REVEALING THE POTENTIAL OF HUMAN-CENTERED DESIGN IN ARCHITECTURE

A THESIS SUBMITTED TO

THE GRADUATE SCHOOL OF ENGINEERING AND SCIENCE

OF BILKENT UNIVERSITY

IN THE PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR

THE DEGREE OF

MASTER OF SCIENCE

IN

ARCHITECTURE

By

Münevver Duygu Gökoğlu

March 2021

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We certify that we have read this thesis and that, in our opinion, it is fully adequate, in scope and in quality, as a thesis for the degree of Master of Science.

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ABSTRACT

REVEALING THE POTENTIAL OF HUMAN-CENTERED DESIGN IN ARCHITECTURE

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M.Sc. in Architecture

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March 2021

The increase of everyday usage of technology has urged consideration of human factors in the human-computer interaction. This thesis focuses on the transformation of design going beyond the human being a factor to the human starting to be the actor by creating new interactions and environments in the human-computer interaction and architecture. Thus, architectural design processes have become a subject to a radical paradigm shift by technologies and digital way of design thinking. This thesis explores the human actor in the user experience design process by implementing the ten usability heuristics of interaction design in the architectural design process.

Recently, the use of user data and creating a design thinking from a compiled data in an interactive environment have become the main topic of user experience design. However, Cybernetics laid the foundations of user experience design with a systematic design process in architecture by proposing a data-based understanding. To consider architecture as a system of which the user is introduced as an active matter, ten usability heuristics, utilized in user experience design will be discussed and explored in the case of architecture. Some of the ten usability heuristics principles will be depicted in order to offer possible opportunities of human actor in architectural design.

Keywords: human-machine interaction, cybernetics, architectural design process, user experience design, user research, usability

ÖZET

MİMARLIKTA İNSAN MERKEZLİ TASARIM POTANSİYELİNİN ORTAYA KONMASI

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Mart 2021

Teknolojinin günlük kullanım eğilimindeki artış, insan-bilgisayar ilişkisinde insan faktörlerinin dikkate alınmasını gerektirdi. Bu düşünce, insan-bilgisayar etkileşimi alanında ve mimarlık disiplininde yeni etkileşimler ve olanaklar yaratarak tasarımda insan faktörünün, insan aktörüne dönüşmesini sağlar. Böylece, mimari tasarım süreçleri, teknolojiler ve dijital tasarım düşüncesi ile radikal bir paradigma değişikliğine konu oldu. Bu tez, mimari tasarım sürecinde etkileşim tasarımının on kullanılabilirlik buluşsal yöntemini uygulayarak, kullanıcı deneyimi tasarım sürecindeki insan aktörünü araştırmaktadır.

Son zamanlarda, interaktif bir ortamda derlenmiş verinin kullanımı ve bu verilerle tasarım düşüncesi oluşturmak, kullanıcı deneyimi tasarımının ana konusu haline geldi. Öte yandan, Sibernetikçiler, veri tabanlı bir anlayış önererek mimaride kullanıcı deneyimi odaklı sistematik tasarımın temellerini attılar. Mimariyi, kullanıcının aktif bir rol oynadığı bir sistem olarak ele almak, mimari tasarımı kullanıcı deneyimi tasarımıyla birleştirmektedir. Önerilerinde, bilgisayarla etkileşim yollarını araştırarak ve mimari yapıyı kullanıcı etkin bir sistem olarak ele alarak mimaride kullanıcı deneyimi kavramının temellerini attılar. Mimariyi, kullanıcının etken olarak tanıtıldığı bir sistem olarak ele almak için, mimari durumunda kullanıcı deneyimi tasarımında kullanılan on kullanılabilirlik buluşsal yöntemi tartışılacak ve araştırılacaktır. Mimari tasarımda insan aktörün olası fırsatlarını sunmak için on kullanılabilirlik buluşsal yöntem ilkesinden bazıları tasvir edilecektir.

Anahtar sözcükler: insan-makine etkileşimi, sibernetik, mimari tasarım süreci, kullanıcı deneyimi tasarımı, kullanıcı araştırması, kullanılabilirlik

ACKNOWLEDGEMENT

First and foremost, I offer my deepest gratitude to my advisor Assist. Prof. Dr. Aysu Berk Haznedaroğlu. I thank her for the guidance and support during the development of this study. She enabled me to gain an academic and scientific perspective by always questioning my continually evolving approaches to the thesis. I would also like to state my sincere appreciation to my co-advisor, Dr. Zelal Öztoprak. I felt her support and encouragement even when I got lost in chasing knowledge during the thesis process. She has always been there to listen and to give advice since my bachelor's studies in architecture.

I would like to thank my examining committee members Assoc. Prof. Dr. Burcu Şenyapılı Özcan and Assist. Prof. Başak Uçar Kırmızıgül for their valuable comments and suggestions to improve the thesis.

I would like to thank Prof. Dr. Varol Akman for his help during my studies on artificial intelligence, especially for accepting me as an audit student for his AI class in the Computer Engineering Department at Bilkent University.

I would like to thank my friends, the teaching and administrative staff of the Architecture Department. I am deeply grateful for people who always cheered me on and always encouraging me throughout the process: my brother Aydın Kaan, my sister Burcu, my beloved friends Adel, Aybike Sıla, Ecehan Berjan, Gözde, Gülsüm, Selcen, Utku, my dearest UX Team colleagues Elif and Serenay. Additionally, I am grateful for my sister-in-law Özge; she made an editorial impact on this thesis with her proofreading.

Finally, I dedicate this work to my parents Şeyda and Vefa Gökoğlu. There is nothing without family, and mine has helped to construct my unusual path while providing me with lots of trust and support. They always encouraged me to be curious and learn. I love you so much. Especially mom, you are always my role model to pursue my dreams and academic life; without your help and encouragement, it could not be possible.

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LIST OF ABBREVIATIONS

AI Artificial Intelligence

HCI Human-Computer Interaction

AmI Ambient Intelligence

UX User Experience

UXR User Experience Research

VR Virtual Reality

AR Augmented Reality

CHAPTER 1

INTRODUCTION

The world has been under the intervention and invasion of technological tools for a while. The emergence of the computer has paved the way for the discussions on automation and cybernetics. This emergence brings together the scientists, philosophers, psychology scientists, engineers, artists, designers, and educators on an interdisciplinary platform to evaluate and research new roles. Following these developments, the computer's widespread use in the late twentieth century caused a sociocultural change, contributing to human activities and the changes at the beginning of the information age, which accelerated their problem-solving phase. With the latest mobile, ubiquitous, social, and tangible computing technologies, the interaction of human and technology reflected on nearly all human activities. While this interaction led to radical changes in many disciplines, architecture which is made up of craftsmanship and structures, is transformed into a discipline including information and technology (Landau, 1968). Computational design and cognitive understanding has entered the scene of architecture, bringing many possibilities on the digital landscape. Accordingly, the role of the architect has changed to respond to all these possibilities and interactions. In this context, architecture became integrated with information technologies such as artificial intelligence, computer sciences, and electrical-electronics engineering. Information technologies suggest a new approach to an architectural representation about using computer. Therefore, the designer strengthened the communication between humans and machines by using the computational interfaces while transferring, organizing, calculating data.

The inclination of everyday usage of technology has urged consideration of human factors in the human-computer relationship. This consideration goes beyond the human factor to the human actor by creating new interactions and environments in the human-computer interaction field. Therefore, in his book titled Where the Action Is, Paul Dourish draws attention to increased interaction with the ubiquity of computer by stating that; "…being incorporated into more and more of our devices, and creating whole new forms of interaction and activity…" (Dourish, 2004:3). In consequence, instead of human-centered or machine-centered approaches, the scope of this thesis proposes an experience-centered approach to the design process.

With technological developments of the twentieth century, architects developed critical perspectives, theories, and methodologies on the interaction between human and machine in design. In the 1960s and 1970s cybernetics and information theories were discussed in architecture. Reyner Banham divides architectural history's interaction process into the first and second machine era (Banham, 1960). Banham defines the first machine age as the use of machines in the industry, while the second machine age is the era of individual use of machines such as motor vehicles, telephones, radio, and electrical appliances in daily life. In comparison to Banham's standpoint, Mario Carpo debates two digital turns regarding technological developments in his book titled The Second Digital Turn (Carpo, 2017). In this book, he defines the first digital turn as the architects' investigation on communication with the computer as a tool, while he is interpreting the second digital turn as a paradigm shift for the ways of thinking with computers.

In 1964, at the Architecture and the Computer conference held at the Boston Architectural Center, how the traditional limits in architecture would change using computers was discussed. In the conference's opening speech, the founder of Bauhaus, Walter Gropius, declared that the change of computers in architectural practice would offer the architects great freedom in the creative process of design by using the non-human tool(computers) entirely by architects (Boston Architecture Center, 1964: 8). Until the 1990s, this freedom was full of exploration to build an interactive foundation and be open to collaboration with software engineers. These investigations help to develop architectural design systems by architects who made an impact on design research, such as Nicholas Negroponte, Cedric Price, and Christopher Alexander. Their design research, that is evolving and learning from their practice, is based on the feedback and control mechanism of Norbert Wiener, who introduced the term cybernetics in 1948 (Steenson, 2017). Therefore, their aim is creating an interactive communication medium for architectural design process in order to prevent passively usage of the computer regarding representation, drawing, or analyzing. On the other hand, until the 1990s, the debates on human-computer interaction have stimulated over human mimicking computer or computer mimicking human, instead of comprehending the human experience during the process. In 1995, Donald Norman coined the term ‘’user experience’’ to understand the various aspects of human experience considering physical and manual interaction with a system, a design, an object, or an interface (Norman, Miller& Henderson, 1995). Ultimately, the comprehensive human experience notion including human behavior, human needs, human goals, and desires has recently been prominent in order to build a human-centered design.

This thesis explores potentials of the implementation of user experience design techniques in the architectural design process and architects’ role in terms of realizing these potentials. User experience design studies on the experience that people have about how they use the product or the system and how they feel when they interact. In fact, architecture has already been familiar with getting feedback from the user regarding their goal, behavior, and needs in the realm of cybernetic theory. Cybernetics hereby proposed an understanding that could form the foundations of user experience in architecture. They also presented the structure as a system, while utilizing the data received from environment and user. Today, implementation of user experience design in architecture needs to be discussed and developed further.

1.1. Problem Statement

This thesis studies the integration of the user experience design to the architectural design process. In architecture, the craftmanship is disappeared with the industrial revolution, which led to the re-evaluation of agents (human/designer/computer) in transferring the thinkers' minds to information technologies. To make this transfer and construct experience-based approach properly, working with the user/human data is the key. In other design disciplines and fields, the relationship of the user, designer, and the design object has developed relatively different than architecture. Recently, data and establishing a design thinking from a compiled data in an interactive environment have been mainly the topic of user experience design in the industrial design discipline. Yet, integration of ubiquitous computing and IoT technologies into built environment has been created a platform for the discussion on the convergence of experience design and architecture. Earlier, cybernetics laid the foundations of the concept of user experience in architecture by proposing a data-based understanding for the problem-solving phase, searching the ways of interaction with the computer, and considering the structure as a system of which the user introduced as an active matter. There are such examples and studies in architecture, but a perspective is required for these examples to have a place in the discipline. Therefore, design processes, in which the user is an active matter, still need to be studied in architecture. This thesis covers research on the effects of user experience design in architecture and how the user also starts to have an impact on design. Ultimately, the ten usability heuristics of interaction design has been chosen as a framework to demonstrate and define these effects.

In this regard, the primary research question of this thesis is: ‘how architectural design is supported and enriched with the contributions of user experience design?’ To explore this point further, the thesis also searches how architectural design is supported and enriched with the contributions of heuristics approach of user experience design?

1.2. Aim and Scope of the Thesis

Computational technologies, algorithms, and artificial intelligence have encouraged designers to produce various types of architectural ideas and prototypes. Today, human-computer interaction becomes essential with the fusion of smart systems and algorithms. In the design process, the buildings' feedback data is mostly evaluated after the construction is completed under the post-occupation evaluation. Therefore, this post-occupancy data from the building and thus the user is too late to be utilized in the early stages of design. However, the life of the building, thus the system, starts from the first scratch of the design. Though, a systemic architectural design process might be considered as the response to evaluation of users and conditions parameters. If these parameters are taken into account systematically at the early design stages, the design would serve the current situation. Considering existing situation enables structures to work longer and increase both design and building lifespan and also meets possible future requirements.

In the last three decades, the interaction of human and non-human approaches is studied extensively. In the 1990s, with the adoption of digital tools by postmodern architects’ new construction techniques were developed with new ideas. Carpo defines this period as when the new cultural and technological paradigm is produced and interpreted (Carpo, 2017). As Marshall McLuhan and John M. Culkin predicted, understanding paradigm change went through the emphasis of the process, and they interpreted it as *"We shape our tools and then our tools shape us."* (Hurme & Jouhki 2017: 13). Therefore, Carpo discusses that in the early '90s, digital technologies introduced us to data while carrying us to new culture and economy. He also mentions that cheaper access to data and facilitating access is one reason for the dissolution of the architectural monopoly, in other words, authorship of the architect in the design process. Visuality was influential in the concept of computational architecture in the 1990s because digital systems played a more representative role in architecture. This role focused more on representation, drawing, and analysis, which was more passive than the 60s and 70s Cybernetics' expectations as being far from the interactivity. As it is stated earlier, Cybernetics have proposed an understanding that can form the basis of user experience in architecture, consider the structure as a system, present an effective process with computers, and depend on data (Figure 1.1).

In this regard, this study aims at revealing the potential of the user experience design in architecture. First, a retrospective study on cybernetic theory and ubiquitous computing is provided. This part will explore the foundations of interaction design in architecture. Second, the implementation of ten usability heuristics of interaction design into architectural design process will be discussed. With this implementation, the thesis aims to develop a perspective to integrate data from the user/human into the architectural design process. It is important to note that, within the scope of this thesis, the terms user centered/human centered are used interchangeably. In general, these terms have slightly different meanings however this difference is out of the scope of this thesis.

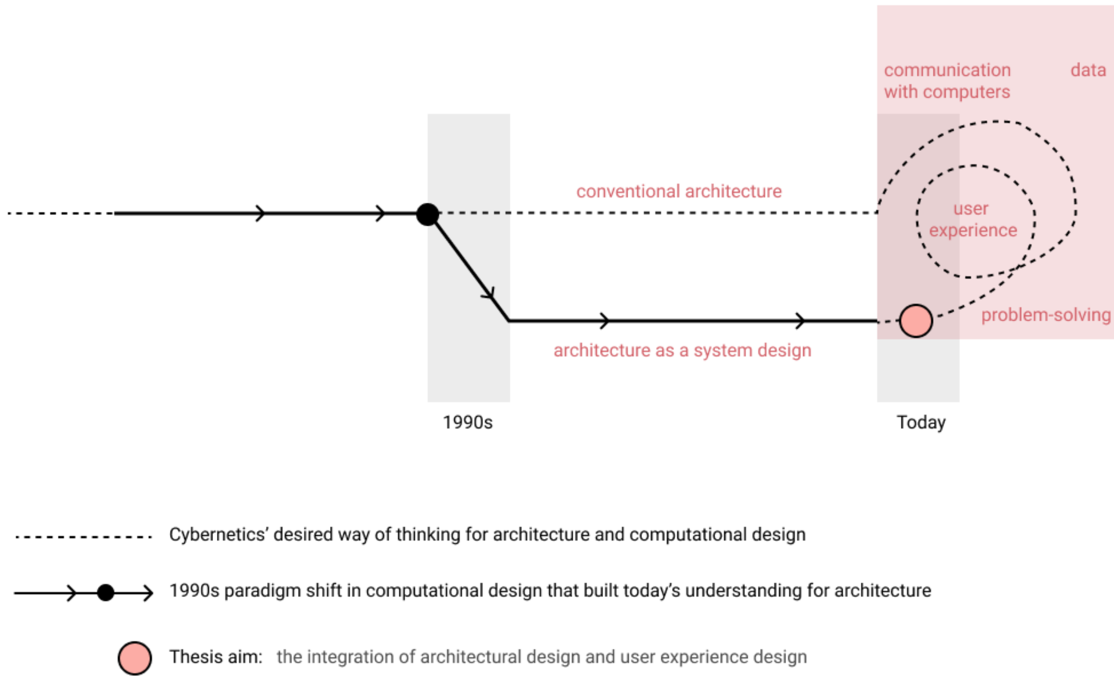


Figure 1.1 Concept of paradigm shift in architecture (developed by author)

1.3. Structure of the Thesis

This thesis consists of five chapters. The first chapter introduces the scope, aim, and problematic of the thesis. In this chapter, the historical development process of digital design and production technologies will be mentioned first. Furthermore, historical process, the architectural design thinking and user experience design relationship will be examined.

In the second chapter, discussions on the user centered design will be examined by focusing on the user being both an actor and a factor (object and subject) in the digital design process. In this narrative, the interaction between human and non-human is discussed with regard to ubiquitous computing, user-centered design, user experience design, and user research. Under the computer systems dominance, how the relationship between human and environment change in terms of interaction will be argued. Consequently, a perspective for a data-driven architectural design process, which utilizes the user experience design thinking and methodologies while taking into consideration user criteria from the very beginning of the design process, will be presented. To emphasize the thesis proposal, user experience based architectural design perspective, the research projects that utilize user experience design techniques in different stages of the design process will be examined.

The third chapter is a detailed literature review on the history of computing to discuss and provide a more comprehensive background for the evolution of an architect's role as a system designer by technological developments. Chapter three will question “How do programming and technologies push and alter architects’ limits overtime?” and “What kind of user-centered contributions are made by cybernetics or digital researchers working along with architects?” This chapter begins with discussions of Cybernetics’ quest that has triggered research on user and environment integration throughout history of computing. This discussion is followed by examining first-generation digital architects' projects to show how they accumulate the use of new tools. Along with these, the history and development of Cybernetics are followed. Since the 1960s, Cybernetics has been drawing attention to user experience that has become a central design concern resulted in the emergence of several user-centered design methodologies. Despite the vast realm of techniques included in these studies; subjects such as, common outcome, how space is responding to people, and how people are engaged to space can provide information to rethink that building in particular and its future rehabilitation interventions.

The fourth chapter discusses the suggested new layer of the Grudin's 5 Loci diagram, which focusses on cultural, individual experiences of users, will be expanded in the scope of embodied interaction with computationally augmented environments. Additionally, Chapter four explores the implementation of ten usability heuristics of interaction design into architectural design process.

In the fifth chapter, the last part of the thesis is the conclusion. In this section, the discussion throughout the entire thesis, the amalgamation of architectural design and user experience design with the investigation of usability heuristics in architecture, will be mentioned. A list of references follows the fifth chapter.

CHAPTER 2

HUMAN [F]ACTOR: FROM HUMAN FACTORS TO HUMAN ACTORS BY USER EXPERIENCE DESIGN

‘’Understanding people as "actors" in situations, with a set of skills and shared practices based on work experience with others, requires us to seek new ways of understanding the relationship between people, technology, work requirements, and organizational constraints in work setting’’

Liam J. Bannon, From Human Factors to Human Actors: The Role of Psychology and Human-Computer Interaction Studies in System Design

Information and technological developments that started to change rapidly in the middle of the 20th century, with social and cultural changes, brought the user-to the forefront in many areas such as industrial design, architecture, etc. and made the user more effective on the design process. This chapter aims to observe the human factor and human experience during the interaction between human and computationally augmented environment. Concerning changes on the term "human actors," the emphasis is on the user as an autonomous agent capable of regulating their interaction instead of merely being a passive factor in human-machine interaction (Bannon, 1989). This chapter will discuss the contribution of user who is both an actor and a factor (object/subject; active/passive) in the digital design process as well as in the architectural design. Therefore, user's active role within the scope of the architecture discipline will be studied throughout the chapter. In this narrative, the interaction between human and environment will be discussed in the light of ubiquitous computing, user-centered design, user experience design.

The foundations of user-centered design approaches are related to the social infrastructure of the 1960s. By the influence of the social infrastructure, including the user as a participant in the design process has begun since 1960s. Towards 1990s, there had been an increasing emphasis on adopting a "user-centered" approach to design as the designer's attention is on the user's needs (Norman; Draper, 1986). Therefore, designing with a user-centered approach requires understanding the specific demands and needs of users. In this process, shifting from being factor to actor, the user was predicted as a participant in order to benefit from the relationship that emerges with the integration of interaction and experience, beyond the physical feature of the space (Dourish, 2004; Bannon 1992). With this foresight, approaches, in which users were an active participant in the design process, have started to be developed (Hacıalibeyoğlu, 2017). For this reason, the relationship between architect and user should be determined with a correct organization in the design process.

