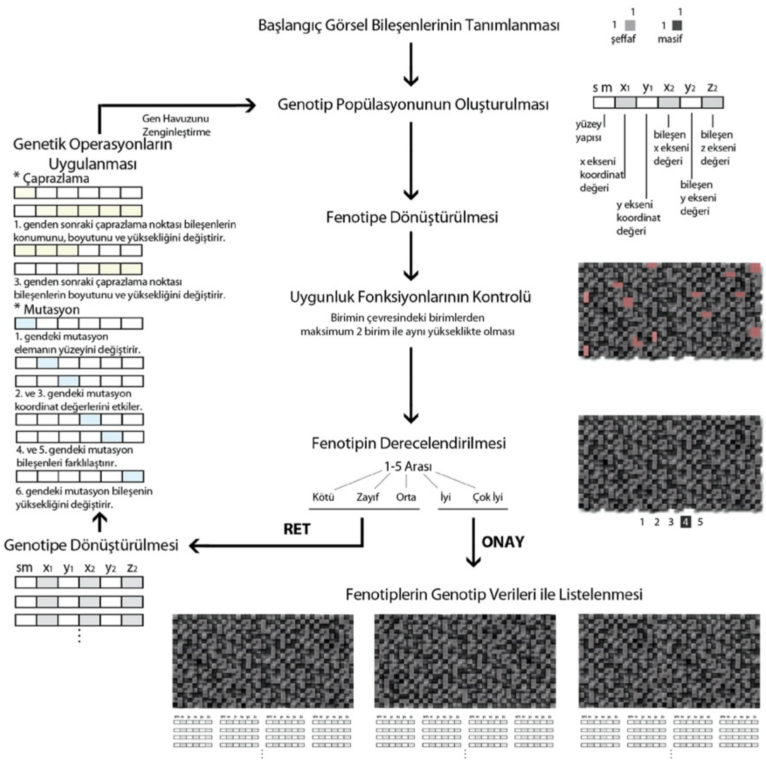
Şekil 12'de yapı elemanları üzerinden genetik algoritma aracılığı ile oluşturulmuş sürecin işleyişi sunulmuştur. Başlangıç görsel bileşenlerinin tanımlanması ile başlanan yaklaşımda 1/1 birim kaplama malzemesi, 1/1 birim pencere elemanı ve 1/3 birim kapı elemanı bileşenleri bulunmaktadır. Seçilen bileşen sayısına da bağlı olarak genotip popülasyonu oluşturulmaktadır. Popülasyondaki genler 5 parçadan oluşmakta 1. parça yapı elemanı türünün, 2. parça x ekseni koordinat değerinin, 3. parça y ekseni koordinat değerinin, 4. parça bileşenin x boyutunun ve 5. parça ise bileşenin y boyutunun verisini içermektedir. Oluşturulan genotip popülasyonu bir sonraki aşamada fenotipe dönüştürülmekte, kullanıcıya görsel olarak oluşturulan fenotip sunulurken uyumluluk fonksiyonlarını sağlayıp sağlamadığı da görüntülenmektedir. Yapı elemanları üzerinden yapılan değerlendirmede uyumluluk fonksiyonları olarak kapı bileşeni için elemanların zemine denk gelmesi, pencere bileşeni için zemin haricinde diğer dış kenarlara denk gelmemesinin ve bileşenler arası çakışma olup olmadığının kontrolü yapılmaktadır. Uyumluluk fonksiyonlarını sağlayan fenotipler bir sonraki aşamaya aktarılmakta ve kullanıcı tarafından derecelendirilmektedir. Değerlendirme sonucunda iyi ve çok iyi alan fenotipler onaylanarak çözüm kümesine aktarılmaktadır. Ret alanlar ise yeniden genotipe dönüştürülmekte ve genetik operasyonlara dahil edilmektedir. Çaprazlamada 1. genden sonraki çaprazlama noktası bileşenlerin koordinat değerlerini ve boyutunu, 3. genden sonraki çaprazlama noktası ise bileşenlerin boyutunu değiştirmektedir. Mutasyonda ise 1. gendeki mutasyon yapı elemanını değiştirirken, 2. ve 3. gendeki mutasyon koordinat değerlerini etkiler, 4. ve 5. gendeki mutasyon da bileşenleri farklılaştırır. Genetik operasyonlar sonucu genlerde yapı elemanı, konum ve biçim bazlı değişimler ortaya çıkar. Oluşan yeni genler gen havuzuna aktarılarak popülasyona dahil edilir ve döngü sonlandırılana kadar devam eder.



Şekil 12: Genetik algoritma aracılığıyla yapı elemanları üzerinden tanımlamalarla görsel üretimi (Visual generation with definition of building elements through genetic algorithm)

Şekil 13'de görüldüğü gibi genetik algoritma ile 3. boyut etkisinin tanımlanmasında ise şeffaf ve masif olmak üzere aynı boyutlardaki iki bileşen üzerinden çalışılmıştır. Tanımlanan elemanlardan seçilen bileşen sayısına bağlı olarak genotip popülasyonu oluşturulmaktadır. Popülasyondaki genler 6 parçadan oluşmakta 1. parça bileşen tipini, 2. parça x ekseni koordinat değerinin, 3. parça y ekseni koordinat değerinin, 4. parça bileşenin x boyutunun, 5. parça bileşenin y boyutunun ve 6. parça ise bileşen yüksekliğinin verisini içermektedir.

Oluşturulan genotip popülasyonu bir sonraki aşamada fenotipe dönüştürülmekte, kullanıcıya görsel olarak oluşturulan fenotip sunulurken uyumluluk fonksiyonlarını sağlayıp sağlamadığı da görüntülenmektedir. 3. boyut etkisi üzerinden yapılan değerlendirmede uyumluluk fonksiyonu olarak birimin çevresindeki birimlerden maksimum 2 birim ile aynı yükseklikte olmasının kontrolü yapılmaktadır. Uyumluluk fonksiyonlarını sağlayan fenotipler bir sonraki aşamaya aktarılmakta ve kullanıcı tarafından derecelendirilmektedir. Değerlendirme sonrası iyi ve çok iyi alan fenotipler onaylanarak çözüm kümesine aktarılırken, ret alanlar yeniden genotipe dönüştürülmekte ve genetik operasyonlara dahil edilmektedir. Çaprazlamada 1. genden sonraki çaprazlama noktası bileşenlerin konumunu, boyutunu ve yüksekliğini değiştirirken; 3. genden sonraki çaprazlama noktası ise bileşenlerin sadece boyutunu ve yüksekliğini değiştirmektedir. Mutasyonda ise 1. gendeki mutasyon yapı bileşenini değiştirirken, 2. ve 3. gendeki mutasyon koordinat değerlerini etkiler, 4. ve 5. gendeki mutasyon bileşenleri farklılaştırır ve 6. gendeki mutasyon bileşenin yüksekliğini değiştirir. Genetik operasyonlar sonucu genlerde yüzey tipolojisi, konum, biçim ve yükseklik bazlı değişimler ortaya çıkar. Oluşan yeni genler de gen havuzuna aktarılarak popülasyona dahil edilir ve döngü bu şekilde devam eder.



Şekil 13: Genetik algoritma aracılığıyla 3. boyut etkisi üzerinden tanımlamalarla görsel üretimi (Visual generation with definition of 3rd dimensional effect through genetic algorithm)

4. SONUÇ (CONCLUSION)

Çalışmada ortaya konulan genetik algoritma temelli model, mimari cepheler için belirli tanımlamalar altında cephenin karakterini taşıyan diğer sanal olasılıkların üretilmesi için bir yöntem önerisi sunmaktadır. Günümüz teknolojik altyapıları ile görsel olarak mimari cephelerin kendini sunması, görünümlerini değiştirebilmesi ve çevresindekilerle etkileşime girebilmesi mümkündür. Projeksiyon haritalama uygulamaları ise bu tip görsel üretimlerin kullanılabileceği birincil alanlar olarak görülmektedir. Projeksiyon haritalama için içerik üretim sürecinde genetik algoritma temelli yaklaşımla elde edilebilecek seçilmiş görseller ile aralarındaki geçişlerin de tanımlanmasıyla yapı cephesini referans alan animasyonlar üretilebilir. Projeksiyon haritalama uygulamaları etkileşim kurdukları her bir çalışma ile birer uzamsal artırılmış gerçeklik uygulamasıdır. Bu nedenle genetik algoritma ve uzamsal artırılmış gerçeklik kesişiminde yeni üretim ve sunum imkanlarının kurulması önemli görülmektedir.

Bu çalışmada öne çıkan çalışmalar da göz önünde bulundurularak mevcut cephe ile ilişki kuran görsel üretimlerin üzerinde durulmuştur. Çalışma kapsamında ele alınan Hamburger Kunsthalle yapısının cephesi üzerinden doluluk/boşluk ilişkisi, yapı elemanları ve 3. boyut etkisi üzerinden örnek tanımlamalar geliştirilmiştir. Bu tanımlamaların yapı yüzeylerini belirli rasyonel yaklaşımlar altında ifade etme açısından önemli olduğu düşünülmektedir. Kurgulanan 3 farklı tanımlama ile genetik algoritma temelli model belirli bir iş akış süreci altında sunulmuştur. Bu süreçlerde mimari cephenin dilini taşıyan görsellerin varyasyonlarıyla üretilebileceği çerçeveler tanımlanmıştır.

Genetik algoritma ile çalışmanın bir sınırlayıcısı olarak, model kullanıcısı üretilecek görsellerde belirleyici bir role sahiptir ve kullanıcının cephenin mimari diline uygun görsel seçiminde uzman olması gerekmektedir. Çalışma kapsamında modelin görsel üretimi adına 2 boyutlu üretim yaklaşımı benimsenmiştir, gelecek çalışmalarda 3 boyutlu üretimler için genetik algoritmalardan faydalanmaya odaklanılabileceği düşünülmektedir.