User-Centered Design	Usage-Centered Design
Focus on users: user experience, user satisfaction	Focus on usage: improved tools supporting task accomplishment
Driven by user input	Driven by models
Substantial user involvement: user studies, participatory design, user feedback, user testing	Selective user involvement exploratory modeling, model validation, structured usability inspections
Descriptions of users, user characteristics	Models of user relationships with system
Realistic or representational design models	Abstract design models
Design by iterative prototyping	Design through modeling
Varied, often informal or unspecified processes	Systematic, fully specified process
Evolution through trial-and-error	Derivation through engineering

Figure 2.1: Comparison of User-Centered and Usage-Centered Design (Constantin, Biddle & Noble, 2003).

On the other hand, Constantin, Biddle and Noble compare user-oriented and usage-oriented design processes in their article (Figure 2.1) (Constantin, Biddle & Noble, 2003). In this reference, these two approaches are viewed similar in terms of user and task modeling styles. However, usage-centered design uses the data received from the user in the design process background with abstraction, simplification and reduction. Therefore, it differentiates this approach from user-centered design. Consequently, architectural design without user experience can be considered usage-centered design in terms of abstraction of user/environment rather than directly using actual users' analysis in user-centered design process. However, in usage centered practice, the architect remains as an expert, empower to make decisions based on the users' interests, keeping the limitations between the designer and user. Hence, user-centered design, in which the user played an active role, differed from the usage centered design practice by investigating the activities, insights and questions of the human to seek answers to design problems systematically. In Figure 2.2. the relationship of the user and designer was summarized in terms of user-centered and usage centered design processes (Figure 2.2).

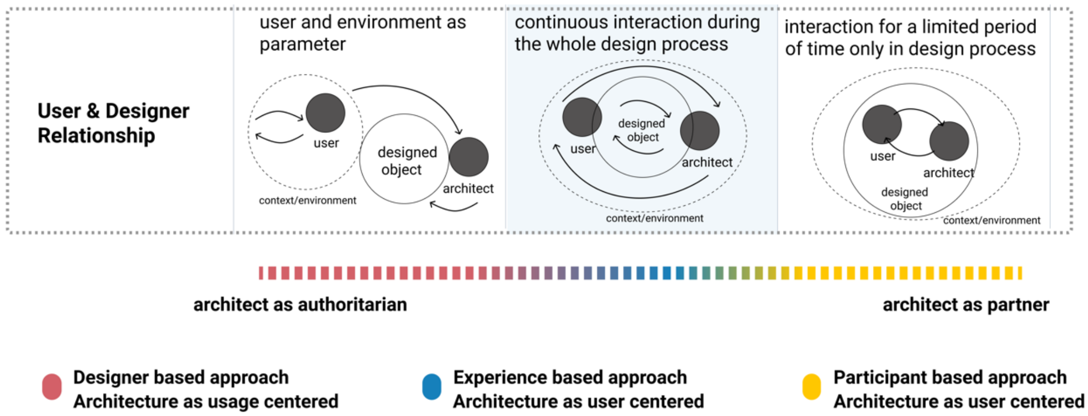


Figure 2.2: User and designer relationship in Architecture (developed by the author)

Apart from the 1990s' user notion, the "Design Methods Movement (DMM)" in the early 1960s was prompted by Christopher Alexander, Bruce Archer, John Chris Jones, and Hors Rittel. With this movement, they envisioned integrating the user's design needs with a participatory model in which the user was an actor and had an active role in the design process (Langrish, 2016; Steenson, 2017; Terlemez, 2018). Christopher Alexander and Barry Poyner, in DMM Conference in 1962, presented the relational method in which the designer had a responsibility to the research on the human actors' needs within the scope of design practice. After a while, Alexander, who was in a position against the DMM community, stood against design research being separated from the design practice. He argued that the designer could only decide the design practice process and methods (Steenson, 2017: 42). Besides, Wellesley-Miller insisted the necessity of designer in terms of establishing systematic design process by stating that: "In place of designing finished objects or structures, we design systems or environments in which structure becomes equipment and equipment is responsive to variable needs." (Wellesley-Miller, 1972).

Thus, Cybernetics' investigations to know the user in the '70s led to the spread of user-centered design with the acceleration of research conducted on human-computer interaction in the '90s. Correspondingly, the influence of Cybernetics' feedback control system, in which the user is included, on HCI research is acknowledged by Wolfgang Jonas in his article '' Research Through Design through Research'' (Jonas, 2007). In this article, Jonas debated that 1962 DDM (Design Methods Movement) Conference was a modernist approach which was strictly linked into use of scientific methods to answer user needs during the design process. User-centered design in architecture is a continuously evolving, process-oriented, multidimensional, and growing data network connected to the concept of time. Also, user-centered design in architecture is realized through communication, which allows for discussions, design alternatives and feedback rather than a linear and result-oriented design.

With the help of user-centered design studies, there have been various points of view in order to understand user integration into design process. One of them is Lefebvre's adaptation which is called as the *collaborative approach* model in user-centered design. In this model, Lefebvre separated the space into two; the first was the "concrete space" where the user lived and experienced, where daily life passed, and the second was the "abstract space" where the designer performed his productions. When these two separate areas are combined, it creates a new area as a "cooperation" area (Lefebvre, 2003). Therefore, space should not only be a physical product but should be handled in a perception that integrates with its user and its life. In Figure 2.3, the analogy of Lefebvre's has been visualized regarding the architect's role as an expert or a collaborative partner in the design process (Terlemez, 2018). Moreover, this figure emphasized the active and passive role of the user in the collaborative design approach.

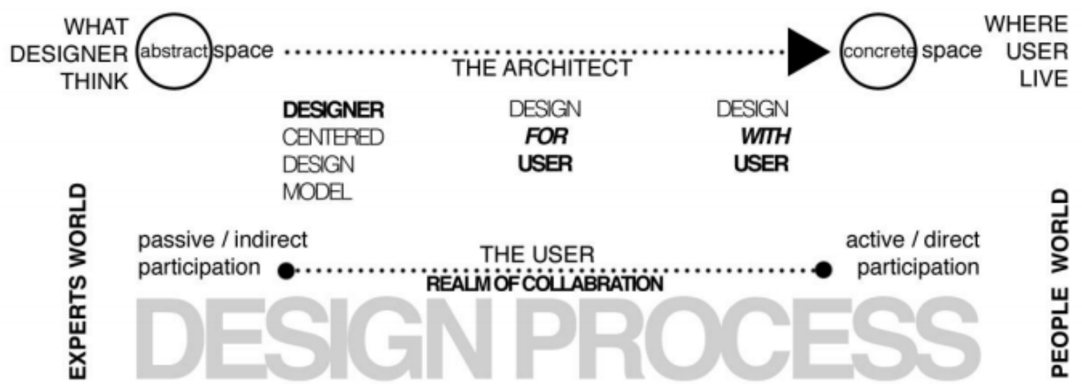


Figure 2.3: Representative diagram of Lefebvre's abstract-concrete analogy in the design process (Terlemez, 2018)

Despite the fact that user-centered design is considered a broad and inclusive field, research on user-centered design in architecture displays that the arguments have been mainly about participatory design which the user plays an active role in the design process. Thus, the participatory design model is not independent, but a model produced with existing experience and knowledge. Ferhat Hacıalibeyoğlu explains this as follows: ``Participatory design processes require development on a multidimensional texture that allows feedbacks, by discussing and continuously giving design alternatives.'' (Hacıalibeyoğlu, 2013). The notion of ''designing for user'' has been called by different names such as: "inclusive-comprehensive design", "user-oriented/centered design", "participatory design", "empathic design", "collaborative design", "joint design", "research-based design", "user-friendly design", "adaptable and user-friendly design" (Şen, 2015:41). To clarify what the term user-centered design covers and how it relates to other design methods involving users, Figure 2.4 analyzes Sander's *evolving map of design practice and design research* (Figure 2.4) (Sanders, 2008).

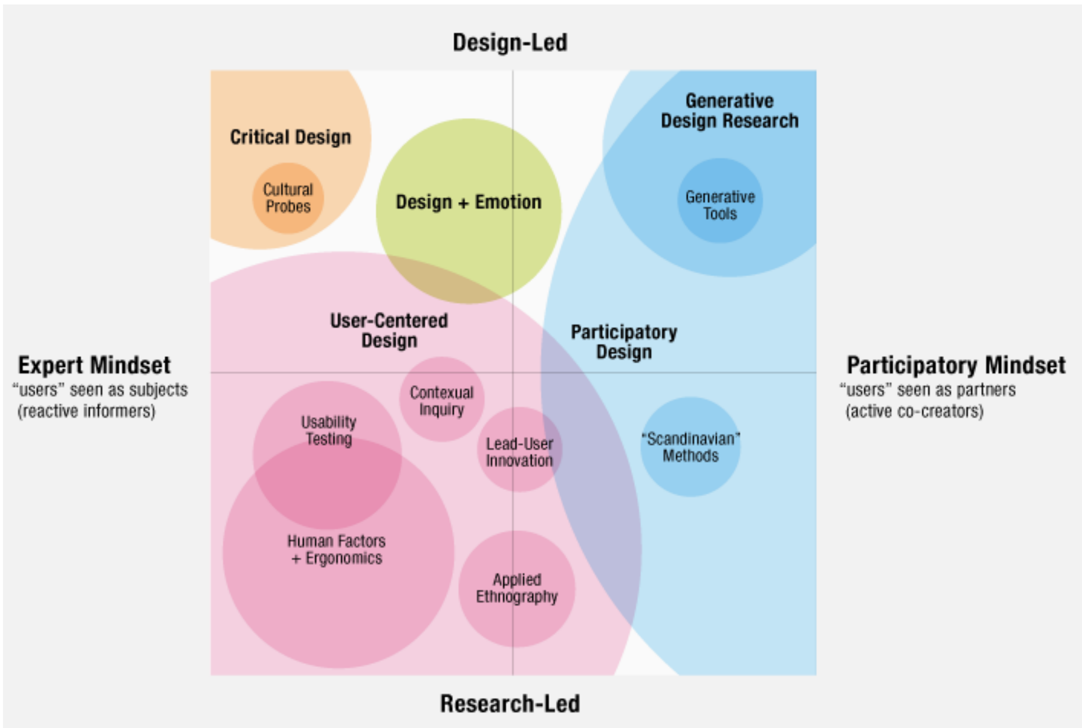


Figure 2.4: Development axes and features of the design process and the user's position in the design process (Sanders, 2008: 3)

Sanders's map pointed out the relationship between design research and user engagement approaches in design practice (Figure 2.4). According to Sanders, the upper part of the map in Figure 2.4, which has a design-led mindset, has recently been investigated on rather than the lower part of the map, supported by research (Ibid). additionally, right part of the map represents human actors in design process as active co-creators, while the left part displays research-based approach by using user data in design.

With the technological developments of the 20th century, human-machine interaction studies have led to various searches involving user participation. Based on these studies, the human presence has initialized investigating the concept of the user in architectural design. Today, the user-centered design approach in architectural design surpasses conventional usage centered design approaches in architecture (Şen, 2015). However, in this process, in user-centered design, different user characteristics have caused some difficulties forming the architectural typology. For this reason, the search for user-centered design models converting users' subjective desires into objective data has gained importance. The objective data is aimed to guide architectural solutions that can respond to high user density and user diversity in design decisions. According to Norman, design decisions should be formed by the users' demands and needs (Norman, 1996). Moreover, user-centered design takes user experience into account to address user expectations. Therefore, the general purpose of user-centered design is to provide harmony between the user and the product produced. Since the second half of the 20th century, user participation has been discussed in the architectural design process, and various investigations have been observed regarding user participation. In this context, when looking at user-centered studies in architecture, participatory studies and applications have been at the forefront.

On the whole, the idea was learning from the user and realized their design practices with the data they received from the user when Don Norman introduced the term to HCI (human-computer interaction) field with his colleague Stephen Draper (Norman, 1988). Besides, in the 90s, designers' ability to recognize users and understand what they want continued to play a dominant role in making appropriate solutions to the design problem.

In architectural practice, Norman's concept of user-centered design, which he created for HCI, has been narrowed, and it has been directed towards user participatory design. Frankly, this understanding drew the reaction of the architects who perceived the user as an active element who took the design decision. Ultimately, the concern of these architects who avoided user-centered design was that the design decision made by the user rather than the designer, whereas user-centered design focused on working with user data in design process. In this thesis, the user phenomenon in architecture has been examined in a user experience perspective. This chapter will investigate ubiquitous computing, user experience design, and user experience research techniques, and user-centered approach in architecture to further this point.

2.1. Ubiquitous Computing

Ubiquitous computing concept describes the omnipresence of technology and the widespread use of it in daily work and life. The concept of ubiquitous computing has started to be discussed under the human-computer interaction technologies. The technological developments on computational systems helped to create intelligent environments tracking the changes of its habitants via ubiquitous computing, learning from the user's data, environmental feedback, and activity patterns. In 1993, the term ubiquitous computing was coined by Mark Weiser. He described as an upgraded computing method to build the next generation environment which is full of invisible computers to their user (Weiser,1993). Ubiquitous computing paved the way for the research for a responsive environment while enabling the intelligent technologies being available for humans in their habitats.

By ubiquitous computing, new layers of interaction between humans, machines, and the environment have occurred. Before Mark Weiser introduced the term ubiquitous computing, At the 1990 CHI - Human Factors in Computing Systems Conference, Jonathan Grudin talked about the human factor and the computer's ubiquity without referring to the term ubiquitous computing (Grudin, 1990). The perspective expressed by Grudin in The Computer Reaches Out, demonstrates the development of the computer interface, and the transformation of human factor into embedded users as explained in Figure 2.5.

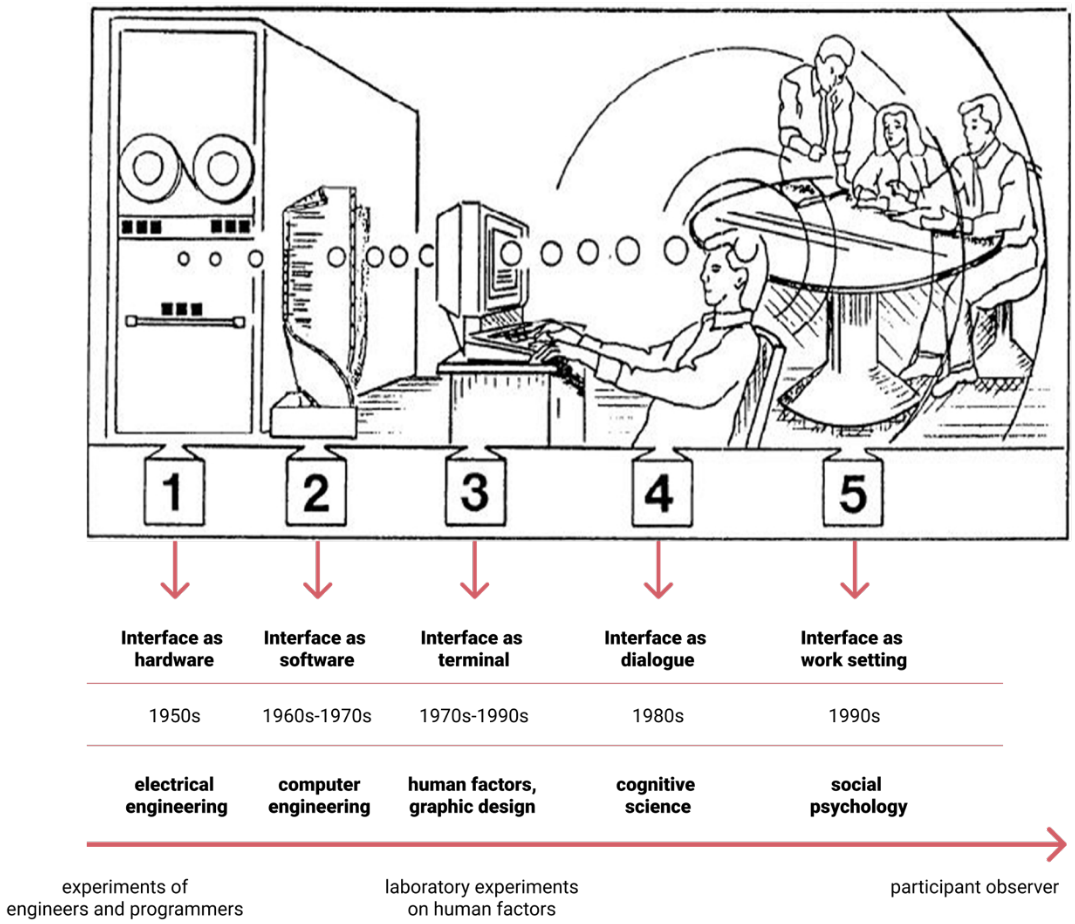


Figure 2.5: Adapted from Grudin's Five loci of Interface development (Grudin, 1990)

Grudin described human-computer interaction in a five-level diagram in which interfaces divided into four sections as hardware, software, terminal, dialogue and work-setting regarding to time periods and main concerns. Respectively, he introduced the part, interface as hardware, that was the subject of electronic engineers in the 1950s and whose users were engineers. The interface as hardware was followed by interface as software, in which engineers and programmers were primary users in the 1960s and 1970s. He described interface as terminal as a transformation towards a human-oriented solution in his diagram. The human factor and graphic research in these interfaces have started to be supported by cognitive research since the 1970s. Lastly, in the fourth and fifth loci, as can be understood from the diagram, human interaction with the computer increases. These periods described as the computer's intertwining with the environment and people, which computer has become invisible and ubiquitous (Grudin, 1990). On that account, Grudin's fourth and fifth loci were advertised to cognitive research on users' social connection and relationship with the context. As a result, Grudin's phenomenon diagram in human-computer interaction emphasizes the importance of research and evaluation on the user's experience. Before the sixth locus, which is formed as the proposition of the thesis, the user experience design and user reasearch techniques will be mentioned in the following sections.

2.2. Emergence of User Experience Design

In the 1990s, when software technologies followed the developments in design closely and imitated them, the concept of user experience has been emerged, created by digital designers. In 1995, the phrase "user experience" was introduced to cover the research on human aspects of interface by Donald Norman and his colleagues Jim Miller, Austin Henderson (Norman, Miller, & Henderson, 1995). In the HCI field, the phrase "user experience" has started to be used without any clarification on its widely definition. Law et al. tried to identify variable definitions for user experience to build common ground, yet the definition was the combination of experience with the conventional concept of usability with aesthetic, behavioral, emotional, or experiential aspects of the user (Law, Roto, Vermeeren, Kort, & Hassenzahl, 2008) (Table 2.1). Table 2.1 displays four different definitions of user experience terminology.

Definition of UX	Source
All the aspects of how people use an interactive product	Alben (1996)
All aspects of the end-users interaction with the company, its services, and its products	Nielsen-Norman Group (2020)
The user's previous experiences and expectations influence the present experience, and the present experience leads to more experiences and modified expectations.	(Mäkelä & Fulton Suri, 2001)
UX is a consequence of a user's internal state (predispositions, expectations, needs, motivation, mood, etc.), the characteristics of the designed system (e.g., complexity, purpose, usability, functionality, etc.) and the context (or the environment) within which the interaction occurs (e.g., organizational/social setting, the meaningfulness of the activity, voluntariness of use, etc.).	(Hassenzahl & Tractinsky, 2006:95)

Table 2.1 Different definitions of the user experience phrase. Adapted from (Law, Roto, Vermeeren, Kort, & Hassenzahl, 2008).

Although there were many definitions of user experience phrase, they shared a common understanding of shifting the focus to human (user or designer or both) actor and his/her interaction instead of the system that has been interacted. Eventually, the description of the phrase of user experience could be summarized as the experience people have about how they use the product or the system and how they feel when they interact. To build a clear understanding of the user experience design, Figure 2.6 displayed the relationship between user experience design and other disciplines (Rajeshkumar, Omar, & Mahmud, 2013). This chart shows the relationship of intertwined disciplines: user experience design, human-computer interaction, interaction design, architecture, and ubiquitous computing.

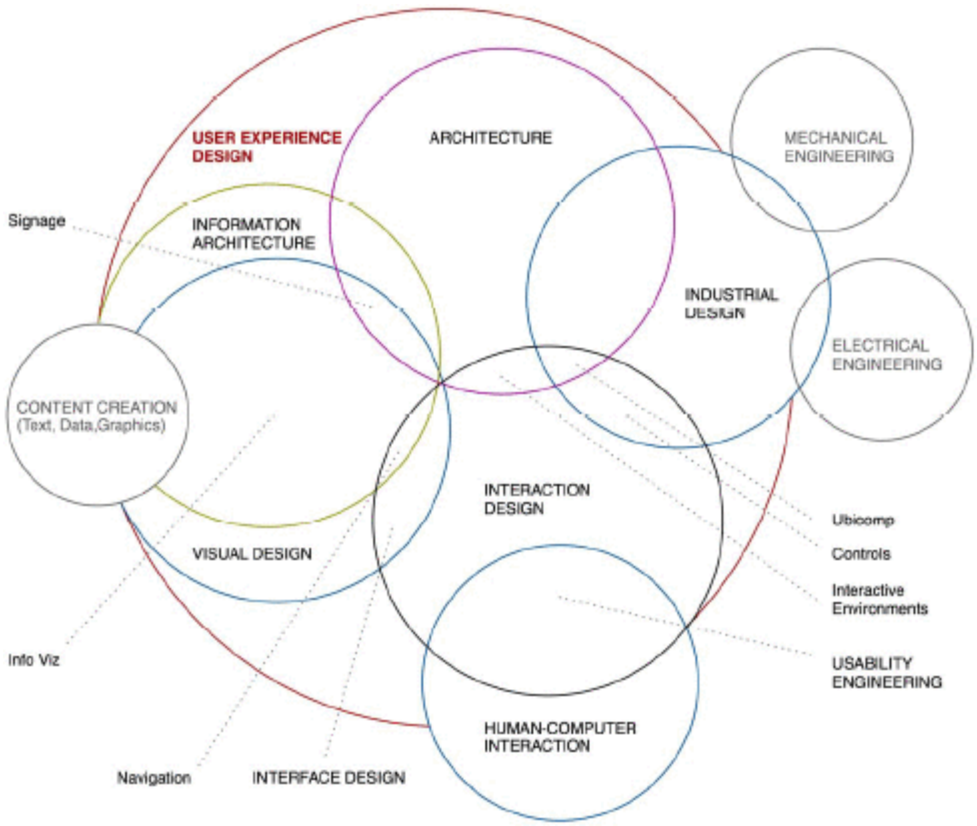


Figure 2.6: User experience design and relationship with architecture and other design disciplines. (Rajeshkumar, Omar, & Mahmud, 2013)

Focusing on the architectural background of the user experience design, Christopher Alexander's contribution to the software industry in the creation of this field was stated to be enormous (Steenson, 2014). As mentioned in the previous chapter, Alexander's research focuses on getting to know the user and systematically monitoring the user's tendencies to solve architectural design problems heuristically, as he proposed in his famous "Notes on the Synthesis of Form" and ''A Pattern Language''(Ibid). User experience design was evolved from the notion of user-centered design in the 1990s. User-centered design, the concept introduced by Donald Norman and Stephen Draper towards the 1990s, had a broad definition that the end-user experience can shape the design process (Abras, Maloney-Krichmar & Preece, 2004). The primary purpose in both user-centered and user experience approaches was to include the user in the design process, and to meet the user expectations with the designer's contribution. Consequently, user experience and usability are intertwined concepts. At this point, the relationship between form, function, and communication had an impact on user experience design. Johan Redström, who saw the Modernist Movement as the initial point for the focus on the user in design, mentioned that in order to understand the relationship between the user, designer, and designed object (building in terms of architecture), it was necessary to understand the perspectives of Modernists (Redström, 2006). He pointed out that the design optimization with the data collected from the user rather than producing a design that reflects the knowledge of the designer and the architect as follows (Ibid:124):

> …the intention to design the user experience is but the latest in a progression towards the user become the subject of design. With its ambition to create a tight fit between object and user, this development seems to point to a situation where we are trying to optimise fit on the basis predictions rather than knowledge, eventually trying to design something that is not there for us to design.

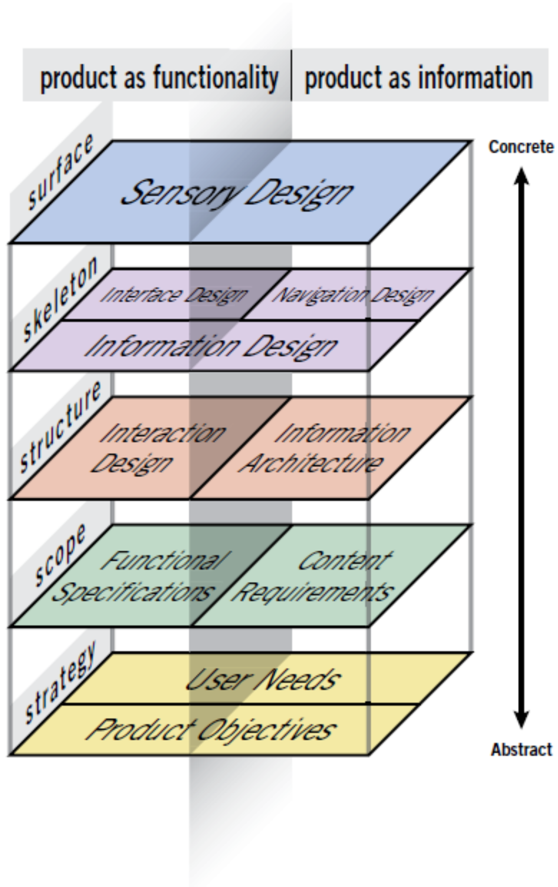


Figure 2.7: Five components of User Experience Design (Garrett, 2011)

Therefore, Redstörm's stance supports this thesis's primary focus, which is shaping the design with data obtained from the user. Like Johan Redstörm, Jesse James Garrett approached user experience by combining the concepts of architecture and user experience. With his ''The Elements of User Experience'' book, where he described the five elements of user experience design components, he systematically solved design problems by identifying user needs and design requirements (Garrett, 2011) (Figure 2.7). Similarly, Joseph Giacomin supported clarifying the meaning and motivation of the design activity with empirical studies before implementing the design object (Giacomin, 2014). Ultimately, observing and defining the users' current experiences, memories, or thoughts into the design process was the shared interest of various user experience definitions. This design process consisted of alternative methodologies: user research, usability engineering, information architecture, and interaction design to apprehend users' tendencies (Bach & Carroll, 2009). Therefore, the user-centered design approach sheds light upon empirical research and qualitative user research at the very beginning of the design phase (exploration) and throughout the project (generation and evaluation) (Hanington, 2010). In Figure 2.8, Bruce M. Hanington described the model of user-centered design research used in his design studio classes to guide the user(human) centered design projects (Ibid).

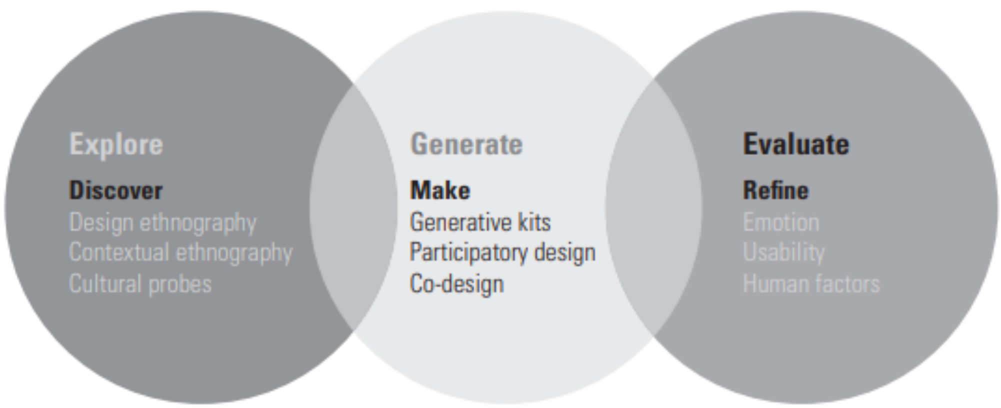


Figure 2.8: User-centered design research of Bruce M. Hannington (Hanington, 2010).

Through identifying the various definitions of user experience phrase, the importance of user and integration to design practice has been investigated. Therefore, the concept of user experience design has recently developed, and many researchers put forward their own definition and approach towards the user. These definitions and approaches bring people and their emotions into focus. User experience has a system that is strongly connected to design thinking to combine research and design during the design process. Thus, user experience design is linked to user research and design thinking. The following section will mention the user research concept and the different perspectives on user experience research (UXR) methodologies.

2.2.1. User Research Techniques in UX

User research is the set of methodologies to meet the physical, emotional, and behavioral needs of the target user profile, which determines the product features (Dodd, 2001). User research aimed to reveal user characteristics, requests, and needs by conducting various observations and analytical studies. Victor Margolin advocated for the development of traditional design education with user experience. In line with research objectives, he encouraged designers to create products and design concepts that would satisfy the user (Margolin, 1997). Therefore, large-scale research linking the design and the user also gives the designer the ability to empathize. Encouraging the designer to empathize in the design process shifts the designer’s focus on authorship and monotony towards continuity in designs and relating to the user with context. Elizabeth Sanders mentions many ways to research on the user for experience design, such as observation and evaluation of their interpretation and learning from these interpretations. In order to design experiences, observing the user is critical (Sanders, 2002). In this manner, these research techniques are used to investigate users' mental activity, which may only be indirectly accessed by the techniques. In this context, Mihaly Csikszentmihalyi and Eugene Rochberg-Halton emphasized the layered relationship between the user and the object as their reflection of their interactions (Csikszentmihalyi & Halton, 2012:1):

> Humans display the intriguing characteristic of making and using objects. The things with which people interact are not simply tools for survival or to make survival easier and more comfortable. Things embody goals, make skills manifest, and shape the identities of their users. Man is not only homo sapiens or homo ludens; he is also homo faber, the maker and user of objects, his self to a large extent a reflection of things with which he interacts. Thus objects also make and use their makers and users.

In order to comprehend layered tendencies of the user, Joseph Giacomin expands the significance of user research techniques conducted by the designer or the expert in the field (Giacomin, 2014:610):

> Today's human-centered design is based on the use of techniques, which are communicate, interact, empathize, and stimulate the people involved, obtaining an understanding of their needs, desires and experiences, which often transcends that which the people themselves realized.

Giacomin's stance for conducting user research and defining user tendencies can be considered similar to Christopher Alexander's. As will be mentioned in Chapter 3, he believed that the designers' task was to categorize and analyze user tendencies instead of that the user identifying their needs. Giacomin called the user research as a human-centered tool. He categorized the human-centered tools in terms of data, values, and simulation of opportunities (Figure 2.9) (Giacomin, 2014). In Figure 2.9 these tools, which are used to recognize the user and discover their inclinations, are presented systematically. According to Hassenzahl and Tractinsky, supporting user experience design with qualified empirical research arises from the design's richness. They also argue that the user experience should not be detached from the user research (Hassenzahl & Tractinsky, 2006).

Human Data and Models	*Capture of Needs, Desires and Meanings*	*Simulation of Possible Futures*
– Anthropometric data sets and models – Biomechanical data sets and models – Psychophysical data sets and models – Cognitive data sets and models – Emotional data sets and models – Psychological data sets and models – Sociological data sets and models – Philosophical data sets and models	Verbally based – Ethnographic interviews – Questionnaires – Day-in-the-life analysis – Activity analysis – Cognitive task analysis – The five whys – Conceptual landscape – Word-concept association – Think aloud analysis – Metaphor elicitation – Be your customer – Customer journey – Extreme users – Personas – Scenarios – Brainstorming – Contextual inquiry Non-verbally based – Game playing – Cultural probes – Visual journals – Error analysis – Fly-on-the-wall observation – Customer shadowing – Body language analysis – Facial coding analysis – Physiological measures – Electroencephalograms	– Focus groups – Lead user design – Co-design – Storyboard futures – Experience prototypes – Para-functional prototypes – Role playing – Real fictions

Figure 2.9: Joseph Giacomin’s deployment of human-centered design tools (Giacomin, 2014:616)

Neilson and Norman group examined the potential user research methodologies in four groups according to iterative design life cycle: discover, explore, test, and listen (Figure 2.10) (Farrell, 2017). The designer tries to know and get knowledge about their stakeholders and introduce the data with the design process in the discovery part. This part also serves to build a relationship of requirements and needs. In the next stage, the exploration part, within the frame of user needs, aims to define the problem space and design scope. The following test part, where the evaluation and validation methods are taking place to check designs during and after development. Finally, in the last part, listen is a place for finding existing design problems and evaluate them for the future. Hence, the importance of starting the design with user research and supporting this research at each step is emphasized. Using different methods at each stage helps to learn different data and perspectives from the user. In this way, the user experience design is supported and designed with data during the design thinking process.

Similarly, Wolfgang Jonas, who suggests immersing scientific and design paradigm, underlines his ‘’research through design’’ notion as a combination of learning and designing (Jonas, 2007). Correspondingly, the learning and designing process rationalized by the cybernetic circular and feedback perspective of prototyping. Jonas indicates that scrutinizing social, technological and cultural developments by research through design manner reinforces the design process. Therefore, design guided and supported by research techniques and circular process bridges for well-structured and consequential outcomes as well as meeting the needs of cultural and technological advancements (Figure 2.8).

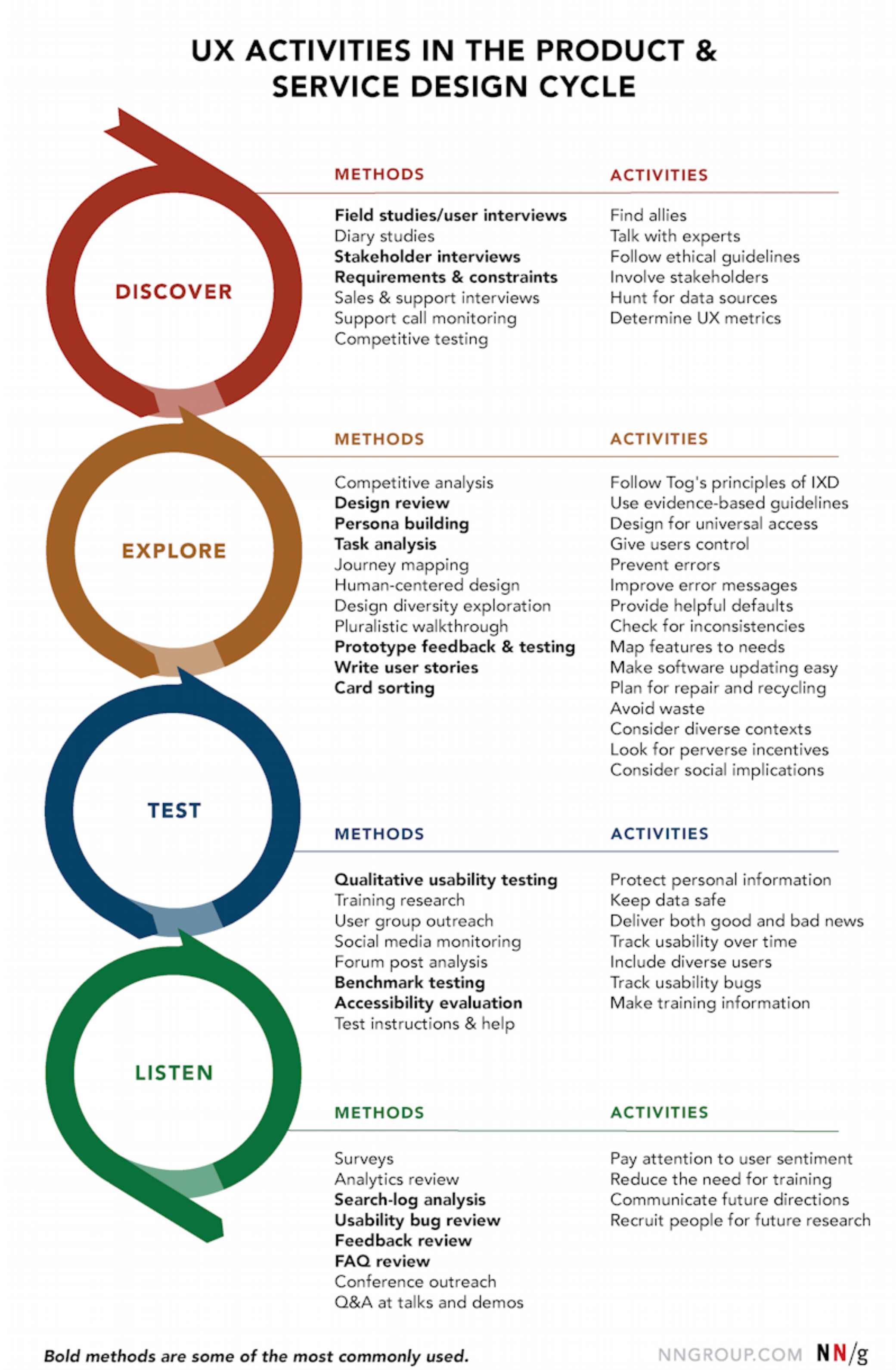


Figure 2.10: Potential UX research methods and activities accordingly stages of design Graphic by Sarah Gibbons for Nielsen Norman Group (https://www.nngroup.com/articles/ux-research-cheat-sheet/).

In terms of design education, Töre Yargın, Günay, and Süner gave a group of student types of user research models in order to make an impact on the relationship between collected data from the user research methods and the design problem in their design studio (Figure 2.11). They explained their goal as follows: (Töre Yargın, Günay, & Süner, 2019: 140)

> We propose UX modeling as a resourceful tool to not only introduce students with a theoretical understanding of what UX is but also guide them towards acquiring skills in making sense of user data, visualising insights and transferring them into design requirements, thereby bridging theory with practice.

Their aim was to impose the importance of creating meaningful experiences by using these strategies. The study also examined when each strategy has been taken part during the user experience design process. As a result, modeling could serve as a bridge between the stages where user trends are generated, and those trends are used to design systems (Ibid). Therefore, this study helped design students build an experience design based on user research data. Töre Yargın et al.'s study could be considered as a response to parameters belonging to different users and conditions in user experience design practice.

MODELLING APPROACH	TYPES OF MODELS	SOURCES
Representing activities and works of users	Work models in contextual design involving the flow model, the cultural model, the sequence model, the physical model and the artefact model	Holtzblatt, Wendell, & Wood, 2004
Representing the user	Personas (both data-driven and inspirational)	Pruitt & Adlin, 2006
	Task-based user segments based on mental models	Young, 2008; Authors' unpublished project work
Representing the concepts and their relations	Hierarchical Value Maps (HVM) based on laddering interviews	Wansink, 2003; Reynolds & Olson, 2001; Miles & Rowe, 2004; Abeele & Zaman, 2009; Töre Yargın, 2013
	Conceptual Maps / Cognitive Maps	Farsides, 2004; Miles, Huberman, & Saldana, 2013; Töre Yargın, 2013; Authors' unpublished project work
	Cross Impact Analysis (CIA) based on laddering interviews or Repertory Grid interviews	Töre Yargın, 2013; Kuru, 2015; Süner & Erbuğ, 2016
Representing experience over time	Experience maps representing user experience over time	Karapanos, Zimmerman, Forlizzi & Martens, 2009; Richardson, 2010; Karahanoğlu, 2013
Representing design recommendations	Mental models	Young, 2008
	Design recommendation infographics	Authors' unpublished project work

Figure 2.11: UX Modelling approaches in design studio given by Gülşen Töre Yargın, Aslı Günay, Sedef Süner at METU ID. (Töre Yargın, Günay, & Süner, 2019)

The study of Töre Yargın et al. offered a perspective on the central problem defined by this thesis. In terms of this thesis's primary concern, the collected data is too late to be evaluated in the design improvement process. Ultimately, this thesis aims to find an answer to a systemic architectural design process. This section provided for awareness and nuances of user research in terms of user experience design. Different types of methodologies were listed, which were categorized by the UX researchers. Lastly, the given study on the educational perspective of conducting user research methods was focused on the symbiosis of design and data in the design process. In the following section, current research on spatial interaction would be discussed under the an alleged sixth locus of the diagram.

2.2.2. Usability Heuristics in UX

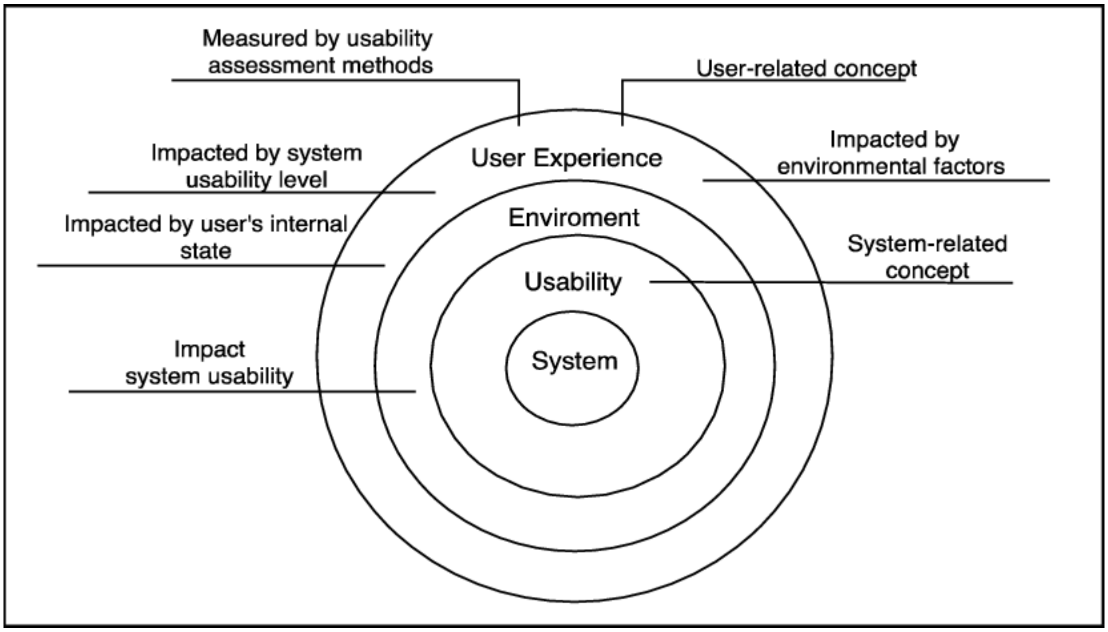


Figure 2.12: Relationship of user experience design and usability. (Majrashi et al., 2015)

As a result of the rapid developments in the field of information and communication technologies in recent years, people have started to interact with technological tools while performing a large part of their daily work. Interaction between user and object in daily activities is necessity in order to discuss usability term as well as user experience design. Usability, which focusses on functional achievement of a particular goal between user, product and environment, is a part of user experience design process (Figure 2.12). As shown in Figure 2.12, user experience terminology contains usability; and also usability is a metric to assess the user experience (Majrashi et al., 2015: 53).