Çıkar çatışması beyanı (Conflict of Interest Statement)

Çalışmanın yazarı bu çalışmada, sonuçları veya yorumları etkileyebilecek herhangi bir maddi veya diğer asli çıkar çatışması olmadığını beyan eder.

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An Exploration of Public Open Spaces with Data Driven Approaches: A Case Study of Beyazıt Square

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Data-driven approaches are widely used to gain insight in urban dynamics and support urban decisions with pervasive adoption of information technologies. In the presented study, the students adopt data data-driven approaches to observe, and analyze public spaces, and make conceptual decisions for urban furniture in the context of the workshop. This workshop is developed within the scope of the Environmental Computing course. It is conducted with 27 students in Beyazıt Square as a case study area. In the scope of the study, open public spaces were observed and analyzed using data-driven approaches. Based on the analysis results, the students were expected to develop urban furniture design that would enhance user experience and activities in the area. This study questions how data-driven approaches aid in exploring public spaces and support design decisions. The objective of the study was to explore user-generated urban dynamics using multiple data and make decisions for urban furniture that augments urban dynamics. The conceptual design process of urban furniture is shaped as results of data-driven approach. The students were introduced to the Public Life Tools developed by the Gehl Institute for site observation. They were divided into particular groups and used relevant digital tracking applications to measure user activities, user profiles, and live traffic in the area. They evaluated the quality of place based on predetermined criteria by Gehl Institute. The phases of the study involve (1) the exploration of digital observation methods, (2) mapping observational, data, urban data, and locative media data in Geographic Information System (GIS), and (3) defining the relationships between the parameters affecting urban dynamics. (4) This was followed by making conceptual design decisions and (5) developing the design of urban furniture considering data analysis results. According to the findings, the use of data-driven observation and analysis methods has been effective in developing user scenarios, determining user profiles, identifying needs, and taking functional decisions in urban furniture design. Based on the students' evaluation, the data-driven decision-making process was effective in identifying needs, problems, and potentials in the area. As the limitations of the study, the students stated that the use of digital observation methods and the learning process of GIS software were challenging. This study contributes to the field of urban computing through its conducted fieldwork.

Keywords: Public open spaces (POS), Digital observation methods, Geographic Information Systems (GIS), Data-driven approaches, Urban dynamics.

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Kamusal Açık Mekanların Veriye Dayalı Yaklaşımlar ile Keşfi: Beyazıt Meydanı Örneği

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Bilişim teknolojilerinin yaygınlaşması ile veriye dayalı yaklaşımlar karmaşık kent dinamiklerini anlamak ve kentsel karar alma sürecinde yaygın olarak kullanılmaktadır. Çalışmada veriye dayalı yaklaşımlar kamusal mekanın gözlemlenmesi, analizi ve tasarım kararlarında uygulanması ders kapsamında geliştirilen atölye çalışması ile deneyimlenmiştir. Çalışma kapsamında geliştirilen atölye Çevresel Bilişim dersi kapsamında 27 öğrenci tarafından yürütülmüştür. Çalışma alanı Beyazıt Meydanı'dır. Çalışma kapsamında açık kamusal mekanlar veriye dayalı yaklaşımlar ile analiz edilmiş, analiz sonuçlarına dayanarak öğrencilerden mekandaki kullanıcı deneyim ve aktivitelerini arttıracak kentsel mobilya tasarımı geliştirilmesi beklenmiştir. Araştırma sorusu veriye dayalı yaklaşımların kamusal mekanların dinamiklerini keşfetmede nasıl yardımcı olacağını ve tasarım kararlarını nasıl destekleyebileceğini sorgular. Çalışmanın amacı kamusal alandaki kullanıcı kaynaklı kent dinamiklerinin farklı veri kaynakları keşfedilmesi, ilişkilendirilmesi ve kent dinamiğini arttırabilecek kentsel mobilya tasarım kararları alınmasıdır. Kentsel mobilya tasarımının kavramsal süreci veriye dayalı yaklaşımların sonuçlarına göre şekillenmiştir. Çalışmada öğrencilere alan gözlemi için Gehl Institute tarafından geliştirilmiş Kamusal Yaşam Ölçme Araçları (Public Life Tools) tanıtılmıştır. Öğrenciler belirli gruplara ayrılarak ilgili dijital takip uygulamaları ile alandaki kullanıcı aktivitelerini, kullanıcı profilini, canlı trafiği ölçmüşledir. Alanın kalitesini Gehl Institute tarafından belirlenen kriterlere göre değerlendirmişlerdir. Çalışma aşamalarını kamusal alandaki veriye dayalı ölçme ve gözlemleme yöntemlerinin dijital araçlar ile keşfi, verinin Coğrafi Bilgi Sistemi'nde (Geographic Information Systems: GIS) haritalanması, veri haritalama sonucunda veriler arasındaki ilişkinin tanımlanması oluşturmaktadır. Daha sonra veriye dayalı olarak kentsel mobilya konseptinin kavramsal tasarım kararlarının alınması ve tasarımını geliştirilmesi ile takip etmektedir. Veriye dayalı gözlem ve analiz yöntemlerinin kentsel mobilya tasarımında kullanıcı senaryoları geliştirme, kullanıcı profili belirleme ve ihtiyaçlarını belirleme bu bağlamda işlev kararlarını almada etkili olmuştur. Öğrencilere göre veriye dayalı karar alma süreci alandaki ihtiyaçların, problemlerin ve potansiyellerin belirlenmesinde etkili olmuştur. Öğrenciler çalışmanın kısıtları olarak dijital gözlem yöntemlerinin kullanımı ve GIS programının öğreniminin zor olduğunu belirtmiştir. Çalışma yürütülen alan çalışması üzerinden kentsel bilişim alanına katkı sağlamaktadır.

Anahtar Kelimeler: Kamusal açık alan, Dijital gözlem yöntemleri, Coğrafi Bilgi Sistemleri (GIS), Veriye dayalı yaklaşımlar, Kent dinamikleri.

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1. INTRODUCTION

With the age of computation, data becomes an important source to create the computational approaches to understand complex urban dynamics. Observing and measuring becomes key aspects to gather data aiming to understand the public life in the cities. The dynamics of the cities become representative and measurable through the computational models generated with computation tools and methods. In urban informatics, Spatial distribution maps are closely linked with computational models. A spatial distribution map is utilized to visualize data in a spatial context. In this manner, it supports spatial computational models, that used to compute complex urban systems with intend to understand and predict an urban phenomenon. It can be said that the spatial distribution map of an urban parameter creates a baseline for computing it. The spatial distribution map of an urban parameter sets a basis to compute its dynamics.

On the other hand, spatial maps of urban dynamics get support from digital technologies. Locative media data, and digital tracing technologies enable to take the pulse of the public life. Locative media is location-based data obtained through mapping or navigating applications, or social media platforms (Wilken & Goggin, 2017). According to Wilken and Goggin (2017, p.1) locative media technologies are “linked to the places and spaces in which they are used and experienced. GPS coordinates, geotagged photos or videos, social media check-ins, or any other digital content linked to a specific physical location”. Digital tracing tools provide to count people in activities, track and trace people movement, which are grouped under advanced tracing technologies (ATT). The ATT involve GPS, mobile phone positioning, Wi-Fi tracking, RFID, Bluetooth, video monitoring, machine learning technologies, and mobile applications like Counterpoint (van der Spek, 2008; van Schaick, 2010). They contribute to urban knowledge by supporting spatial and functional maps (van Schaick, 2010). These technologies are used to collect spatial and temporal data with high accuracy, supporting urban planning decisions by providing data on pedestrian movement patterns, speed, transportation mode, and time spent at specific locations (van der Spek, 2008; van Schaick, 2010). In the scope of this research, digital tracing methods and locative media data have been employed to conduct data-driven decision-making process in order to improve the quality of public space. In the time of digitization, this study poses the question of how to include digital technics for understanding the urban place experiences and develop a design product that increases place experiences.

This study employs a data-driven approach to urban furniture design, in Beyazıt Square as the case study area. The aim is to incorporate data-driven decision-making into architectural education within the context of the workshop. This workshop forms part of the Environmental Informatics course, hosted by the Istanbul Kültür University's Faculty of Architecture Interior Architecture and Environmental Design Department. This lecture, comprised of 50 third and fourth-year undergraduate students from the fields of interior architecture and environmental design, promotes collaborative efforts with group projects involving 3 or 4 students each.

The workshop aims to introduce participants to digital tools and methods for investigating place dynamics and developing design concepts that enhance people's interaction with public spaces. The workshop begins with an introduction to the concepts of public space, public life, liveability and placemaking in public open spaces (POS). A range of digital tools, within various applications, analysis techniques, design strategies, and representation tools, are introduced to the students as a method to understand the place dynamics and formulate a design concept for urban furniture to augment public interaction with the space. The data-driven decision-making process (DDSS) workflow is depicted in Figure 1.