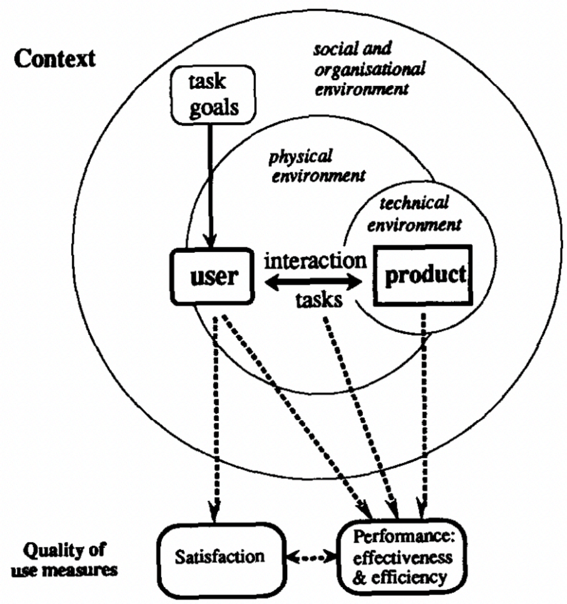


Figure 2.13: Usability measures in terms of contextual interaction. (Bevan, 1995:118)

Nigel Bevan stated usability as "the highest interactivity level afforded to a product with respect to the user" regarding human factors (Bevan, 1995: 115). In Figure 2.13, the Bevan’s diagram summarizes usability within a contextual interaction between a user and a product. Bevan defines this contextual interaction as the ease and quality of use in specific task with a particular product in order to acquire effectiveness, efficiency and satisfaction. By the same token, according to the "Usability Guide", which is a part of the ISO 9241 standard of Turkish Standards Institute, usability is defined as the degree to which a product can be used happily by certain users for specific purposes, effectively, efficiently and within a specific usage framework (*Usability*, 2021). Hence, to build a usability guideline, the ten general usability principles for user interface design are developed by Jacob Nielson and Rolf Molich (Nielson & Molich, 1990). These ten heuristics examine the interface in terms of usability, and the compatibility. Heuristic analysis is a usability engineering method applied to detect usability problems on the user interface (Nielson, 1994:152). While performing heuristic analysis, various heuristic scanning principles and qualitative guidelines supported by past experiences. The ten usability heuristics for interface design are:

Visibility of system status

The system should notify about what is happening in the system, through feedback within a convenient time. Predictable interactions with the user provide gaining trust to the brand.

Match between system and the real world

The system should communicate with the user in familiar terms and concepts that come along with information resembled real-world examples. Having a user-oriented language of the design improves the experience rather than focusing on what is understandable to the designer.

User control and freedom

Since users often choose system functions by mistake, the system should offer them an escape door to escape this situation without having to engage in lengthy dialogue. For example, undo and redo actions should be visible and available to the user as an emergency exit.

Consistency and standards

Users shouldn't have to understand and learn whether different words, situations and actions within the same and similar actions and context. According to Jakob Nielson, increasing the cognitive load on the user by encouraging users to learn new things is not provide a usable system.

Error prevention

Situations that increase the possibility of users to make mistakes should be eliminated or the users should be approved whether they want to take an action or not.

Recognition rather than recall

Minimize the user's memory load by making objects, actions, and options visible. The user should not have to remember information from one part of the dialogue to another. Instructions for use of the system should be visible or easily retrievable whenever appropriate.

Flexibility and efficiency of use

By anticipating user needs, the number of steps required should be reduced and the system should allow for customization to experienced or inexperienced users.

Aesthetic and minimalist design

Dialogues in the interface should not contain unnecessary or irrelevant information. Since each extra unit in the dialogue will compete with the information that is actually relevant. At this point, focusing on the basic points of content and visual design is significant to increase visibility.

Help users recognize, diagnose, and recover from errors

Error messages should be expressed in a clear language that does not contain a code or a misleading term, the problem should be explained clearly, and a solution should be offered to the user in a positive way.

Help and documentation

Help and documentation information should be provided in case the user needs assistance to use the system. This information should have high availability and clarity. Keeping it as short as possible and explaining the concrete steps to be followed are crucial.

2.3. User Experience Based Perspective in Architectural Design

This section offers a data-driven architectural design process that utilizes the user experience design thinking and methodologies while considering user criteria from the beginning of the design process. The goal of the user experience-based perspective in architectural design is expressed with the spiral model that deals with experimentation and experimentation during the design process (Figure 2.14). Thus, a design process is formed by the data received from the human experience and the environment. This system, which aims to improve the design process with user data, increases the rate of utilitarianism by providing the opportunity to redirect and evaluate between design phases. The critical thing in this process is to maintain the harmony between multiple actors in a good organization and discipline by keeping the architect's position as a specialist. In this way, the systematic perspective eliminates the blockages caused by an indirect or disconnected organization between these actors.

Furthermore, this perspective provides a planned and systematic strategy by allowing the re-evaluation and transformation of critical concepts derived from the user data. The architect, the main actor, reads the emerging data and concepts and reviews the analyzes that reveal the starting point of the design, form, connections and content like an expert. Within the design problem framework, the architect, by asking the reasons, changing or placing them according to their features, is an influential curator during the design process. Indeed, the architect plays a leading observer role, as an avant-garde. From this view, the architect's role is to create the intended effect in this suggested perspective by preserving the dependent relationship of the object and subjectivity. User experience-based design perspective is an approach where experience and architecture are intertwined in a spiral form. In these intersections, the main actor who initiates action, shapes, solves problems, thinks, and makes the design sustainable is the architect. With this strategic role, organizes the users' perceptual approaches and tendencies and reveals the result by design.

In the systematic approach in the proposed perspective, the architect acts as one of the facilitators/actors. In this spiral model, similar to the DNA model, the architect can be considered as the RNA that processes data during an iterative design process. The suggested perspective is related to the architect's observation, likewise the architect's approach in cybernetic theory which enables application to the entire design process as it is a feedback-based approach.

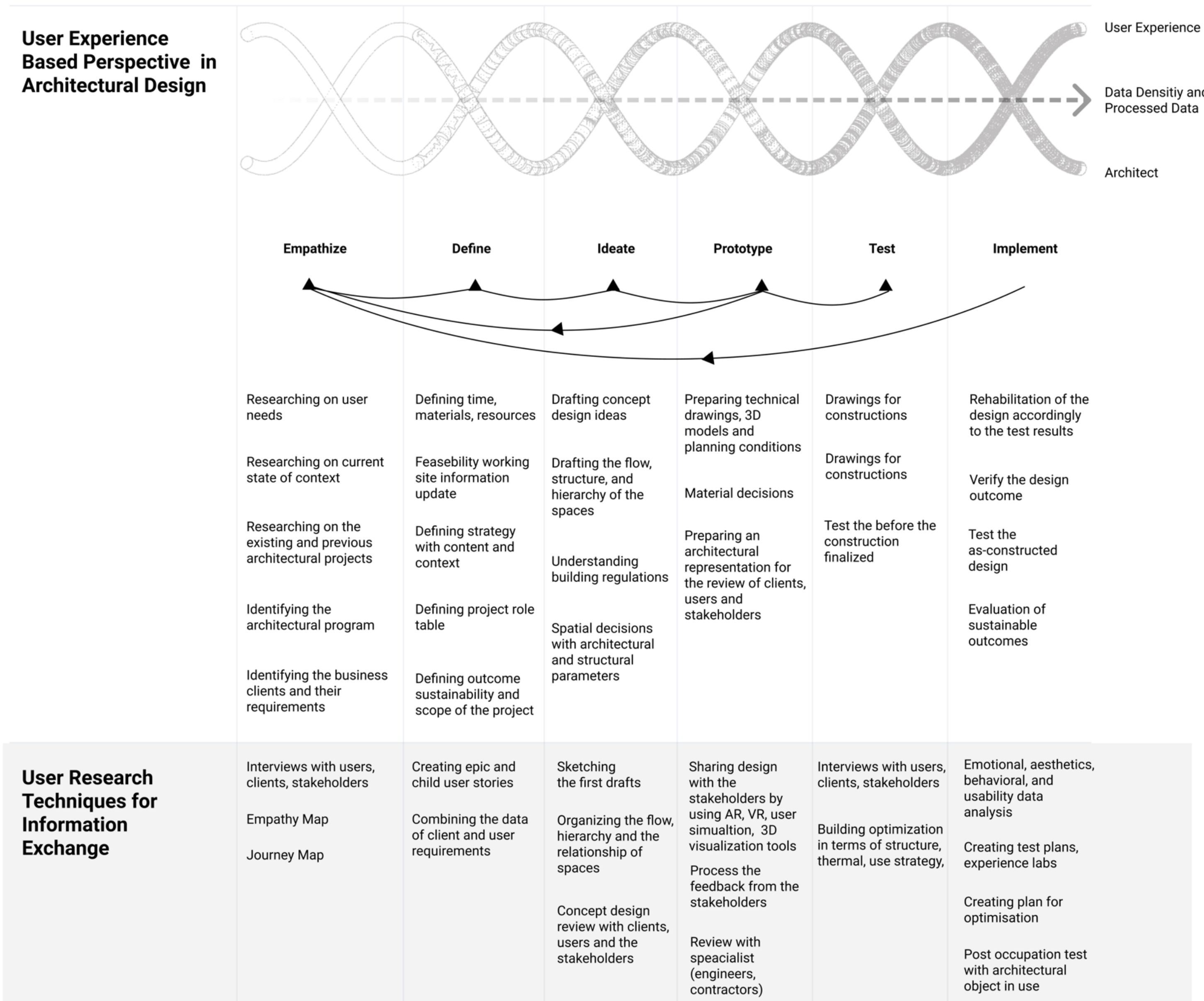


Figure 2.14: User Experience Based Perspective in Architectural Design (developed by the author).

This model's feature is presented in a relationship that includes professional knowledge and a design based on meeting user demands in a balanced way. Despite a linear and result-oriented design, the model suggests a constantly evolving process-oriented iterative design structure that is fed by design alternatives and feedback. Additionally, this model has a multidimensional and growing data network related to the concept of time realized through communication.

As a result, the user experience-based architectural design suggests taking advantage of continuous information during each layer of the iterative design process. Thus, interpretation of user data throughout the design process triggers creativity of designer to set up novel grounds for providing sustainable architectural design decisions. In addition to designer's benefit, the user experience-based perspective in architectural design provides for establishing a way to embrace inhabitants their environments by considering them as a human actor. Also, pre- and post- occupancy of inhabitants can be evaluated systematically regarding their needs, behaviors and demands. On the other hand, this model has a significant potential on an architectural design process that affects not only the professional practices of architects but also the architectural education.

Defining a systematic model to design makes a place for considering human as actor in the process rather than passively representing human factor in design. Transferring the users' experience-based data to the design process in this environment requires visual and interpretable tools. As stated in the user research techniques in Figure 2.13, virtual, augmented reality solutions and human behavior simulations have become a common starting point for thinking about iterative processes that can be integrated into architectural design processes. In the following section, projects and research that engage user techniques will be mentioned to reinforce suggested perspective in architectural design.

2.3.1. Contemporary Design Research Cases for User Experience-Based Perspective

This section focuses on research projects, which debate on evolving technology and design fluctuations respecting the way users feel, think and act in designed environments, in order to support the proposed perspective. These research projects, that include the empirical methods of users' interaction throughout the thesis, have been selected and listed in Figure 2.15. In this list, the names of the studies, their motivations, the user experience methods, the stage of the design in which these methods and the participants involved the research are analyzed. The analyzed eleven studies are classified in five different categories according to the methods used in the research. In Figure 2.15, research applied the virtual and augmented technologies in architectural design process are signified as red color in the list. Yellow and blue color indicate the usage of ubiquitous techniques in the design process, yet blue colored research includes user experience techniques along with ubiquitous computing. Lastly, purple indicator displays the application of user experience research techniques, while green color shows the study in which participatory design methodology applied.

Research Name	Motivation of the Research	Which user research technique utilized	In which stage the user research technique utilized	Participants	Source
Human behavior simulation in architectural design projects:An observational study in an academic course	**human behavior simulation** for optimal match between built environments and human activities in architectural design.	**Human behavior simulation Virtual-users** Design iteration	experience for the **concept design review**	**12 undergraduate** students	Hong, S. W., Schaumann, D., & Kalay, Y. E. (2016)
End-Users' Augmented Reality Utilization for Architectural Design Review	**getting reliable feedback from end-users** for the improvement of design options	**virtual reality (VR) and augmented reality (AR)** technologies and evaluation of the experience with **questionnaires**	experience for the **concept design review**	**76 participants** designers, students, engineers and end-users	Lee J.G., Seo J., Abbas A. & Choi M. (2020)
A virtual reality integrated design approach to improving occupancy information integrity for closing the building energy performance gap	focusing on a lack of **use of pre-occupancy evaluation methods** to understand the interaction between occupant behavior and building design alternatives.	**virtual reality (VR)** technologies and evaluation of the experience with **questionnaires**	**pre-occupancy stage** of users (not explicit)	not explicit	Niu, S., Pan, W., & Zhao, Y. (2016)
Towards user centred design (UCD) in architecture based on immersive virtual environments	a gener ic concept of how to combine **the experience of user centred design** in the field of **Human Computer Interaction (HCI)** with the traditional approach of **participatory design** in an architectural design process.	**virtual environment (VE)** technologies	information and communication in all stages of architectural design	the architect, technical engineer facility manager contractor and end-users	Bullinger, H., Bauer, W., Wenzel, G., & Blach, R. (2010).
The User Pre-Occupancy Evaluation Method in designer–client communication in early design stage: A case study	enhance the designer–client communication by applying **building information modeling, user activity simulation,** and requirement management techniques.	**virtual environment (VR) and BIM** technologies	**pre-occupancy stage** of users (not explicit)	end-users	Shen, W., Zhang, X., Shen, G. Q., & Fernando, T. (2013).
Responsive environments: User experiences for ambient intelligence	review the emerging field of responsive environments as an **ambient intelligence** system with a focus on user experience.	Laboratory tests, surveys observation, interviews, using sensors and actuators	**in the design and specifications phases**	end-users	Lino, J. A., Salem, B.,& Rauterberg, M. (2010)
Impact of built environment design on emotion measured via neurophysiological correlates and subjective indicators: A systematic review	the built environment as one significant component of environmental enrichment, draws together evidence on the **impact of the design of interior spaces on human emotion**	Laboratory tests, surveys observation, interviews **VR, VE, Physically** experience	**post-occupancy stage** of users (not explicit)	end-users	Bower, I., Tucker, R., & Enticott, P. G. (2019).
Using a Live-In Laboratory for Ubiquitous Computing Research	Showing **PlaceLab** living laboratories may help researchers bridge from laboratory testing to larger studies in real homes using portable ubiquitous computing technologies.	Surveys and interviews Experience sampling Direct observation Portable kits of sensors for in-home studies Demonstration labs Short tests in parts of live-in labs tests with limited sets of sensors	**pre-occupancy stage** of users (not explicit)	end-users	Intille, S. S., Larson, K., Tapia, E. M., Beaudin, J. S., Kaushik, P., Nawyn, J., & Rockinson, R. (2006).
Developing Design Solutions for Smart Homes Through User-Centered Scenarios	This study investigated ways to control and adapt the technology to **fulfill user daily needs,** which are the active **drivers of smart housing** technology adoption.	**Scenario analysis** (in UX persona) User stories and child stories	**pre-concept design** (not explicit)	**12 experts** developers, researchers, architectural designers, and employees	Kim M.J., Cho M.E. & Jun H.J. (2020)
Future Users, Future Cities: Dweller as Designer	focus on the possibility of the non-architect users of architecture as decision makers in order to reach design requirements	design hierarchy, methods steps of the user scenario, prototyping	**in the design process**	students	Germen, M., & Kavlak, E. (2010).
Co-Adaptive Environments: Investigation into computer and network enhanced adaptable, sustainable and participatory environments	investigates how to design systems that **encourage occupants and users of buildings to actively understand,** manage and customise their own spaces	participatory systems, web interfaces	**all stages design** with user participant	the architect, technical engineer facility manager contractor and end-users	Santo, Y., Frazer, J. H., & Drogemuller, R. (2010).

Legend:
- augmented reality, virtual reality, virtual environment, virtual users
- ubiquitous computing, living aboratory
- ubiquitous computing, living laboratory and UX research techniques
- UX research techniques
- participatory design techniques

Figure 2.15: Design Research Cases for User Experience-Based Perspective (developed by the author).

2.3.1.1. The PlaceLAB

One of the cases from the list, which uses ubiquitous computing, living laboratory and user experience research techniques, is the study of Kent Larson and Stephen S. Intille. They investigate the future of the environment towards user-adapted interaction with ubiquity in their research living laboratory PlaceLAB. In the research, users' behavior is observed through participation and experience of users in a place where most of the user's daily activities automated and controlled by computers (Larson et al., 2005). Larson, and Intille focus on human activities, behaviors, experiences in their inquiry towards a responsive environment. Larson and his colleagues focus on the experiences through interaction with the ubiquitous environment in their empirical studies. Recently, the ubiquitous computing research idea has evolved into Ambient Intelligence (AmI) research, which is known as an expanded model, that scrutinizes the user experience. AmI environments, integrated with autonomous computational technologies, aim to combine user-centered touch with qualified research on everyday activities and technological instruments through user experience and information technologies (Bravo, Fuentes, & Ipiña, 2011). AmI systems, enabled by recent advancements in Artificial Intelligence (AI) and Internet of Things (IoT) technologies, offer new mechanisms for data-driven decision making in architectural design. AmI postulates notion of human actor through interactive communication and intelligent behavior between user and architectural space. Thus, Larson, and Intille take Weiser's and Grudin's notion of the ubiquitous computing to the next level, which is the sixth locus which mentioned in the chapter three of thesis, with their research concern. With the concept of ubiquitous computing, people are designed to live in smarter environments and environments where they will be more integrated with user experience-oriented work.

2.3.1.2. Human Behavior Simulation in Architectural Design Projects: An observational study in an academic course

Another research from the list, Seung Wan Hong, David Schaumann and Yehuda E.Kalay's study which aims at teaching iteration and empirical approaches in architectural design projects to students by using human behavior simulation methodologies in architectural design studio. The simulation serves a medium which conducts the usability testing combined with evaluation of user behavior in ambient intelligent environments (Hong, Schaumann & Kalay, 2016). Creating virtual copy of users and their investigated behaviors in 3D game engines, such as movement patterns, are utilized for answering complex contextual interactions in technologically augmented environments (Figure 2.16). As a result of this study, functional, psychological and social aspects of design solutions observed in a virtual context. Furthermore, human behavior simulation gives the designers a platform to observe dynamic interactions of user for further analysis regarding usability evaluation with expected and unexpected results throughout the observation. In comparison to a laboratory research such as PlaceLAB, conducting the research with a simulation give flexibility to use large amount of human behavior data in different architectural environments during the design process.