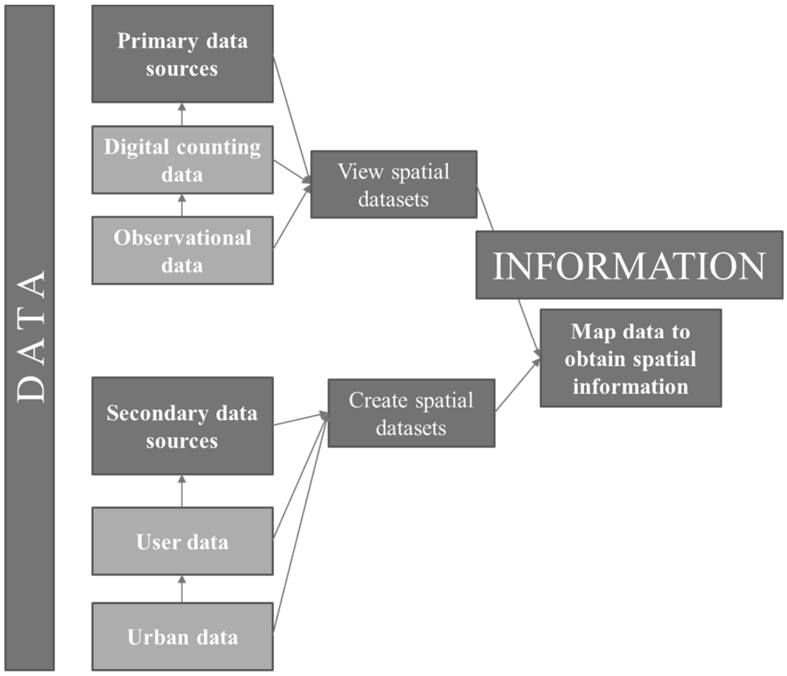


Figure 1: The workflow of data-driven decision process (developed by the author).

2.LITERATURE REVIEW

2.1 An Exploration Of Successful Public Spaces

Public spaces serve as the foundation for the public life of cities, where people engage with society and different activities (J. Gehl, 2007). These spaces play a crucial role in enhancing place image, fostering place attachment, and promoting a sense of place through people-place interactions (Urban Design Guidelines for Victoria, 2017). Public spaces used to be evolved organically according to human experiences, activities and uses. With the rapid urban growth, public life has been neglected through the car-dependency and large-scale urban development (J. Gehl & Svarre, 2013). Modernist cities have faced criticism due to their poor living environments, large-scale urban development, loss of control over public life, social segregation, inequality, and a decline in place attachment and place identity (A. Jacobs & Appleyard, 1987).

Since the 1960s, the focus of environmental design has been increasingly concentrated on the interaction of public life with public spaces, to gain a better understanding of the user dynamics and urban functioning (J. Gehl & Svarre, 2013). Jacobs' (1961) seminal work pointed out the drawbacks of modern cities for livable urban spaces and the need for livable urban spaces that center around human needs and experiences. Alexander et al., (1977) further emphasized community-centered design, which laid the foundation for the concept of public life. Kent (1975) asserts that everyone has the right to live in a good place, and therefore, individuals also have the right to contribute towards making a place better (PPS, 2007). Regarding the emphasis on human-centered public spaces, Kent (1975) established the organization of Public for Project Spaces (PPS), which played a pivotal role in implementing placemaking initiatives to improve the quality of life in public spaces (PPS, 2007). The placemaking approach empowers people to shape physical, cultural, and social aspects of public realm (PPS, 2016). The Project for Public Spaces (PPS, 2007) introduced 'the place diagram,' a tool designed for the assessment of public spaces. This diagram represents the key attributes, within their qualities and quantities for successful place, as shown in Figure 2. Four primary attributes are delineated for successful places, which are accessibility, comfort, and image, uses and activities, and sociability (PPS, 2016). Accordingly, the successful places are accessible and well connected, comfortable and have a good urban image, attract people for different activities, and sociable environments to visit (PPS, 2016).

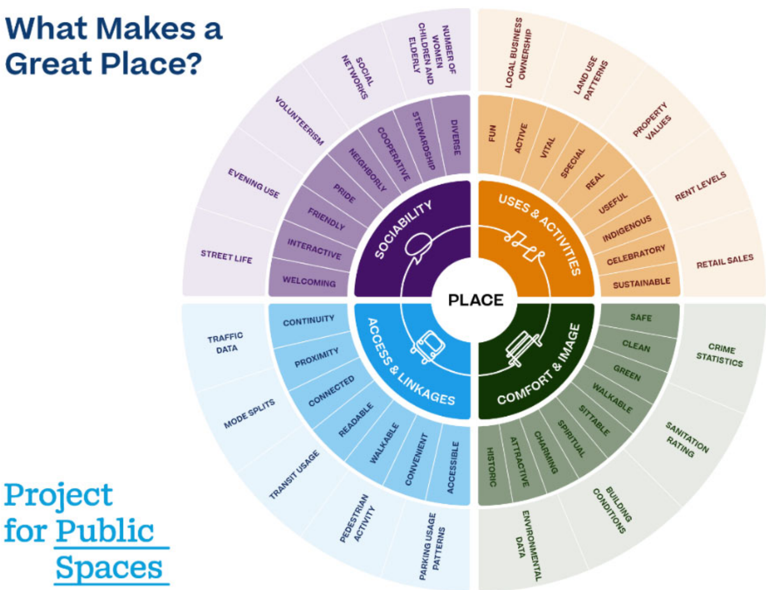


Figure 2: The key attributes for successful public spaces (PPS, 2016).

To achieve successful public spaces, architects and urban planners have increasingly underscored the social life in public open spaces (POS) considering the comfort, use, activities, access and attractions. Gehl

(1987, 2007, 2010) further emphasized the need to design spaces that align with human scale and accommodate various activities by highlighting 'life between buildings.' New methods, measurements, and tools have been developed to monitor the public life in the cities. These advancements signify a growing effort in both academic and practical fields to prioritize human-centric, sustainable, and livable urban spaces.

2.2 Observation and Measurement in Public Spaces

Observation is the key to measure and understand the public life (Gehl & Svarre, 2013). Observing people experiences through the activities enables to understand the interaction of people with public space and reveal the potential of public space (Gehl and Svarre, 2013). There have been many methodologies and indexes to assess public life by conveying observations into quantitative measures. While Whyte (1980) concentrates on user behavior in public spaces, Brower (1988) focuses on the physical qualities of public space affecting people use. The focus of public space evaluation is on use and activities in Gehl and Gemzoe (1996) study. Addition to physical and activities, Mehta (2014) assesses social qualities of public spaces based on inclusiveness (tolerance for different people), meaningful activities (activities foster socializing and place attachment), comfort (physical, climatic), safety (sense of safety with eyes on street, and traffic safety), pleasurability (spatial attributes for likeability). Similarly, Skjæveland et al. (1996) also assesses social qualities through the lenses of social interaction, sense of community and place attachment. Zamanifard et al. (2019) present an index for measuring experiential qualities (EQs) of public spaces, based on qualities of comfort, diversity, vitality, inclusiveness, image and likeability. The reference studies indicate that, the key theme across these measurement approaches is their focus on assessing the success of public spaces from a user perspective, through social, physical, experiential factors. This study focuses on user activities and diversity, therefore Gehl's (2010) observation methods have been applied in this study.

Gehl (1987) categorizes the activities taking place in urban spaces in terms of its relationship with place. According to Gehl (1987), the activities, taking place in public spaces, are as necessary, optional and social activities. This categorization is useful to conduct observatory methods to understand how public open space (POS) is functioning.

Commuting to work, going to school or buying groceries are examples of necessary activities (Gehl, 2010). They are daily tasks or obligatory activities, which are independent from the physical quality of urban environment. Walking or relaxing in a park are optional activities, which take place under favorable conditions of urban environment. Making conservation, communicating, greeting other people or passive contact are examples of social activities, which are the outcome of the necessary and optional activities (Gehl, 2010). The more people in public space means more activities, more spending time and leads to more meaningful contact. It can be deduced that the quality of urban public space matter for the activity types, and people amount engaged in activities. Figure 3 displays the relationship between place quality and the rate of activities (Gehl, 2010). Accordingly, when the place quality is high, the optional activities' occurrence increases in parallel. Additionally, the increase in optional activities results a rise in social activities' rate (Gehl, 2010).

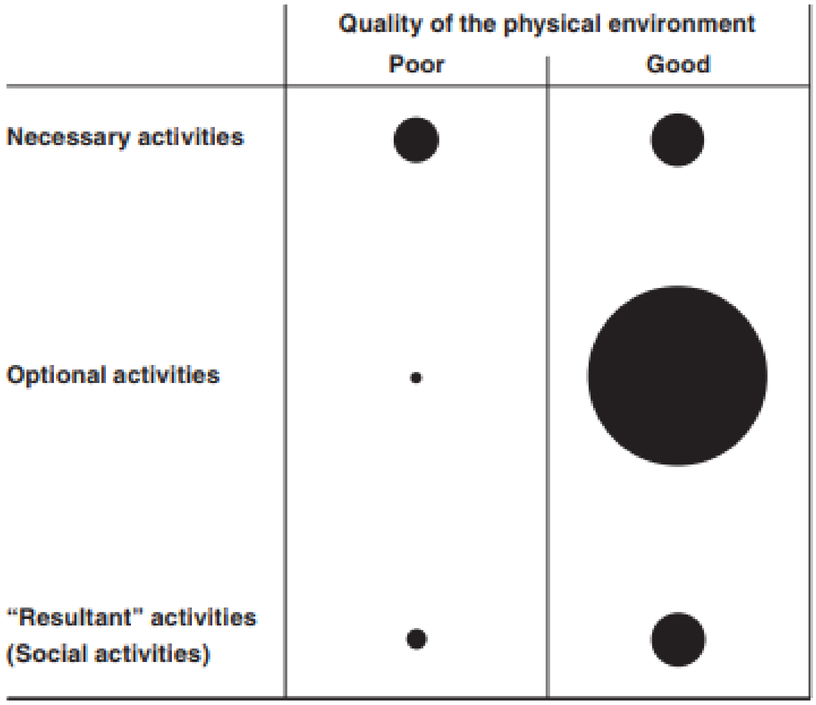


Figure 3: The graphical representation of place quality and rate of activities (Gehl, 2010).