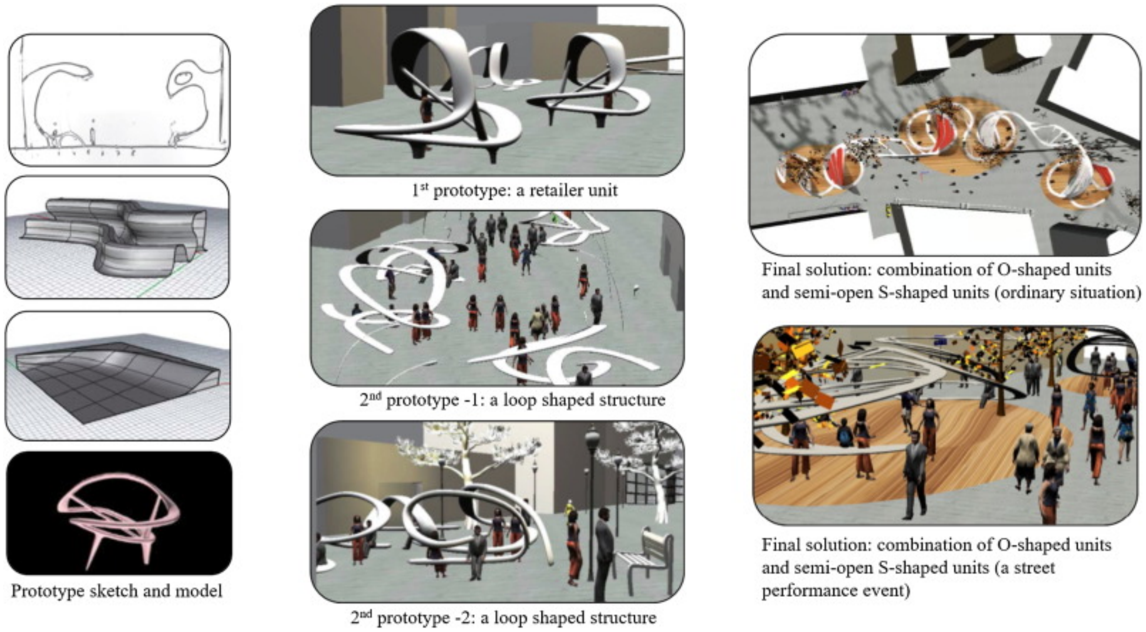


Figure 2.16: Virtual users' prototypes (Hong, Schaumann & Kalay, 2016)

Consequently, in this section, recent architectural research projects that support user experience design are listed and two from the list are described. One of these examples is PlaceLAB, research that uses an artificial environment to observe user experience and interaction within the framework of determined factors. The other is a study conducted by using a virtual environment and virtual user simulations prepared based on the possible behavior of the user and to create awareness of the interaction design in the design process for architecture students. The purpose of these two studies being selected for the discussion in this section; is their common purpose to emphasize the importance of user experience and interaction in architectural design. And in addition to this, these two studies are distinguished by the methods and parameters determined while observing the interaction design.

In conclusion, this chapter exposed insight into the discussion of the user's active role within the framework of the discipline of user-centered design. In this chapter, an overview of the discussions on the human interaction in the design process was addressed by ubiquitous computing, user-centered design, user experience design, and usability heuristic analysis. In addition, this chapter delved into the user's active role within the scope of the design discipline. Furthermore, integration with the user, architect, and other interdisciplinary actors enables the space to be shaped in real terms. Because living spaces need to be shaped in line with daily needs, technology, and social behavior; creating suitable spaces under wide range of living conditions requires a user experience-based perspective. Therefore, user experienced based architectural perspective, in which the user takes an active role, presented in this chapter. Also, examination of architectural projects illustrated by the user experience based architectural perspective. In the following chapter, background of the user integration in architectural design process will be examined withing the scope of cybernetics.

CHAPTER 3

DEVELOPMENTS TRIGGERING USER INTEGRATION IN ARCHITECTURE

‘Therefore, design cannot be confined to disciplinary boundaries while searching to ‘explore the future and anticipate change.’

Wolfgang Jonas, A Scenario for Design

Automation is defined in Merriam-Webster as " automatically controlled the operation of an apparatus, process, or system by mechanical or electronic devices that take the place of human labor " and " the technique of making an apparatus, or a system operate automatically ". Although the concept of automation is used in conjunction with the industrial revolution, it goes back to ancient times. The availability of the automation technologies we have been using since the industrial revolution extends to Homer's Iliad. Homer frequently mentions "automata" in Iliad and Odyssey. The Homeric word 'automata' is used for machines acting on their own will. Homer's automata is utilized as internal energy, like living beings (Vasileiadou, Kalligeropoulos, & Karcanias, 2003). Over time, automation has been utilized for daily lives and working areas to solve the problems. This period, early 20th century, is called the first machine age in which machines are replaced with human and animal power (Banham, 1960). Humans improved their coping mechanism with the increase in transportation and communication. Over a period, the transformation process from machines focusing on speed, efficiency, and power towards machines modeling the human brain has begun. This transformation period is called the second machine age. According to Andrew McAfee and Eric Brynjolfsson, the second machine age replaces human labor in the workforce with the combination of intelligent technologies that can grasp the mind's functioning and the work in the robotic field (Brynjolfsson & McAfee, 2018). According to the first machine age, one could argue a more significant change between man and machine in this process. Because at the beginning of the twentieth century, in the first machine age, the calculations of machines/computers were still made by man (Figure 3.1).

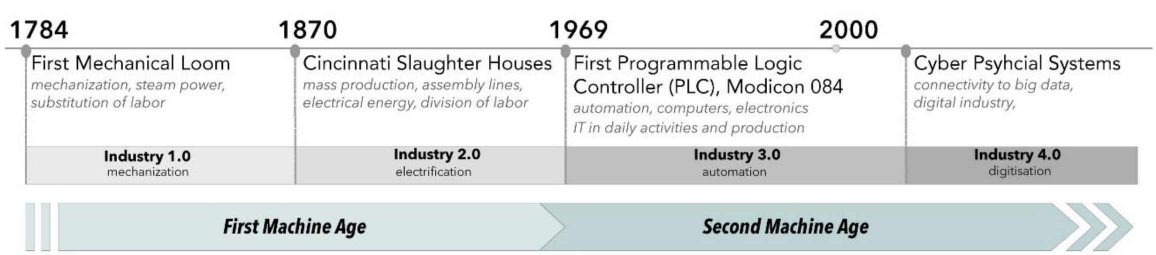


Figure 3.1: Historical Timeline of Automation Integrated with Industrial Revolution (developed by author)

Currently, how to use data and make it usable in automation with developing technology gain prominence. Thus, data regulation in human-machine interaction enabled the development of informatics automation in the period that Mario Carpo defined as the second digital turn (Carpo, 2017). Autonomous options instead of human-based rules replace intelligent technologies. Even this change is observed in the field of architecture and design. In this process, the architects who made early studies on automation developed heuristic methods by considering architecture as a problem-solving discipline with the cybernetic theory. These methods have origins in understanding four-phased problem-solving processes (understanding the problem, devising a plan, carrying out the plan, and looking back) proposed by mathematician George Polya's (Polya, 1988). In this reference, the heuristic approach is considered as a cycled process rather than a linear process. In this chapter, to better understand its impact on design and architecture, the period from the mid-twentieth century to the second digital turn will be described mentioning the the development of computing in history. This chapter will examine cybernetic theory to comprehend the notion of the architect as a system designer. Considering architect as a system designer help to build a systematic relationship between user and design / psychical space throughout the whole process of design.

To emphasize, in the 1960s and 1970s, the architects who worked with the Cybernetics community tried to establish new relationships between humans and machines. Moreover, they manifested new methods to understand user needs and behaviors and to control architecture user participation. The emergence of the modern computer caused paradigm changes in science and architecture (Figure 3.2). This chapter reveals the user-centered design in architecture with the Second-Order Cybernetics' studies on that the buildings were considered not as objects, but as a system that responded to feedback.

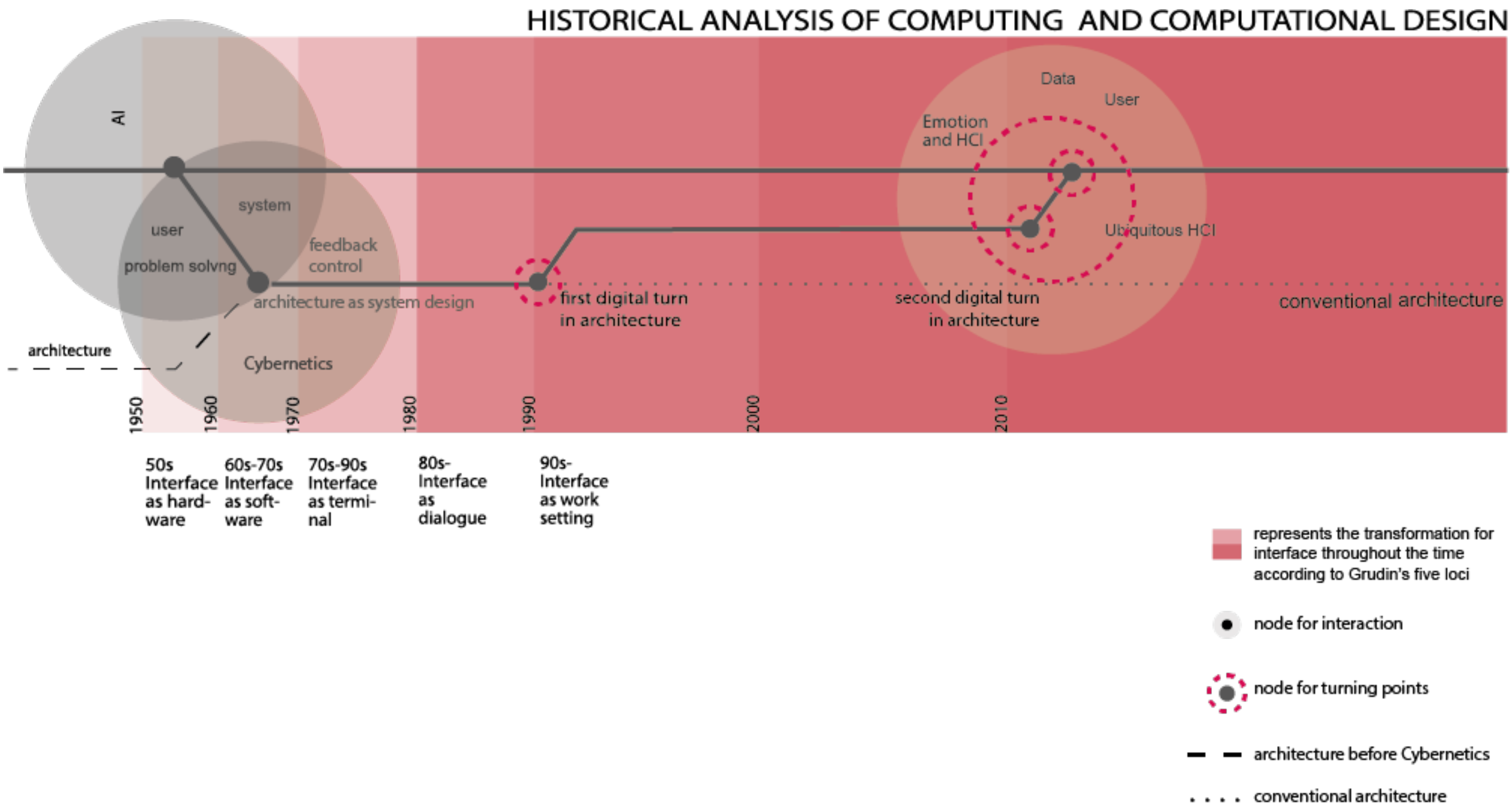


Figure 3.2: Historical analysis of computing and computational architectural design (developed by author)

3.1. Emergence of Cybernetics

With the idea of developing machines that duplicate how the human brain works, many researchers have worked to produce intelligent machines by various methods to mechanize the mind towards the 1950s. With these methods, they tried to program how the human mind performed the tasks. In the early 1940s, Norbert Wiener and other scientists captured the similarity of feedback systems' features in machines and animals. (Crawford & Joler, 2018) Figure 3.3 also represents the feedback system as a reference input: the system that feeds the input with feedback to obtain the desired output value. In 1943, the behavior was classified and utilized for laying the foundations of cybernetics without using the cybernetic concept (Rosenblueth, Wiener, & Bigelow, 1943). Figure 3.4 schematizes the feedback system as a reference input to obtain the desired output value, that is, the system that feeds the input with an active contribution (Figure 3.4).

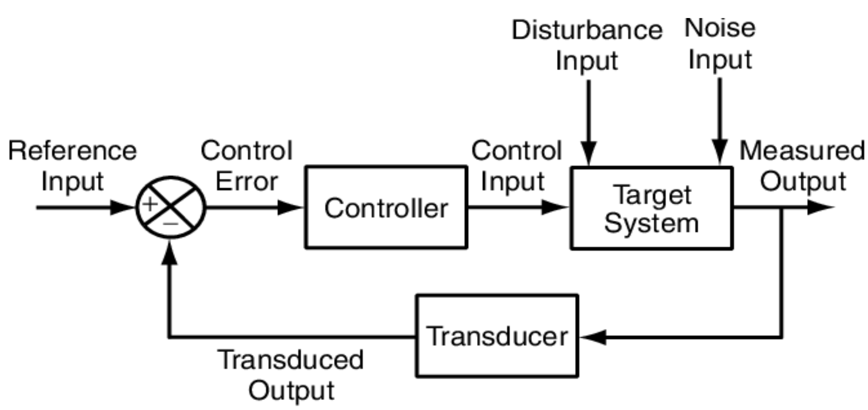


Figure 3.3: Feedback Control of Computing Systems, (Hellerstein, Diao, Parekh, & Tilbury, 2004:5)

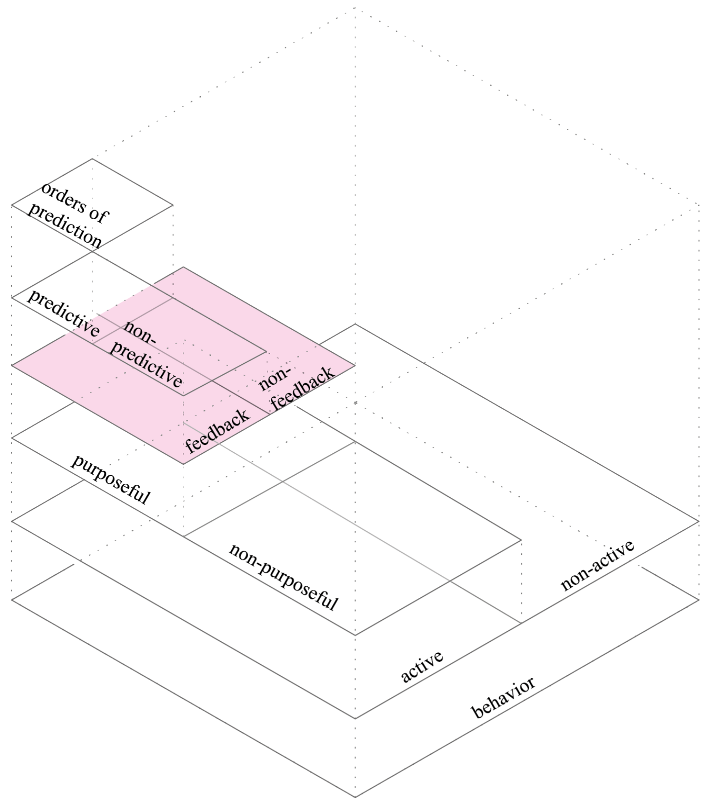


Figure 3.4: Feedback and Behavior adapted from Behavior, Purpose and Teleology article (Rosenblueth, Wiener, & Bigelow, 1943: 21)

In 1948, Norbert Wiener mentioned cybernetics concept for the first time in his book (Wiener, 1948). In this book, he defines cybernetics as a science based on a feedback system. The system is described as self-determining, self-renewal according to environmental requirements. According to Weiner, cybernetics is able to control and communicate biological and non-biological systems. Besides, cybernetics is defined as information that returns from a system to its environment (Dubberly & Pangaro, 2015). Moreover, Wiener mentions how meaningful information feedback while making environmentally sensitive machines (Wiener, 1947). In this regard, Mario Carpo also states that the technical feedback loop builds a favorable environment in postmodern culture, in which digital technologies take root in many areas (Carpo, 2013).

Consequently, these researchers of cybernetic theory establish a discussion on the relationship between user and environment through feedback theory.

British psychiatrist W. Ross Ashby devotes the *homeostatic adaptivity* to the studies in the field of Cybernetics. He defines the Homeostat as an analog computer which responses to the changing environment (Ashby, 1960). Steenson called the homeostat an artificial brain capable of performing adaptive and learning behaviors (Steenson, 2014). Moreover, the homeostat imitates the brain that organizes itself as being an electromechanical tool with a feedback mechanism and an organism in communication and integrity with the environment (Figure 3.5). Klaus Krippendorff states that Ashby's work encourages designers and researchers to replicate cybernetics discoveries and discusses human-centered design, which he sees as the focus of Second-Order Cybernetics (Krippendorf, 2007). Krippendorff describes the term cybernetics as a dialectic between science and design. In other words, cybernetics is a synthesis of both science and design which follows a method of intellectual inquiry. Another contribution to the cybernetic descriptions belongs to Nicholas Negroponte seeing cybernetic as the state of limitlessness in human-machine interaction (Negroponte, 1970).

Figure 3.5: The Homeostat (Ashby, 1960:101)

3.2. Emergence of Artificial Intelligence

The increasing momentum of computer investigations have been contemplated since the middle of the twentieth century till to the present. In the 1950s, studies made to search for ways to transfer the mind to the machines were mutually exclusive but took the automation discipline one step further. In the 1950s and early 1960s, researchers aimed to gain their machines' ability to be related to human thought, with puzzles, chess-style games, and easy-to-answer questions. Their aim was the reason to link artificial intelligence to other disciplines as an interdisciplinary field. The fundamentals of these studies lie in how human brain can solve problems as do machines. One research that has carried out this purpose focused on the use of the Bayes rule, a statistical and machine learning technique, in the classification of data (Zheng & Webb, 2000) . The Bayes rule uses the subjective probabilistic approach taken by the observer himself and his past data to find the clues while mechanizing the perception. These approaches have formed the basis of today's artificial intelligence studies (Nilsson, 2009:53).

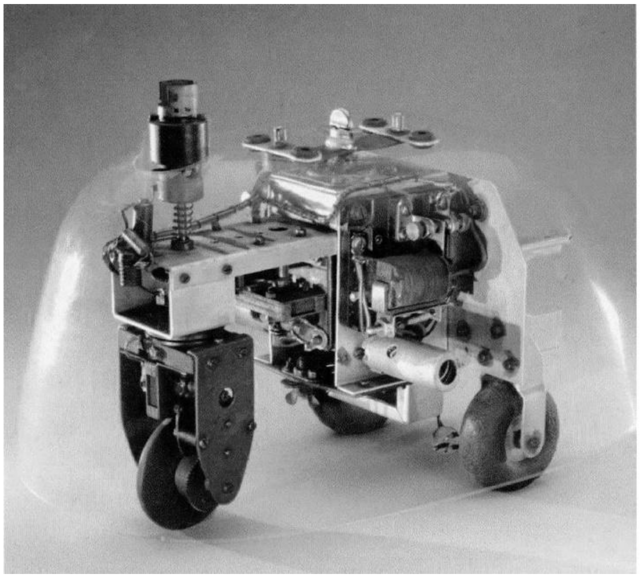
The emergence of artificial intelligence has been shaped by three critical meetings, brain modeling, and communication between machines that can calculate: “Session on Learning Machines” in 1955, “Summer Research Project on Artificial Intelligence” in 195,6, and “Mechanization of Thought Processes” in 1958. At the meeting held in 1955, the researchers shared their work with the mental phenomenon's symbol process and the definition of patterns on the neural network. The "Dartmouth Summer Project" in 1956, when the term artificial intelligence was introduced, was also a continuation of the *Automata Studies* of McCarthy and Shannon. Most attendees of this meeting were concerned with copying human thinking from a higher level and presenting their work that aimed at reviving the mind in the machine (Timeline of Computer History, 2020). They shared researchers on logical artificial intelligence, which based on the meeting, held in 1958, that reasoning is a key for artificial intelligence (McCarthy, 1959). According to McCarthy, the phrase of artificial intelligence should not be the same as cybernetics because cybernetics’ works are mainly about feedback systems. As a result of that, they detached their research from the cybernetics term.

In contrast, looking at technology from a critical perspective, Dreyfus criticizes artificial intelligence in terms of the brain not being a computer. These researchers have tried to match the brain and computer, which has failed (Dreyfus, 1992). Dreyfus's point of view supports the difference between artificial intelligence and cybernetics; the former roughly tries to mimic humans in order to beat humans, the latter tries to learn from machines to co-create together. Similarly, Don Norman, who introduces the phrase of user experience, criticizes the understanding of humanizing the machine and mechanizing the human. He mentions the importance of symbiotic interaction as follows: (Norman, 1999:159)

> Because humans and computers are such different kinds of systems, it should be possible to develop a symbiotic, complementary strategy for cooperative interaction. Alas, today's approaches are wrong. One major theme is to make computers more like humans. This is the original dream behind classical Artificial Intelligence: to simulate human intelligence. Another theme is to make people more like computers. This is how technology is designed today: the designers determine the needs of the technology and then ask people to conform to those needs.