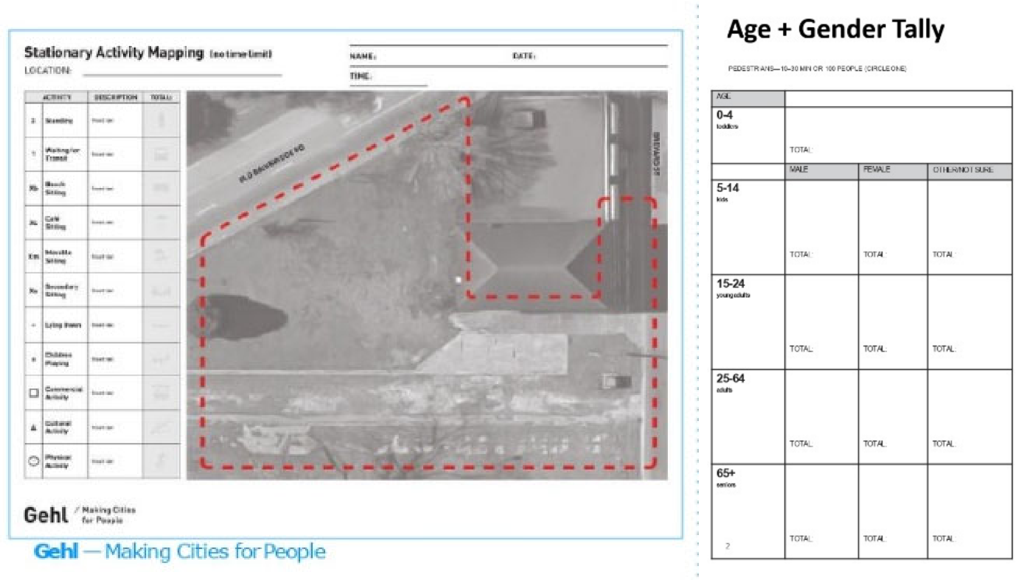
For observing the activities in POS, the questions of "how many, who, what, where, how long" are helpful to delineate the urban dynamics. They are grouped under observatory questions in the scope of this study. The "how many" question is fundamental in assessing city life, by quantifying people's actions and movements. The "who" question is central to understanding public space usage, implying the need to identify and categorize people based on gender or age attributes. The "what" question explores the types of activities carried out in public spaces, which can range from necessary tasks like shopping or commuting, to optional activities like jogging or reading. The "how long" question is associated with the time people spend doing activities in public spaces (Gehl & Svarre, 2013). Gehl and Svarre (2013) categorize the main methods to measure the public life and answer abovementioned questions:

- Counting the people in activities to answer *who* and *how many* questions;
- Mapping the activities on the survey area (behavioral mapping) (what);
- Tracing to follow people movement (where);
- Tracking to observe people movement and presence (shadowing) (where);
- Photographing (what/how);
- Keeping an activity diary (what/who/how/how many) (Gehl & Svarre, 2013).

Public Space Public Life (PSPL) survey methods, developed by Gehl, to measure the human-place interactions in the public spaces These survey tools, developed by the Gehl Institute, employ various data collection methods, including activity mapping, people counting, and interviews, to gather observational data (Gehl Institute, 2017). ***Stationary Activity Mapping*** method is used to capture people's postures and activities (Figure 4a). This method involves observing and documenting different postures such as standing, sitting (in public, private, or commercial spaces, as well as informal settings), lying down, and in movement. Furthermore, it captures various activities including waiting for transportation, consuming food and beverages, engaging in commercial activities, conversing, participating in cultural activities, and recreational activities such as play or exercise. The Stationary Activity Map visually depicts people engaging in different activities and adopting various postures using different symbols. ***Age and Gender Tally*** focuses on observing people of different age groups and genders to gauge to what extend this area is inclusive for all age and gender groups (Figure 4b). Individuals are divided into several categories based on their age ranges, including toddlers (0-4 years old without gender distinction), kids (5-14 years old), young adults (15-24 years old), adults (25-64 years old), and seniors (65 years and older).

Gender distinction is considered for all age groups except toddlers. *Twelve Quality Criteria* is used to evaluate to what extend the area provides protection, comfort, and enjoyment for the people engaging in activities (Figure 4c). The protection criteria encompass the availability of protection against unpleasant exterior conditions such as traffic, climate and noise. Comfort involves the availability of options for conducting stationary activities. Enjoyment encompasses the factors that enhance people-place interactions, including appropriate scale, aesthetic quality, pleasant climate conditions, and sensory experiences (Gehl Institute, 2017). By utilizing these PSPL survey methods, urban planners and designers can gather valuable data on to assess the quality and effectiveness of public spaces, within the needs, desires and interactions of the individuals.

Figure 4.: (a) Stationary Activity Mapping, (b) Age and Gender Tally, (c) Twelve Quality Criteria (Gehl Institute, 2017).



Gehl Architects (2015) developed a public life diversity toolkit as a prototype for measuring social mixing and economic integration in public space. They prototyped three different tools, to give a snapshot of social mixing between people in different economic groups (Gehl Architects, 2015). They apply intercept survey, observational analysis using Public Life methodology, and social media data to understand how diversity of public life occurs in public space (Gehl Architects, 2015). EMBARQ and Gehl Architects (2013) also evaluated public spaces and public life in Istanbul Historical Peninsula to increase urban vibrancy by using the public life methodology (PSPL survey tools). The quality of place has been assessed considering People activities, and different user profiles, quality of public spaces, pedestrian movements and network, traffic and mobility, perception of safety, have been assessed and visually represented through informative maps and diagrams. Accordingly, EMBARQ and Gehl Architects (2013) assert recommendations interaction to promote accessibility, walkability, traffic calming, public transportation use, attractive public spaces, and successful mix-use with variety of activities for revitalization of the place (EMBARQ & Gehl Architects, 2013). **Figure 5** depicts the stationary mapping analysis in Istanbul Historical Peninsula.

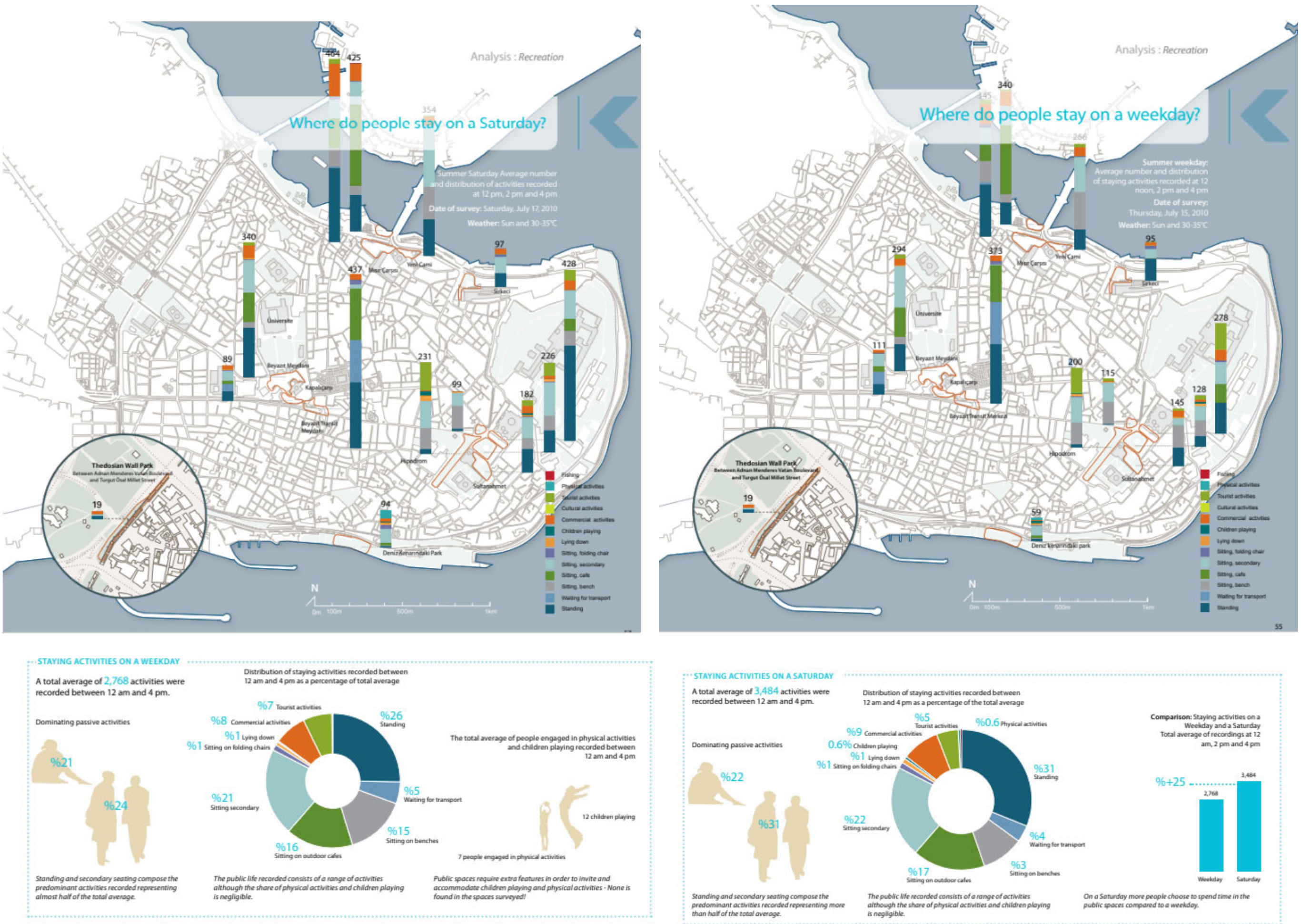


Figure 5.: Activity analysis in Istanbul Historical Peninsula (EMBARQ & Gehl Architects, 2013).

In this study, the PSPLs are used as a guideline to answer the observatory questions. This study takes advantage of Stationary Activity Mapping, Age and Gender Tally, and Twelve Quality Criteria Tools to measure to what extend this area is attractive for activities, inclusive, and inviting. It employs utilizes the Counterpoint mobile application as a digital tracing method to track live traffic, gender and tally within activities in POS. As locative media data, this study benefits from the user check-ins in Foursquare, photo-sharings in Flickr platforms, and activity places in Google Places. Data is obtained through web scrapping of the Foursquare, Flickr and Google Places APIs. Web scraping is a technic of data extraction from public websites or APIs, and structuring data sets using automated with programming tools. The aim of integrating digital tracing and locative media data is to support the observations with user generated data to gain better understanding of user dynamics and pattern in public space.

2.3. Beyazıt Square

The Istanbul Historic Peninsula District, renowned for its rich and layered cultural heritage, was among the earliest settlements in Istanbul (EMBARQ, 2014). This district has been included in the UNESCO World Heritage List in 1985, as 'outstanding universal value' (Site Management Directorate of Istanbul Historic Peninsula, 2011, 2018). The district is characterized by its diverse vernacular architecture, building and social patterns, and a population with varied socio-economic backgrounds (Turgut & Özden, 2005). Moreover, it is also recognized for distinctive skyline, shaped by historical urban fabric and topography, significant historical masterpieces, and the unique, layered urban pattern formed by multiple civilizations. As a cosmopolitan city center, the Historic Peninsula District serves as a primary hub for commerce, history, culture, and education (Site Management Directorate, 2011). It combines its unique historical center value with the dynamism of a cosmopolitan city that continues to adapt to changing times. This duality of historical and metropolitan elements offers both challenges and opportunities, influencing the functionality of the urban environment.

The Historical Peninsula encounters imbalances in functions, activities, and user demographics in different times and places, alongside a decline in place attachment, awareness, and social interaction, within the low quality of POS (EMBARQ & Gehl Architects, 2013; IMM Cultural Assets Conversation, 2016). The quality of open public spaces is 'underperforming' due to limited size, undefined spatial definition for activities, and low engagement with surrounding areas and green spaces (EMBARQ & Gehl Architects, 2013). The public spaces fail to offer diverse activities and multiple uses; resulting in low attraction for users (EMBARQ & Gehl Architects, 2013). This study selects Beyazıt square as a case study area. Beyazıt Square is among the vital public spaces in the area, that embraces the potentials and drawbacks of the site.

Beyazıt Square has historically been a central shopping location throughout the Ottoman Period (Kuban, 1994). During the Byzantine Period, this square housed the Tauri and Theodosius Forum (Kuban, 1994). The square has continually served as a market area (Kuban, 1994). Beyazıt Square holds a significant position in city history due to its historical background, strong image, and dynamic attributes (Kuban, 1994). It has served to different functions for social and cultural, religious, administration, education, and shopping purposes (Site Management Directorate, 2018). Situated on the historic axis of the Historic Peninsula (Eminönü-Hagia Sophia-Beyazit-Aksaray axis), the square is at the center of commercial, tourist, and cultural activities. From the early Republican era, numerous modifications have been applied to the square to centralize this place for activities and mobility (Site Management Directorate, 2018). More recently, efforts have been made towards pedestrianization and revitalization to prevent the square from being solely transport-oriented (Site Management Directorate, 2018). Figure 6 illustrates a tag cloud compiled by students, reflecting their initial impressions of the site. The common perception is that Beyazıt Square is bustling, noisy, and a tourist hub, full of cultural activities.

Figure 6.: Tag cloud about Beyazıt Square.

3. METHODOLOGY

3.1. Data Collection and Representation

The students conduct site observations to observe functioning of the place, and quantify user movement and activities. For observational site analysis, the Public Life Toolkit (Gehl Institute, 2017) is utilized as a digital application to record the place activities (Gehl Institute, 2017). The Counterpoint smartphone application is employed for crowdsourced traffic counting (Counterpoint, 2023). The students are divided into different groups based on the observation tasks. These observation tasks are live traffic counting, stationary activities counting, age and gender tally, building types, and twelve quality criteria observation. They are conducted using the related extensions of Counterpoint mobile application. The students use the digital app and count the people in activities, different age and gender groups, live traffic on the streets and assess POS in twenty-minute timeframe. The Live Traffic Counting Group counts the live traffic at five determined locations, located at the street intersections (Gehl Institute, 2017). The Stationary Activities Counting Group observes and counts people engaged in activities (Figure 4a). The Age and Gender Tally Group tallies people and categorize them based on gender and age group in twenty minutes (Figure 4b). It gives information about the age and gender tall, which is the baseline of this application. The Building Types Group classifies building functions along the street facades and ranks the buildings based on their types. Finally, The Site Observation Group evaluates the square based on twelve quality criteria (Gehl Institute, 2017). They map the locations that met or did not meet the quality criteria, found in Figure 4.c (Gehl, 2010).

Geographic Information Systems (GIS) has been employed to process the observation data into digital environment. GIS serves as a tool to organize, analyze, visualize, and disseminate a range of data from different time and analysis scales (Campbell & Shin, 2011). GIS is a unique form of information technology that aids in understanding the “what”, “when”, “how”, and “why” questions by answering “where.” The database system of GIS has the ability to combine the spatial and temporal data and attribute data of an object, thus creating knowledge for spatial analysis (Campbell & Shin, 2011).

Students use a reference map as a template and create thematic maps to illustrate the spatial distribution of human patterns and urban functioning. Their work has two main parts which are (1) mapping a spatial dataset, and (2) generating a new spatial dataset. In the first part, they convey the results of digital counting applications into a Geographic Information System (GIS), sourced from the Counterpoint database (Counterpoint, 2023). They download the count results in csv format and transfer them to GIS by adding a delimited text layer. In the second part, they develop a spatial dataset based on their observations. This involves creating a new vector layer and assigning their observations as new attributes to the related location. Once the spatial dataset is defined, the students categorize the attributes to display their density level. In the final step, they customize the symbols with varying colours and pictograms to visually represent the data. These steps outline the process of mapping observational data. Urban data is collected by querying the Open Street Map (OSM), using the building and highway layers from OSM. Additionally, Flickr photo sharing and Google Places data are provided to the students as locative media data. In this study, data gathered through observations and digital apps serve as the primary data source, while urban data from OSM and locative media data act as secondary sources. Students then juxtapose the different datasets and draw conclusions about site issues and design concepts.

3.2. The Relationship Analysis of the variables

A range of data types is compiled to create a QGIS database, as a result of data analysis and site observation. Data types encompasses building form (maintenance, condition, height) and function, to demographic data (age, gender, types of population groups), density of people and transport (bikes, vehicles), activity data, and visit data (visitor density, time and day of visit). Visit data is derived from Flickr analysis, while building function data comes from Google Places Analysis. Both are provided to the students as secondary data sources. Other types of data, are counting and activity data collected digital counting methods, and observation data. Sensorial data (smell and noise) are out of the scope of this analysis in order to limit the number of cases and variables. Data is aggregated using the spatial join method in GIS. The generated spatial dataset is comprised of 17 variables and 71 cases, distributed across grids measuring 15 m x 15m, as illustrated in Figure 7 on GIS, and in Table 1 in tabular form.

Table 1: The dataset, shown partially.

id	tour is_le v	local_ lev	Bike	Ped estri an	Vehi cle	traffic _lev	act_ people	building _ cond	height	ambia nce	crowd_ lev	gender	age	visit _de ns	visit_time	Buildng_ function
1			19	196	54	high	83	new	mid	bad	not crowded	woman	adult	2	weekday_ daytime	shopping
2			19	196	54	high	83	new	mid	bad	not crowded	woman	adult	2	eekday_d aytime	dining
3			19	196	54	high	83	new	mid	bad	not crowded	woman	adult	2	weekday_ daytime	accommod ational
5	3	3	19	229	40	low	86	new	high	bad	not crowded	man	adult	1	weekend_ daytime	shopping
6	3	3	19	229	40	low	86	new	high	bad	not crowded	man	adult	1	weekend_ daytime	accommod ational
7	3	2	11	605	20	low	78	old	low	bad	very crowded	man	adult	32	weekday_ daytime	dining
8	3	2	11	605	20	low	78	old	low	bad	very crowded	man	adult	32	weekday_ daytime	shopping
9	3	2	11	605	20	low	78	old	low	bad	crowded	man	adult	26	weekday_ daytime	dining
11	3	2	3	947	15	high	56	old	low	good	crowded	man	adult	44	weekday_ daytime	dining
12	3	2	3	947	15	high	56	old	low	good	crowded	man	adult	44	weekday_ daytime	shopping
13	3	2	3	947	15	high	56	old	low	good	crowded	man	adult	44	weekday_ daytime	dining
18	3	2	3	947	15	high	56	old	high	good	crowded	woman	adult	44	weekday_ daytime	dining
19	3	2	3	947	15	high	56	old	high	good	crowded	woman	adult	44	weekday_ daytime	shopping
21	3	2	3	947	15	high	56	new	low	good	crowded	man	adult	44	weekday_ daytime	shopping