Psychologist B.F.Skinner, with his behavioral psychology studies in the early 1950s, simply investigates whether the mind can be understood through the Black Box model of the mind through the relationship between input and output (Graham, 2019). Chomsky, who works on cognitive psychology, does the same work with Skinner. To understand the internal structure of the system, that is, to solve the black box metaphor, Chomsky tries to unravel the brain as a software system instead of turning to the behavioral system's communication with the environment. However, Skinner is struggling to predict the future through the function of the past (Nilsson, 2009). In 1956, computer scientist John McCarthy, who introduced the concept of artificial intelligence and defined it as "imitating intelligence on a computer," tried to solve the human biological system with human-made equipment while sampling intelligence by using human-made hardware. Thus, McCarthy, similar to Skinner and Chomsky, focused on the transfer of human intelligence to the artificial environment. At the same time, they were searching for the transformation of human intelligence into the artificial environment by decoding the biological system's algorithm to achieve human-made/artificial intelligence. In the 1960s, John Holland performed his first studies on biological evolution, based on Darwin's theory of evolution, on genetic algorithms defined as evolutionary calculations (Holland, 1992). In the study of John Holland, He encodes chromosomes and mutations on them with binary (0 and 1 like computer language) and tries to solve the problem based on the evolutionary process. On the other hand, some researchers try to look for how evolution leads to intelligent life in machines instead of copying evolution. In this context, in the late 1940s and early 1950s, W. Gray Walter, as a cyberneticist, and neurophysiologist, built a phototropic worker, tortoise-like*,* an early example of human-made life. These machines, which are sensitive to the surrounding light and allow light to act on their systems, offers a critical perspective to intelligent behavior. According to Nils J. Nilsson, *Machina Speculatrix* machines designed smarter than made between 17th - 19th automata samples regarding feedback system works with the environment - which is similar to Second-Order Cybernetics concern even before they ever exist- by stating: (Nilsson, 2009:47) (Figure 3.6; Figure 3.7)

> Their behavior was otherwise fully automatic, requiring no human guidance. But, they had an important limitation – they did not perceive anything about their environments. (The punched cards that were "read" by the Jacquard loom are considered part of the machine – not part of the environment.) Sensing the environment and then letting what is sensed influence what a machine does is critical to intelligent behavior. Grey Walters's "tortoises," for example, had photocells that could detect the presence or absence of light in their environments and act accordingly. Thus, they seem more intelligent than a Jacquard loom or clockwork automata.



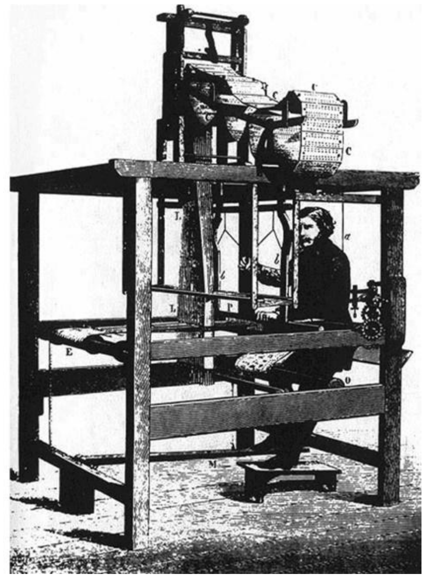


Figure 3.6 (Left): Machina Specularix,(https://www.extremenxt.com/walter.htm)
Figure 3.7 (Right): The Jacquard Loom (https://www.computerhope.com/jargon/j/jacquard-loom.htm)

To better understand the novel communication forms, the investigation through the history of computing includes the studies of Ada Lovelace, Charles Babbage, and even the Jacquard loom as the implementation of mechanical computing for industrial production. It could perhaps be emphasized Turing, von Neumann, or any of the other significant figures in computing.

In the light of all these studies, today's researchers think artificial intelligence as follows: Andrew Moor says that artificial intelligence is the science and engineering of copying the human mind by computers (High, 2017), whereas, Tom M. Mitchell, the leading name in machine learning, says that machine learning is a study that computer algorithms develop with computer's experience automatically. In her book "An Introductory to Genetic Algorithms", Melanie Mitchell states that the origin of artificial intelligence dating back to the beginning of the computer age. (Mitchell, 1996) Moreover, she pursues her opinions how computer scientists such as Alan Turing, John von Neumann, and Norbert Wiener model the brain to imitate human learning. These scientists tried to smarten computer programs and contributed to turning them into machines that could be learned and adapted from the environment. Mitchell argues that research in computer science started in the artificial neural networks in the 1980s, moving towards machine learning and then evolutionary computing, which included genetic algorithms (Ibid:2).

In summary, in the early artificial intelligence (AI) research advocates artificial intelligence to reach out the human mind level. Moreover, earlier examples of AI research devote mimicking human brain to creation of adaptive environment. Therefore, some research on artificial intelligence can be listed as in cybernetics studies. However, AI studies have recently been shifted into machine learning, deep learning, and neural networks terminologically instead of cybernetics. For instance, Figure 3.8 shows that the changes from the 1950s until 2010s regarding both the use of cybernetics and neural network. In the Deep Learning book, the terminological change of Cybernetics to the concept of neural networks has been discussed through studies, which led to alternate these terms. (Goodfellow, Bengio, & Courville, 2016:13). Even though, AI and Cybernetics differentiate by their approach, both disciplines try to examine how machine works to corporate with the human brain.

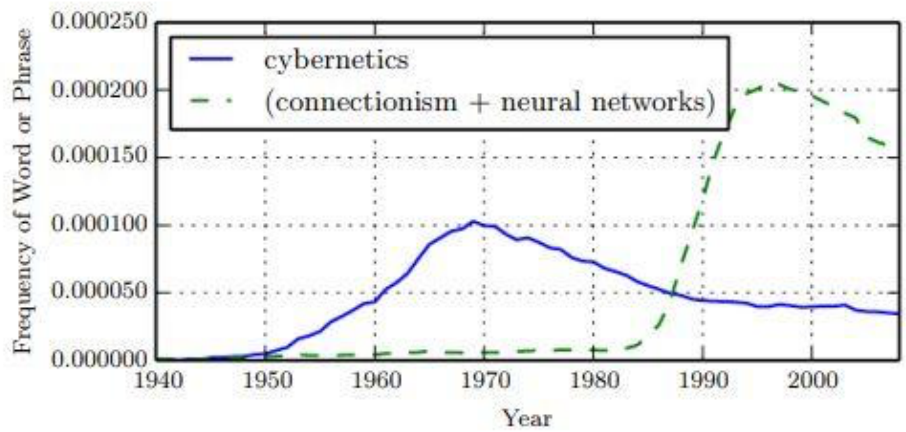


Figure 3.8 The figure shows the usage of "cybernetics", "connectionism", and "neural networks" according to Google. (Goodfellow, Bengio, & Courville, 2016:14)

3.3. Second Order of Cybernetics

At the Macy Conferences (1946-1954) held in New York City, cybernetics developed several milestones into systematic feed-back approach. One of them is the term of second-order (Cybernetics) coined by Heinz Von Foerster (Scott, 2004). In these conferences, concept of dialectics was expanded by incorporating the observer into the concept of cybernetics theory. Thus, this regulation stimulated communication between machine, human and environment (Figure 3.9). Gordon Pask, one of the members of second-order cybernetics, has claimed that the human touch is missing in the system, including the human in the system (Haque, 2007). Establishment of the observer to the system diminished manipulation of the machine over the process to solve Rittel and Webber's concept (1973) of ''wicked problems'' for design. Hence, the system's active user role provides a human way of thinking to the environment for its transformation. Table 3.1 demonstrates the controller (observer) idea and controlled entity(system) developed from

Gordon Pask's approach. He tremendously contributes to the Second Order of Cybernetics with his studies (Table 3.1). In that respect, instead of evaluating design as an object, design has started to be seen as a process that focuses more on production and usage processes.

Controller	Controlled Entity
Systematic environment	Inhabitants
Designer	System being designed
Urban plan	City

Table 3. 1: Pask's idea of Controller and Controlled Entity

The Second Order of Cybernetics worked closely with designers and architects, such as Gordon Pask working with Cedric Price, John Frazer, and Nicholas Negroponte working with MIT Architecture Machine Group. Thus, the design has started to be taken as a system consists of a designer, computer, and inhabitants. This systematic approach supported the idea of problem-solving, while drawing attention to importance of understanding needs, intention and experience of each participant.

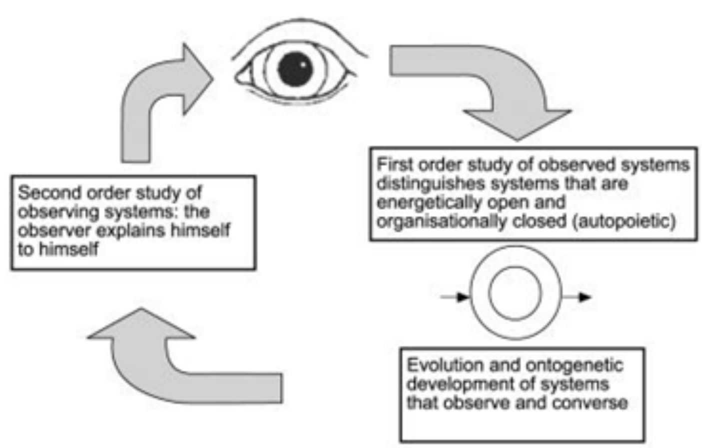


Figure 3.9: The epistemology of the observer circularity in the domain of explanation(Scott, 2004)

Furthermore, the work on cybernetics started to shift on user-oriented interaction due to the incorporation of the human as a part of the system by the Second Order of Cybernetics. According to Glanville, who always matches the activity of design with the theory of cybernetic, the notion of second-order cybernetics is considering user/observer as a participant to the design process which follows circular feed-back system (Glanville, 1999):

> Over the last 30 years, and visible largely through application in other areas, it has (in the form of "second order cybernetics" or the "cybernetics of cybernetics", the "new cybernetics") explored the nature of circular systems and those actions in which the observer (in the most general sense) is a participant. Cybernetics has elucidated conversation, creativity, and the invention of the new; multiple viewpoints and their implications for their objects of attention; self-generation and "the emergence" of stability; post rationalisation, representation and experience; constructivism; and distinction drawing and the theory of boundaries.

The design activity is answered and enlightened by the problem-solving methodologies and the observer's contribution to the system. At this juncture, Glanville sees the relationship with the observer to this system as an interactive communication between human and non-human (Glanville, 2000):

> In current cybernetic understanding, control exists between the systems within a control system. The act of control is neither action nor reaction: it is interaction.

Glanville talks about the systems in which the observer is integrated in feedback cycle. These systems are supported by the dualism of internal and external factors. Wolfgang Jonas (Jonas, 2001:69) explains Glanville's perception a reinforced science with the social entity that human-nonhuman can both understand each other in shared language by stating:

> …it also provides the theoretical basis for the observer in any experiment—or the designer in any design—as being involved in a circular, feedback process in which the observer's description and the experimental arrangement's behavior interact and modify each other until they are in apparent agreement, allowing predictions to be made (inductively) without the need for any recourse to "truth."

In this process, John Frazer, Cedric Price, and Nicholas Negroponte, who contributed to cybernetic theory, continued their studies by transferring their user-centered studies on the systems they developed with the data they learned from their users. On the other hand, Christopher Alexander moved from Ashby's concept of ultrastability and emphasized that the machine had more consistent system on the effects it received from environmental factors rather than human-machine symbiosis (Ashby, 1960).

In the 1960s, design discipline was also concerned with the complexity of the situations in the problems. They cooperated with different disciplines to produce solutions, resulting in the boundaries of this discipline to stretch. According to Wolfgang Jonas, who has a user-centered / human-centered perspective, a very few of these results were optimistic (Jonas, 2001). He argues that the consequences of the dominance of negative results led architects such as Christopher Alexander to be questioned again in architectural discipline and withdrew from their work in the architectural field. He explains that automation of design differs from art, science, technology, and economics in the following way: (Ibid:65-66)

> Design is not art because it does not aim at individual expression but instead to serve various stakeholders, even though there are all of those intuitive, creative, and individual components. Design is not technology because it deals with fuzzy, discursive criteria rather than objective criteria, even though

> design shares many functional objectives. Design is not science because it does not offer new explanatory models of reality but changes reality more or less purposefully, and yet the experimental process of research resembles the design process. Obviously, design is something very special.

In this case, Jonas's view of design differs from Glanville, who sees design as a problem-solving discipline and contributes to the cybernetics works with elucidation on the idea of design adopting scientific methods. According to Jonas, limiting design to science can hardly be possible. Instead, the design is an experimental process rather than science because design is reinforced by reality and the data. Today's understanding of user experience design is in parallel with Jonas's notion of user-centered design understanding.

3.4. System Thinking in Architecture: Towards User Integration

The introduction and development of digital technologies generate tremendous changes in our lives and work. These changes, which are developing rapidly in many fields, influenced the field of architecture. The research in the field of cybernetics, in the mid-sixties, was contemplated architecture as an information exchange mechanism and the architects as system thinkers/designers. Discussions on architecture were about the system of interactive practice between the human and non-human tool. With the work of Nicholas Negroponte in the 1960s, not only the boundary between the designer and intelligent agents (computers/machines) became active but also the artificial intelligence and information studies became a part of architectural research. In fact, in 1954, Norbert Weiner was the first to introduce the transparency of the boundary between two agents in his book: (Weiner, 1954:16)

> When I give an order to a machine, the situation is not essentially different from that which arises when I give an order to a person. In other words, as far as my consciousness goes, I am aware of the order that has gone out and of the signal of compliance that has come back. To me, personally, the fact that the signal in its intermediate stages has gone through a machine rather than through a person is irrelevant and does not in any case greatly change my relation to the signal.

The development of computers provided a deeper perspective on the relationship between cyberneticists and architecture. Although cybernetics put effort into this relationship, computational technologies have been accelerating in architectural practice since the 1990s. Mario Carpo argues that involvement of computational technologies in the practice of architecture is changing the way of making and thinking in architectural design: (Carpo, 2013:8)

> Some also concluded that many activities and functions would soon migrate from physical space to cyberspace, and that the design of new electronic venues in bits and bytes would soon replace the design of traditional buildings in bricks and mortar.

Over the years, this process has directed the perception in practice to an approach that focused on the process rather than the product. With Ivan Sutherland, creator of Sketchpad that is one of the early machine-human interaction examples, the first steps were taken to integrate computer systems into architectural practice (Timeline of Computer History, 2020). Sketchpad is an early example of a cybernetic approach regarding the co-creation of designer/ architect/ human and computer/nonhuman. The graphic language used in the Sketchpad paves the ways for communication between nonhuman and human. Early computer tools such as ENIAC were used for automation (Rosen, 1969). The automation typology is described by Yershov as how information is received and processed in a closed circle. (Figure 3.10) Defining the machine as a black box in its diagram, Yershov puts the human's creative process into the format in which it can interact with the machine, making it operable by the machine, which means a limited creative process with the mind of the person. According to Gannon, Yershov's creative process constructs the roots of the CAD technologies we have been still using today. (Gannon, 2013) These developments on tools helped to establish user interface graphic systems and at least to prepare a foundation for consideration as a medium to have a reinforced interaction.

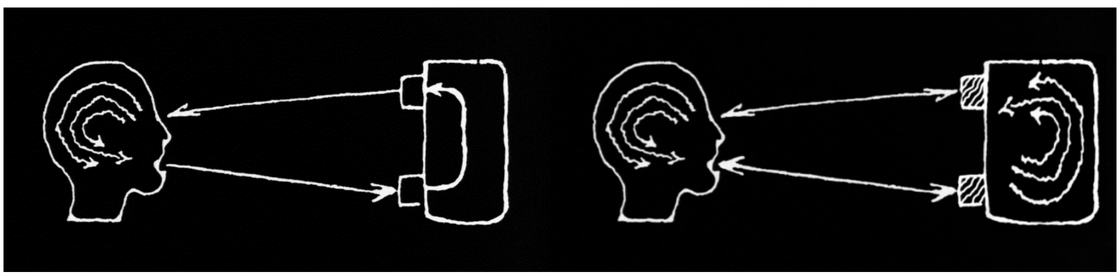


Figure 3.10: Yershov's human-machine interaction diagram (Gannon, 2013: 18)

In the 1970s, Nicholas Negroponte argued the designer's relationship with the smart tools by utilizing a dialogue approach between the machine and the human (Negroponte, 1973). In his research, he tried to activate the boundary between man and machine with dialogue-based communication. Thus, the passive boundary between man and machine, which has been a problem for years, has disappeared with the man and machine dialogue. For instance, Negroponte's computer-aided design project URBAN5 is an example of his desire to build dialogue-based communication. In Figure 3.11, there are numbered screenshots from the Demo of the reconstruction of the URBAN5 project developed by Eric Ulberg with Prof. Daniel Cardoso Llach at Carnegie Mellon University for the ongoing research ''Experimental Archaeology of CAD'(Llach, Donaldson, & Kedia,

2017) (Llach & Ulberg, 2020). In the first image, the designer introduces herself to the nonhuman; the second one shows how to create topography by selecting squares; the third one represents the drawing section of the process, and the designer is able to speak with the nonhuman. In the last one, the designer is able to see what is simulated from the drawing by the nonhuman agent through the created path by the designer. As they are shown on screenshots, the nonhuman agent gives its designer/user feedback communicatively after asking the designer's name. Then, with the given name, it answers the commands of the designer. Since the dialogue between the user and the URBAN5 is based on the user's interaction, the dialogue is unique. Eventually, Negroponte shows his idea of conversational interaction between the designer and machine through the project.

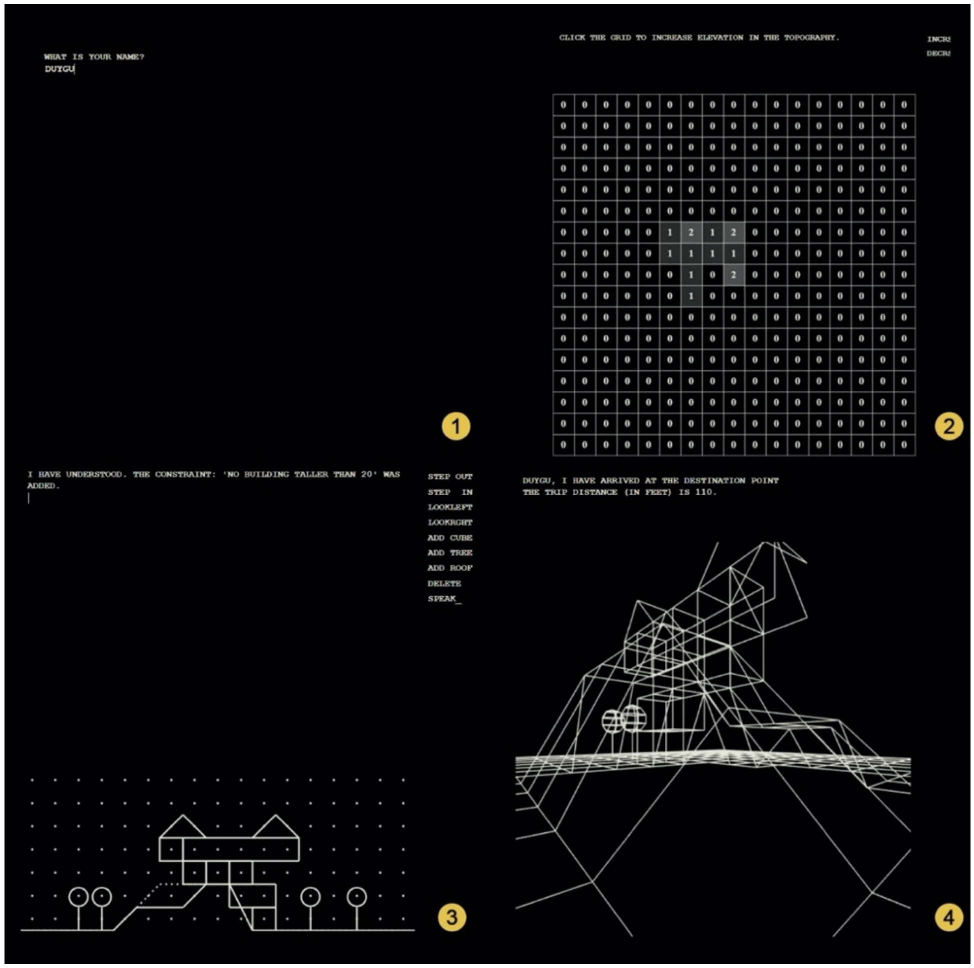


Figure 3.11: Screenshots from Demo of the URBAN5 reconstruction developed by Erik Ulberg in 2019 (https://c0delab.github.io/URBAN5/ for the Demo: https://c0delab.github.io/URBAN5/)

After 30 years of URBAN5, Asanowicz says that the passive contact of humans with nonhuman has already ended, and an entirely new concept of communication has occurred between the man and computer at the "Information at Early Design Stages in Architectural Information Management" conference held in Helsinki in 2001 (Asanowicz, 2001). In this reference, he argues that information processing has moved from our brain towards the machine by using computers. Consequently, Asanowicz supports the concept of limitlessness between human and nonhuman, which is emphasized by Nicholas Negroponte at this point. Similarly, Paul Dourish agrees that the conversational approach in the systems simplifies the embodied interaction between nonhuman and human (Dourish, 2004:102):

> …conversational computer systems, which use natural language-processing techniques and attempt to incorporate the rules of conversational interaction, may well make it easier and more natural to interact with computer system in as much as they can exploit familiar patterns of everyday human action.