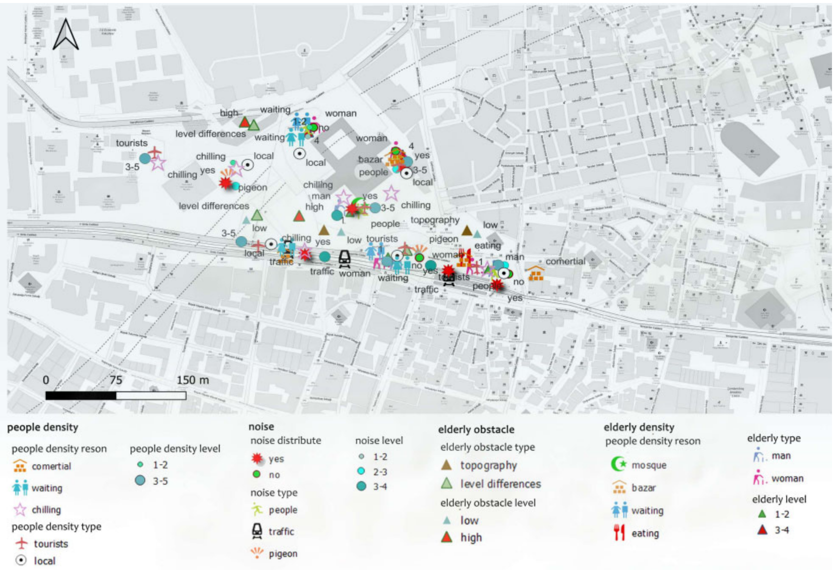


Figure 7: Spaital distribution of the observational data (Dalya Abushhawish, Nada Elgaphry).

Following the database, a mental map is created with students. This mental map is formed according to the relationships of the variables, derived from site observation. The crowd level (target node) is influeced by visitor density including tourist and locals and visit time, age and gender of people, people engaged in activities, traffic (vehicle, bike and pedestrian density), building functions and ambiance (height, condition). Students were asked to examine the relationship between the state of being crowded and other parameters (Figure 8).

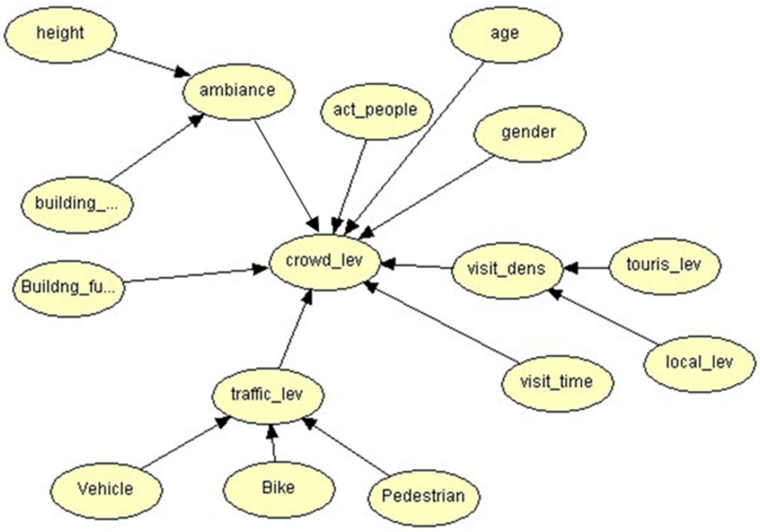


Figure 8: The relationship network, created by students.

The relationship network is assessed with artificial intelligence method, using Bayesian Belief Network (BBN) that imitates human probabilistic thinking to make decisions in uncertain and complex situations (Nilsson, 2010). Pearl (2006) transfers the human probabilistic-intuitive reasoning capabilities in uncertain conditions to artificial intelligence systems through BBNs. BBNs are compact probabilistic graphical models that combine probability and graph theories (HUGIN Expert, 2013). These networks comprise directed acyclic graphs (DAGs) that depict causal associations between nodes and conditional probability tables (CPTs) detailing the conditional probability distribution for each node (HUGIN Expert, 2013). BBNs are valuable tools to be used for knowledge discovery (Fusco, 2008; Han et al., 2012; Heckerman, 1997). Their ability to manage incomplete datasets and learn causal relationships for predictions sets them apart as valuable tools for knowledge discovery (Heckerman, 1997). BBNs provides to visualize intricate relationship networks (Fusco, 2008). In urban studies, BBNs have been utilized to explore relationships between sustainable mobility indicators (Fusco, 2004), traveler satisfaction indices (Yanık et al., 2017), neighborhood popularity (Ardıç et al., 2020) and social network parameters (Kemperman & Timmermans, 2014), and spatio-temporal dynamics (Fusco, 2008). In this study, BBN is employed to explore direct and indirect relationships between variables.

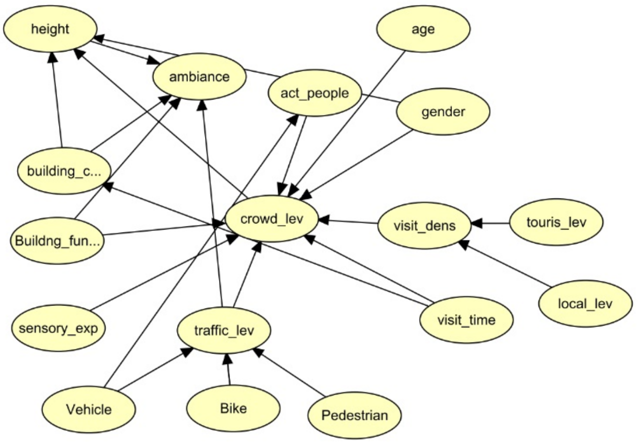
This relationship network is also constructed through Bayesian Belief Network (BBN). The aim is to explore hidden relationships and also to evaluate the performance of this relationship network. This study creates a hybrid BBN that combines expert knowledge and learning algorithm. As learning algorithms, the Necessary Path Condition (NPC) has been used to assesses conditional independencies between nodes using statistical tests (Steck & Tresp, 1999). The relationship network -created by the students- conveyed to Bayesian Network, and applied NPC to find indirect relationships between variables (Figure 9.a, 9.b).

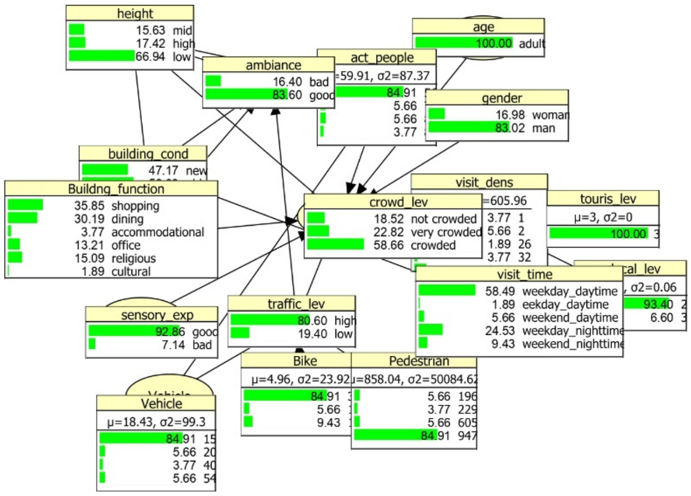
Bayesian Belief Network (BBN) is evaluated based on learning and prediciton performance. The EM algorithm, also known as the Expectation-Maximization algorithm, has been employed to calculate the conditional probability distribution of variables according to the contructed BBN, using dataset. The algorithm performs learning until expectations are maximized; it reaches maximum likelihood, known as log-likelihood (Timmermans and Kemperman 2014). Another BBN is created using NPC without expert knowledge for comparing learning and prediction performance. The expert based hybrid BBN generated a log-likelihood score of -345.596, after performing EM learning to the dataset; while the automated BBN the learning performance is
-367.644.

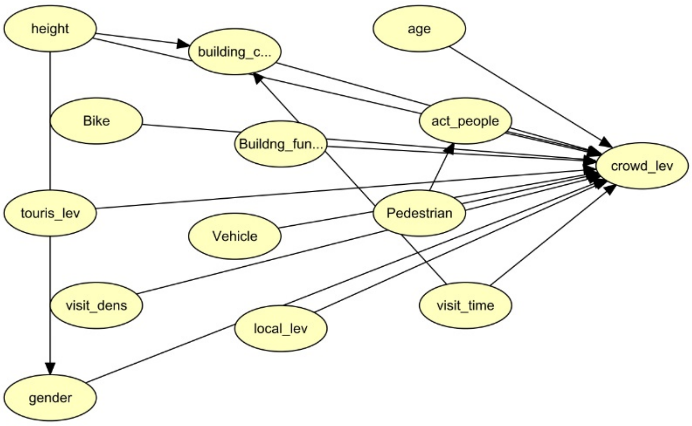
For prediction performance, the dataset is divided into a 70% training set (53 case) and a 30% testing set (17 case). The researcher configures batch propogation to the dataset and propogate belief of being crowded. For this, she selects the crowd level as target node, and being crowded as target state. The beliefs of being crowded (probabilities) and the states (evidences) are compared with binary classification model (BCM). In BCM the ROC (receiver operating characteristics) curve curve divides area as positive (true positive rate) and negative class (negative positive rate). The area under curve indicates how well the BBN correctly predicts the probability of being crowded. In this hybrid BBN the area under curve is 0.875, while 0.625 in automated BBN. This indicates that the 87% of the possibilites are predicted correctly in hybrid BBN, while this rate is 62% in automated BBN. Based on these performance test results, it can be deduced that expert based hybrid BBN shows greater performance in learning and prediction. Figure 9 exhibits automated BBN (Figure 9.a) and hybrid BBN (Figure 9.b) monitoring the probabilities. The expert based hybrid network has more complex relationships. The relationships between building height and condition, traffic level and ambiance, vehicle and active people, visit time and building condition, gender and building height are found

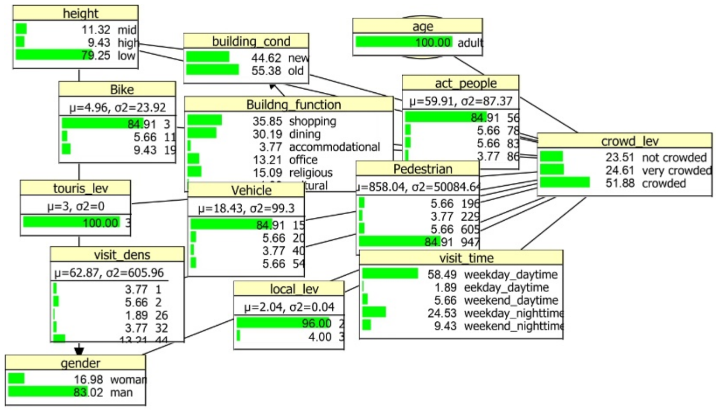
Figure 9: The hybrid expert BBN (Figure 9.a), and automated BBN (Figure 9.b) constructed through learning algorithm.

by the algorithm. Apart from the last two relationships, the relationships seems meaningful based on the observations.









4. CASE STUDY RESULTS

According to the results of site observation, several problems are identified by different groups. The unbalanced distribution of the population in terms of age and gender is one of the most highlighted problems in the site (Group A1, A2, C4, and S4). Another drawback is lack of activities and overcrowding of people and vehicles leading to traffic congestion (Group B1, S1, S3, and S5). The insufficiencies of gathering places for both people and animals in emergency situations is another focused problem (Group Q3). Additionally, lack of place perceptions and experiences pose another problem and Group S2 draw attention to awareness in sensorial experiences. In terms of design concepts, Group A2, A1, and S4 propose an inclusive design approach, while Group C4 emphasizes designing for children. Group B1, S1, and

S3 suggest enriching activities, while Group Q3 focuses on design on emergency considering human and animal protection. Group S5 proposes design for enhancing tourist activities, and Group S2 highlights the importance the audio-visual sensorial experiences in this historical site. Based on the students' assessment, design decisions could involve addressing the unbalanced population distribution, enhancing activities while minimizing overcrowding and traffic congestion, providing gathering spaces for both people and animals in emergency situations, promoting inclusive and child-friendly design, enriching tourist experiences, and fostering sensorial engagement.

The students take into consideration the relationship network to make conceptual decisions. Group S1 focuses on activities. They consider the positive effect of active people, and people diversity (age & gender) on crowd level, and negative effect of vehicles within traffic level on active people. Group S2 concentrated on the relationship between activities, population groups, and sensory experiences. The noise and smell level are evaluated under sensory experience. They consider the relationship between sensory experience and crowd level, sensory level and people activities, and also people activities and crowd level. Based on Group S2 observation, more people density and activities create more smell and noise affecting sensory experience. Lastly, Group S4 focuses on the activities of elderly people. The impact of traffic level, crowd level and visit density on elderly people becomes significant. The affecting factors of crowd level including visit density, active people within age are the focus in this study.

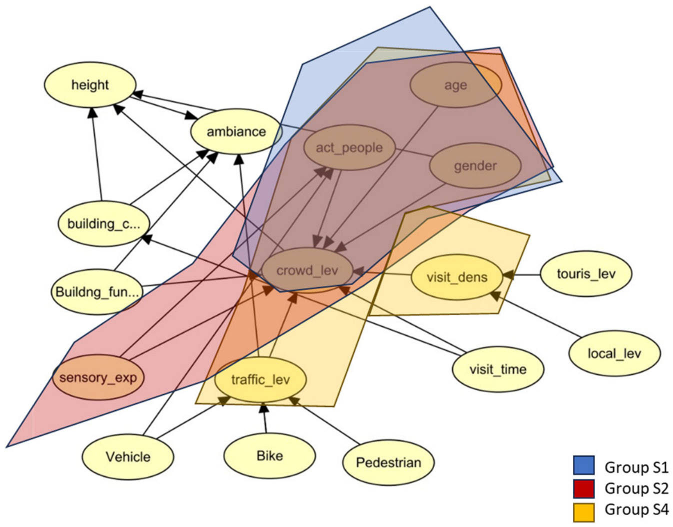
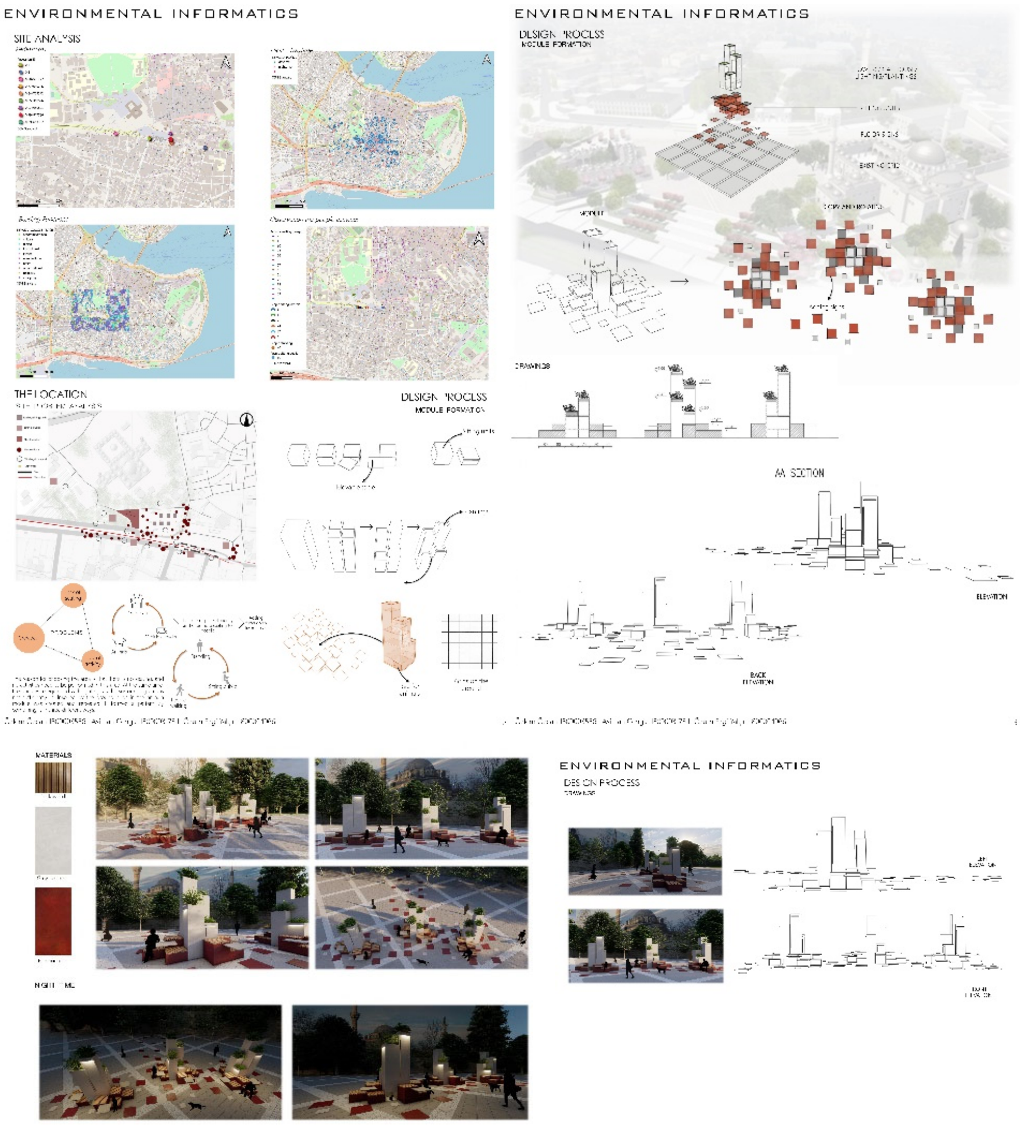


Figure 10: Mapping relationships used by students in conceptual decisions.

This study concentrates on a selection of case study projects from among the student submissions, to present the outcomes of the data-driven process. Students in Group S1 identified activities as the most significant parameter, subsequently activity is the central focus of their urban furniture design. They pointed out lack of activities, seating, and lighting as key issues preventing the efficient use. To address these problems, they leveraged modular design approach for urban furniture to provide additional opportunities for sitting, walking, waiting for transport, relaxing, and participating in social activities. They target to make this area attractive for conducting social and optional activities, which are place-dependent activities during both day and night time (Figure 11).

Figure 11: Group S1 proposals for augmenting place activities (Özlem Özcan Özüm Ezgi Yalçın, Asiman Cengiz).



Group S2 investigates the relationship between activities, population groups, and sensory experiences. They observed that increased activity and diverse population groups (including tourists and locals), along with higher people density, influenced the levels of noise and the range of smells at the site. More activities led to high level of different sound and smells. Focusing on the aspect of sound, Group S2 designed a space to enhance the auditory experience while protecting users from external noise. In their audiovisual hub, individuals can experience the soundscape of the place and learn the history of place; while relaxing in a semi-open area that is insulated from external noise (**Figure 12**).