Besides Negroponte’s notion of cybernetic, communicative design process, the second order Cybernetics were also working on user-oriented interactions and influenced researchers who developed adaptive systems. Furthermore, they are also responsible for its users’ needs and conditions in architecture (Uçar Kırmızıgül, 2011:67). From the perspective of the Second Order of Cybernetics, the user is the one who observes and is observed, signifier and signified. (Figure 3.12, Table 3.1)

Figure 3.12: Understanding the Second Order of Cybernetics developed by the author

Cedric Price working along with Gordon Pask uses architecture and technology together and sees architectural projects as an open domain of systems shaped by users' individual needs and interactions. This adaptive system arises from the confluence of biology and the cybernetics' point of view. Keeping up with the changing system reveals adaptive architecture over time. According to Molly Wright Steenson, Cedric Price sees technology as means of the stimulus of alteration over design and interaction: (Steenson, 2017:129)

> Price used technology as a provocation for change-change in the design process, change in how people interacted with buildings and cities, change in the status quo

According to Price, technology urged adaptation to inhabitants' needs and the requirements of the environment in design. Additionally, Andrew Rabaneck saw this adaptive approach in architectural cybernetics systems as a provider for a longer lifespan of architecture (Rabeneck, 1969). Along with this adaptive concept, Charles Eastman introduced adaptive-conditional architecture, which was explained by the thermostat analogy based on cybernetics' feedback concept (Eastman, 1972:53; Vardouli, 2016:26). He was exploring the architecture of change accordingly to its users and space (Kolarevic, 2015). Theodora Vardouli drew the diagram for the thermostat model of Eastman to build the relationship between human activity patterns and the environment. In the diagram, the nonhuman, co-creator with the user was explained in the black-box automation once Yershov described the automation in the creative process with a black-box model (Figure 3.13). Eastman, in the "Design Participation" Conference 1971, described his thermostat analogy to demonstrate user input importance in adaptive-conditional architecture (Eastman, 1972: 57):

> In the thermostat, the control setting is the substitute for user studies. The control setting allows the user to bring his values into the decision-making process. In order to achieve a similar arrangement in physical design, we must first: a) identify the critical variables that allow variation according to individual preference; b) develop the appropriate control algorithms to allow this input and to alter its outputs to reflect the inputs of the user; c) develop the input mechanism by which the user communicates his preference.

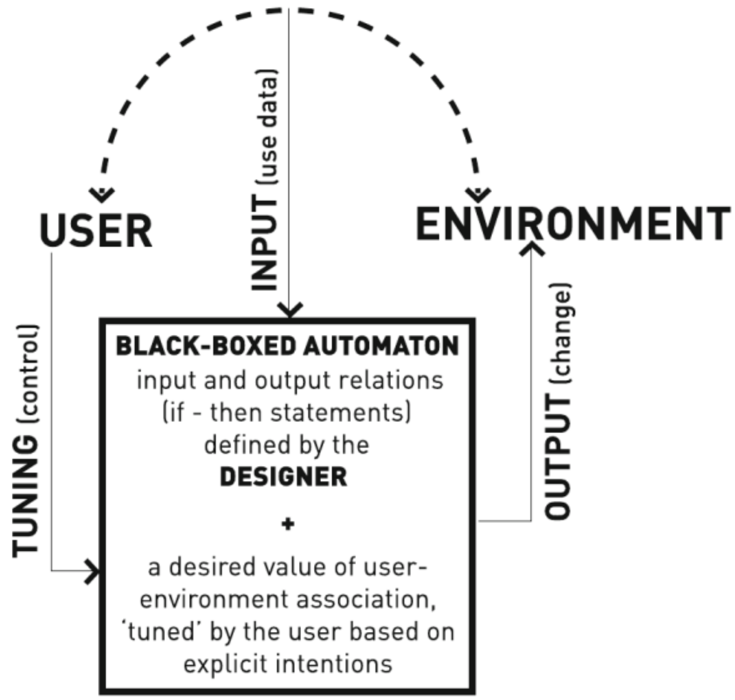


Figure 3.13: Charles Eastman's thermostat model for understanding adaptive-conditional architecture drawn by Theodora Vardouli (Vardouli, 2016:26)

Charles Eastman was concerned that when architects and designers design for the unknown user, they cannot use user data and make design decisions with their values' weight. That is why he asked architects to use empirical research to set conditions for design process (Eastman, 1972: 53). Likewise, Negroponte was trying to deepen the user's understanding in his responsive architecture research and included it in the design (Negroponte, 1972: 63). However, in the "Design Participation" Conference 1971, Negroponte's perspective on users has changed from the thermostat model of interaction by seeing the machine as a control mechanism that could regulate itself with algorithms (Negroponte, 1972). Ultimately, the ''Design Participation'' Conference was a place for the digital designers to display the research on user interaction in design process. In this conference, they contributed to the Second Order of Cybernetics, such as Charles Eastman, Yona Friedman, Nicholas Negroponte. These researchers thought about user and user's interaction with the environment and the system to search for the feasible design process.

The user phenomenon has affected other designers as well. These were Cedric Price and Christopher Alexander; while Price was expanding his research on cybernetics with Fun Palace and the Generator projects, Alexander developed ''a pattern language'' with the help of his quest for ''living structure' (Steenson, 2017). However, Christopher Alexander was reluctant to use the concept of user need; instead, he preferred to focus on user tendencies; because he tried to examine the intricate patterns of inhabitants for complex design problems through a user-centered approach in adaptive architecture (Ibid:41). According to Alexander, it would not be a realistic approach to expect the user to understand their own needs in such a complicated situation. However, instead it was the designers' task to categorize and analyze user tendencies. Charles Eastman also had these concerns to designate human activity patterns by empirical research and to create algorithms for the system and the environment conditions.

With these user potentials, Cedric Price's projects Fun Palace and the Generator provided a learning framework. The latter is mainly about how the environment changes and transforms accordingly with its users' needs and desires by structurally modular components moving by cranes (Figure 3.14; Figure 3.15); the former is an investigation on architecture supported by artificial intelligence. In the Fun Palace project, Cedric Price worked with the theater producer Joan Littlewood who wanted to create a theater which was a social experiment shaped by transformation according to human (Mathews 2006). Later, Gordon Pask combined his cybernetic theory with Fun Palace while the cybernetic committee established a system through a flowchart that answered the changing human activity and needs (Ibid). Hence, creating a systematic flowchart was reinforced the project's systematic approach to an adaptive environment. As a consequence, hybrid understanding of the user needs and technology in Fun Palace project encouraged Price to follow new approaches in his Generator project (Uçar Kırmızıgül, 2011:56). Opportunities of concerning and utilizing user needs and behaviors during the design process gave a socially controlled and effective perspective to the architectural projects.

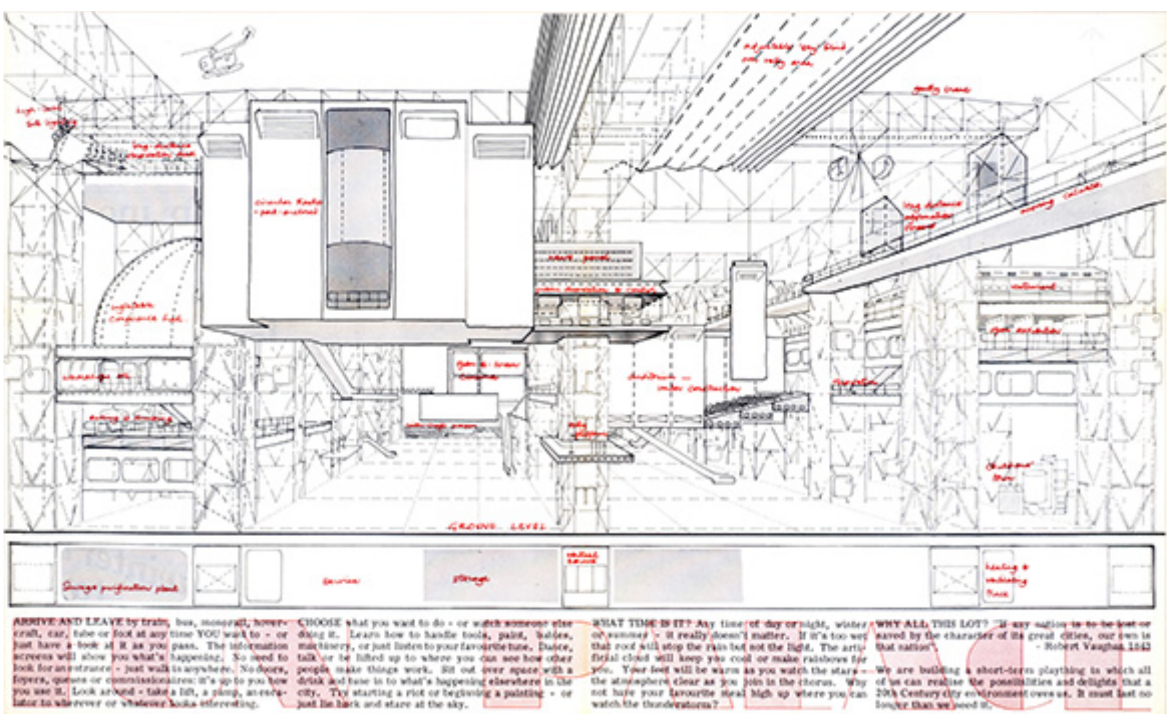


Figure 3.14: Fun Palace 3D Section, 1964. DR1995:0188:525:001:016 Cedric Price Archives, Canadian Centre for Architecture, Montréal.

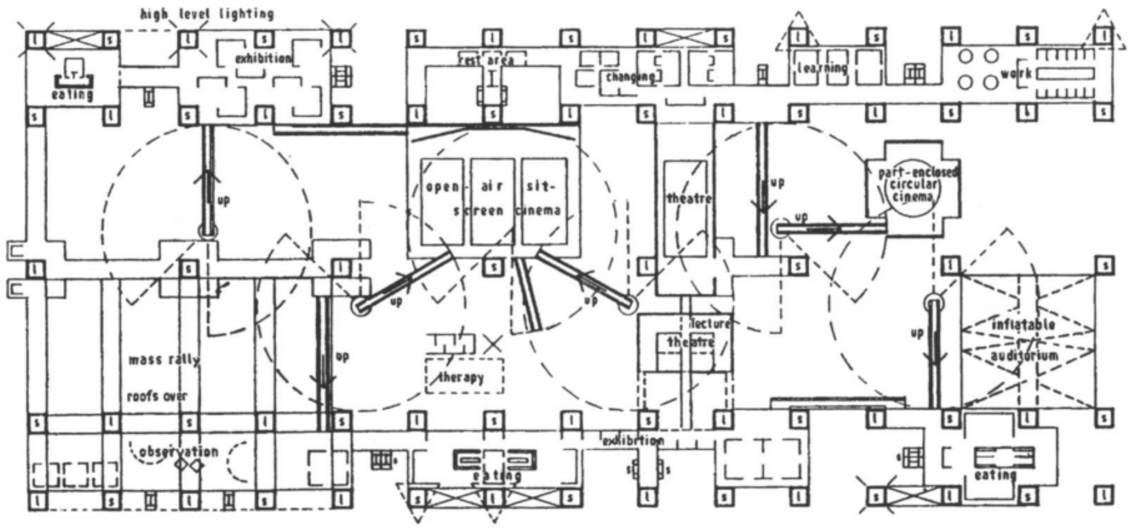


Figure 3.15: Fun Palace floor plan, 1964. Cedric Price Archives, Canadian Centre for Architecture, Montréal.

In Generator project, Price collaborated with John and Julia Frazer as computer consultants (Frazer, 1998). They tried to design an intelligent system which let its users track their design decisions (Steenson, 2017). Frazer stated their intention on Generator project as (Frazer, 1998:131):

> …we intended that the Generator would learn from the alterations it made to its own organisation, and coach itself to make better suggestions. Ultimately, the building itself might be better able to determine its arrangement for the users benefit than the users themselves. This principle is now employed in environmental control systems with a learning capability.

Therefore, the Generator project expanded the discussions on human-nonhuman interaction in architectural design (Figure 3.16). The Generator was the symbiosis of intelligent nonhuman designer (computer) and its inhabitant, so this was quite similar to Negroponte’s approach to the user. Cedric Price built a multi-disciplinary approach in his design process while collaborating with experts in computational technologies (Figure 3.17).

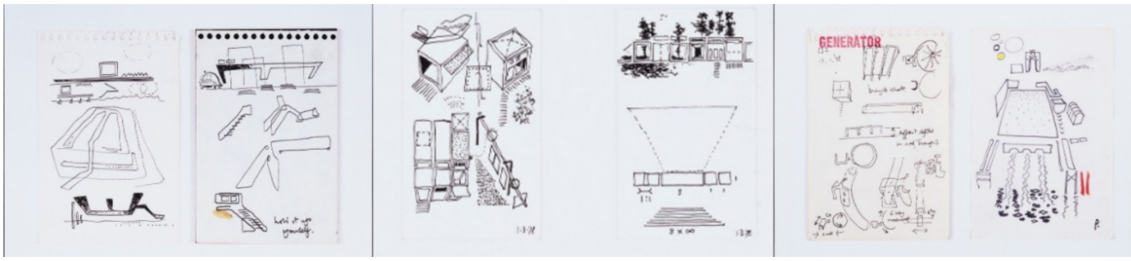


Figure 3.16: Sketches for the Generator Project's. Cedric Price, Generator Project (https://www.moma.org/collection/works/887)

To conclude, user perspectives of Charles Eastman, Nicholas Negroponte, Christopher Alexander and Cedric Price are in their design processes. As mentioned above, Eastman and Alexander had common understanding in terms of user and intelligence. They argued that the designer set up systematic approaches to understand the user and supported them with smart systems. On the other hand, Price and Negroponte came up with the more innovative systems than their users, so that the system itself regulates the users in terms of intelligence (Steenson, 2017: 160).

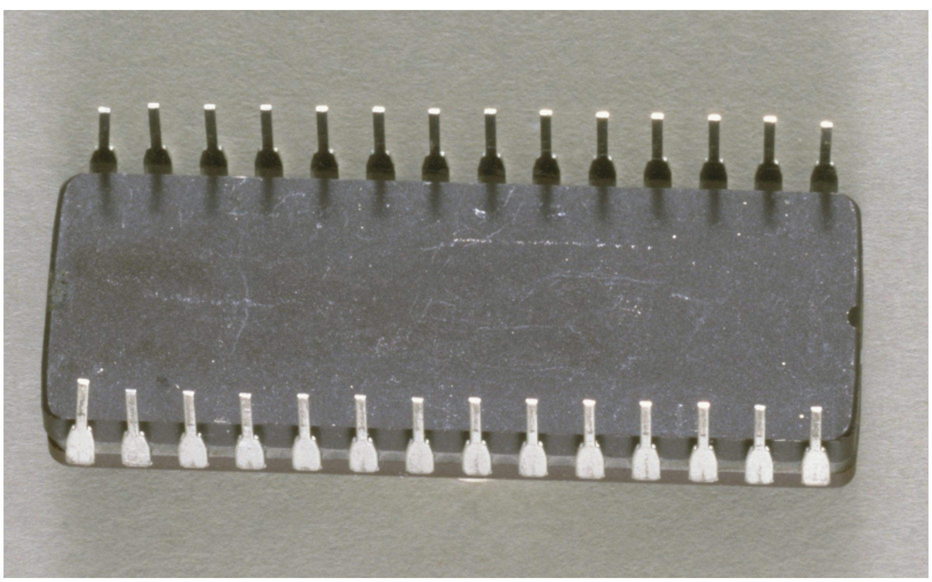


Figure 3.17: Computer chip responsible for the Generator Project's computation. Cedric Price, Generator Project (https://www.moma.org/collection/works/874)

As a summary, the concept of cybernetics has been discussed in order to associate technology with architectural research. Due to technological developments and the implications of mass production, interest had to be shifted from hardware and form to the consideration of human needs. This required a new look at the subject of design methods. Emerging cybernetics and information theory; design systems, human-machine interaction, computer representations at various levels (algorithms, computer programs and computer graphics) suggest a new language, human and machine within a conceptual framework through these instruments.

Hence, developments on technology help the architects and scientist discover new potentials of interaction between human, machine and environment. Their research aims to create a responsive and adaptive system to its environment and its user' needs. The idea of responsiveness, especially the second order of cyberneticians emphasized and reflected in architecture, has reached today's concept of intelligent architecture. Despite the first order of cybernetics, second orders suggested relative living systems interacting to their environments and users. Accordingly, learning from users and the environment is fundamental to fulfill their intelligent machine idea. Apparently, playing with uncertainties in the historical process has a significant effect on novelties.

Ultimately, the discussions provided in this chapter help to build a relationship between user experience design and cybernetics' theories on user participation in design process. This chapter's discussions paved the way for a more quantitative and qualitative research of users' activities in post and previous occupancy to inaugurate a systematic design in architecture. Moreover, this chapter findings were establishment of communication and interaction with paradigm changes on design research. These findings show that the theme of Cybernetics contributes and is related to current interactive architecture discussions. Consequently, the following chapter shed light on importance of interviews, observations and sensing the user behaviors during the design process with user experience techniques and ubiquitous computing.

CHAPTER 4

INTEGRATION OF USABILITY HEURISTICS IN ARCHITECTURAL DESIGN

This chapter intends to offer a perspective that compares and summarizes the usability heuristics caused by the technological developments in the human computer interaction studies architectural design process regarding usage centered design, human-centered design, and participatory design approaches. This chapter sheds light on the transformations of the interactions in the design process and as well as the redefinition of architectural design practice, which is supported by obtained data from the active participation of the environment and the user in human-centered design applications. Moreover, this chapter reveals the potential of user-experience design in architecture by combining the design process of user-experience and architecture. This combination presents a systematic approach to the design process with help of user data. By the cybernetic approach, this systematic approach emphasizes utilizing user feedback data during the design process in architecture. However, this systematic approach is hardly employed because the feedback is mainly received from the built object to make optimization for sustainable buildings, rather than the design and the user of the building. Therefore, in the usage centered architectural design process, the buildings' feedback data is collected and evaluated after the construction is completed as a post-occupancy evaluation, instead of during the design process and pre-occupancy. In this regard, the collected data might not inform and enhance the design process. However, if a methodology is developed for systematically collecting and sorting data from the buildings, the collected data can be employed in the future designs. For this reason, this thesis suggests a user experience-based perspective in architectural design. The user experience-based perspective, which is a systematic architectural design process, provide typology optimizations or enable overcoming current problems.

4.1. Unfolding the Sixth Locus into the Grudin’s Five Loci Diagram

Unfolding the sixth locus to Grudin’s diagram aims to generate spatial interaction of users with computationally augmented environments. The sixth level is as an enhancement of the fifth locus of Grudin, as it also deals with domestic areas rather than focusing on work-settings and organizations only. Grudin’s fifth level has been insufficient regarding embedded computers in places where every day activities takes place, particularly in domestic spaces. For this reason, this thesis suggests the sixth locus which stances for social and cultural level of integration with the environment. Considering all settings but not only work-settings, which is mentioned in the fifth level of Grudin's diagram, requires to create meaning through humans' everyday life activities which are engaged in responsive environments.

Interactive and responsive environments are consequences of embedded computers and embodied interaction (Carpo, 2017). Similarly, Dourish describes the embodied interaction as *"...the creation, manipulation, and sharing of meaning through engaged interaction with the artifacts."* (Dourish, 2014: 126). Therefore, Paul Dourish's embodied interaction approach involves the user's body, mind, and gestures to interact with responsive environments. Users have various set of values regarding phenomenological approach finding means of actions to have a better understanding of embodied interaction (Dourish, 2004). Thus, Dourish's arguments highlighted the embodiment for creating meaning through interactions. Embodied interaction made an impact on the active role of human, during interaction regarding its participation, perception, and experience (Uçar Kırmızıgül, 2011). Norberg- Schulz emphasizes that the concept of existential space is a mutual process that feeds back the relationship between the user and the environment they live in (Norberg- Schul, 1971). In this reference, he expresses the architectural space as an embodiment of this relationship regarding the phrase of *genius loci* (spirit of the place). With his phenomenological approach, the "spirit of the place" is attempted to elicit the user's data and its environment and/or habitat. Therefore, the necessity of comprehending the designed space is cultivated by a reproducible continuity through user data. (Hacıalibeyoğlu, 2013). To illustrate, Philippe Boudon examines Pessac, designed by Le

Corbusier, consisting of 70 residential units in the mid-1920s (Boudon, 1972). In his book Lived-in Architecture, Boudon reveals the contradictory situation between the architect's space and the reactions of those living in that space. Further, the tension between user and space, which occurs due to the operation of two different worlds, is actually due to the user's presence in the process that does not go beyond physical data. Hence, space should not only be a physical product but should be handled in a perception that integrates with its users and their everyday activities.