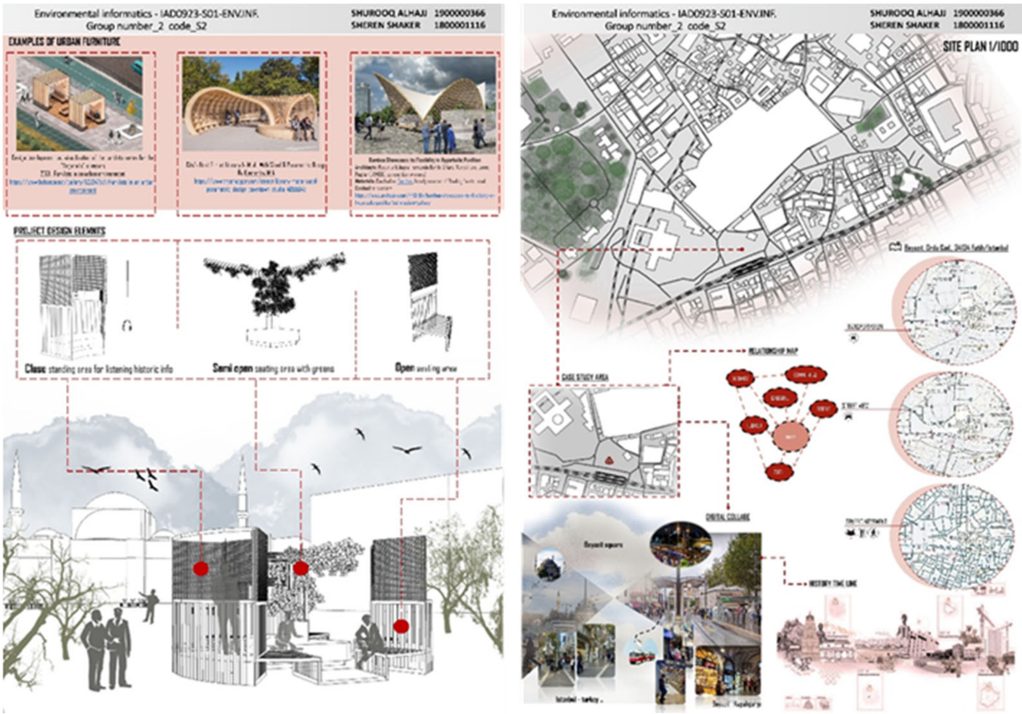
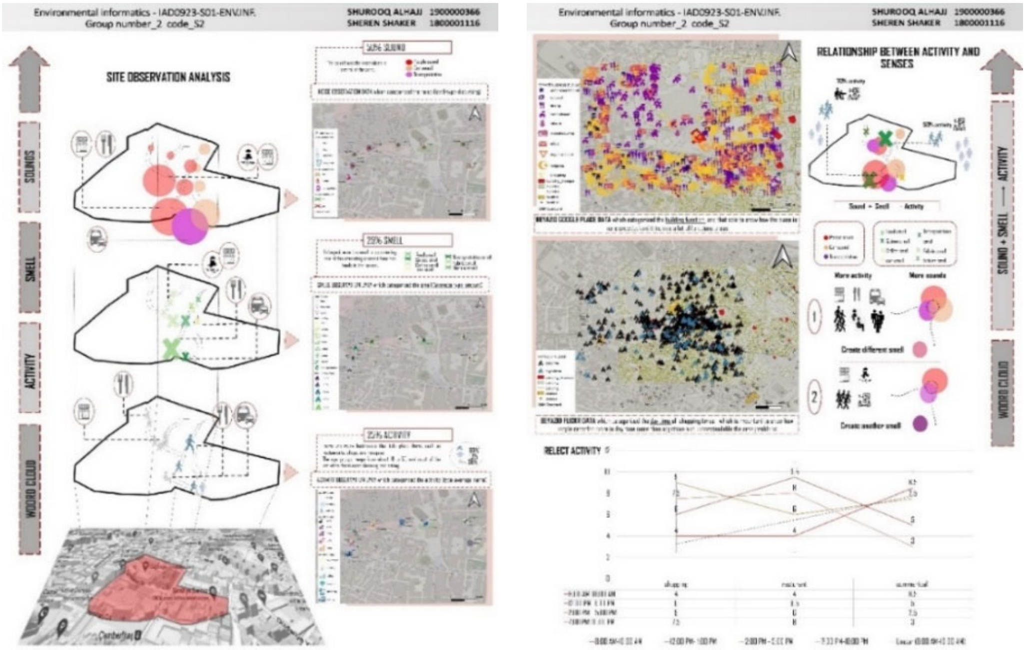
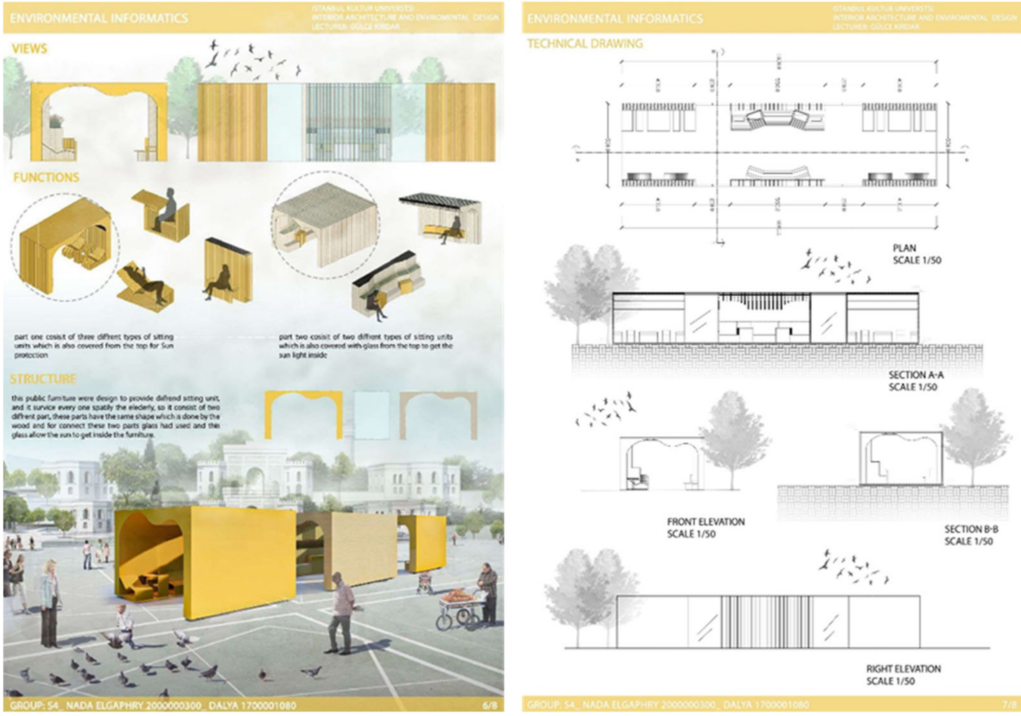


Figure 12: Group S2 proposals for improving sensorial experiences (Sheren Shaker, Shurooq Ali Mohammed).



Finally, **Group S4** concentrated on the density of the elderly population, their activities, and obstacles in the square. From their observations, they concluded that the elderly population is negatively affected by the density of people and noise. Consequently, they designed urban furniture to facilitate optional and social activities in the area, and protect from density of the crowd (**Figure 13**).

Figure 13: Group S4 proposals for elderly people (Dalya Abushhawish, Nada Elgaphry).



4. CONCLUSION

In conclusion the aim of this workshop was to introduce the students with the developing design decisions considering observation data. Data driven design process is experimented. Data-driven design process support the conceptual decisions for urban furniture considering urban dynamics. People activities and profiles is monitored, the urban movement is traced, the POS quality is assessed. The collected data are mapped in GIS to create spatial maps. The spatial maps act as a mental map to convey the students' site observation.

The participants find the use of digital tracking application (Counterpoint) challenging, but useful for observing the live traffic and people. The digital observation tools inspired them to determine their focus group for urban furniture. On the other side, the majority of participants assess the use of GIS easier in comparison to digital tracing tool. This tool is useful to process observation data obtained through digital applications, create spatial datasets, and integrate them to create a database. Compared to conventional observation and analysis methods, digital methods offer a range of advantages. Digital methods enhance the process of organizing and analyzing data. This enhancement is due to their ability to process a variety of data types quickly, thereby improving overall data handling speed. Furthermore, these digital methods are more accurate, providing detailed and precise information. As a result, the versatility, precision, time and labor efficiency of digital methods make them more preferable. They facilitate to observe people movements and activities within the live traffic. Moreover, the digital observation methods inspired them to define their focus and find target user profile.

The spatial distribution of urban elements is represented in GIS. The spatial maps act as a mental map that gives the impressions and observations of the participants. They aid in understanding and monitoring urban functioning, and discovering the problems and shortcomings in the site. The students utilize observational data the most, user-generated data second most, and urban data third when generating the concept of urban furniture. The relational map is useful to create relationships between distinct analysis concept and determine the focus of the concept considering the relations. Overall, the outcomes of the spatial analysis contribute on determining the function, user group and concept of the urban furniture. As the results demonstrate, the application of data-driven observation and analysis methods has been useful in developing user scenarios and detecting target user profile, identifying user needs and demands, and making functional decisions during the design of urban furniture. The students highlighted the challenges posed by the use of digital observation methods and the learning curve associated with GIS software as limitations of the study. The technical glitches and connectivity problems also limit the site observations.

In the further stages, site observation is expanded with a questionnaire to include place perceptions and experiences in the public spaces. Moreover, the site observation methods become limited with counting through digital tracking application; however, site observation methods can be supported with conventional observation methods including sketching, photographing or video recording and keeping activity diaries, as stated by Gehl and Svarre (2013).

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Conflict of Interest Statement

The author of the study declare that there is no financial or other substantive conflict of interest that could influence the results or interpretations of this work.

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