Moreover, Dourish focused on the social setting of the interaction that took place; likewise, a decade earlier, Jonathan Grudin emphasized the embedded interaction of the user in the work-setting in his ‘’Five Loci of Interface Development’’ diagram (Grudin, 1990). According to Dourish, Grudin predicted the future of user integration with an automated environment and described the concept of embedded interaction as experienced today (Dourish, 2004). In a spatial perspective, Dourish and Grudin’s arguments have the features of Wellesley-Miller’s argument concerning design systems and environments as responsive equipment to inhabitants needs instead of finished objects (Wellesley-Miller, 1972). Additionally, Mario Carpo articulated that the tenets of functional design have been embedded in user interactions, tendencies and experiments since the digital turn in architecture has started (Carpo, 2017). As a consequence, the suggested sixth locus by the thesis argues embodied interaction of users with their intelligent architectural environments (Figure 4.1).

With the help of establishment of Web 2.0, the focus has shifted into organizing, predicting and utilizing vast information in order to integrate with user centered design and culture (Carpo, 2017). Integration of user centered design and culture emphasizes the importance of embodied interaction. Currently, the augmentation of architectural spaces by digital sensors and gadgets are limited to non-constructive elements of the building (Carpo, 2013:12). Besides, sensors and gadgets enabled to yield architecture as an interface translating information; so that architectural spaces deal with information in order to observe and learn from, communicate and make decisions (Frazer, 2015; Boychenko, 2019). Therefore, starting from the early 1990s, ubiquity of computers has led designers to the novel approaches of making, thinking and also utilizing the user data. For instance, architectural practice has started to embrace user/human behavior simulation by utilizing building information modeling (BIM), internet of things (IoT), ambient intelligence (AmI), virtual reality (VR) and augmented reality (AR).

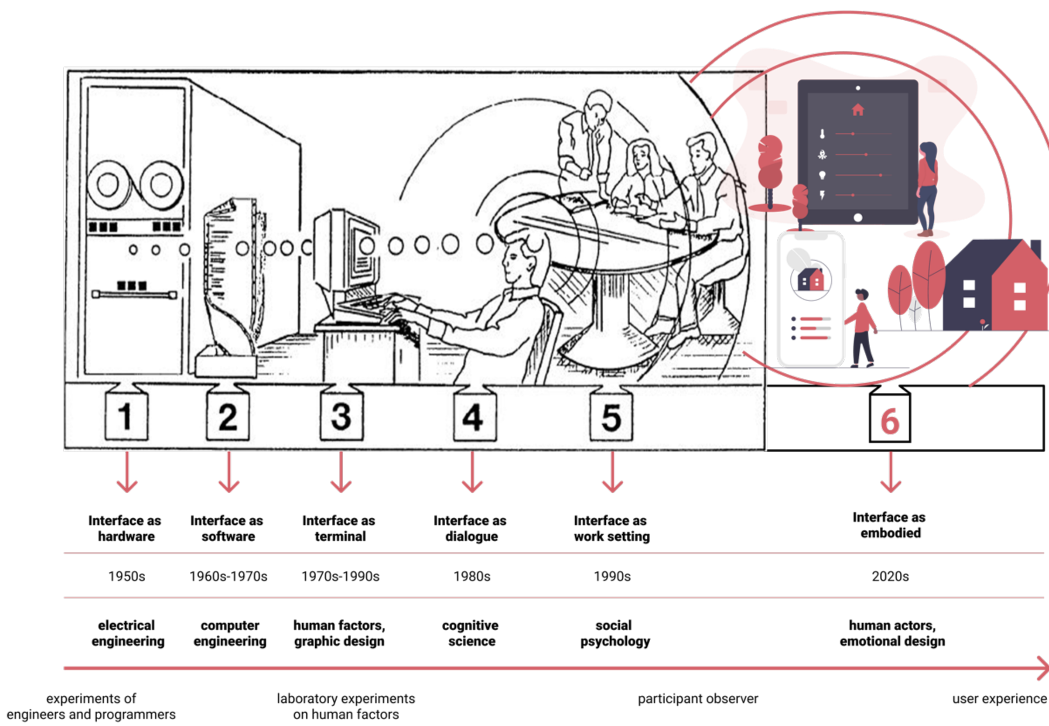


Figure 4.1. Suggested 6th locus to Grudin's Five Loci diagram (developed by the author)

The article ‘’User-centered design: for users or by users?’’ evaluates user focus with two approaches (Eason, 1995). In this article, the first approach is about theories and data emerging from users' behavior. In the second approach, the results are obtained from the users' participation in design benefit the design. These two approaches support the strategy that integrates users to design for and with them. Hence, Eason’s two approaches are in parallel to user experience design process. As a result of technological developments, fast communication tools, digital networks and the usability of the user experience studies gain significance.

Eventually, all these evaluations reveal the necessity of user integration in the design process, as the user, who has a variable and dynamic nature, is the subject of the design. The sixth locus that has been discussed throughout this section has a standpoint for future spaces where the embodied interaction takes place. Additionally, the sixth locus heralds the user experience-based perspective in architecture which is an interaction-oriented structure consisting of a designer, user, and computer that transforms into the ability to manage the design process with its tools and organizational structure. Ultimately, Liam J. Bannon articulates that with the ubiquitous computing, the user diverges from the operator role into the system and fed the system by taking a role as an active agent (Bannon, 1992). He stressed the importance of getting to know the user from the early stages of a design process to interact with them through an iterative design approach. Therefore, iterative design process has been utilized by the design process of the user experience. In the following section, the ten usability heuristics of interaction design will be applied into architecture towards reinforce user interaction and experience in a built environment where the criteria of the sixth locus are met.

4.2. 10 Usability Heuristics Applied to Architecture

Usability discussed in Chapter two through the lens of interaction design, yet within the concept of architecture will be debated on this section to re-envision spatial aspects of usability term in terms of interaction between user and built environment. The concept of usability in interaction design can be utilized to ensure that the architectural space meets the needs of its inhabitants and users. By taking advantage of the intersection of architecture and interaction design, the qualities of the architectural space can be rearranged (Wiberg, 2015). In architecture, investigation of the usability in architectural features within the scope of functional, technical, aesthetic and economic parameters are not novel. Vitruvius, in Ten Books on Architecture, states three attributes of good architecture which are stability, utility and beauty while emphasizing the usability of architectural systems (Vitruvius et al., 2005). Stability focuses on functionality of the structural system, technologies and quality of materials. Usability examines the meeting of user requirements of the space within the concept of architectural scale. Beauty refers to aesthetic concerns. In this context, architectural quality is presented as an integration of functionality, aesthetics and usability. By integrating technological developments into the built environment, usability must be supported by user experience beyond these three parameters of Vitruvius. For this reason, the static Vitruvian evaluations leave their place to multidisciplinary and dynamic interaction-oriented evaluations.

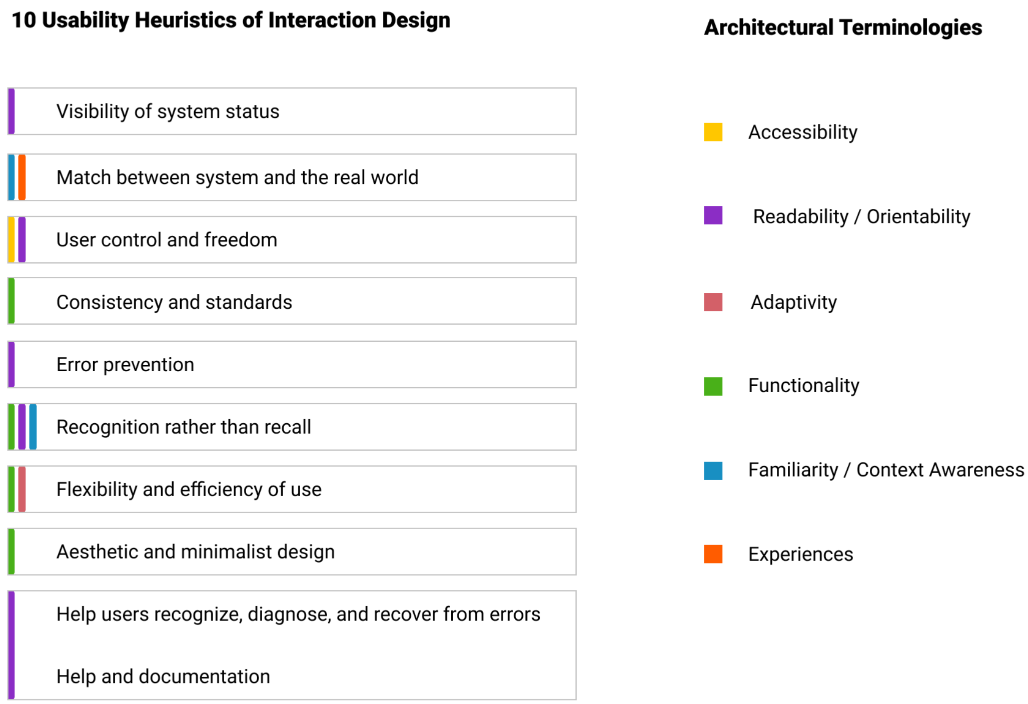


Figure 4.2: Integration of usability heuristics with architectural terminology (developed by the author).

In architecture, six architectural terminologies have been determined to discuss the ten usability heuristics of interaction design. These terminologies are color-coded in order to match with ten usability principles as shown in Figure 4.2. These architectural terminologies are accessibility, readability / orientation, adaptivity, functionality, context awareness / familiarity and experiences.

Accessibility

In design of an architectural system, accessibility allows all people to experience the space, regardless of their physical and cognitive capacities. Güleç Özer defined accessibility as the degree to which a product, vehicle, service or environment can reach as many people as possible (Güleç Özer, Özkan Özbek & Şener, 2016). Accessibility takes into account that different users have different needs and therefore the interaction provides a positive experience to different users. In architectural plan, parking lots, horizontal and vertical circulation elements, sanitary areas and doors are designed in consideration of accessibility concept.

Readability / Orientation

Readability includes reference directions that will help the user to perceive and mentally process spatial information. Being perceptual and behavioral, the concept of direction finding is one of the factors that significantly affect architecture. While people move on a certain route, the space affects the people, and the people affect the space by cognition. The possibility of accessibility in the space is related to the effective direction-finding action, so that accessibility and readability are related each other as well as other principles in order to evaluate usability.

Adaptivity

Adaptation is the change in the characteristics of the space and context in a way that responds to the needs and actions of the user. Adaptivity can be exemplified by the responsive facade designs and smart home that take input from the user and the environment.

Functionality

The configuration of the spaces is the consideration of the building depending on the purpose of use and the architectural program. Functionality in architecture, includes the coherence of the architectural scale and spatial arrangements of the organization.

Familiarity / Context Awareness

Examines the relationship of architectural spaces with context and users' reconciliation of this relationship with their previous experiences. Familiar contexts guide defining actions and interpreting the action for users. For example, designing structures such as hospitals and schools within certain typologies makes it easier for the user to find meaning in their new experience.

Experiences

It is the terminology that establishes a ground for symbolic and physical connections to the emotional interaction of individuals and society. It provides socio-cultural studies in places, as it includes memories, emotional connections, and historical events.

To illustrate these principles, researches on wayfinding in multilevel buildings; accessibility in hospitals and user perspective in policlinics are investigated as case studies (Hölscher, Brösamle, & Vrachliotis, 2010; Güleç Özer, Özkan Özbek & Şener, 2016; Şen, 2015). In these case studies researchers uses only one of the given ten usability heuristics to evaluate and enhance architectural design. In the research of Hölscher et al.'s, vertical orientation and navigation in multilevel buildings are evaluated by using space syntax methodology. The other example which utilizes space syntax methodology (convex and axial mapping) in terms of accessibility in hospitals is Güleç Özer et. al.'s research (Figure

4.3). Güleç Özer examines relationship system of programmatic spaces or building types by convex mapping; and behavioral characteristics of the spatial environment by using axial mapping regarding accessibility in architectural projects. Lastly, Asena Kumsal Şen highlights user perspective in policlinics design by utilizing user research methodology in her research. Şen set parameters to be used during the application with different users were determined as spatial organization, distance and time that affect navigation and orientation. Ultimately, these three projects have been utilized accessibility and readability/orientation principles in order to have a successful direction finding and spatial configuration in buildings. Yet, orientation is a form of behavior and includes knowing where it is and the best route, being able to follow the spatial signs. Therefore, behavioral way finding in the buildings is also related to familiarity principle. Connectivity between the ten usability heuristics can be interpreted throughout these given three research. Even though, the only one principle is emphasized in the projects, their research findings display that accessibility and orientation (way finding- navigation) evaluations are included familiarity, functionality and experiences of users. As a consequence, the ten usability heuristics can be utilized as a checklist framework to evaluate architectural design and built environment.

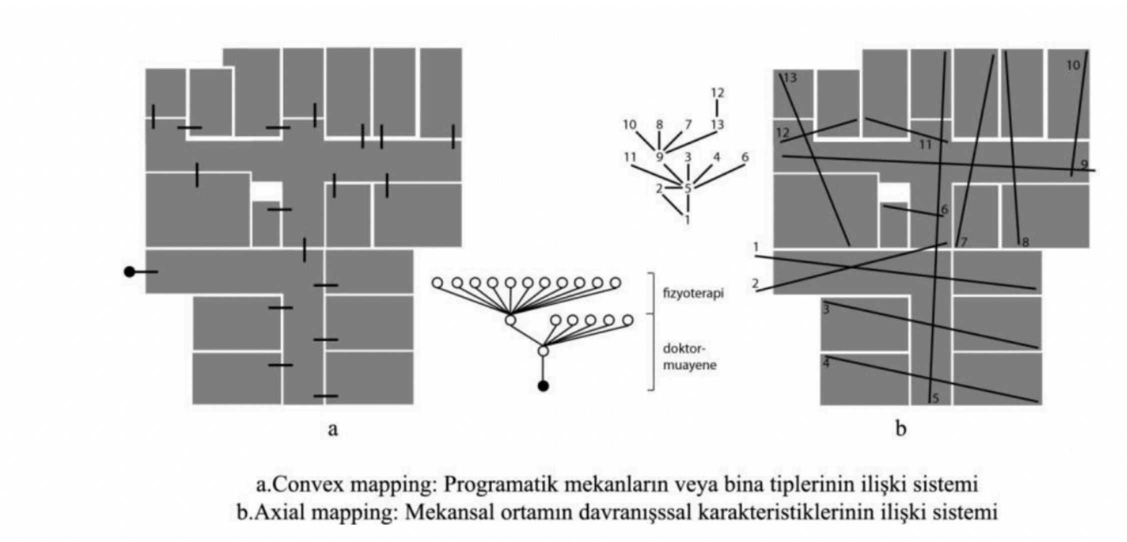


Figure 4.3: Convex and axial mapping schemes of hospitals by space syntax analysis (Güleç Özer, Özkan Özbek & Şener, 2016).

In conclusion, it can be observed that the 10 usability principles have an architectural equivalent. This classification provides a framework for evaluating the design of architectural spaces in terms of usability. In this classification, the evaluation of user behavior in the design process was investigated by usability methods. In this context, these ten principles have been examined by three research examples in terms of analyzing and evaluating the user's behavior, regarding the contribution to design by spatial usability. This review defines these ten principles through architecture. User experience and needs are considered within this framework. In future research, ten usability principles can serve as a source for more comprehensive studies on usability and quality of use in architectural design.

As a design subject, "space" changes and transforms for users who live in different needs and cultural lifestyles throughout time. While creating design objects, they are developed over user-oriented projects. In this context, it can be said that design objects are the products of a wide inter-scale relationship ranging from the simplest housing unit to complex buildings and the fictions of the living environments in which people live. The correct design of the space is directly proportional to the ability of the people using that space to move comfortably in the interior at a functional level. The formal or aesthetic levels of the building follow this functional integrity and strengthen the subjectivity of the building.

The common point of these ten principles is to produce systematic solutions by including certain parameters at the architectural plan level. While examining the contribution of usability to architecture, methods belonging to these ten principles are examined. These principles are a guide that will ensure the integration of theoretical knowledge into practice.

As a result of this research, the needs of people are brought to the forefront in the design of the physical environment in the architectural field. In addition, application of ten usability heuristics as an evaluation checklist can reduce costs in many ways and offer a more livable environment. This evaluation checklist of usability can contribute to the solution of spatial architectural problems that have been going on for many years.

CHAPTER 5

CONCLUSION

This thesis aimed to show the consideration of the user who is the actor in architectural design process by discussing ubiquitous computing, user experience design and usability heuristics of interaction design. Furthermore, this thesis questioned the intersection of experience design and architecture. As discussed throughout the entire thesis, the amalgamation of architectural design and user experience design investigated the users' interaction as being a human actor to the design process. At this point, as discussed in the Chapter three, the concept of cybernetic theory by evaluating the user/observer and the feedback from them during the design process triggered the development of experience design. Lastly, ten usability heuristics discussed and explored in the case of architecture. Through the lens of ten usability heuristics of interaction design, possible opportunities to integration of human actor in architectural design was pointed out. By investigating ten usability heuristics, it is aimed to develop a research method for user-oriented design for buildings that have not yet been designed, to create a basis for the design of buildings and evaluation of their design. In this way, ten usability heuristics creates a guiding method that will enable the spatial organization relations of all buildings to be reviewed and improved.

In the search for the intersection of user experience and architectural design, thesis provides an interaction and experience-based approach by introducing usability heuristics into architecture. Concerning adaptation of usability heuristic in architecture would provide a multidimensional understanding and knowledge on user experiences and behavioral characteristics. In contrast to usage centered architecture, the architect approaches the design process as an expert and reviews the obtained data qualitative and quantitative. The design process, which has a complex and ambiguous structure, creates the design systematic by using the data in a specific circular problem-solving process. Similarly, Asimov expresses morphology of design as a process consisting of cyclical actions progressing over time (Asimov, 1962). Thus, the design process developed with data has expanded the boundaries of design and architecture. In the thesis, the proposed usability heuristics, which reinforces experience-based perspective in architecture, shows the user's contribution to the architectural design process. As a result, the thesis presents a point of view in which data systematically classifies and guides the architectural design.

The inclusion of computer technologies in the design process has brought new methods and processes with it. With the development of technology, the data-oriented design was adopted by Cybernetics in the 1970s, while in the 1990s, architecture preferred to use technology as a representation tool. In the 1960s, they laid the foundations of today's user experience design, with cyberneticians and with the opportunity for interdisciplinary studies to arouse curiosity by researchers and find new ways. In the 1970s, names such as Christopher Alexander, Cedric Price, and Nicholas Negroponte described the user. Although their point of view to the designer was distinct, they all built systems that included the user, taking data from the user. These systems created different user parameters for the designer.

A systemic architectural design process can be considered as responsive to parameters belonging to different users and conditions. If these parameters are taken into account from the beginning of the design process, buildings might not need to be treated as finished object after the building is constructed. For this purpose, the architectural design should be considered systematically in order to fit the existing conditions and users' tendencies. By saturating sustainability, social and economic conditions while serving the current situation, considering possible future needs and requirements, structures will be able to work longer and increase design and building lifespan. Therefore, the thesis offers a new level to Grudin's ''Five loci of interface development'' diagram to form the basis for a user experience-based perspective in architectural design. The sixth locus that has been discussed in Chapter 4 has a standpoint for future spaces where the embodied interaction takes place. Ultimately, the ten usability heuristics of interaction design applied into architecture towards reinforced evaluation of user interaction and experience in a built environment where the criteria of the sixth locus are met.

In architectural design with a user experience perspective, interaction is established with the user data involved in the process. Hence, context, user, designer and, designed object are part of the same system that works as a whole. The designer expresses his/her thoughts with quantitative and qualitative data. This data-driven design process works rationally, systematically and highlights creativity with experience by information processing throughout the design. The user experience-based perspective changes the concepts, techniques, and stages used in the conventional architectural design process. This thesis reveals that the measurements required for usability in architectural design. The main contribution of this study is the construction of a general usability framework to architectural design in terms of utilizing user experience design in architecture. This thesis emphasizes the need for the usability heuristics of user experience in architecture for future research and aims to make this work. In this context, the potentials of these methods in architecture can be highlighted both in practice and in education.

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